The forts on Hadrian s wall: a comparative analysis of the form and construction of some buildings

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The forts on Hadrian`s Wall: a comparative analysis of the form and construction of some buildings

in three volumes

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Volume 1

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I confirm that no part of the material offered has previously been submitted by me for a degree in this or in any other University. If material has been generated through joint work, my independent contribution has been clearly indicated. In all other cases material from the work of others has been acknowledged and quotations and paraphrases suitably indicated.

Abstract

The thesis undertakes a comparative analysis of some of the stone buildings within the forts of the completed concept of Hadrian's Wall. The buildings included are the *principia*, granaries, gates and barracks. Each building type has been measured and inspected on site, or the data obtained from archival or documentary sources. As a background to the study the forts are set in the context of the Wall, examining its structure, garrisons and taking an overview of the archaeological record, additionally general Roman building techniques are reviewed . The selected buildings within each fort are then discussed and compared with other buildings on the Wall, or on other military sites. In this way their form, dimensional analysis, construction sequence and building techniques are considered and discussed. Common features and major differences are highlighted in the forts and the buildings, and comparisons drawn. Some tentative links are made as to the builders of the forts and the probable use of standard units of measure. Reconstructions of the buildings are put forward, taking into account the archaeological evidence and architectural considerations. Supporting information supplied in the appendices includes data relating to each fort as well as schedules of dimensions of the buildings, together with comparative tables. A catalogue of the decorated and moulded stonework sets out and discusses the stonework from the various buildings.

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Preface

The detailed analysis of buildings has been a neglected area of research in British archaeology. This study of some buildings within the forts on Hadrian's Wall is an architect's interpretation of those buildings, as seen from the extant remains and archaeological evidence. The author was an architect in private general practice for over three decades, with a special interest in historic and vernacular buildings. The interpretation and views expressed are made with the benefit of experience gained on all types of building, during that time in practice.

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The notes to to sections 1, 2 and appendix 4 are placed at the end of each section, however, for the convenience of the reader the notes to section 3 are placed at the end of each main sub-section.

1.0 INTRODUCTION

'Just when you think you are at the world's end, you see
a smoke from East to West as far as the eye can stretch,
houses and temples, shops and theatres, barracks and
granaries, trickling along like dice behind -
always behind - one long, low, rising and falling,
and hiding and showing line of towers.
And that is the Wall!'

Puck of Pook's Hill by Rudyard Kipling

1.1 Objectives

The stone buildings within the forts associated with the Roman Wall have received little attention both from their excavators and other researchers, and relatively little has been recorded about them. This thesis will consider selected buildings from each fort, and discuss their form and construction, together with any architectural detail. A comparison will be made of similar buildings *per lineam valli*, together with other selected sites within the Province. The construction sequence of the forts, and their buildings, will also be considered. Site dimensions have been taken of the buildings studied where possible, or alternatively obtained from documentary and archival sources. This measured record will enable the size of various elements within the buildings to be considered both singly and comparatively[1], and reconstructions drawn of the buildings in part or in whole.

The thesis will examine some stone buildings within the forts of the completed Hadrianic concept of the Wall. The buildings selected are the *principia,* granaries, gates and barracks. These building types have been chosen as they are represented in each fort, and have been more widely excavated and recorded in past excavations than other building forms.

1.2 Previous Research

The Antiquarians and Early Research

The words of Kipling at the head of the introduction vividly describe how the southern aspect of the Wall might have looked at some time during its later occupation. The population *per lineam valli*, including military and civilian, would have been considerable, and this is reflected in the legacy of the number and scale of the buildings that remain. These naturally attracted the attention of the early antiquarians and is discussed in some detail by Birley, E. (1961, 1-24). It is not proposed to discuss this aspect further except to highlight the advances in Wall studies.

William Camden is the first author to publish details of the Wall at any length, in the original edition of *Britannia* in 1586. The two later editions of the volume by Bishop Edmund Gibson in 1695 and 1722, stimulated much interest in the Roman remains. A few years later Alexander Gordon, in *Itinerarium Septentrionale,* wrote a more populistic view of the Wall, rather than a methodical study. He carried out the first detailed study of the Wall, and calculated the length of the *Vallum.* This work, although relying heavily on the contributions of contemporary antiquarians, is significant in that it used the *Notitia* list to establish the names of the forts on the Wall. Gordon also prepared the first plans of some of the Wall forts. However, it was John Horsley`s *Britannia Romana*, published in 1732, which proved to be the authoritative study for many years, and so effectively discouraged new research and ideas. Horsley noted the condition and spacing of the different features, together with the occurrence and remains of the forts and milecastles. He also describes and discusses inscribed and sculptured stones. William Stukeley published *Itinerarium Curiosum* in 1776, which included a study of his recent visit to the Wall; this work is useful in that it includes many contemporary sketches of the sites. Dr. John Lingard's notes of his research, following several visits to northern sites, were used by John Hodgson in his substantial work on the Wall (Hodgson, J. 1840), which is included in his *History of Northumberland.* His work was meticulously researched, and was responsible for a further upsurge of interest in the frontier. He pays particular attention to the structural relationship between the forts and the Wall, and reassesses many of Horsley's views

The first pilgrimage occurred in 1849 following a visit to the Wall in 1848 by John Collingwood Bruce, who was much influenced by Hodgson's views. The sites, and the extensive remains of the Wall itself, had impressed him greatly, and he felt the urge to draw the experience to the attention of his fellow antiquaries. The success of the pilgrimage resulted in the publication of his magisterial work, *The Roman Wall* in 1851; the work does, however, include much of Horsley's and Hodgson's earlier researches. This volume, with its two later editions, established Bruce as the foremost authority on the subject for the next four decades. The third edition of 1867 included a copy of Henry Mac Lauchlan's survey of the Wall (Mac Lauchlan 1857), which was carried out for the Duke of Northumberland; this was the first survey to be carried out since that of Gordon's. The survival of the central area of the Wall was due to the interest of John Clayton, on whose lands it stood, and to whom Bruce dedicated his Work on the Wall. Clayton was fortunate in that he had the means to pursue his antiquarian interest, and purchase and restore much of the Wall, as well as carry out many excavations. Clayton showed greater judgement and objectivity than Bruce, with whom he carried out much of the work; he was prepared to pass the information to Bruce, who published it, and took most of the credit. Clayton with Bruce's assistance, provided much more for the interested visitor to see and understand.

Late 19th Century and Recent Research

During the last decade of the nineteenth century several major excavations took place within the forts which set the pattern for the future. In 1875 to 1876 Dr. R. E. Hooppell (1880, 126-167) excavated the central area of the fort at South Shields, in 1897 J. P. Gibson (1903, 19-64) excavated much of the western portion of Great Chesters, and the following year, R. C. Bosanquet (1904, 193-300) excavated the whole of the interior of the fort at Housesteads. These excavations were by any standards large, and the excavators prepared a general report of the buildings uncovered, together with a plan prepared by experienced surveyors. Detailed specialist reports were included by Hooppell on the coins, bone, building materials, stamped pottery, inscriptions and some small finds. At Housesteads Bosanquet obtained a report on the *principia* and architectural fragments from the architect A. C. Dickie, and the inscriptions from F. Haverfield. The reports prepared by Hooppell and Bosanquet were of a standard which was not matched for a considerable time, whilst that of Bosanquet was significant in that it was one of the first to include a specialist report on a building. All the reports of this period tended to ignore most of the finds and architectural fragments, and came to few firm conclusions on dating; however, inscribed stones were much sought after. It is remarkable that these sites were excavated by men who had no training in archaeology, but by possessing the confidence and scholarship of the late Victorian gentleman, managed to achieve such high standards.

Haverfield actively researched the Wall from the turn of the century for a period of several decades. At Chesters, in 1900, he showed that the Wall Curtain had been built and then demolished, with the ditch being filled in prior to the building of the fort (Haverfield 1901, 84-88). He held the view that the Wall, as commenced by Hadrian, was built of turf, and that it was later rebuilt by Severus in stone. At around the same time F. G. Simpson began actively excavating the Wall, its milecastles and the *Vallum* (Simpson, G. 1976, 75-169), spending the first two and a half decades of the twentieth century pursuing his personal research. He established that the Wall had been built by Hadrian, and also solved the purpose of the *Vallum* and its crossings. Simpson during this time recorded his excavations meticulously, keeping detailed notebooks, as also did his foreman Thomas Hepple.

The beginning of a major period of study of the Wall began in 1924, with the formation of both the North of England Excavation Committee and the Durham Excavation Committee (Birley, E. 1961, 35). The committees were made up of members of the Newcastle upon Tyne Society of Antiquities and the Cumberland and Westmorland Antiquarian and Archaeological Society, together with representatives from the University of Durham. These committees were to dictate the excavations on the Wall for over 40 years. Brief reports appeared regularly in the journals of the respective societies as well as the *Durham University Journal*.

Some of the first excavations, under these new arrangements, were undertaken by James E. Petch, who excavated at Benwell between 1926-1928 (Petch 1927, 135-192;

1928, 46-74). The reports on these excavations give a detailed account of the findings, and the stratigraphy; an extensive summary was also appended on the pottery, glass, inscriptions, coins and metal objects. A site plan and some detailed plans were prepared, but very little information on the buildings was recorded and, unfortunately, there was no record of any photographs having been taken. During the 1930s more excavation was carried out on the forts associated with the Wall than at any other period. Excavation was carried out at Benwell, Halton Chesters, Carrawburgh, Housesteads, Great Chesters, Birdoswald, Castlesteads, Stanwix and Bowness-on-Solway, together with Birrens, Chesterholm and Old Church Brampton[2]. Excavation was also undertaken on several milecastles and turrets, by Birley, Simpson, and Brewis. The reports on these latter sites were accompanied by excellent plans which were prepared by Brewis[3] (e.g. Simpson, F. 1931, 305-27; Birley, Brewis and Simpson 1925, 93-120; Simpson, F. 1932, 255-9).

Brewis had also earlier excavated part of the fort at Rudchester (Brewis 1925, 93-120), and again the clarity of the plans of the buildings excavated contributed much to the report. This report also had a list of small finds, a coin report and a very brief summary of the bones. In contrast, the report of the excavation of the fort at Halton Chesters by Simpson and Richmond (1937, 151-71), is much more limited in content. This major excavation, which covered a large section of the eastern quadrant of the *praetentura*, as well as three gates, devotes just nine pages, including two plans, to the *praetentura* and north gate. No specialist reports of any kind are appended, and the drawings of the east and west gates show nothing of the clarity of the plans produced by Brewis.

Photographs were limited, and as far as the buildings were concerned, confined solely to the gates.

During this period, Eric Birley, who had purchased Chesterholm in 1929, carried out many excavations on the site. In 1932 he began at his leisure to excavate the *principia,* later collaborating with Richmond and Stanfield (Birley, Richmond, Stanfield 1936, 218-257). This major excavation, which revealed the Hadrianic as well as the Constantian stone buildings, must be regarded in retrospect as one of the most unfortunate of the period, in view of the loss of excavated data from the site. The Hadrianic *principia* revealed two startling finds. The first was a carved relief embodying the Sun God in his chariot; the report stated that the fragments would be published later when their study had progressed further (ibid., 231). These fragments were put in store at Housesteads, and during the War about a decade later, were lost without any study or record having been undertaken. A clenched fist is all that remains, presently in Carvoran museum. The second was the form of construction of the Hadrianic building, which was described as being in the *adobe* tradition and `unique in the Wall area, and without parallel in Britain` (ibid., 232). No drawings, photographs, or written record were made to substantiate this statement, and there is no additional information available of any kind. The plans of the *principia* show a minimal amount of detail, and photographs are few. No detailed drawings or specialist reports accompany the report.

Simpson and Richmond again collaborated at Benwell in 1937, when an urgent excavation was carried out in advance of residential development (Simpson and Richmond 1941, 1-43). On this occasion the whole of the *retentura* was excavated, together with the adjacent temple dedicated to *Antenociticus*. Whilst it is appreciated that the excavation was carried out over a short period in difficult circumstances, the knowledge gained from this important site was, unfortunately, limited. The priority would seem to have been to obtain a plan of the buildings within the fort, and in view of this only the walls were trenched. Although a good overall plan was prepared of the *retentura*, the only detailed plan of a building recovered was that of the temple, which was outside the curtilage of the fort. A full drawing and description was made of a water cistern in the *principia*, but any detailed account of the buildings was minimal. Photographs were also limited, and specialist reports only obtained on the soil samples.

Much work was done at other major sites *per lineam valli*, as previously described, including Corbridge which is outside the scope of this research. Great Chesters became the site where the first excavation of the Durham University Archaeological Committee took place in 1925, under its director F. G. Simpson, and in 1939 the work continued with the north rampart being investigated (Wright 1940, 149-155). At Stanwix and Castlesteads the position and size of the forts was established for the first time. Meanwhile at Birdoswald, between 1927 and 1933, Simpson and Richmond excavated extensively, and from coin and epigraphic evidence established the four Wall periods (Richmond and Birley 1930, 202-205; Daniels 1989, 10). These remained the foundation of Wall studies, and did not come under scrutiny until the 1970s (Breeze and Dobson 1972, 200-206). Excavations also took place at the outpost forts where at

Birrens the ramparts and the interior of the fort were investigated (Birley *et al.* 1938, 275-347), and at Bewcastle where the north gate and fort interior were excavated (Richmond *et al.* 1938, 195-237). Looking back at this decade and a half of archaeology, a great deal was learnt about the Wall and the forts. It had now become apparent that the forts were additional to the original Hadrianic proposals, and some sequence of their construction had been identified.

This period was dominated by Birley, Richmond and Simpson, and in particular the first two, who appear to have been the more ambitious personalities. The amount of work undertaken by these two men during the ten years 1930 to 1940 was prodigious, and must have made great demands on them. Birley, was appointed lecturer in Romano-British History and Archaeology at the University of Durham in 1931; Richmond became the Director of the British School at Rome from 1930 to 1932, and from 1935 was lecturer in Roman-British Archaeology at Armstrong College, Newcastle upon Tyne. With these additional commitments, adequate time to prepare excavation reports would have been limited. The position would seem to have been exacerbated, as there would seem to have been no one to share in the post excavation work (Simpson, G. 1976, 18-19). Thus all that is available to reassess these excavations some sixty years later are accounts, which by today's standards compare more with interim reports, containing very little in the way of specialist reports and other detail. Most of the finds and site records would seem to have been lost, for despite many enquiries, little trace of any primary record can be found. Simpson`s detailed notebooks cease at this time, and Thomas Hepple was no longer involved on the site to make his own records. Richmond`s notebooks in the Ashmolean Library are limited in the unpublished material they give, but it is unlikely that they formed the total site record. Robin Birley (pers. com.) states that none of his father's papers, of this period, relating to these sites have survived.

In retrospect it can be seen that if Birley, Richmond, and Simpson had restricted the amount of excavation they had undertaken, and prepared reports, which used those of Bosanquet and Hoopell as a starting point, such reports might then have become a model for post war archaeology. Their failure to do so almost certainly influenced post war archaeology, particularly in the north, where the minimal reports[4] of the 1930s were seen as models, so continuing the shortcomings in reported information. The Reports of the Research Committee of the Society of Antiquaries of London produced for major excavations of that period are by contrast of a high standard, with specialist reports on most aspects, together with full plans and photographs. These reports included sites such as Camulodunum (Hawkes and Hall 1947), Maiden Castle (Wheeler 1943), and the Jewry Wall, Leicester (Kenyon 1948). That their work influenced archaeology on a national scale can be shown by the fact that by the 1920s the excavation on Roman sites exceeded 40 per cent of all excavations annually; three of the leading figures were Birley, Richmond and Simpson.

It must be appreciated that the scenario in which archaeology existed sixty years ago was very different from that of today, and that priorities were arranged using different criteria; events of that period should be judged with the benefit of historical perspective. In particular it must be remembered that the results of most of the early excavations were based on a series of narrow trenches and that no large area excavation took place. It is on the basis of the small samples from these trenches that Simpson and Richmond based their interpretation of the Wall and the forts. After a period of sixty years it is difficult to understand the excavation policy of the two excavation committees, but from the large number of sites opened and closed up after a relatively short period, it is hard to imagine that there was a considered research strategy. Both Birley and Richmond were students of R. G. Collingwood, who kept Romano-British studies alive at Oxford after the death of Haverfield. Collingwood preached of the Baconian revolution (Collingwood 1939, 133-134), a revolution which converted a random study into one where definite questions were asked, and definite answers insisted upon. It is possible that many of the excavations were based on these principles, as on many sites the excavator sets out to identify set targets or answer specific questions. The only site on which work continued for any length of time was at Birdoswald, where excavation was undertaken between 1927 and 1933. Possibly if the committees had given more thought to an overall archaeological strategy, the value of the excavation record would have been greater. Perhaps a clue to the thinking of the period can be adjudged from the title of the committees, where "excavation" is included in both of them, and the word "research" omitted entirely. Both Birley and Richmond took a "broad brush" approach in their reports, and in a great many cases usefully set a recently excavated site in the broader context of the Roman Empire. Thus, Richmond, who had recently been excavating in North Africa before coming to Halton Chesters, likens the approach along the *via praetoria* to the fore-hall of the latter to a similar architectural concept at Lambaesis (Simpson and Richmond 1937, 169-70). Unfortunately the grand vista of Halton Chesters is unlikely to have been that which he envisaged.

The outbreak of the war, of necessity, curbed the work of both the excavation committees, and it was many years later that research on a much smaller scale was resumed. Richmond's re-excavation and consolidation at South Shields was one of the first major sites to be undertaken (Richmond 1955, 297-315). In the late 1950s and early 1960s the annex at Halton Chesters was excavated by M. Jarrett (1959, 177-190), and two barracks at Housesteads by J. Wilkes (1960, 61-71; 1961, 279-300). All these reports were modelled on the style of the 1930's reports, and lack much detail, particularly on the buildings. Some limited pottery reports were now being added to the reports as a matter of course. This pattern was followed during the 1960s with the reports on Housesteads by D. Charlesworth (1975, 17-42; 1976, 17-30), and on Carrawburgh by D. J. Breeze (1972, 81-144), with increasing attention being paid to the building and the finds. The mid 1970s saw major work commence at Wallsend, under the direction of C. M. Daniels, which was to culminate in the excavation of virtually all the fort over a period of ten years. During the late 1970s C. M. Daniels and J. P. Gillam excavated the north-east corner of the fort at Housesteads, for which the report is expected shortly.

The shortcomings of earlier reports are apparent when compared with P. T. Bidwell's (1985) volume on Chesterholm, for the Historic Buildings and Monuments Commission for England, and later with S. Speak (Bidwell and Speak 1994) on the excavations at South Shields since 1983. This latter report is the first since that of Bosanquet on Housesteads to examine in any detail the architectural fragments, and to consider the architectural form and construction of the buildings. The report on the excavations carried out at Birdoswald over the last decade by T. Wilmott (1997) for

English Heritage also considers the form and construction of the buildings, together with specialist reports on elements of the building. It is hoped this excellent report will set the standards for all future work.

The brief outline set out above shows that over a period of almost a hundred years of excavation and research on the Wall, little regard has been paid to the buildings which were being excavated. From the published information, which is all the student of today has available, apart from Bosanquet's excavation of Housesteads and the more recent reports, there is little of detail provided on the buildings. Although the productive years of the twenties and thirties were able to provide valuable information on the overall concept of the Wall and its forts, they gave little insight into the form and construction of the buildings.

1.3 An Overview of the Wall and its Garrisons

The extravagant expansion of the Empire which was undertaken by Trajan, forced Hadrian to realise that Rome could no longer afford to continue the expansion of the Empire and envelop the whole known world as foreseen by Augustus (Frere 1978, 147). During Hadrian's many protracted visits of inspection and reform throughout the Empire, he spent a large part of his reign away from Rome, so establishing that the capital of the Empire was wherever the emperor might be. He determined to define the limits of the Empire and consolidate the defences, during the course of which in 121 to 122 he visited Germany to reassess the linear German-Raetian frontier. This artificial frontier, which demarcated the eastern limits of the Province, was defined by a bank on which were set large stakes sunk into the ground, forming a palisade, behind which were set a series of timber watch towers (Maxfield 1990, 157-9). This was probably the first fixed frontier defence to be built, with the forts associated with the *limes* being set well back behind its line. In 122 Hadrian came to Britain to establish the northern limit of the Empire. The time of the visit could have followed a period of insurrection by the northern tribes culminating in the construction of the Wall. The following inscription was erected at the east end of the Wall to commemorate the victory and completion of the frontier (RIB 1051). `Son of all the deified emperors, the Emperor Caesar Trajan Hadrian Augustus, after the necessity of keeping the empire within its limits had been laid upon him by divine precept ... thrice consul ...: after the barbarians had been dispersed and the province of Britain had been recovered, he added a frontier-line between either shore of the Ocean for 80 miles. The army of the province built this defence-work under the charge of Aulus Platorius Nepos, emperor`s pro-praetorian legate`. The fact that a fixed frontier was built implies that further trouble was anticipated from the tribes to the north.

Hadrian`s Wall was set slightly to the north of the Stanegate and its associated forts. This chosen line between the Tyne and the Solway kept to the higher ground, with the central section positioned along to the northern edge of the Whin Sill, with its north facing outcrop of volcanic rock. The Wall was first planned to run from Newcastle-upon-Tyne to Bowness-on-Solway, a distance of 70 miles (113 km), and was later extended to Wallsend to the east. It is only proposed to outline briefly the form of the Wall as this is covered fully elsewhere (Daniels 1978, 14-47; Birley, E. 1961, 70-131; Breeze and Dobson 1991, 27-85). The Wall was designed to be constructed in stone

10 Roman feet wide east of the River Irthing, and in turf 20 Roman feet wide to the west of the river. The width of the Stone Wall, as designed, was reduced from a point close to the turret 24b to the River Irthing. The thickness of this Narrow Gauge Wall is of variable width (Daniels 1978, 18). Milecastles with gates were to be positioned every Roman mile, with two turrets equally positioned between each milecastle. A ditch was formed to the north of the Wall beyond a berm, 6 metres wide, this varied between 8 to 12 metes in width, and 2.700 to 3 metres in depth. Recent research has shown that the Broad Wall core was made up of clay, freestone, and pebbles, with the core of the Narrow Wall being similarly formed (Bennett 1998, 27-28); no mortar was used in the core[5]. The material for the clay and stone core was almost certainly taken from the Wall ditch, with some of the surplus upcast thrown to the north side of the ditch. No ditch was formed where the Wall ran on the Whin Sill ridge. The walls surrounding the milecastles were in stone to the Stone Wall, and turf to the Turf Wall. The turrets are built in stone throughout. Both the milecastles and turrets were constructed independently of the Wall, and in most cases both stone milecastles and turrets show evidence of having been built to the Broad Gauge Wall where they conjoined the Wall built to the narrower gauge. The stone milecastles measured *c.* 50 by *c.* 60 Roman feet internally, with the turf wall milecastles measuring *c.* 60 by *c.* 70 Roman feet. Gates were formed both in the north and south walls, whilst one or two ranges of buildings were situated within the enclosure. It is likely that a tower was formed over the northern gate. The turrets were *c.* 6 metres square, with access to the upper level gained by means of a ladder within the turret. The level of the upper floor would equal that of the walkway of the Wall, which was a minimum of *c.* 4.300 m high (see chapter 4.3).

The *Vallum* was constructed to the south of the Wall and was built in a series of straight lines, generally following a route clear of natural obstacles. It took the form of a substantial ditch with mounds to each side (Breeze and Dobson 1991, 53-57). The purpose of the *Vallum* was to define the southern boundary of a *cordon militaire*, being the area between the Wall and the *Vallum*. Access across it was provided at forts, and other defined positions. The V*allum* was dug after most of the forts had been built or planned as it diverts to the south to avoid them where necessary. The exception to this is at Carrawburgh, which was built over the line of the V*allum*; this fort is known, however, to be a late addition to the amended proposals.

This original concept of the Wall fulfilled what Hadrian`s biographer wrote, that he `drew a wall along a length of eighty miles to separate barbarians and Romans' (Birley, A. 1976, 68-69). This concept reflected the form of the German-Raetian *limes* in that the Wall relied on the forts on the Stanegate for reinforcements in case of need. Its main purpose was to control movement in and out of the Province, as well as forming a base for military activity on or north of the frontier, and was never intended to be a defensive feature.

Shortly after building had been commenced, three major alterations were made to the original design. These alterations were the addition of forts on the line of the Wall itself, the reduction in width of the central section of the Wall, and the digging of the *Vallum* to the south. The frontier was extended to the east to Wallsend at this time. The construction of stone forts on the Wall itself was an abrupt change of policy, and is a feature found nowhere else outside Britain on any *limes*, during the period of the Western Empire. This same policy was adopted on the Antonine Wall some twenty years later. The decision to build forts on the line of the Wall could only have been taken if, at the same time, a decision had been made to run down the forts on the Stanegate, so as to avoid duplication. These Stanegate forts had been rebuilt or refurbished as an early part of the original Hadrianic scheme. This change in the concept could have been brought about by the amount of activity and unrest caused by the building of the fixed frontier, and the need to control this, and anticipated future aggression (Frere 1978, 151). The German and Raetian *limes,* generally, were built adjacent to rivers and fixed natural features (Maxfield 1990, 140), and was in most places constructed across areas of low population. On the line of the Wall there are many indications of a settled population, with evidence of ploughing having been seen beneath forts viz. Wallsend, Halton Chesters, and Carrawburgh. The Wall would of necessity have displaced or split communities, and it is certain that the lands of the Brigantes, and probably the Votadini, Novantae, and Selgovae would have been affected. The effect of the construction of this permanent barrier across the traditional tribal lands would have had a devastating affect on those directly concerned. The Brigantes had always possessed a close connection with the Selgovae and Novantae (Frere 1978, 147), and it must not be overlooked that the goddess Brigantia was commemorated at Birrens (Robertson 1975, 284). The realisation by these three particularly troublesome tribes that a physical barrier was being erected on their traditional lands, must have manifested itself in attacks against the Roman builders, in the forlorn hope that the decision might be reversed. The loss of freedom of movement between the northern tribes must have been particularly galling, and could be compared with the erection of the Berlin Wall in more recent times.

Bennett (1998, 26) puts forward the proposal that work on the Broad Gauge Wall stopped after the decision had been made to construct the Wall forts, with the construction of the Wall only recommencing after the completion of the forts, but to the Narrow Gauge. This proposal suggests that a large number of troops were required on the frontier to allow the Hadrianic concept to be completed in the face of opposition from the northern tribes.

A suggestion has been made (Breeze 1990, 206-7) that the forts were built astride the Wall, as the frontier itself was proving to be a barrier to troop movements. He suggests that the single gate of a milecastle would have caused undue restriction of troop movements, so forts were constructed with three gates, with twin portals, north of the Wall. That this was an overprovision is clearly seen by the early blocking of many of the portals at an early date. If it was found that the width of the milecastle gates were restrictive it is difficult to see why the easiest option was not implemented, that is to enlarge the gate to accommodate a double portal.

The forts were evenly placed along the line of the Wall at a distance of *c.* 7 miles (Breeze and Dobson 1991, 50). The main criteria required in siting the forts were, the best possible strategic position and a plentiful water supply (Milner 1993, 76-77). Many of the forts *per lineam valli,* and secondary sites, have been built on or close to sites of pre-Roman activity, these include, Wallsend, Newcastle upon Tyne, Rudchester, Halton Chesters, Carrawburgh, Birdoswald, Carlisle, South Shields and Chesterholm (Bennett 1998,19). The probability should be considered that an existing native site was chosen in preference to a virgin site, as it would have been well positioned, and also its occupation by the invaders would remove any potential risk[6]. The forts in the eastern section from Wallsend to Chesters, excluding Newcastle, were built with the *praetentura* projecting forward of the Wall so as to allow the gates of the *via principalis* to discharge north of the barrier. It is likely that the reason for the provision of three gates with twin portals forward of the Wall, was to provide flexibility and speed in dispatching the troops.

It must have soon become obvious that the number of gates presented a weakness in the design. This is reflected in the later forts of the central section where at Housesteads, Great Chesters, and Carrawburgh, the north gate and rampart are on the line of the Wall curtain. Many of the portals to these gates were blocked at a very early date, and in some instances before completion (Breeze and Dobson 1972, 193-195). These later forts were constructed at the same time as the narrow wall, which at both Housesteads and Great Chesters was re-aligned to take account of the siting of the fort. The width of the narrow wall had been reduced from the broad wall of 10 Roman feet to 8 Roman feet, and in some instances as little as 6 feet. Birdoswald and Stanwix were also set behind the Stone Wall which replaced the Turf Wall. In the case of Birdoswald the Turf Wall was slighted when the later stone fort was built, and the narrow stone Wall constructed to join up to it[7].

Castlesteads is the only fort of the revised scheme which does not abut the Wall being situated on a strategically sited high bluff between the Wall and the *Vallum*. Carvoran, one of the original Stanegate forts, is situated to the south of the *Vallum* which changes direction to the north of the fort (Daniels 1978, 188). It would appear to have been retained to operate as a Wall fort. Of the three forts on the Solway, Drumburgh and Bowness-on-Solway are behind the Wall, but Burgh-by-Sands, a third century fort, is astride the Wall.

In most cases the forts *per lineam valli* face north, and the main threat of attack. Two forts in the centre at Housesteads and Great Chesters break this rule, being orientated to the east. It is possible that the former fort is orientated in this way due to the steep incline from the north gate, although a ramped access was formed up to the gate. Stanwix also probably faces east. The forts at Drumburgh and Bowness-on-Solway also face east but this is almost certainly due to the proximity of the estuary on their north side.

The main communication route to the Hadrianic forts was the Stanegate running from Carlisle to Corbridge; these forts being the main supply depots for the Wall and its garrisons. Main roads crossed the Wall in two places, the road travelling north from Carlisle, and Dere Street running north from Corbridge passing through the Wall at the Portgate, west of milecastle 22.

Outpost forts at Birrens, Netherby, and Bewcastle formed part of the Hadrianic original scheme, and controlled the lowlands to the north of the Solway. The forts of

High Rochester and Risingham cannot be dated to the time of Hadrian, and are probably third century, and must be considered later additions. Breeze and Dobson (1991, 45-46) consider that the purpose of the original outpost forts was to maintain control over the portion of Brigantian territory isolated from the rest of the Province by the construction of the Wall. In addition the forts could be seen to lend support to the suggestion that the Novantae and Selgovae resented the intrusion of the barrier and were proving troublesome, so requiring a military force north of the Wall. There can be no doubt that these forts would have contributed considerably to the overall scheme in providing three cohorts in forward positions in a potentially volatile area.

To complete the northern frontier defences, a series of forts at Beckfoot, Maryport, Burrow Walls and Moresby were built, together with a series of fortlets down the coast. This system of defences which is well documented elsewhere (Daniels 1978, 259-286; Bellhouse 1989), terminated at the port of Ravenglass. Its purpose was to prevent the aggressive northern tribes carrying out a flanking movement and obtaining a foothold behind the Wall.

Relatively little is known about the tribes north of the Wall. The Votadini occupied the eastern lowlands and coast north of the Tyne, with the Selgovae the central region, and the Novantae the south west of Scotland, although it is not possible to define the tribal boundaries accurately. The Brigantes occupied much of Northern England, together with the area around the Solway, and their lands would appear to have been characterised by few hill forts. There is positive evidence for arable activity in the settlements in the valleys, with a pastoral use in the uplands (Higham 1980, 41-47; Ramm 1980, 28-40). Van der Veen (1992, 158) has shown that arable farming played an important part in the economy of the late Iron Age people of the Highland zone in the nort-east. The territory of the Novantae and Selgovae is characterised by many hill forts and in this respect they differ markedly from the Brigantes; the presence of so many fortified sites suggests to Frere (1978, 72-73) a more advanced culture with greater agricultural resources. The three tribes were bitter and unrelenting in their hostility to the Romans, and this probably relates to their first contact with the Roman Army (Frere 1978, 126-7). It is likely that the tribes suffered retribution in their support of Venutius following his breach with Cartimandua, and they were also subjugated by Agricola in the course of his campaigns in the north. The Votadini, on the other hand appear to have been on good terms with the invaders, and this is reflected in the number of artefacts and pottery showing evidence of continuous trade (Johnson 1980, 55-8). It is likely that the Brigantes, Novantae and the Selgovae, between whom there was an alliance were involved in the rebellion in the north which occurred shortly after Hadrian became Emperor (Frere 1978, 147-8; Birley, A. 1997, 130). Evidence of the continued unrest by of these three tribes can be seen by the number of forts which were constructed on their territory; by comparison there are very few forts in the lands of the Votadini.

The Garrisons

Overseeing the design and construction of the Wall were three legions, the *Legio II Augusta* which was based at Caerleon, the *Legio VI Victrix* based at York, and the

Legio XX Valeria Victrix from Chester. The *Legio VI Victrix* arrived in Britain from Vetera in Lower Germany, with the specific intention of constructing the Wall. Aulus Platorius Nepos its commander, formerly governor of Lower Germany, was appointed by his friend Hadrian to succeed Falco as Governor of Britain in 122, and was given the responsibility of overseeing the building of the Wall. It is probable that Hadrian crossed over to Britain with Nepos and the sixth legion in June of that year (Birley, A. 1997, 124). Although the legions carried out a great deal of the construction work, their main impact was in the design, and organisation of the works on site.

Although the Wall was conceived and built by the legionaries, with the additional help of auxiliary units and slave labour, the occupation of the forts and the responsibility of controlling the frontier was that of the auxiliary troops (Watson 1983, 15-6). In the early second century, the *auxilia* were under the command of officers from either Italy, or the more Romanised provinces of southern Gaul and Spain. The officer would have been of equestrian rank, and this appointment would have formed part of his career structure. To serve in the *auxilia* a man had to be free born, and satisfy army requirements; it was normal for the units to be raised in the provinces. Pay and conditions were not as attractive as the legions, but conversely training and service was not as harsh or exacting. The regular pay and other benefits meant that there was a steady stream of recruits. Compared with the legionaries, the *auxilia* were lightly armed, and due to this could provide flexibility and mobility in action. Many of the *cohors quingenaria equitata*[8], who were part mounted, were less well trained and equipped than an *ala* (Davies 1989 141-151), and this again was reflected in pay and conditions (Watson 1983, 99-101). The role of the *auxilia* was ideally suited to the patrolling and policing of the frontier, and in dealing with small skirmishes. It is almost certain that in times of attack, these units would have been supported by legionary troops drafted in to offer assistance.

The forts were built in the majority of cases to hold a quingenary cohort of auxiliary troops. In some cases an *ala* was housed, as at Chesters, Stanwix and possibly Benwell. The size of the forts varied noticeably (see appendices 1 and 2), even though they were designed to accommodate the same number, and type of garrison. The size of the fort at Chesters, together with its favourable situation, reflected the seniority in rank of the *ala* known to be in occupation. The fort at Housesteads, however, was built to house a garrison of a *cohors milliaria peditata*, the lowest grade of auxiliary troops. Although Chesters would have had to accommodate the horses for the cavalry, it would have had nominally only half the number of men to house, yet the fort is some 266 square metres greater in area than Housesteads. It is likely that the status of the intended occupying garrison influenced the size of a fort, as well as the nature of the terrain, and that this status could also have been reflected in the size and detailed design of the building.

1.4 The Sites

It is proposed to consider some stone buildings within the forts associated with the revised Hadrianic proposals for the northern frontier (fig. 1). These primary forts include those which formed part of the Wall curtain, together with the outpost forts. Some forts on the Stanegate are included as these were rebuilt early on in the construction of the frontier before the decision was taken to move forts up on to the Wall (Breeze 1990, 206). Chesterholm and Brampton, Old Church are representative of this secondary group as excavated data on this group of buildings is limited. Carvoran, although a Stanegate fort, is treated as a Wall fort in view of its proximity to the Wall.

The forts forming the defences to the Cumbrian Coast to the west of Bowness-on-Solway can only provide limited data due to the lack of excavated detail. Beckfoot and Moresby are included as they formed part of the amended scheme, as also is Maryport which was either built, or rebuilt to handle supplies for the construction of the Wall. South Shields, although built *c.*163, is included as it was a new fort built specifically to augment the defences of the frontier, and has many similarities with the other forts *per lineam valli.*

The forts listed below are to be considered as the primary sites (figs. 2-22):

Wallsend	Carvoran
Newcastle-upon-Tyne	Birdoswald
Benwell	Castlesteads
Rudchester	Stanwix
Halton Chesters	Burgh- by-Sands

Chesters	Drumburgh
Carrawburgh	Bowness- on-Solway
Housesteads	Beckfoot
Great Chesters	Maryport
	Moresby

The following forts are considered as secondary sites (figs. 23-28):

Birrens	South Shields
Netherby	Chesterholm
Bewcastle	Old Church, Brampton

It is intended that a comparison of the primary and secondary sites will be made together with other military sites within the Province. The sites will be chosen because of similarities in the buildings, or because of their known association with the builders. In the text, the enumeration of the primary forts will generally be given from east to west, followed by the secondary forts.

As there are some inconsistencies in the names used for the forts, including the assumed Roman name, those which are used in this thesis are those set out in the 13th edition of the *Handbook to The Roman Wall* (1978), edited by Charles Daniels. It will be found, therefore, that Chesterholm is used for the now more familiar Vindolanda.

The only exception is Halton Chesters where Bruce`s description is preferred (Bruce 1867, 136).

The Layout of the Forts

The layout of the forts *per lineam valli* followed very closely the model of a temporary camp put forward in the treatise, *De Munitionibus Castrorum,* by an unknown author with an unknown original title. The author is usually assigned to one of two people both named Hyginus, who each wrote a treatise on surveying, but it is now thought that neither Hyginus was responsible (Polybius, 59). The date of the work is most likely to be *c.* 110, but a later date of *c.* 220 has also been suggested (ibid., 62). Although this theoretical layout was intended to hold three legions, the general form is that of the forts *per lineam valli*. The layout was consistent in that the principal street, the *via principalis* ran across the width of the fort. Between this street and the *via quintana* lay the *latera praetorii,* in this block were situated the *principia*, the *praetorium*, and usually the granaries. A gate was situated on each side of the fort where the *via principalis* passed through the rampart. In the forts built astride the Wall, secondary gates were situated at each end of the *via quintana,* so as to give access to areas behind the Wall, as the gates to the *via principalis* were set forward of the barrier. The *via praetoria,* leading to the main gate, was positioned on the central axis of the *principia,* which in most cases faced the enemy, and so orientated the forts to the north. Exceptions to this occur at Housesteads, Great Chesters and Stanwix, together with Drumburgh and Bowness-on-Solway on the Solway estuary, where the fort, and hence the *principia,* are orientated to the east. The *via decumana* ran on the main axis, in the opposite direction from the *via praetoria,* and led to the main gate at the rear of the fort.

The author of *De Munitionibus Castrorum,* (Polybius, 73, 12), states that the centre line of the *principia* on the axis of the *via praetoria* is called, `the place of the surveying instrument`. This point, known as the *stella,* was where a line on the *portae praetoria* and *decumana* intersected the *via principalis.* The implication is that this position was used as a datum in setting out the camp. The block fronting onto the *via pincipalis,* and bisected by the *via paetoria,* was the *praetentura,* and the block fronting onto the *via quintana* and bisected by the *via decumana,* was the *retentura.* Whilst the author of *De Munitionbus Castrorum* describes the layout of the tents in the *praetentura* to be laid out *per scamna,* and those to the *retentura, per strigas,* this was probably due to the great variation in the military personnel who had to be accommodated. One dictating factor that influenced the layout, was the length required to accommodate the tents for a full century of 80 men. As a tent took up 10 feet[9] and sheltered 8 men, 10 tents were required, which took up 120 feet including the space needed between them. In the forts *per lineam valli* the barracks run both *per scamna* and *per strigas* the officers` quarters, however, were always positioned adjacent to the *intervallum* road, so that in case of any disturbance they could be quickly on the scene.

The Buildings

The buildings within a fort to be included in this research are the gates, the *principia*, the granaries, and the barracks. The hospital and *praetorium* are not included, due to the limited number of sites where these buildings have been excavated and recorded. Store buildings and stables have also not been included due to the difficulty of identification, and lack of positively identified sites. The selected building types are all well represented on the northern frontier, so as to enable comparisons to be made.

The buildings erected within the Wall forts were of necessity functional, and therefore simple in form and construction. The form of the *principia* with its courtyard surrounded by an ambulatory on three sides, the cross-hall with or without an aisle adjoining the courtyard, and the rear range of five rooms, reflects the form of the building type found on the east German *limes* (Baatz 1975; Fellman 1959, 56-58). The buildings in all cases lack any rooms off the ambulatories, and at the two ends of the cross hall, and also are consistent in having five rooms in the rear range, with two either side of the *aedes*.

In Roman military garrisons under the Empire, the granary was often of long rectangular plan form with substantial buttressed walls. The floors were usually raised, but not always so, for it is likely that other foods were stored. The building type seems to have been determined early, for there are clear examples in the camp built by Scipio Aemilianus in 134 BC, whilst besieging Numantia (Rickman 1971, 2). Contrary to the military design, the massive *horrea* at Ostia that served Rome, are not heavily buttressed. The granaries in the forts in Britain are easily recognisable, and have been comprehensively catalogued (Gentry 1976).

Examples of timber gateways and towers are depicted on Trajan`s column, and their general development, with particular reference to the reconstruction of the south-west gate at South Shields has been discussed at length (Bidwell, Miket and Ford 1988). An earlier study on the gateways of the forts on Hadrian`s Wall was made by Richmond and Child (1942, 134-154). There is probably more evidence on the frontier sites relating to the gateways than any other building type. The main point of contention on any reconstruction rests with the number of storeys and height of the towers, over the guardchambers.

The barracks are the most common building type seen on the Wall, but relatively little has been published on this building form *per lineam valli.*

Each extant building has been measured in plan, and a schedule of dimensions is included in appendices 1 and 2. The dimensions recorded have been chosen to highlight the similarities in each of the building types. Also to be found in the appendices is a schedule of data relating to each fort, which also includes details of the past excavation record. In addition a selected list of building inscriptions, taken from RIB, together with an overview of dating evidence is appended. A plan of each fort is placed in volume 3, in the collection of figures. The method of recording, where most of the measurements are taken over the external walls, is described fully in the next section on methodology.

Dating

The intention of this dissertation is to examine the buildings of the final Hadrianic concept of the northern frontier. The commencement of the building of the Wall can be closely dated to the summer of 122, following the probable arrival of Hadrian, Nepos and the *Legio VI Victrix* in June of that year (Birley, A. 1997, 124). It is quite possible that a start had been made on the Wall before the troops retired to their winter quarters in late 122. It is not possible to determine exactly when the original concept of the Wall was changed to include the forts. The Turf Wall had been built as far as the Irthing, and the Stone Wall built for a length of 18 miles to the Portgate. In addition much preliminary work had been carried out in the central section; at this stage there is clear evidence that building work stopped abruptly (Breeze and Dobson 1991, 46). Nepos must have been responsible for the amended proposals, for two of the new forts were built during his governership. It is likely that the forts were started around 125 as Benwell and Halton Chesters were completed, or nearly so, by 126 before the departure of Nepos (ibid., 76). On stylistic grounds, it is probable that the other eastern forts which were built projecting forward of the Wall curtain are contemporary, so it is likely that Wallsend, Rudchester and Chesters were built within a few years of each other. The central forts are almost certainly later, and it will be shown (chapter 3.4.5.4) that a probable constructional sequence was Housesteads, Great Chesters, and Carrawburgh, with the latter fort being built *c.* 130. Carvoran was rebuilt in stone in 136-7, but this may have been one of the last forts to be rebuilt by the legions, as there was an earlier fort on the site (Daniels 1989, 41-43). The mid-Antonine fort of South Shields has been firmly dated to *c.* 163 following the recent interpretation of the site (Bidwell and Speak 1994, 9). This replaced an earlier fort close by, and could be representative of the period of reoccupation of the Wall following the return from the Antonine Wall. The total number of forts constructed within the eleven or twelve year period between *c.* 125 and *c.* 136-137 would have represented an enormous commitment of men and material.

The outpost forts which formed part of the original scheme are of Hadrianic date. An earlier Flavian fort had been erected at Birrens, with a substantial Hadrianic fort being constructed *c.* 122 to *c.* 128 (Robertson 1975, 278). A Flavian fort probably existed at Netherby prior to the construction of the subsequent fort, although the record is very sketchy, and no firm chronology has been established. Bewcastle was a new Hadrianic outpost fort, and can be securely dated to the frontier concept (Austen 1991, 30).

A possible criticism of this thesis could be that some of the upstanding Hadrianic masonry that has been studied, cannot be shown to belong to that period. Great care has been taken in identifying the relevant contexts both on site and in any excavation report. Whilst it is accepted that there may be some differences in the dimensions due to the irregularities of the masonry over the actual length, the data is presented with confidence. The general criterion used to identify the building phases is that the earliest context of the primary forts falls within the Hadrianic period. However, it is possible that there may have been problems of misinterpretation, by some of the early excavators, of the earliest archaeological evidence on site.

1.5 The Recording of Dimensional Data

This section sets out the manner in which the units of measurement were recorded and are tabulated for the buildings that are being studied.

SI Units

The acceptance of the metre and millimetre exclusively for linear measurements in the UK conforms with international agreement, and to subsequent ratification of that agreement in BS 1192:Part 1:1984. Section 19.4.3 states that where both metres and millimetres are shown on drawings, there is a risk of misinterpretation, and for this reason dimensions should be given to three places of decimals; they should normally be written, for example, as 2.100 m.

The acceptance by the writer of BS 1192:Part 1:1984 as a recording standard is due to the nature of this work, which is based on the survey and interpretation of buildings where measured surveys have been undertaken and drawings prepared. To avoid any ambiguity in this dissertation, all written dimensions will be stated to three places of decimals[10].

Site Measurement and Recording

Long dimensions on site were measured by two people using a 30.000 m or 50.000 m Fibron tape (which was checked periodically for accuracy). Smaller dimensions were taken using a steel rule. Where linear dimensions were taken, there was often some irregularity in the external face of the stonework, and in such cases an average was determined. In the majority of instances the opposing elevations of a building differed in length (i.e. north and south elevations), and subsequently each elevation of a building, where possible, was measured. Such variations are given as a range in the text.

Dimensions in most cases record external measurements. This is due to evidence of buildings being designed to predetermined overall external dimensions, as will be discussed in chapter 3.3.1. This is substantiated by the considerable variance seen in the thickness of external walls, as it is considered that the overall size of the building was the significant factor, and not a predetermined room size.

It is proposed that selected dimensions relating to each building type will be compared. The positions of these dimensions are indicated on typical building plans (figs. 31 and 32). Data sheets tabulating the dimension for the buildings to each fort are set out in appendices 1 and 2.

The selected dimensions to be used for comparative purposes:

Principia — overall dimensions to each external elevation

cross-hall length and width

width of aisle (where extant)

courtyard length of each internal elevation

width of ambulatories (from inside of external wall)

aedes internal dimensions

Granary — overall dimensions of each external elevation, excluding buttresses

overall dimensions over buttresses

spacing of buttresses - a range will be given

projection of buttresses - a range will be given

Gates — overall dimensions of each external elevation

width of gate passage

depth of gate passage

width of portals to each elevation

dimensions of each elevation to both guardchambers

projection of face of rampart from portals to each side of the gate passage

Barracks overall dimensions of each external elevations to *contubernia*

overall dimensions of each external elevation to officer`s quarters

internal width of *contubernia* - a range will be given

width of verandah (where extant)

The dimensions set out in the appendices will be those discussed in the text. Dimensions in the data sheets which have been measured on site are in standard script, whilst those which have been scaled or obtained from other sources are shown in italics. Orientation is described as stated in an excavator`s report; an elevation or feature may not therefore correspond to the cardinal point described.

1.6 Summary

It is almost certain that the scale and assessment of the cost and time taken to erect the permanent frontier would seem to have been flawed. It is also probable that the magnitude of the modifications, particularly the construction of the *Vallum,* were underestimated. It is likely that the misconceptions were those of Hadrian, who conceived and constructed buildings on a grand scale, and disliked having his architectural abilities questioned. This is reflected in the fate of Appollodorus, Trajan`s brilliant architect, who was exiled and later executed for doubting Hadrian`s architectural abilities (Salway 1982, 181-2; Birley, A. 1997, 56 note 18).

In this introduction the present research has been placed in the context of the discoveries of the early Antiquarians and later research, particularly that of the 1930s. The overview of the Wall and its garrisons provides an outline of the northern frontier in which this present work sits. The sites under review have been divided into primary and secondary, the former being part of the revised Hadrianic frontier concept, and the latter being used for comparative purposes. The greater emphasis will be placed on the primary sites.

The thesis will first consider the general architectural principles and constructional techniques used by the Roman builders. The central part will be a discussion on the buildings, set out in five sections. In this part the design and form of each building type will be considered, to be followed by a dimensional analysis of the buildings and an examination of the constructional sequence of the forts and buildings. This part will continue to discuss the constructional techniques used in each building type, and will end with a conclusion. The following section will discuss the reconstruction of the buildings under study with hypothetical illustrations, based on archaeological evidence and architectural considerations. The thesis will conclude with a summary and recommendations.

Volume 2 will include the appendices. Appendices 1 and 2 set out details of each fort with schedules of the dimensions relating to the buildings recorded. Appendix 3 sets out tables and collated dimensions to accompany discussions in the text. Appendix 4 sets out a schedule of decorated and moulded stonework associated with the primary and secondary sites. Appendix 5 includes calculations prepared by D. Lingard and Associates to support the discussion in chapters 3.2.4 and 3.4.1. Volume 3 contains the figures and plates.

Notes

1 The information relating to each fort is set out in the appendices 1 and 2, and in most cases is omitted from the text. The data included gives details of a fort`s size and garrisons, together with a record of past excavations.

2 As this list is extensive, and in view of the numerous references, the reader is referred to appendices 1 and 2 where full bibliographical details are given.

3 The quality of the plans prepared by Brewis was due to his training as an architect.

4 These excavation reports were extensively published in the journal of the Society of Antiquaries Newcastle-upon-Tyne, *Archaeologia Aeliana* and the transactions of the Cumberland and Westmorland Antiquarian and Archaeological Society.

5 It would seem on balance that the Wall core varied from stretch to stretch depending on the builders and materials available. Whitworth (1999, 5) quoting Anderson who maintained the Wall for the Ministry of Works for about four decades, states that the core of the Wall at Blackcarts was built in layers with lime mortar, and acted as a tie to each leaf of masonry.

6 Birdoswald is now seen to have been sited, for strategic reasons, close to an Iron Age site as it was not built in a good position, the site being marshy and uneven (Richmond 1931, 123-124).

7 It is now known that a turf and timber fort was built astride the Turf Wall (pers. com. T. Wilmott).

8 In a *cohors quingenaria equitata* there were nominally 120 mounted cavalry in four troops; each *turma* was commanded by a *decurio* (Davies 1989, 141).

9 As will be shown in chapter 3.2.8 the nominal width of a tent is very close to many of the widths of a *contubernium* in a barrack block.

10 Architects, and all professions in the building industry, work to this standard. The centimetre, represented by two decimal places, does not have a place in SI units. It would seem sensible for the archaeological profession to also adopt the same standards.

2.0 THE TECHNIQUES OF ROMAN BUILDING CONSTRUCTION

The Hadrianic dynasty could be said to reflect the pinnacle of Roman architectural achievement. Of all the buildings, the one which probably reflects this achievement more than any other is the Pantheon, with the perfect harmony of its interior brought about by the ingenious marriage of brick and concrete. Other buildings which reflect the architectural splendour and technical competence of this period are the Temple of Venus and Rome, Hadrian`s Villa at Tivoli, and his Mausoleum. All these buildings reflect Hadrian`s architectural ambitions and are of a quality not subsequently matched.

It is against this background that the Roman military engineers and architects built the forts on the Wall. The builders` conservative nature would not allow them to adapt the traditional form of the buildings to suite the harsh climate of the northern boundary of the Empire. The Roman military mind was trained not to accept defeat; and there was no building obstacle which could not be overcome, either by design or construction. Where any problem occurred, the military mind used its cunning and inventiveness to overcome it.

In the sections below, the techniques used by the Roman military builders will be outlined. The general principles of constructional techniques as used *per lineam valli* will be discussed, and comparisons made with those used by the military in Britain and elsewhere in the Empire. Where appropriate, comparisons will be drawn with non-military examples. Each main building trade will be examined and the source of the materials and the manner of their use on site will be discussed. This chapter will provide the background for the subsequent chapters, when each building type will be examined in detail, together with the building techniques used.

2.1 Masonry

Quarrying

In normal circumstances the Romans obtained the building stone for the forts from the nearest quarry to the fort. A comprehensive study of the quarries is yet to be undertaken, but a summary of much of the known data is provided by Daniels (1978, 41-5); Breeze and Dobson (1991, 31-2) and Bidwell and Holbrook (1989, 48, 63).

From epigraphical evidence at the quarries and the Vindolanda writing tablets, it is known that the Roman army worked in the quarries, and were involved in the transportation of the stone (Daniels 1978, 41-45). Clearly this transportation from the quarries to the building site would have been a major operation involving significant members of men, animals, and carts. This is borne out by another tablet (*Tab. Vindol.* II, 316) where the writer asks his correspondent `to consider what size of wagons he needs to transport the stone, since the Vocontians have filled 100 wagons with stone in one day`. This amount of material must have reflected the number of operatives at the quarry, and the scale of the building operations. There are several instances where troops have recorded their thoughts during a boring or fatiguing job. The recorded comments of the troops in the Cumberland quarries provide such an insight (Davies 1968), many of whom must have had the same inclination as the soldier at Coombe Crag who wrote, `*Appollonius Daminius nolui*` (RIB 1952).

Kendal (1996, 129-52) has endeavoured to estimate, at some length, the transport logistics associated with the building of the Wall and its forts. One major omission in his calculations, is the stone required to construct the roads used for the transportation of the stone and other materials to site. Whilst it is accepted that the period during which much of the work was carried out on the Wall was limited, as will be discussed later in this chapter, this need not have applied to the winning and delivery of materials. It is suggested that it could have been possible to quarry and deliver stone and sand, together with the burning of lime, for a notional 300 days a year, taking in to account severe weather conditions and other factors. As Kendal's figures have been worked out on a 200 day year, this reduces his estimated requirements dramatically. Instead of 1500 vehicles and drivers, plus 2900 oxen, and 7100 mules/horses being required if the Wall was to be completed in 10 years, the requirements would be reduced to 1000 vehicles, 1933 oxen, and 4733 mules/horses. The logistics of gathering men, animals, and vehicles together for such a relatively short period are very considerable, and it is suggested that works continued, to some degree, throughout the year on the construction of the Wall and the forts, with the exception of the laying of stonework.

Foundations

Vitruvius (1.5.1) states that foundations should be dug down to solid ground and be of a breadth greater than the walls. Alberti[1] (1955, 46) comments on the many different methods used by "the ancients" in forming foundations, all of which have endured firm and sound. Palladius (Plommer 1973, 16, 17) states that foundations in clay should be one foot wider than the walling above, and that the walling above the foundations should be five times the depth of the foundations itself. Due to the limited examples of excavated foundations *per lineam valli*, there are few sites on which to base the construction methods of the Roman builders. The present method of forming foundations is to lay a strip foundation of concrete below the load-bearing walls. In this method the load of the building itself, together with any live loads, are transmitted to the ground through the walls. It is essential that the underside of the foundation is firm, and that any top soil or soft material is removed, so as to reduce any settlement. If the bearing capacity of the ground is low, the width of the foundations is increased so as to spread the load of the building over a greater area. The relative bearing capacities of the sub-soil were not appreciated by the Roman builders.

A good example of strip foundations was seen at the west gate at Birdoswald (chapter 3.4.3.1). In this case stone walling was laid on foundations made up of clay and stone. The usual practice was to excavate a foundation trench down to a solid clay and fill it up with compacted clay and stone. On this, the foundation courses of walling were laid with large stones forming the lowest course, with another two or three courses of a reducing offset course above, off which the wall was constructed. In an extreme case where a building was constructed over an existing ditch, as at Halton Chesters (chapter 3.4.3.1), seven offsets were formed in the massive foundations, together with a considerable amount of dead walling above (pl. 1).

A raft foundation is laid where the ground is known to have poor load-bearing qualities, and it is necessary to distribute both the dead and live loads of the building, to the ground, over the whole area of the building. It is probable that such a foundation was laid to the granary at Halton Chesters (chapter 3.4.2.1). Here a mass of clay and stone was laid below the floor, and the edge of the foundation was seen to have been retained by a stone kerb. Stiff clay and stone would have been an ideal material for a raft as it would have given slightly in the case of any subsidence, and yet have been rigid enough, provided it was of adequate thickness, to distribute any loads evenly.

Walling

The general walling seen in the forts was of roughly squared, coursed rubble facing stones, with each stone tapering slightly to the inside face. The walling stones, both to the Wall and the forts, bear a strong resemblance to each other, and were the product of semi-skilled operatives turning them out in very large quantities. It is probable that some form of guidelines were issued to the quarries, so that the stones were cut to approximately the same size. The size of the stones varied somewhat from site to site, but were usually squared up to roughly the same height of not more than 250-300 mm. Each stone was worked on site before laying, to ensure a close fit with adjoining walling stones, as abundant mason`s chippings show. The task of laying the masonry is one which is usually carried out by a skilled/semi-skilled operative, using a walling hammer or a punch. The stonework and its execution, on Hadrian`s Wall, is discussed at length by Hill (1981; 1991b).

The walling, with each stone bedded in mortar, was laid so that the perpends on each course were staggered, and did not line through. The centre of the wall between the facing stones was filled with small and discarded stones bedded in mortar. At the external corners, stones of approximately twice the length were laid, alternating to each adjacent face (pl. 2), these larger stones would have given greater strength to the corners. In some instances stones or quoins, two courses high, were found. It is suggested that the square proportions of the stones, used in the walling to the forts and the Wall curtain itself, were designed to offset the effects of direct attack. Vegetius

(1965, 74) recommends that, `To resist battering rams calls for stone walls at least eight feet thick, of selected large hard stones, cut long and laid as headers`. The use of headers rather than stretchers would reduce the damage caused to a wall by a battering ram as there would be less tie between the individual piece of masonry. This type of walling is known as *opus vittatum*, and is hardly seen before the Augustus period (Adam 1994, 135). It was used particularly in Italy during the Lower Empire and middle ages (Marta 1990, 34). It is possible that *opus vittatum* is a development of *opus reticulatum* (Vitruvius 2, 8, 1 - 2). This method of walling is made up of small square stones bedded in mortar and set at an angle of 45 degrees, as a facing to *opus caementicium*. Once the first course had been laid the form of the masonry allowed very little variation in appearance and width of joint, provided each stone was the same size. This allowed the laying of the masonry to be carried out by workers with little skill. Adam (1994 131) suggests that *opus vittatum* was a development of *opus reticulatum*, whereby the courses of the stones were turned through 45 degrees, which would facilitate laying, although there was likely to be more variation in the size of the mortar joints. The proportion of the stones however, being almost square, reflected the earlier walling type.

The masonry to a high proportion of the lower status buildings, such as barracks and storerooms, was bedded on clay, probably due to a shortage of lime required to make the lime mortar (chapter 3.4.4.1). There are many instances where masonry to high status buildings, such as the south aisle external wall to the *basilica* at Birdoswald, was also similarly bedded, probably for the same reason.

Large blocks of stone were brought onto site in a roughed out finish. In these cases the bed would be dressed smooth and the stone laid, and the other faces then dressed off. The usual practice was to cut chisel drafted margins on the same plane to each face, and then form the arrises (Hill 1981, 13-14). It can be seen in many instances (pl. 3) that well in excess of 50 mm of material was removed in shaping the stone, usually resulting in a punched face finish of various stages of completeness. The large blocks were laid without a mortar bed.

Opus quadratum was the other type of masonry used on the Wall, though to a lesser degree, and examples can be seen at the *Vallum* gate at Benwell, and the Wall bridges. This can be described as masonry walling formed out of rectangular blocks laid in horizontal courses, without mortar, and in many cases joined together with cramps or dowels. *Opus quadratum* continued the Greek tradition of walling, and Vitruvius (2, 8, 5-7) describes the technique using Greek terminology. It was generally used with a finely dressed or ashlar finish.

Openings

The preferred method of forming the head to an opening was by means of a semi-circular arch, either monolithic or bilithic for short spans, or by means of voussoirs. Keevill (1996, 51) cites several examples for comparative evidence; these include arcading at Meonstoke, Hants. (King and Potter 1990), windows and doors at Lebach, Germany (Miron 1990), windows in the basilica at Pianabella, Italy (Coccia and Paroli 1990, figs. 5.4, 5.5 and 5.6), bathhouse windows at Sparsholt, Hants. (Johnston 1978, 82), and the veranda arch to the villa at Dewlish, Dorset (Putnam and Rainey 1975, 54). Many examples of upstanding round headed arches can be seen, including the Porta Nigra, and Basilica of Constantine, Trier.

The technique of forming the head to a medium width opening with voussoirs allowed flexibility, in that considerable tolerance was allowed in forming the width of the opening. Forming an opening with voussoirs was also simpler to construct as small pieces of stone were used, instead of a much larger heavier piece in the form of a lintel. A stone lintel would also be more difficult to quarry, transport, and build in, as well as being quarried and worked to fit an exact opening. It is almost certain that there was some use of timber lintels. The use of stone voussoirs to openings *per lineam valli* is widespread, and was probably the most common form applied to openings; there is no evidence of brick voussoirs having been employed. In all known examples the voussoirs formed a ring to the opening, whereby the distance from the intrados to the extrados was constant in all the voussoirs. This form of construction simplified work on site, as the coursed bonding masonry would only have had to be cut abutting the extrados. Alternatively, if the voussoirs were to have been bonded into the coursed masonry, considerable cutting and fitting of the bonding courses would have been required. It can be seen at Birdoswald from an extant springer to the east gate, that the distance between the intrados and extrados (630 mm), was almost equal to the depth of the block (600 mm), which was close to the width of the respond. It should be noted that if the face of the voussoirs to every gate *per lineam valli* were *c.* 600 mm deep, then the full ring would not be seen in the lower courses directly above the impost. This is because the projecting faces of the responds adjacent to the guardchambers were less than 600 mm. This detail could have been the result of a conscious decision to strengthen the portals, by tying the outer ends of the arch rings into the masonry of the guardchambers (pl. 4); taking into account aesthetic considerations it would have been more satisfying if the full ring had been seen.

The radius of an arch can be calculated (Hill 1991, 2) using extant voussoirs. From a study of the voussoirs at Birdoswald, it has been shown (Wilmott 1997, 67) that, a slight variation in any of the dimensions can have quite a marked influence on the width of any opening. It is suggested that once work had commenced on site, a supply of standard voussoirs was cut, *c*. 300 mm high by 300 - 250 mm deep, which were then used for the smaller openings to a building. Any voussoir could have been made to suit any opening, within a reasonable range, by reworking before being laid, or by varying the width of the bed joints.

Smaller openings were closed up using the arcuate lintel, which reflected the traditional arch form. This lintel was widely used to span openings of *c*. 600 - 650 mm width. Linear decoration was often applied to the face of the arch, or decorative motifs to the spandrels. The arcuate lintel would seem to have been used as an alternative to voussoirs to an arched opening over narrow spans of *c*. 600 mm maximum (see Appendix 4). They would seem to have been associated with the latter, as lines simulating voussoirs have been seen on lintels from South Shields (Bidwell and Speak 1994, 149, fig. 5.4).

All window openings are likely to have had splayed internal reveals, and perhaps sills, as can be seen in existing examples at the bathhouse at Chesters (MacDonald, 1931, pl. LII facing 274), Benwell (Spain 1929, 126-130) and elsewhere at Pompeii (Adam 1994, 305, fig. 699). This is considered by Harden (1961, 49) to be the normal practice of forming window reveals, and many other examples are cited (ibid., 49-51). This form of window would ensure that the maximum amount of light could enter the building.

Stone thresholds were laid to door openings. Many of these show evidence of a mortice for a door pivot. Where these were placed within the thickness of the wall it would indicate that the door closed up against the inside of the external lintel. In the case of a round-headed external lintel, this would have enabled a door with a square head to be used, with a horizontal internal lintel. Two pivot holes to each side of a door opening are indicative of the door being in two leaves. Some thresholds had a raised upstand to act as a stop to the bottom of the door, as the east door to the *principia* at Chesters (chapter 3.4.1.1).

Door thresholds at the *principia* of both Wallsend and Housesteads show evidence of linings having been used to the sides of the door openings. An example of such a lining can be seen to an extant door opening in the bathhouse at Chesters (MacDonald 1931, pl. LIV opp. 292). The threshold to the *principia* in each case is grooved (90 mm wide at Housesteads, and 160-230 mm wide at Wallsend) by *c*. 50 mm deep. By implication a head of the same thickness would also have been used, which probably acted as a lintel. Similar thresholds to the *praetorium* at Chesters (pl. 5) can be seen to project beyond the face of the internal wall of the building[2]; it cannot be stated whether the two previously stated examples were originally similarly placed, due to possible recent displacement. The implication of the door linings suggests that they were used where the wall to a building was rendered up to the side face of the linings. This supports the view taken by the author that the major buildings within the fort were probably rendered, as will be discussed in chapter 4.0. The fixing of projecting door linings would have made the application of the render easier in producing a "stop", so that no return angle into the openings needed to be formed, a difficult and time consuming operation. In the case of door linings flush with the face of the wall, the lining could be seen as providing a smooth face to the reveal rather than the carrying out of time consuming labour in dressing the separate walling stones to the opening. Similar thresholds have also been seen at Caerwent (Ward 1911, 270).

From the little evidence to hand, it would seem that sill heights to windows were set somewhat high when compared to today's criteria (Ward 1911, 271). This is understandable in a bathhouse, but a little more difficult to understand in the third century barracks at South Shields, where a window has been seen to be *c*. 1.600 m above street level (chapter 3.4.4.1) and in the probable window to the east guard chamber at Chesters which is *c*. 1.400 m above street level (chapter 3.4.3.1).

2.2 Mortar and Render

Both mortar and render use the same constituent materials, lime and sand. Lime, before the introduction of cements in the 18th century, was a valuable commodity, without which mortar could not be made. The Romans therefore, at a very early stage, sought out the location of limestone prior to commencing building works *per lineam valli*. Fortunately, between Newcastle and the Red Rock Fault the Roman army was able to find adequate sources. References to the obtaining of lime are found in the Vindolanda Tablets (*Tab. Vindol.* II, 156, 314).

Cato (1934, 38) describes the construction of a lime kiln, `....ten feet across, twenty feet from top to bottom, sloping the sides in to a width of three feet at the top`. Simpson`s (1976, 152-157) excavation of the lime kiln at Knag Burn, close to Housesteads fort, showed that the internal diameter of the kiln was 6.100 m (20.00 ft.) above an offset *c.* 1.500 m (5.00 ft.) wide, positioned above the firing pit. The sides of the kiln tapered outwards towards the top and it might possibly have been domed. In contrast the mid-second century kiln at Weekley, Northants. (Jackson 1973, 128-40), which was probably associated with a nearby villa, was similar in size to that described by Cato. The kiln was 3.000 m in diameter, with an offset 450 mm wide above the firing pit. The sides were approximately vertical with a flue set in to the side opposite the stoke hole. It is suggested that the greater size of the kiln at Knag Burn is representative of the large quantities of lime that would be required for the mortar for the Wall.

The source of sand was found in the rivers or in pits. Vitruvius (2, 4, 2-3) shows a preference for pit sand, this is probably due to the presence of clay impurities which would have given greater strength to the mortar. These are not found in river sand, having been removed by differential sorting in the river. Sand from the seashore was not to be recommended as it contained saline impurities. Evidence of gravel extraction can be seen on Bishop Rigg near Corbridge where the size of the material varies from pea size to fist size (Jobey 1979, 99, 104-105).

Following the burning of the limestone, calcium oxide or quick lime is formed. The process of making the mortar involves the slaking of the quick lime with the addition of water[3]. This is a process which generates considerable heat, and traditionally was carried out in a pit. The resulting lime putty should be left for as long as possible to mature before being used; ideally this should be a minimum of two months or even years.

The Romans inherited their basic mortar technology from the Greeks. Vitruvius (2, 5, 1, 2) describes the making of lime mortar using three parts of pit sand to one of lime, or if it be river or sea sand, two parts of sand to one of lime. Faventius and Palladius (Plommer 1973, 37) on the other hand prescribe two parts of sand in all cases. It is suggested that the high quality of Roman mortar was due to the thoroughness of the mixing and beating the lime and the sand (Vitruvius 8, 3, 10; Lea 1970, 3). Ashurst (1983, 10) states that recent fieldwork has shown that, mortar rammed and beaten with a wooden rammer and paddle, interspersed by chopping with a shovel, does improve its workability and performance. The importance of mixing is to increase the overall lime-aggregate contact, and to remove any surplus water by the compaction of the mass. It is also suggested that the very best marriage of the lime and sand can be obtained if the quick lime is already present at the time of mixing the mortar (Lea 1970, 3; Ashurst 1983, 10). In this process the quick lime and sand are mixed together before slaking, and the slaking process ensures that all particles of sand are covered with lime paste in such a way that cannot be matched by conventional mixing.

The process of setting is as a result of the slow carbonation of the whole of the mortar, as carbon dioxide is absorbed from the atmosphere. This takes place over a very long period of time, and can continue for many years. It was essential that the mortar once laid, was protected from frost or rapid drying out, the effects of both of these could cause a failure of the mortar[4].

It is possible for the strength of lime mortar to vary, depending on the purity of the limestone, as some limestones include a proportion of magnesium carbonate. "Dirty" limes, containing impurities such as clays with silicates and aluminates, will yield hydraulic cement after calcination. These limes will set by a reaction of the hydraulic compound without the presence of air and have a greater strength. Crow (1991, 55) draws attention to the very hard mortar used in the Severan rebuilding of the Wall. He suggests that the Roman experience of the qualities of the limestones in the area was limited when the Wall was built, and that the best sources of the lime, often some distance away, were not recognised.

In order to make a stronger mortar, Vitruvius (2, 5, 2) states that crushed and sifted potsherds could be added in the proportion of one to three. The effect of adding the potsherds was to add a burnt clay pozzolana to the mix; this is produced by burning clay up to 900 degrees centigrade (Lea 1970, 420). A burnt clay pozzolana contains aluminium silicates and ferrites, and has the effect of forming a hydraulic mortar. No mortar of this type has been recognised in the stonework of any building *per lineam valli*. *Opus signinum*, which is the same mix, has been seen in several contexts including two floors in the *principia* at Housesteads (Bosanquet 1904, 221).

A report giving details of some mortar samples from Hadrian's Wall has been produced by Johnson and Wright (1985). A report by English Heritage and the National Trust will shortly be produced of all mortar research carried out on Hadrian's Wall during the past ten years. A sample of mortar taken from the Wall at West Denton has been analysed and publication is due shortly (pers. com. P. Bidwell).

There have been several problems related to mortar analysis which can cast doubts on the results. The most important factor is that mortar mixes are always stated by volume, yet the results of any analysis are obtained by weight. There is also a danger that any sample may be taken from an area of rebuilding or repointing.

Frizot (1982, 303-4) draws attention to a wide disparity in mortar mixes on various Roman sites in Gaul when compared to the guidance set out in the classical texts. The samples discussed range between 1: 1.2 and 1: 8.5 which, as he states, puts the recommended mix of 1: 2 or 1: 3 happily within this grouping. Recent mortar samples taken close to the fort at Carlisle are representative of the mortar from the fort (Caruana 1996, 347-8), and show a 1: 3 and 1: 4 proportion by weight.

There is some evidence that emphasis was given to mortar joints, so expressing the coursing of the stonework. Bidwell (1996, 22-3 and fig. 3.6) shows from a section of collapsed Wall at Denton, that a portion of the south face was covered in a lime rich plaster. A section of the plaster had a groove 50 mm wide cut into the surface, to correspond with the bed of the stonework. It is possible that the plaster only covered part of the masonry, and could be termed "lobbing", that is where no attempt is made to make a clean joint, and the mortar is smeared over the surface of the stonework around the joint. This type of work is usually used on irregular, poor quality stonework and can be widely seen in the north of England at the present time. The joint could then have been incised to give a better appearance to the overall work. Horizontal lines were incised into the stonework and filled with red paint, at the amphitheatre at Caerleon (Wheeler and Wheeler 1928, 121-2, pl. XXIV, 1-2).

Military buildings known to be rendered are the watchtowers on the Upper German limes, which were rendered and finished with simulated stone courses in red paint (Baatz 1975, abb 15, 16). The fort wall at Saalburg has been reconstructed similarly finished, with red painted joints simulating ashlar (Bidwell 1996, 19).

It is not possible to know to what extent the buildings within a fort were rendered. From what is known of Roman buildings in Britain of the period (Bidwell 1996, 19-29), the likelihood is that most of the major buildings within the fort were rendered or limewashed. The render would have been applied in a minimum of two, and probably three coats (Adam 1994, 216-220), the coarseness of the sand decreasing as the coats were applied, with the finest sand being used in the top coat[5]. When used internally the final coat was usually of pure lime. The texture of the sand, together with the scoring of the surface of the primary coats, assisted the bonding of the render coats. Clay daub was used as a substitute to a sand/lime external render on lower status buildings, as seen in a third century barrack block at South Shields (Hodgson, N. 1994, 49-50). Here the clay bonded stone walling was finished with clay daub and limewash. The application of a limewash would have acted as a shelter coat to a render or daub, which could otherwise have suffered rapid deterioration in exposed situations. Limewash traditionally contains tallow and natural materials such as blood, dung, and coloured clays, would have given the warm red and yellow colours; it is traditionally applied annually. Where lime was short it is possible that a coating of lime plaster could be applied on a backing of clay. Plaster was seen to have been applied on a 1" - 2" (25 - 50 mm) clay backing in a building in the south-east of the *retentura* at Bainbridge Roman fort (Wade 1955, 156, 158). Evidence of rendering to buildings can be implied by the projecting linings to door openings as discussed above.

Lime and sand renders break up when exposed to the elements and soon leave little trace on the walls of buildings. Any material on the ground is soon broken down to its original constituent parts with the lime usually being dissolved by ground water.

2.3 Carpentry

Timber Supply

The great need by the Roman army for timber and its availability has been recognised (Hanson 1978, 293-305; McCarthy 1986, 339-343). Timber was not only required for the construction of buildings, furniture, and general purposes, but also as firewood. It would also have been required for the construction of temporary roads and bridges (Meiggs 1982, 154-6), during the construction of the Wall curtain and the forts, to enable supplies of stone and other materials to reach site.

References are made to the wooded nature of the terrain, some of it dense, by Caesar (IV, 32; V, 15; V, 19; V, 21) and the problems which this created for the advancing armies. These references are usually taken too literally and obscure the real picture. It is likely by the early second century that, some large areas of the Eden Valley to the west had been cleared of the natural forest, and agriculture established; the many prehistoric settlements could have developed some form of timber management. Bewley (1994, 79-81) finds that the prehistoric agricultural economy was based on domestic animals and the diverse resource base was not substantially altered by the arrival of the Romans. The only major impact the Romans had was quantative rather than qualitative. Although some crops were grown, there is no evidence that the local population supplied the army. The east, in contrast, is likely to have remained well wooded. Relatively few pollen cores have been taken in the region encompassing the

Wall, and so evidence of the range of woodlands over the period of Roman occupation is limited. These cores should be treated with some caution as certain trees give off less pollen than others, and it is difficult to obtain an accurate representative picture.

The central section of the Wall to the east of Greenhead and to the west of Chesters is for the greater part between 250-300 m above sea level, although this drops to a slightly lower height to the east of Carrawburgh. To the east and west of the high section, the line of the Wall tends to follow the high ground above the river valleys. A large number of the forts on the Wall do not follow the usual Roman pattern in that they are on high ground and not situated in the valleys, often close to a river

At Fotherley Moss (Turner and Hodgson 1981, 182-185), altitude 204 m, situated some 11 km south of the Wall and almost due south of Halton Chesters, a late pollen diagram FM-6 estimated 0-2000 BP (no C14 dates recorded), shows the prominent tree species to be birch (approx. 50%), with oak, alder, hazel and a small amount of pine. There is a large increase in herbaceous pollen at the top of the diagram. The Fotherley Moss area lies to the east of the main Pennine watershed and although it is sheltered from the prevailing westerly winds, it is exposed to the north east winds. The site can also be shown to have less sunshine than similar latitudes in Britain. If it is assumed that climatic conditions at the time of the Roman occupation were similar to those of today, it is considered that the natural forest would have resembled that of the Cairngorms rather than that of the Eden Valley to the west, with a larger incidence of pines and fewer broad leafed trees.

Turner (1979, 285-290) in a study of the environment of the north east by pollen analysis, shows that during the Iron Age the area north and south of the Tyne as far west as the South Tyne, was well forested. In complete contrast, by the end of the Roman period these same landscapes had lost most of their tree cover. Instead of tree pollen there were large amounts of grass pollens and pollens of cereal crops. In an assessment of the likelihood of clearance relating to the sites closest to the Wall, at Fellend alt. 210 m, there is a real possibility that the catchment area was cleared after 80. Fenton Thomas (1992, 51-62) estimates that between c. 100-400 AD just less than 15% of pollen was of arable type. From a pollen core at Vindolanda dated AD 100-125, it is shown that the landscape was largely treeless with some cereal pollen and associated weeds.

Three sites to the west have been examined by Dumayne and Barber (1994, 165-173), Walton Moss 13 km north east of Carlisle and 3 km north of the Wall, Glasson Moss 16 km west of Carlisle and 0.5 km south of the Wall, and Fozy Moss 7 km north of Haydon Bridge and 200 m north of the Wall by Sewingshields Milecastle. The woodlands prior to the Roman occupation were shown to be predominantly oak and alder in equal amounts with hazel; birch was also present. At Walton Moss and Glasson Moss there was evidence of significant clearance during the Iron Age with virtually no evidence of habitation at Fozy Moss. The fact that there were significantly large cleared areas enabled the turf wall to be built to the west. Renewed clearance begins at both Walton and Glasson Mosses about 125, and the decline in external pollen is greater than in the Iron Age. At Fozy Moss a rapid forest clearance takes place, leaving an almost treeless landscape around the same period. As Fozy Moss is at an altitude of 132 m it should be expected that the size of the trees is somewhat less than those found on the floor of the sheltered Eden Valley. Dumayne (1994, 217-24) further argues the point, stating that the pollen samples from Fozy Moss show a rapid and dramatic clearance of woodland during the Roman occupation, and that this seems to be stimulated by military events. Hanson (1996, 354-8) casts doubt on Dumayne`s reading of the core samples and her interpretation[6]. He draws attention to site based pollen analysis, which consistently indicates a largely cleared landscape at the time of the Roman arrival. There is also increasing evidence of extensive arable agriculture by the pre-Roman Iron Age in the upland areas.

The general conclusion, at the time the Wall and its forts were constructed, is that some deforestation had occurred to the area of the Eden Valley, and that larger timbers in the central uplands were not available (Birley, R. 1994, 130). The area to the east of the Whin Sill ridge would seem to have had abundant timber supplies, but the timber at the higher altitudes was more sparse and of poorer quality than that to the east. It is apparent therefore that some larger section timbers were being brought into the central area of the Wall to construct the buildings of the primary phase. Oak was plentiful to the east and west, and was the preferred timber during the occupation (Huntley 1987). By the end of the occupation timber supplies, particularly in the central area, were becoming short and often less suitable timbers like alder were used for building purposes (McCarthy 1991, 39). Later pollen evidence shows that the woodlands recovered after the occupation (Turner 1979, 289).

The timber which was most widely available, and the most useful, was oak[7]. It rarely produces straight lengths longer than around nine metres in Britain, and this would have influenced the clear span of any roof. The advantage of oak was that it could be used "green", that is unseasoned. In this form it is easier to work and frame up, and although it can shrink when it dries out, it does not twist. Fir was the Romans preferred timber for building (Vitruvius 2, 10, 2; Meiggs 1982, 226-227), being tall and durable, and allowing the immense spans of the buildings of the Empire to be roofed; it was not available in any quantities in northern Britain.

Oak can remain "green" and easily worked for several years whilst unconverted and in the log. It is possible to remain in this condition for 5-6 years depending on circumstances, although the timber is harder to work the longer it has been felled. Eighteen months after felling is an ideal time to work green timber, less than six months is too short a period as there is too much sap in the timber and it is likely to shrink excessively (pers. com. Tim Walton, Carpenter, Oak and Woodland Co. Ltd.). From this evidence it is possible that dendrochronological dates have been giving too young a date for archaeological dating (Bowman and Thomas, 1996, 311)

Of the other timbers readily available, alder is unsuitable for general building work as it rots quickly when exposed to the elements, and internally is prone to woodworm. Its one advantage is that it retains strength when immersed in water, and was used for piles (Vitruvius 2, 9, 10), where foundations could not be formed in the traditional way. Oak, surprisingly, was the cheapest timber set out in Diocletian's edict of 301 which was designed to stabilise prices (Meiggs 1982, 365-8). This was probably due to there being a plentiful supply; it was in the same price bracket as ash and beech. Fir, showing its preference by the Romans, and evident relative scarceness, was many times more expensive.

Timber Conversion

It is likely that most structural members were of oak[8], with unseasoned or "green" oak being used. Felling was preferably carried out in the winter when there was no sap rising. The best course of action would have been for timbers to have been felled for fixing during the following summer.

Structural members such as large beams and main roof timbers, would be converted from the log by hewing the four sides with the axe or adze[9]. Each member being "sized" for a particular function, taking into account the span or the use involved (Brigham *et al.* 1995, 45-47). This was a relatively unspecialised skill used also in many other types of construction, such as ship building, scaffolding, and engines of war. The smaller timbers such as rafters and some floor joists, could have come from halving or splitting the tree along the medullary rays using wedges and mallets. This method of conversion (Charles 1990, 51-58) involves splitting the tree along its length on the line of the grain, and is a skilled operation. The usual section of a halved timber is in the proportion 2:1 with the depth being the shorter dimension (fig. 33). The heart of the log is usually exposed on the centre of each half. The splitting of the timber results in a flat upper surface, although its length is often curved or irregular (Yeomans 1991, 46).

Radial cleaving of oak requiring large straight logs was known, and many examples are found in London, having been seen in lathes, shingles, water pipes and boarding for wall cladding. In London, sawn[10] planks are more commonly found than cleft boarding. Evidence for radial cleaving is known from Ribchester, where wall boarding with nails was seen re-used in a drain (pers. com. D. Goodburn). This, with the evidence of cleaved planks from Carlisle (McCarthy 1991, fasc. 1, 135), together with no evidence of sawn planks (pers. com. J. Huntley), would suggest that cleaving rather than sawing boarding was the normal method of converting timber used by the army in the military zone. Sawing would have been a time consuming operation as an adequate finish could have been obtained by cleaving with the use of an adze. It is perhaps significant that the saw is not shown as being used by the army (Meiggs 1982, 187) on Trajan`s Column, although it is mentioned by Josephus (1970, 196) as being carried by the general`s bodyguard of picked infantry. Cato (1934, 14) lists the materials required for the building of a new steading. Whilst the contractor is responsible for all the walling and fittings together with some furniture, the owner would furnish the timber and also one saw and one plumbline. The contractor would fell, hew, square, and finish the timber. It is suggested from this that most timber would be finished using the axe and the adze, and that the saw was only used when a good finish was required, such as in the internal joinery. It is also relevant that whilst the adze and the axe would be relatively cheap to manufacture, the saw would have been much more expensive to produce, due to the cutting and setting of the teeth, and consequently is likely to have been more rarely used. It is worth noting that it is suggested that it took around two days work to saw a 12` 0" (3.650 m) log into five planks (Meiggs 1982, 369, note 145). At this rate of working it is most unlikely that much carpentry work in the buildings *per lineam valli* had a sawn finish.

The skill of the operatives would have been such that cleaved boards used for flooring and the roofs could have been produced with a minimum deviation in thickness[11]. An alternative to timber floor boarding, where heavy use was expected, such as in a granary, could have been stone flags. Stone flags were used in conjunction with stone sleeper walls and there is no reason why they could not have been carried on the timber joists of the Hadrianic granaries as will be discussed in chapter 3.4.2.2. This is a detail that has been used in recent times, particularly in domestic architecture.

The Truss

It was probably in the Hellenistic period (Meiggs 1982, 226), that it was discovered that if two rafters and a tie beam were firmly joined together as a triangle, a stable structural member was formed. In this member all forces were equalised, and the outward thrust created at the feet of unrestrained rafters, was eliminated.

The standard form of roofing to a basilica type building, as seen in the *principia* is considered to have been the use of trusses at *c*. 2.500 m centres, carrying a ridge beam, with purlins placed on the top of the principal rafters (see chapter 4.1). This form of roof can be seen in the Byzantine basilica of Aegosthenes, Porto Germano, Attica, (Adam 1994, 210, pl. 493), and dates to the Middle Ages. This form is similar to the truss described by Vitruvius (4, 2, 1). Here he describes a roof of a considerable span to have a ridge piece with rafters projecting to the edge of the eaves, with a cross piece (tie), and stays (king post or other intermediate member). Purlins are described as being placed above the principal rafters. As an alternative a tie could be placed midway on the principal rafters connecting with the tie beam.

In a roof of similar design at the Cathedral at Syracuse (Adam 1994, 210, pl. 494), the span of 9.800 m is close to that of the average span of the cross-halls. The size of the timbers in this roof are considerable, the tie beam being 600 by 350 mm, and the principal rafters 350 by 350 mm. This roof configuration reflects the earlier arrangement in the fourth century basilica of St. Peters, Rome, where the span of the nave was 24.000 m (ibid., 211). Here principal rafters were connected to a tie beam at the eaves and a king post was introduced; a second tie beam was introduced halfway up the height of the king post. Unusually the principal rafters and ties were duplicated and placed either side of the king post, the whole being secured by iron fixings. (Choisy 1873, 152). The tie beam was formed out of a single timber. The Romans had a preference for using single beams to span even the widest spaces (Meiggs 1982, 242), even though this was unnecessary as they had the technology to join lengths of timbers (Weeks 1982, 159, 166).

The longest structural members were probably used in the roofs of the buildings in the forts. From the knowledge that is available, amongst the longest lengths of timber which were required, were the ties for the trusses to the nave of the *basilica* at Birdoswald of *c.* 9.000 m, and the principal rafters to the mid-Antonine granary (A5) at South Shields of *c.* 8.000 m. It should be remembered that many timbers of this size would be required, probably twelve in the case of Birdoswald, and the same number at South Shields. The size of the trees required to produce these timbers would have required some careful selection; a tree of around eighteen metres height would have been needed for the ties (Charles 1990, 48-9), and sixteen metres for the principal rafters. This quantity of timber required, together with the matching of the size, could not have been done without a considerable degree of selection. The implication is that trees were selected, felled, and stored by size for use in the short term when required for a specific function. This is a course of action that is followed traditionally today.

Joinery

There is little evidence for joinery work in Roman military buildings. A door has been seen at Vindolanda in third century context (Birley 1977, 115, pl. 56, 57). This door is of framed, braced and batten construction.

An unpublished moulded timber window frame made of ash of Severan date has been seen at Cramond in an industrial complex outside the fort, although the section probably comes from a high status building. The frame is *c.* 25 by 40 mm with moulded faces to inside and outside, with a groove cut to receive the glazing which would have to be inserted in the frame prior to it being joined together (pers. com. N. Holmes).

2.4 Roof Coverings

Design Criteria

Three factors influence the pitch of a roof, the degree of exposure to the weather, the type of roofing material, and its lap. In general terms the smaller the unit of material covering the roof, the steeper the pitch. This results in a roof clad with clay tiles being set at a lower pitch than that of a thatched roof, in order for the roof to be watertight.

Modern roofing specifications take into account several factors in determining the fixing specification of a material on a site. The following factors relating to the degree and type of exposure (Marley 1990) determine the lap and fixing requirements:-

1 The exposure rating, expressed in four categories from open grass and moor-land, to the centre of large towns or cities.

2 The wind parameters of the site. These can be as low as 37 m/sec in the south-east of England to 48 m/sec in the north.

3 The pitch of a roof. The form of the roof influences the forces applied to a pitch. Roofs steeper than 35 degrees generally present sufficient exposure for there to be positive pressure on the exposed face, with suction being produced on the leeward pitch. However, with slopes of less than 30 degrees the windward pitch can be subject to severe suction or negative pressure.

The lap of a slate or tile is the cover which is given to those underneath it. In the case of slates, where the setting out is designed to provide a thickness of two slates over the whole of the roof, it is the amount by which the tail of one slate covers the head of the course next but one to it. This means that there are three thicknesses of slate at the lap (fig. 34). In single lap tiles (i.e. a roof using *tegulae*) there are two thicknesses of tile at the lap. The amount of cover is critical in ensuring the watertightness of a roof, as a much greater lap is required where a building is subjected to exposed conditions.

The effect of the exposure factor on Roman tiled roofs, could have caused the specification for a roof, in say the south-east, not to have been the same as that in the central area of the Wall, in order for the roof to remain watertight. The latter roof is likely to have failed due to tiles being displaced by wind action, or rainwater blowing back under the tiles; this latter weakness could have been minimised if the tiles had been torched or back pointed. Modern tiled roofs overcome this potential defect by the formation of capillary grooves. The most likely areas where slates or tiles would have become displaced by wind action is around the perimeter of the roof, to the eaves and verges. In modern roofing specifications for tiles, where often not every tile is nailed, this problem is overcome by nailing the verge and eaves courses, and also often securing the edge of the verge. It is suggested that when *tegulae* were nailed, it was at the verges and the eaves, in order to overcome possible displacement. Whether the builders altered the specification to overcome the problems caused by the increased exposure in the North of England will never be known. However, it is suggested that the Roman builders` empirical approach enabled them to adjust the specification as necessary, and might have resulted in the roofs in the North being at a steeper pitch than those in the South. It is highly probable that in many reconstructions roof pitches of too shallow a pitch have been utilised for some roofing materials (Shirley 1996, 115-117; Taylor forthcoming).

Little is known of the arrangements of the roofs, but it is likely that junctions caused by intersecting pitches were avoided as far as practical. Intersecting pitches would create the need for an internal valley gutter, which would require the formation of the gutter and the cutting of the tiles or slates to four pitches. This is a time consuming operation, as well as a source of weakness in the roof envelope, leading to possible water penetration. It is significant that little or no information on cut tiles indicative of a valley gutter or hip have been published. Hips, in most cases, could easily be avoided by the creation of a gable wall.

It would have been possible to design the buildings studied so as to avoid internal valley gutters. The only place where they are likely to have occurred is to the roofs to the ambulatories surrounding the courtyard to a *principia*. Even so it is probable that they were "designed out" at Chesters, by having the aisle to the cross hall and the northern ambulatory at higher levels, so that the east and west roofs finished up against a wall (chapter 4.1; fig. 35). It is perhaps relevant to look at the illustrations of the *Notitia Dignitatum* where the Paris manuscript is compared to Boecking`s rendering (Birley 1939, 226 and fig. 1 & 2 opposite). The former illustration shows the many roof configurations of the forts, and although double pitched and single pitched roofs are shown, there is not one example of intersecting pitched roofs.

Roof Slates

The source of the slates was a stone that could be split easily along its bed into equal thicknesses. The form of the slates are generally a sub-diamond, sub rectangular, or sub-rectangular with a rounded tail[12]. A nail hole was formed in the apex or a top corner in the case of a rectangular slate. The position of the single nail hole in the rectangular slates, allowed the slate to lock into the horizontal covering, as the tile balanced around the nail hole. Sizes were usually irregular, and the slates were dressed on site when fixing to ensure a close fit.

The slates would have been laid in courses of equal length but probably random width, with the slate of the course above covering the nails of the lower course. This would result in the roof being covered by two layers of slate in most areas, with three thicknesses at the lap. This technique is similar to modern slating except that uniform sized slates are now used. In areas of high exposure today large sized slates are used and laid to a minimum pitch of 30 degrees and a lap of *c.* 100 mm. For a roof to be watertight, using Roman slates, a roof pitch of a minimum of 35 degrees and up to, and possibly in excess of 45 degrees would have been required, depending on the size and regularity of the slates. This is borne out by the slated roof over the nave to the aisled building at Meonstoke, Hants. which was found to be 47/48 degrees (King and Potter 1990, 195-204; King 1996, 56-69). Although this building was erected close to the south coast the pitch is very steep; this could have been constructed for architectural effect. A further slated roof has been found on a rural building at Carsington, Derbyshire, were the roof pitch was seen to be approximately 40 degrees (Ling 1992, 233-236). All slated roofs would have been vulnerable to slates fixed at the verge, being displaced in windy conditions, particularly if any slates had been cut to form a straight edge so reducing their size. The traditional eaves detail in the North of England, devised to get over this problem, is to bed the slate onto the top of the gable wall, and then construct above it a coping with possibly one course of masonry; a detail known as tabling.

In modern slating the slates are of regular size (but possibly of random widths or diminishing courses) and are nailed, or hung on laths at regular spacings set out to ensure a constant lap[13]. The slates used by the Romans were generally of irregular size, and so a constant lap (necessary to ensure watertightness) would have been more difficult to achieve. It is suggested that the slates were nailed to a close boarded roof, a practice which is still carried out in central France using slates which are indistinguishable from those found on some Roman sites. The general effect is rather untidy but no doubt effective (pl. 6 & 7). It is suggested by King (1996, 66) that the slates might also have been secured by pegs. In that case laths would have been fixed, and a slate held in position by an oak peg placed through the slate, and hung over the lathe.

The nails used for securing the slates and tiles were generally well made to exact dimensional specifications. Their quality is reflected in John Hodgson's (1840, 187) description of the nails to the west gate of Housesteads, `......and large spike nails of beautiful white iron, only a little corroded in rust`. It is suggested in view of the large and varying quantity of nails found at Inchtuthil (Tylecote 1976, 53-4) that, the nails were probably not made on site, but sourced and supplied by the efficient military supply service.

Clay Tiles

It is probable that the army set up additional tileries for the roofing tiles required for the forts, as it is unlikely that there was sufficient existing capacity, or any civilian kilns in the region (Welsby 1985, 137). It is likely that clay tiles were made only between the spring and the autumn, as tile making was a seasonal occupation (McWhirr and Viner 1978, 360-361; McWhirr 1979, 6). Little is known of the extent of the tileries, but kilns have been found at Brampton, Birdoswald, Corbridge, and South Shields (McWhirr and Viner 1978, 372-74). Roofing tiles of the *Legio VI Victrix* have been found at Wallsend, Carrawburgh, Chesters, Corbridge, Vindolanda and High Rochester (RIB 2460, 48, 49, 50). The stamped tiles found on a site can often relate to the original builders of a fort.

Whilst many fragments of tiles have been found, complete tiles are exceedingly rare, and consequently the sizes of most tiles are unrecorded. A *tegula* from Caerleon (Brodribb 1987, 12) measures 550 by 380 mm and weighs 11.34 kg, the *imbrices* were 550 mm long and weigh 7.98 kg[14]. A modern concrete tile would weigh *c.* 3-5 kg. At the present time no research has been carried out on the tiles *per lineam valli,* so no comparisons can be drawn (pers. com. I. M. Betts).

As the *tegulae* were of regular width there would have been no need for the roof to be close boarded over rafters, where they were used, as opposed to boarding laid on purlins. Rafters which could have been 150 m wide and laid at centres approximating to the width of a *tegula*, would have provided sufficient tolerance to lay out the tiles to a roof between two fixed points, such as would occur over the portals between the two towers to a gatehouse. Any slight variations in spacing could have been increased or taken up between individual *tegula,* the gap between which was covered by an *imbrex.*

In view of the degree of exposure it is probable that the tiles were laid to a pitch of a minimum of 30 degrees. The tiled roof pitches to the aisles at Meonstoke (King 1996, 66) were seen to be *c.* 20 degrees, whilst the pitch of the gable wall to the villa at Redlands Farm, Northants. (Keevill 1996, 44-55) was seen to be 22.5 degrees. The shallow pitch to both these roofs reflects their sheltered positions in southern England.

Although there is some evidence of nail holes it would have been sensible, in view of modern practice to nail the tiles to the verge and the eaves[15]. The weight of the tiles would have greatly assisted them to stay in position (Rook 1979, 295), but the verge would have been the area most at risk to failure. The smoothness of the tile surface reduces capillary attraction at the lap of the tile, which would have needed to be in the region of 75-100 mm. Torching or backpointing would almost certainly have been necessary in very exposed situations to avoid water penetration.

It is probable that tiles were introduced on site at a very early stage in the construction of the fort at Carrawburgh, as will be discussed elsewhere (chapter 3.3.1). It is also known that slate was used in the Severan granaries at Housesteads, as also in the final phase of the west gate, and third and fourth century barracks. It is put forward that tiles were used in the primary buildings for the major buildings within the fort in the *latera praetorii* and possibly gates. During later rebuilds and repairs it is suggested that slate was used increasingly rather than tile. Of the tileries mentioned South Shields is the only one known to be producing fourth century material. Without close standardisation in tile sizes and design, it would have become impossible to match tiles in a building when replacements were required, if the original tilery was no longer in production. This course of events could have encouraged the use of other materials to replace tiles, such as slate and organic materials.

Organic Materials

There is no doubt that thatch and shingles were used as roof coverings. Alberti (1955, 60) records that shingles were widely used in Germany. The absence of slate or tile on the site of a building is often used to justify the use of such materials, but it must be remembered that slate and tile was a valuable commodity which could easily be stripped from a roof for re-use. It is quite possible that the use of black thatch, the traditional Northumberland thatch made of heather, could have been used as an alternative to reed. All types of roof covering would require a roof pitch of a minimum of c. 45 degrees to ensure that the roof remained watertight (Taylor forthcoming). Turf, interpreted as a roofing material, has been seen at Carlisle (McCarthy 1991, 60). It should, however, be borne in mind that turf was used along with thatch, on later vernacular buildings in the North of England particularly, to the ridge and the edges of the roof (Walton 1979, 53-58).

Floors

The ground floors to the *principiae* and gatehouses in the forts were generally of stone flags. Those to the barracks were often of beaten clay or sometimes stone flags. Officers' accommodation in third century barracks at South Shields had high quality mortar floors in contrast to the usual floor finish. A lime floor is recorded as having been laid in the north guardchamber of Birdoswald (Gillam 1950b, 66).

The raised floors to the granaries were supported on sleeper walls or timber joists. The sleeper walls averaged 600 mm wide with *c.* 500-600 mm between the walls. The floor itself was either stone flags or timber boarding. The underfloor void was ventilated with vents, usually placed centrally between the buttresses.

2.5 Structural Integrity

Masonry

The success of Roman buildings lay in their massive construction and design, whereby all building elements were designed to be in compression. The size and quality of the coursed rubble walling was such that, provided a level bedding for the stonework was obtained, mortar was unnecessary to bond the stonework together; there are many instances where clay was used successfully as a bedding material. In the case of the dressed coursed stonework, where level beds were formed, no bedding material was necessary. The weight of the coursed stonework, the floors, roof, together with any live loads, held the structure together in compression.

The use of lime mortar and clay as a bedding material allowed the building to take up any differential settlement without causing permanent damage to the walling. In the case of clay, the material was flexible enough to take up any deformation; in the case of lime mortar the pliable properties of the lime, together with moisture in the atmosphere, allowed the joint to be remade naturally.

The consistent use of a semi-circular arch made up of a ring of voussoirs, allowed the forces to be transferred vertically, with very little transference of lateral forces. As all the members forming the arch were in compression, this added to the strength and longevity of a building. The arch should be contrasted with the use of a lintel, which when placed over an opening is in tension. The lintel, over the course of time, is prone to failure, as it is in a state of stress and so could contribute to the early failure of a building.

The division between the nave and aisle of a cross-hall to the *principia* would have almost certainly been made by the formation of an arcade. Apart from being easier to construct, this form of construction can be deduced by the regular spacing of the arcade piers; the span and therefore the height of each arch being similar. Structurally the arcade is seen as a solid wall in which the arched openings are formed; in most cases a structural wall runs below the arched openings. An instance where trabeated construction was probably used, in preference to arcading, was to the forehall at Halton Chesters. Here the irregularity of the spacing of the piers, suggests that the arch could not have been used.

Despite the massive nature of the walls, the granaries were built with buttresses, in nearly every case to the long walls, and often to the short walls. The use of buttresses is hard to understand as they are not required to resist lateral forces as the massive walls were more than able to carry out that task. It is even more problematic when one considers that most granaries up to the Trajanic dynasty were constructed of timber, with walls even less resistant to lateral forces.

Structural Timber

It is likely that the sizes of the timbers used in a building were well in excess of that necessary to take the required loadings. Sizing would be based on empirical traditions, together with a strong sense of conservatism. The pitches generally would have been steeper than those of today to take into account the roof coverings already discussed.

The spans of the roofs were probably met structurally in five ways (figs. 36, 37):-

1 The couple roof, formed of two rafters, which would have been used in very with a short span *c*. 3-4 m.

2 The close couple roof (a couple roof with a tie beam) which could have spans up to *c*. 6-7 m. In the case of both couple roofs the roof members were probably spaced at *c*. 600 mm centres and boarded to receive the roof covering.

3 The use of purlins set at close centres bearing on internal walls carried up to the underside of the roof. The purlins would then be boarded to receive the roof covering. The maximum economical span for a purlin is up to *c*. 5 m.

4 A roof formed of rafters is likely to have been used over the ambulatories, where a short span had to be covered. The rafters would bear on the external wall and on a beam on the line of the courtyard. The spacing is likely to have been *c*. 600 mm.

5 The truss would have been used where the greatest spans were met, such as over the cross-hall in the *principia*. The maximum economic span of a close couple truss is *c*. 9-10 m. This dimension also coincides with the maximum

single length of timber that was economically obtained in the natural woodlands. The trusses are likely to have been placed at *c*. 2.500 m centres (see chapter 3.4.1.2), and have received purlins placed on the principal rafters.

This spacing is somewhat less than would be expected today. The roofs are likely to have been constructed to a minimum of 30-35 degrees. It is likely that no ridge piece was used (Yeomans 1992, 16).

Lateral forces are transferred to the top of the external walls if a couple roof configuration is used. This form of roof, lacking a tie beam, tends to spread under the weight of the roof covering, so pushing the tops of the walls outwards. A couple roof with a tie becomes a close couple roof. In a close couple roof, as all the forces in the members were equalised and provided the connections of the members were secure, the forces at each bearing position acted as a point load. The form of the roof truss took the form of a close couple configuration with all three members greatly increased in size due to their greater spacing. The principal rafters in such a close couple configuration are in compression, whilst the tie beam is in tension. The tie beam tends to deflect on account of its own weight, which in turn pulls the feet of the rafters in and pushes the apex up, a development of this form is the insertion of additional members. A king post joining the apex and the centre of the tie, or intermediate members, overcomes this defect and when inserted members are consequently in tension.

The Life of a Building

When a building is designed, the design concept and materials are taken into account to reflect the anticipated life of the building before major refurbishment is required. In the case of a domestic property, the notional life is *c*. 60 years, reflecting materials that do not have a particularly long life, such as softwood timber. A modern cathedral, such as the Liverpool Metropolitan Cathedral, was designed so that the structure was in permanent compression, with no major structural members in tension, and long life materials chosen for internal and external finishes. This form of building with minimum stressed members, would have a notional life of several centuries. The Roman buildings were constructed using traditional methods, and probably would have required major refurbishment after some *c*. 60 years. If no maintenance had been carried out, since the buildings were constructed, repointing would certainly have been required to all elevations after this length of time, with those facing the prevailing winds being the most affected. It is also probable that the roofs would require stripping and re-tiling/re-slating as the nails, lathes, or underboarding, would be showing signs of decay, particularly as the timbers would not have had the benefit of timber preservative, now universally used.

This period when major refurbishment would have been required, coincides closely with the period of the reconstruction of the Wall, and its forts, in the early third century. It is possible that this reconstruction was brought about by a lack of maintenance during previous decades, rather than any other cause.

Major reconstruction of the buildings took place during their lifetime, but in the majority of cases took place on the existing Hadrianic foundations, and the lower courses of the buildings. Evidence that one or more of the gates at Housesteads was taken down to around first floor level, and apparently rebuilt, is the reuse of string course mouldings as paving in the fourth century chalet-barracks (Crow 1995, 86). Whether this rebuilding included the raising of the portal can never be known. The continuous raising of the ground level, by the laying down of the various occupation levels, must have caused difficulties at the gates due to the fixed headroom dictated by the portal heights. It can be seen at the south gate at Chesters that the level of the final ground level to the east portal is some 1.000 m above the primary ground level as exposed at the west portal.

A traditional stone building built of lime mortar only tends to collapse once it is not watertight. The loss of the roof covering leads to the decay of the timber roof structure, culminating in its eventual collapse into the building itself. This collapse in turn could bring down any internal floors. Any timbers remaining in their bearings are likely to put stress on the building, unless both ends of a member are in their original position. Once a lime mortar wall is open to the elements, the pointing is eroded on both faces, leading to loosening of the stonework and eventual collapse.

The Building Season

Frontinus (11.123) recommends that building work should be restricted to between April and October. He further recommends that work should avoid the excessive temperatures of mid summer. Although Frontinus was writing about the Mediterranean, high temperatures could cause the mortar to dry out leading to failure. The only practical reason that such a restriction could have been made, was the effect of frost on the lime mortar. Lime mortar is very sensitive to frost action, which causes it to break up; as the mortar dries out very slowly, the period when it can be affected by frost is prolonged. In this context the building period between April and October seems sensible for the northern provinces. It is not easy to understand therefore, why Frontinus applied these recommendations, particularly in respect of Rome`s water supply. It is possible that Frontinus had not forgotten his term as governor of Britain, 74-8, and the harsh climate of the Province; a building season becomes more easily understood in that context. Mortared stonework can be protected from frost, to a certain degree, or excessive rain once it has been laid, by covering the work.

It is suggested that the detrimental effects of frost on the Wall structures have not been fully appreciated in Wall studies. If, as this thesis proposes, the Wall and its forts were built in some haste, as a direct response to attacks from the northern tribes, then it is likely that work continued up to and possibly beyond the recommended time scales. If mortared stonework was being laid at these times, then there was a strong possibility of it being affected by frost, and the work spoiled. If this was the case, bearing in mind it could have occurred some time after the stonework had been laid, the work may not have been replaced (such as in the case of the Wall or fort structures). This in turn could have led to the early failure of such work. It is perhaps relevant to point out that evidence of fires has been seen in several buildings under construction *per lineam valli*.

It is always suggested that these fires were built for the benefit of the builders. An alternative suggestion is that they may have been lit to ward off the action of frost.

Vitruvius (2, 9, 1-2) recommends that timber be cut in the autumn when there is less sap in the tree, particularly if it is going to be used within a short period and there is little time for it to season. It is likely that the selecting and cutting of timber was carried on throughout the year, as there was no reason why it should be limited to the building season. There is no evidence of seasonal felling in the north of England (pers. com. J. Huntley).

It has already been suggested that quarrying was carried on throughout the year. This would almost certainly have been necessary if adequate stone supplies were to be made available to the legionary builders, for the likelihood is that the masons could lay stone faster than it was being brought from the quarry. It is suggested that stone was stockpiled on site throughout the winter, at various points, for use by the builders during the building season.

The model which has been put forward suggests that the greater number of the legionaries retired to winter quarters over the period of October to April. These soldiers included the masons, carpenters, and labourers. However, it is suggested that a considerable force remained at the Wall throughout the year. This body of specialists, men, vehicles, and animals, would have been involved in the quarrying and delivery of stone to site, the burning of lime, and the selecting, felling, and transporting of timber to stockpiles. It is suggested that there is no reason why these operations could not be carried out for the greater part of the year. However, the proposal is dependant on an adequate road system which would allow the transportation of materials in poor weather. The most important factor however, is that it is unlikely that sufficient stone and timber could be delivered to site during the short building season. Complementary to this is that it is unlikely that such a large body of men, vehicles and animals would be disbanded, and then reassembled, when there was no compelling reason to do so.

2.6 Summary

Roman building techniques, like those of today, would have had to make the most of the resources of men and materials. A building season is likely to have been respected, mainly because it was not possible to lay mortared stonework in frosty weather. The winning and working of materials, and their transportation to site is unlikely to have been affected, although the weather would have had to be taken into account. In the selection, felling, and converting of timber and the laying of masonry, techniques cannot have varied much from the vernacular tradition of today, for to vary them would not have made the most of the resources, and would not have followed empirical knowledge. Similarly, in the selecting and laying of roofing materials, any wide variance from the traditions of today, would have led to a failure of the roof covering. Overall the pattern of building operations is unlikely to have differed much from those used in traditional vernacular architecture today. However, above all, these operations imply a degree of organisation which formed the basis of the efficiency of the Roman army.

Notes

1 Alberti wrote his treatise on architecture in 1452 and based most of what he wrote on the large quantities of upstanding Roman masonry then visible in the principal towns and cities in Italy. He constantly returned to Roman design and construction techniques, referring to the builders as "The ancients". His writings and the buildings he designed were influential in the birth of the Renaissance.

2 Identical examples can be seen in the bath suite of the same *praetorium* where the thresholds project forward of the wall to receive the wall plaster, the face of which would be flush with the outer face of the lining.

3 The slaking of lime is a dangerous process in which the water can reach boiling point, and particles of lime can spit out. In modern slaking the operatives have to be fully protected and goggles must be worn.

4 Modern mortar specifications used in Northern Britain are rarely a pure lime : sand mix, due to the exposure encountered. A common mix could be 1 : 2 : 8 , cement, lime, aggregate. The addition of the cement, apart from giving strength to the mix, also acts as a setting agent.

5 Alberti (1955, 125) records that he had seen some plastering in ancient buildings of nine coats.

6 These doubts are addressed by Dumayne in Dumayne-Peaty (1998, 315-322).

7 Oak was also the dominant species in the central European forests (Meiggs 1982, 187).

8 Oak was the most suitable building timber and was likely to have been widely available. Its favourable properties were that it was easy to work whilst "green", being also strong, resistant to insect attack and available in long lengths. Oak is the most widely seen structural timber in sites *per lineam valli* (McCarthy 1991, 39-40, 57-58; Birley 1994, 128-130), and elsewhere (Brigham 1990, 99-183; Brigham et al 1995, 1-72; Goodburn 1991, 182-204).

9 Whilst this thesis is only concerned with the stone buildings it is worth pointing out that Birley (1994, 124-125, 130) shows that the construction techniques for building V at Chesterholm, in the early 120`s, differed from those of the earlier buildings. This is shown in larger and better prepared timber sections and a different form of construction using sill beams and morticed uprights. This change could have been brought about by the involvement of the troops constructing the Wall.

10 Brigham *et al.* (1995, 42-45) found the planks to the Roman timber buildings at Southwark had been sawn.

11 The variation in extant boarding formed this way in the late medieval period is within close limits.

12 Slates of these forms have been found at Chesters, Housesteads and Birdoswald (pers. com. M. J. Astill).

13 For a normal 30-45 degree pitch, with slating, a normal lap is 75 mm which is measured from the centre of the nail hole in head nailed slates. An example from Birdoswald has been identified of a 400 mm slate with a 110-125 mm head lap (pers. com. M. J. Astill).

14 The metric weights are incorrectly given by Brodribb, the corrected values are stated.

15 Evidence of bedding the slates as opposed to nailing them, has been seen at Piddington Roman Villa, near. Northampton.

3.0 THE BUILDINGS

This section will consider in detail the selected stone buildings in the forts of the final Hadrianic concept of the wall, namely the *principia,* granaries, gates and barracks. In view of the amount of material this section will be divided into four sub-sections. The first will consider the design and form of the buildings, whilst the second will be a dimensional analysis with a short chapter on design and metrology. The third sub-section will examine the constructional sequences of the forts and buildings, and the fourth and final section, the building techniques used in the buildings. The section will close with a conclusion.

Illustrative tables set out in appendix 3 tabulate selected dimensional data relevant to each fort and type of building. A space will be left between the forts listed in the tables to distinguish between those set out in appendix 1 and those in appendix 2, the primary and secondary forts. The dimensions in the tables relate to the Hadrianic phase or the closest relevant period. Where comparisons are cited these will, in most cases, relate to forts considered to have been built by the legions involved in constructing the Wall and associated sites. In cases where a range of dimensions is given, this takes into account the variance in the dimensions of that building part.

3.1.0 Design and Form

3.1.1 The *Principia*

This chapter, apart from considering the form of the *principia*, will also consider the forehalls, together with the *basilica* building at Birdoswald which has many similarities to the *principia*. The form of the *principia* in the forts on the northern frontier, shows consistency in the planning arrangements, although considerable variation can be seen in the size and proportion of the plan form (appendix 3, tables 2, 3, 4).

The main entrance is situated on the axis of the *via praetoria,* and passes into an ambulatory which runs around three sides of a courtyard, the cross-hall forming the fourth side, with its entrance on the axis of the main entrance. The cross-hall to many of the forts has an aisle facing onto the courtyard (table 3). This is divided from the main body of the cross-hall by an arcade. On the opposite side is the rear range with arched openings leading into the *aedes,* and usually the two rooms adjacent. The cross-hall, aisle and rear range took the form of a *basilica* with clerestory lighting to the central space.

The entrance into the *principia* was through a small opening, in a large blank wall probably with minimal decorative relief, entered off the *via principalis.* At Housesteads, some time after the completion of the building, a portico was built in front of this wall, projecting 2.130 m into the street (Smith 1954, 1-3). This feature is not mentioned in Bosanquet's final report (Bosanquet 1904), and was probably built to give a more imposing frontage to a building, which clearly must have had a somewhat unsatisfactory appearance due to it being built on sloping ground.[1]

The ambulatory is of similar width to the three sides of the courtyard (where known) to all the forts with the exception of Chesters. At Chesters the depth of ambulatory at the main entrance is less than that to the sides, being reduced from 5.870 - 5.920 m to 3.560 m. If it is assumed that the line of the top of the mono-pitched roof over the ambulatories lines through, then the reduction in width would result in a higher eaves level to the length adjacent to the entrance (fig. 35, sections a a & b b). An interpretation of this design feature is that the height of the entrance, and that through the ambulatory, were such that it would have been possible for a man on horseback to enter the courtyard. At Chesters the extant masonry to the north of the courtyard could be interpreted as being the remains of an arcade with three equal openings (fig. 35, section b b). This arcade is matched by three similar openings to the north elevation of the aisle.

At the other forts where full details of the ambulatory are known, viz. Wallsend and South Shields, the columns are spaced wider apart on the axis of the main entrance. This would have enabled the entrance into the courtyard to have been emphasised by a different architectural expression or detail, as put forward in the reconstruction of the northern ambulatory at Wallsend (fig. 38). This would also have enabled additional headroom to be provided through the ambulatory. It is likely that there was no roof over the ambulatory opposite the main entrance of the mid-Antonine *principia* at South Shields. Here two stone channels flank the entrance into the courtyard and return around adjacent ambulatory piers (Bidwell and Speak 1994, 62). A similar set of circumstances occurs at Carrawburgh, where drainage channels are seen to the sides of the main entrance in the final phase of the fort (Breeze 1972, 111).

The supports to the roof of the ambulatory were either full height columns, as at Wallsend and Housesteads, or square piers as at South Shields (Bidwell and Speak 1994, 66-7). At Chesters either piers with a splayed plinth course, or possibly dwarf columns on a plinth were built. It is difficult to see why square piers were used in such a situation as they were markedly more bulky than a column, having sharp arrises where it would have been more advantageous to have a rounded surface. A possible explanation is that the expertise, in the form of a specialist mason, was not available to turn the columns at the time they were required.

The courtyard to almost every *principia*, and certainly to those *per lineam valli*, has a well sunk within it. It is thought (Bidwell and Speak 1994, 58) that this well might have provided water for use in religious ceremonies. It is perhaps significant that drains are located in central positions in both the cross-hall at Housesteads and the stone fort at Chesterholm. An open water supply in a cistern is also available either inside the courtyard or close to the front of the building at Wallsend, Benwell, Birdoswald, South Shields, and the late first century forts of Strageath, Fendoch and Inchtuthil.

The emphasis given to the main entrance into the *principia* is reflected, across the courtyard on the central axis of the building, in the main entrance into the cross-hall. From the extant archaeological evidence, it is likely that this entrance was more elaborate than that into the courtyard from the *via principalis*. Evidence of possible column bases to the cross-hall entrance was seen at Chesterholm stone fort 1 (Birley, Richmond and Stanfield 1936, 229-30; Bidwell 1985, 14). At Chesters and Housesteads projecting nibs are formed to either side of the entrance, possibly supporting a decorative pediment. These are echoed at Housesteads by large piers in the centre of the range of piers to the aisle (fig. 30). It is likely that these piers supported an arch or a lintel to an opening the same height as that to the fort entrance. The three openings to the north wall of the aisle at Chesters mirror those in the south wall of the ambulatory. It is probable that the openings to these two elevations were arched, and that greater detail was applied to the cross-hall entrance (fig. 35, section c c). This reconstructed detail is implied by a return in the gutter to the courtyard on the west side of the opening, and could be indicative of a projecting cornice or moulding, supported by a nib to each side of the entrance. The problems of designing and constructing a doorway with elaborate architectural detail would have been easier where there was no aisle to the cross-hall. This would have been due to the lack of height constraints due to the lower roof of the aisle, and possible design problems due to intersecting planes with the aisle roof.

The cross-hall is likely to have been an impressive space, being almost as high as it was wide, with trusses supporting a pitched roof. Lighting could have come from low level openings in the wall to the nave or aisle flanking the courtyard, together with a clerestory to each side of the nave, and possible windows in the gable walls. Most reconstructions have tended to show minimal openings to the clerestory, often providing one per structural bay (Crow 1995, 27; Bidwell and Speak 1994, 100). It is suggested that the amount of clerestory lighting has been understated, and that due regard has not been paid to the low levels of natural lighting in winter months prevalent in northern Britain. Parallels of close spacing of openings in the clerestory are few, but examples can be seen in the fourth and fifth century Syrian basilican churches, where in many cases the maximum number of openings possible has been constructed in any length of walling (Butler, 1969, 52, 60).

The tribunal is placed against the wall at the right hand side when entering the cross-hall; this arrangement can be seen at Wallsend, Chesters, Housesteads, South Shields periods 4, 5, 7 & 8 and Chesterholm stone fort 2. The platform to the tribunal is usually placed up against the rear range, against which a flight of steps is formed leading up to the platform. There are four risers in the flight at both Chesters and Chesterholm. The height of the tribunals above floor level is *c*. 640 mm minimum at Chesters and *c*. 970 mm at stone fort 2 Chesterholm. A seat ran across the front of the tribunal at Chesterholm. A room, possibly a strong room, is formed below the platform at Chesters and South Shields, the latter being sunk *c*. 1.000 m below floor level. It could be significant that the pier closest to the tribunal at Chesters is significantly larger than the others in the arcade. Doors are positioned into the cross-hall directly opposite one into the *praetorium* at Wallsend (Daniels 1989, fig. 39) and South Shields (Bidwell and Speak 1994, 68-9). Both these doorways face the tribunal.

The width of the aisles adjoining the nave of the cross-hall are comparatively narrow, and are divided from the cross-hall by an arcade or trabeation, supported by either columns, or piers as at Chesters, and the *basilica* at Birdoswald. In most forts the arcades are symmetrical, and supported by regular spaced piers. Due to the amount of cross fall along the length of the cross-hall at Housesteads (some 750 mm), and the variance in the spacing of the columns, it is likely that trabeated construction was used in order to overcome structural and dimensional difficulties.

The inside of the pier to the aisle at Chesters, on the line of the western piers to the ambulatory, is not symmetrical to that on the east. The one to the west is thicker so as to form on the inside a centrally placed pier 2.160 m wide, with returns at each end of 100 mm set 570 mm in from each end of the stonework. It is possible that this could have had some significance due to its proximity to the tribunal.

The scale of the arcading or trabeation is likely to have been matched by the openings into the rear range. Later alterations have made interpretation more difficult, but the width of the opening into the *aedes* at Chesters and Housesteads is equal to the width of the opening in the arcading on the main axis. It is likely that the height of the opening to the *aedes* was equal to the height of the arcading, and the probability was that the openings to each side were of similar height. At Carrawburgh, however, the excavator did not think that identical arches to those to the *aedes* were formed to the two flanking rooms (Breeze 1972, 100).

The rear range is likely to have been roofed with a mono-pitched roof, with its height above ground level against the nave wall close to the height of the aisle at the same point. This should have enabled a minimal acceptable height to have been maintained against the inside of the external wall. It is probable in instances where the floor level of the *aedes* was raised, by the introduction of steps, that the roof was set at a higher level. This could easily have been achieved by raising the internal walls to each side of the *aedes,* and forming a mono-pitched roof above that to each side over the adjoining rooms. It is unlikely that a gable was formed, with intersecting pitches and internal valleys, as suggested for the period 4 *principia* at South Shields (Bidwell and Speak 1994, 100), when a much quicker and easier solution could have been achieved, with little risk of water penetration.

In all forts *per lineam valli* the number of rooms to each side of the *aedes* is two, making a total of five. In all cases where the plan is known, the two outside rooms are entered from the inner rooms. The rear range of the Trajanic fort of Old Church, Brampton, has only one room to each side of the *aedes.*

The architectural form of the *principia* was a simple functional and effective interplay of spatial effects designed to impress. The natural progression through the building culminated at the *aedes*, which formed the focal point of the building.

3.1.2 The Forehall

The forehalls to the forts on the Wall are a significant addition to the Hadrianic *principia,* and it is in this context that they are discussed. Forehalls were built at the forts at Wallsend and Halton Chesters. In each case the building was an early third century addition to the front of the *principia*, spanning the *via principalis*. At Wallsend the eastern wall of the building is in line with the east wall of the *principia,* and the forehall extends westwards to 6.000 m beyond the western wall of the granary adjacent. The building at Halton Chesters would seem to extend either side of the *principia,* to the granary on the west, and to the *praetorium* on the east. The amount of overlap on these two buildings is unknown but is unlikely to be great.

The form of both forehalls is long and narrow with a pitched roof. At Wallsend the frontage of the *principia* and granary are in line, so forming a continuous rear wall to the building. It is probable that the same conditions applied at Halton Chesters. It is likely that the front wall to the *principia* was built up, so as to clear the ambulatory roof, avoiding any junction with an existing roof. It is difficult to envisage how support, for the rear wall, was gained from the front wall of the granaries, but it could have involved the front buttresses. Whatever solution was found, the resulting junction of the buildings would have appeared architecturally contrived and uncomfortable.

The forehall at Halton Chesters was excavated by Simpson and Richmond (1937) who attached great importance to the building. They likened "the great building" to the forehall `at Lambaesis and the towns on which the idea is based to form a unified architectural conception` (ibid., 169). Whilst it appears likely that the forehall and the frontages to the east of the *via praetoria* were built at the same time, it is unlikely that the buildings had quite the architectural impact the excavators envisaged. The long narrow street, reduced in width due to the encroachment of the buildings on the east of the *via praetoria* (fig. 7) following the blocking up of the east portal to the north gate, would hide the mass of the forehall. All that would be seen would have been the main north entrance and a considerable area of roof. The irregular spacing of the piers is likely to have detracted from the overall unity of the building, and would of necessity have resulted in trabeated construction over the openings. The overall concept would have been rather cramped, and cannot be compared with the free-standing concept of the forehall at Wallsend with its probable arcade.

The size of the building at Wallsend, 46.100 m by 9.000 m, with a minimum internal width of 6.500 m, and the similar size structure at Halton Chesters, makes it difficult to see how they could be used effectively to exercise even a small proportion of the nominal 120 horses in a *cohors equitata quingenaria*. At Brecon Gaer, where a cavalry unit was known to be stationed, an early second century forehall 44.810 m by 12.190 m was built in front of the *principia* (Wheeler 1926, fig. 30 opp. 38, 42). This forehall is placed asymmetrically around the extended *principia* to the north and projects towards the *praetorium* on its south side, with its greatest length projecting towards the adjacent granary. At Newstead the mid-second century *principia* had a forehall 48.770 m by 15.240 m which linked the two granaries sited on each side to the east and west (Curle 1911, 43-4).

The forehall has traditionally been associated with the Roman cavalry, as this type of building and cavalry units are invariably associated with one another where they occur. It is however difficult to understand why an exercise hall for the cavalry should have been built over the *via principalis* and attached to the *principia,* when such a structure could have been free-standing and even sited outside the fort. It is suggested that the forehall, rather than being a late second or third century introduction for the benefit of the cavalry, was built at a chosen fort because the cavalry were already there, and that it was to be used in the course of the military duties of the fort. Wheeler (1926, 43) points out that a large proportion of the forts in Germany which have forehalls were not garrisoned by cavalry units. It is perhaps also significant that in the two cases studied, both the *principia* and granary were physically linked by the forehall. It is a possibility that the forehall might have some connection with the receiving, recording and distribution of foodstuffs, possibly including the *annona.* This would have been an activity involving administration and labour from both buildings which would have benefited by being carried out under cover.

Although the association of the forehall with the adjacent granaries at these forts might suggest a possible link between the buildings, the more likely suggestion is that they were used as exercise halls for the troops. There can be no doubt that, taking into account the location of the forts *per lineam valli,* provision for exercising the troops during inclement weather and the winter months, would have had to be made. It is suggested that when the forts were initially constructed, this exercise took place in the cross-hall of the *basilica*. Wilmott (1997, 95, 97) shows that the term *basilica* can be applied to any building having that plan form, with a nave and aisles, together with clerestory lighting, as seen in the cross-hall of the *principia*.

The identification of a *basilica* building at Birdoswald in the primary context of the fort is initially surprising. The excavator associates the use of the building as a *basilica exercitatoria* of the kind described by Vegetius (Wilmott 1997, 97), and cites examples at Brecon Gaer, Newstead, Halton Chesters, Wallsend and Rudchester. Johnson (1983, 314 n. 73) shows that of the thirty one forehalls known, half are connected with cavalry units. Schonberger (1969, 169) disagrees and thinks that forehalls were `roofed places where soldiers could fall in`. In practical terms it is difficult to see the need of an enclosed building to exercise the cavalry. Surely all that was required was to let the horses exercise around the fort on a daily basis in inclement conditions - a situation similar to many riding stables today. The use of an indoor riding hall must be considered too great a luxury for the cavalry *per lineam valli,* where the practising of elaborate routines would hardly have been a consideration. On balance Schonberger`s opinion would seem to be the more reasonable. The forehalls and *basilica* at Birdoswald are much more appropriate as buildings to house several hundred men rather than a large number of horses. This is further supported by the erection of a forehall at the Raetian fort of Hesselbach of 0.6 hectares, built for a *numerus*.

The construction of the forehall in the forts *per lineam valli,* must have been brought about by a change of circumstances which warranted their introduction. If the cross-hall of the *principia* was used for this purpose previously, could it be that at the forts where they were erected, the cross-hall was then being used for other purposes?

3.1.3 The *Basilica* Building at Birdoswald

The strong links between the architectural form of this building, and the cross-halls found in the headquarters buildings justifies the inclusion of this building in this section.

The building is unique in any auxiliary fort in Britain and was probably built as a *basilica exercitoria* (Wilmott 1997, 95-8) as discussed above. The building is sited in the south-western sector of the *praetentura* and is set back from the *via praetoria* by some 10.000 m (Biggins and Taylor forthcoming), so reflecting its importance. The form of the building was very similar to that of a cross-hall with its single aisle and rear range, the only difference being that there was an aisle to each side of the nave (fig. 39, 40). The effect of the two aisles, separated from the nave by arcading, together with the length and height of the building, would have created a very impressive enclosed space. The overall length of *c.* 40.000 m is some 12.500 m longer than the cross-hall at Chesters (27.540 m).

3.1.4 The Granaries

The storage buildings in a fort have tended to be referred to as granaries or *horrea*. The word *horrea* was used to designate buildings where anything could be stored (Rickman 1971, 1), although it was normally used in the context of a building storing food (appendix 3, tables 5, 6, 7)

The criterion for storing foodstuffs is that the building should be cool and not subject to wide fluctuations in temperature. The storage of grain, particularly, is affected by high temperatures, and it is necessary to cool it to a maximum of 15 degrees centigrade to eliminate insect activity (Gentry 1976, 3). The moisture content of the grain is also critical, for if it is stored whilst it is too wet in high temperatures, bacterial, fungal and insect infestation will occur. Cooling can be assisted by storing the grain in sacks rather than bins. The smaller unit of the sack allows water vapour and heat to dissipate more readily, provided that the environment in which they are stored is well ventilated (ibid., 3). It is likely for this reason, and for the ease of handling, that the Roman army stored its grain in sacks.

The stability of the temperature within the building could readily have been obtained by the use of substantial stone walls with the minimum number of openings, and a heavy pitched roof. Some ventilation would have been required, but this could easily have been introduced in the form of ventilation slots. Columella (I.VI.10) advocates that 'granaries should receive ventilation through small openings on the north side'. It is suggested that these ventilation slots to the walls mirrored in size and form those to the underfloor space (fig. 41). There is no reason for them to differ to any part of the elevation, as the function was the same below ground level as to the upper levels. The parallel to the granary in a modern building would be the traditional stone built barn.

Evidence for the greater wall thickness in granaries can be seen in many instances. At Housesteads the walls of the granaries averaged over 800 mm with the addition of buttresses, whilst those of the *principia* averaged 700 mm, similarly the west granary at Carrawburgh had walls 1.200 m thick and the *principia* 900 - 950 mm. The walls to the Severan granaries at South Shields were over 1.000 m thick, with many in excess of 1.200 m, whilst those of the *principia* measured only *c*. 800 mm. This greater difference in wall thickness is not apparent at Wallsend where the granary walls are 800 - 820 mm thick and the *principia* 860 - 970 mm.

A clay tiled or stone slated roof provides minimal insulation properties in hot weather, and reliance would have had to be made on ventilation to prevent a build up of temperature. This build up of heat would be very gradual, as would also be the effect of chilling in the cold winter months; this set of circumstances can be experienced in the traditional stone buildings of today.

It is likely therefore, that the substantial stone walls and roof would have provided storage conditions with minimal temperature variations. These temperature variations could not have been maintained if large areas had been introduced for ventilation in the form of louvres (Richmond and McIntyre 1939, 131-2; Bulmer 1969, 10; Rickman 1971, 237). The proposals put forward by Richmond and McIntyre for the reconstruction of the granaries at Fendoch were that, the upper space of the walling above the grain storage bins was `occupied by carefully weatherproofed double louvres to give the abundant supply of fresh air which a building of this type would require`. Although the provision of ample ventilation would have been very advantageous, the louvres in themselves would have had negligible insulation value. The overall effect of the louvred areas would have been to allow large fluctuations in temperature to occur in the granaries.

It is unlikely that the granaries with solid floors were used for the storage of grain or other perishable foodstuffs. Such a floor would be subject to dampness either through rising damp, or condensation caused by a chilled sub-floor and a warm air temperature. It is also possible that the storage areas could be subject to flooding if its floor level was only slightly raised above that of the surrounding roads.

Columella (I.VI.12-17) distinguished between granaries with solid and raised floors (table 7). He states that granaries with solid floors, unless they are dry, could lead to the grain spoiling with mustiness. He recommends that, `we living in regions which abound in moisture, approve rather the granary that stands on supports above the ground ...`. He also refers to the plastering of the walls with clay, oil lees, and olive leaves in place of chaff so as to discourage weevils and other vermin. The same care has to be taken to discourage vermin lodging in the floors. It is possible, in view of Columella`s remarks, that the internal walls to Roman military granaries were plastered so as to discourage vermin and other pests.

The suspended granary floors as built by the Roman army would fulfill the conditions advocated by Columella, such floors being adequately raised to eliminate the damp conditions listed above. Ventilation, in all instances, is provided by a ventilation slot in the centre of each bay between the buttresses, with openings being formed in any sleeper wall. However, the underfloor space would have been a haven for vermin and the doors into this space must have allowed access for dogs and other animals to eliminate it (Wilmott, 1997, 136).

The presence of central single sleeper walls in the granaries at Birdoswald and Old Church, Brampton give a possible indication of a support at foundation level for an upper floor. The proposition will be discussed in chapter 4.2 that upper floors were formed in granaries of narrow width. If a central row of supports were provided this would dictate the layout of the storage bays, as it would not be possible to have a central passage with storage to each side. It must follow that storage would have been to one side only, with the access passage being against an outside wall; this may account for the presence of buttresses to one side only at Birdoswald where a central spine sleeper wall exists, the buttresses giving support to the wall against which the grain is stored. Columella refers to vegetables being stored in bins (I.VI.13). From the practical point of view it might have been an option to store loose vegetables and other foods in bins at ground level, and grain in sacks being stored at first floor level, with delivery made through a door at high level by means of a hoist over the loading bay (fig. 42).

The double width granaries, with single pitched roofs, would of necessity have had much taller gable walls, and it is likely that the central dividing wall, or arcade in the case of Housesteads, supported the ridge (fig. 41, section y y). The alternative section y y (fig. 41) would have been to provide a separate pitched roof over each half of the granary, with a valley gutter positioned on the dividing wall. Wheeler (1926, 38) has interpreted the late first-second century double granary at Brecon Gaer to have been roofed in two spans. This form of roof would be a constant source of weakness as the rainwater from the two inner roof pitches would be directed to a central valley gutter, for which the builders would not have been able to guarantee the watertightness. Any water penetration on the dividing wall between the two granaries could have had serious consequences for the stored food. On balance it is likely that a single pitched roof was used as it would have been unlikely that the Roman army would have jeopardised the storage of foodstuffs.

The design of the building, with projecting buttresses adjacent to the loading doors, is likely to have made the provision of loading platforms, as well as the positioning of carts close to the loading doors, difficult. The only granaries to auxiliary forts which have projecting buttresses to their side but not the gable walls are at Benwell, Rudchester, Halton Chesters, possibly Drumburgh, and Old Church, Brampton. Similar examples can be found in the late first-second century double granary at Brecon Gaer (Gentry 1976, 62, fig. 7), a probable Antonine linked double building at Caerhun (ibid., 64, fig. 7), single granaries at Antonine or later forts of Camelon (ibid., 66, fig. 8), Castell Collen (ibid., 67, fig. 8), probably Caernarfon (ibid., 64, fig. 7), Chester-le-street (ibid., 70, fig. 8), Lyne, (ibid., 84-85, fig. 12) High Rochester (ibid., 81, fig. 11), the Trajanic fort of Gellygaer (ibid., 78, fig. 10), and also Ribchester (ibid., 89, fig. 13).

Examples of substantial stone built loading platforms can been seen *per lineam valli*, against the south walls of the granaries at Rudchester, Halton Chesters and Wallsend. The platform at the former extends for the full width of the building over the buttresses, and projects 3.000 m. That at Halton Chesters originally projected *c.* 2.430 m and was later extended to project *c.* 4.110 m. The edge of the platform was slightly inside the side walls (pers. com., J. Dore). The platform at Wallsend projected 1.400 m in front of each of the south facing doors and was 2.400 m wide. A lesser platform some 800 mm deep and 2.730 m long was seen to the north west elevation of the mid-Antonine granary A5 at South Shields. It is likely that timber loading platforms were provided at some granaries. Loading doors are always positioned in the end walls of the granaries. There is little evidence of doors in the long side wall, the only known example being at Wallsend where a narrow door was seen.

Evidence of porticos can be seen at Wallsend, Benwell, Rudchester and South Shields (A5). It is to be expected that the provision of porticos, allowing loading and unloading undercover, was far more common than has been recorded (Simpson and

Richmond 1941a, 19). It is likely that the portico took the form of an extension to the main roof. The splayed bases with a square top were likely to have supported timber posts which gave support to the horizontal tie member of a truss (fig. 41).

The structural necessity of buttresses to the long side of the granaries will be discussed elsewhere in this section (chapter 3.4.2.4). Much discussion has taken place on their purpose, and it is likely that their only use was to offer additional support to the external walls (e.g. Gentry 1976, 15, 16 & fig. 1). An alternative use is most unlikely, and in Gentry`s proposal, where it is suggested that opposing buttresses support roof trusses with the areas between the buttresses being covered by a roof overhang, impractical, as in many cases the buttresses do not exactly oppose (e.g. Wallsend, South Shields). This suggestion for the use of buttresses is also put forward by Webster (1969, 197), who suggests that the projection of the roof was to keep the walls dry so as not to cause dampness inside. This proposal has little foundation, for it is found in vernacular buildings and churches, with walls of similar construction and usually a lesser thickness, that penetrating damp does not occur if the structure is well built and maintained.

The nature of the form of the granary, with projecting buttresses outside the main walls of the building, necessitates a site considerably larger than that contained just by its external walls (table 5). This obvious requirement was taken into account in the Hadrianic design of forts and also in the layout of the Severan supply base at South Shields (Bidwell and Speak 1994, 22 fig. 2.7). However, the requirement does seem to have been overlooked in the case of the later second century granaries at Corbridge, where the proximity of the buttresses required them to be staggered.

3.1.5 The Gates

The function of the main gates, at the time of the building of the forts, was to control the passage of people and goods into a fort, whilst at the same time acting as a watch tower (appendix 3, tables 8, 9, 10). Provision would have also have had to be made for defending a potential weakness in the forts ramparts caused by the insertion of the two portals. The width of the portal was dictated by the requirement to allow access by a loaded cart, whilst its height had to be great enough to allow a rider on horseback to pass through (table 9). The towers and the area above the portals would have provided vantage points for look-outs, and at the time be secure positions from which the gates could be defended.

All the forts *per lineam valli* have the portals set back from the face of the curtain wall (table 10). At the later forts of South Shields and Chesterholm the guardchambers project forward of the rampart wall. The doors to the portals closed, generally, against a stone threshold *c*. 100 mm, a section of which was often raised where the two leaves met. The threshold would seem to be a feature designed to prevent ready access by wheeled vehicles, and may have been a means to control it, with access only being allowed if tapered blocks were placed to either side.

The form of the *spina* between the two portals varies considerably. At Chesters and Rudchester it takes the form of a dividing wall between the two passages pierced only by a door. At Wallsend, Halton Chesters, Housesteads, Great Chesters and Birdoswald, it takes the form of two piers, with or without a return pier along the line of the passage. The relatively small size of some of the piers at Birdoswald and Housesteads could reflect adversely on the strength of the portals in resisting a forcible attack. This could reflect supreme confidence by the fort builders in that an attack on the fort was never envisaged as a possibility (Bidwell 1997, 44).

In most instances the depth of the responds (i.e. depth of the reveal) to the front and rear portals is a common dimension, generally falling within the range 580 - 880 mm, which would probably reflect the dimension of the voussoirs forming the arch over. At Rudchester it can be seen that the outer responds to the south and west gates are much deeper than to the inside of the gate (Brewis 1925, plates II-IV). At Halton Chesters the responds to the *spinae* to the east and west gates are narrower than those abutting the guardchambers (Simpson and Richmond 1937, figs. 2 & 3). In most cases the gates have two responds to each portal at the front and rear. The exception to this is at Housesteads where no responds are formed against the guardchamber to the rear of the gate.

The guardchambers to each side of the portal are accessible from ground level by a doorway which in most cases is entered off the passage. At Rudchester (south gate, west guardchamber only), Birdoswald and South Shields, this is formed in the rear wall facing into the fort. The doors to the portals when opened would obscure, or partially obscure, the doors leading into the passage at Rudchester, Halton Chesters and Chesters. Access to the upper levels was almost certainly gained from the rampart walkway. The curtain wall is reduced in thickness, and a recess formed the length of the guardchamber, at the forts of Wallsend, Rudchester, Halton Chesters, Chesters and Great Chesters. This recess does not occur at Benwell, Housesteads and Birdoswald. There are no guardchambers to the gates of the fort at Bewcastle.

The single gates to the Hadrianic fort at Bowness-on-Solway, and the late first and early second century at Chesterholm, are of timber construction. Assuming a first floor level equal to that of the rampart walkway of *c.* 4.500 m, and some form of enclosure to the tower over the gate, the lengths of the posts required to construct the gate would be around 8.000 m. If a second storey was formed, then posts in the region of 11.000 m would be required. The size of the posts to the late first century gates at Chesterholm were some 250 - 280 mm diameter (Birley 1994, 37), whilst those to the early second century gate were double posts made up of two timbers each between 140 and 155 mm square (ibid., 54), probably reflecting the unavailability of larger timbers at the time of construction. It is highly unlikely that three storied timber gates were built due to the difficulty in obtaining cut lengths of timber in excess of 10.000 m, which would involve locating and felling an oak some 21 m tall (Charles 1990, 48-9). It is also unlikely that the 200 mm square posts at Bowness-on-Solway would have supported a second floor in view of their size. It is difficult to see how the conservatism of the Roman army could accept two storey timber towers, yet construct three storey towers in stone. It is suggested therefore that the towers to timber gates were two storeys high, and that stone gate towers were of similar height. This is further borne out by the final Hadrianic concept of the Wall where the forts were added to a defensive system where milecastles were positioned at every mile, with two turrets equally spaced between them. With such a sophisticated system of look-outs to each side of a fort, providing wide angles of vision due to the undulating ground and lateral spacing, it is hard to see why the towers to the gates of a fort needed to be greater than two storeys. There might be a case for arguing that a north gate with three storeys might be of advantage in certain circumstances, as at Halton Chesters where visibility to the north is limited, or a similar height gate to the west at Housesteads where the land rises. No obvious advantage would have been gained by having the other three gates, to the forts cited, three storeys high. One wonders whether the Romans' strong sense of conservatism would have allowed them to construct a fort with gates in an asymmetrical form. However, there is a strong case for three storied gates to the west coast and outpost forts, where they were not linked into such a comprehensive linear defence system. It could also be argued that if the towers to the gates were three storeys high, then the towers over the gates to the milecastles should be of similar height.

The fenestration to the towers over the guardchambers is likely to have been purely functional, and to have been the minimum to allow a good field of vision to front and rear. From the many examples found, the arcuate lintel was widely used as the form of window head.

Much has been said about the form and direction of the roof pitch to the towers and this will be discussed further in chapter 4.3. From the purely functional aspect, it is unlikely that the Roman Army would have built the towers to the guardchambers with the ridge to the roof at right angles to the rampart. This form of roof would have enabled any missile hitting the roof to roll down onto the rampart and open area over the gate, so further hindering the defender in the case of an attack.

3.1.6 The Barracks

The barracks within the Hadrianic forts were set out in both the *praetentura* and *retentura,* abutting the *intervallum* roads and the *via praetoria* and *via decumana* (appendix 3, tables 11, 12, 13). In most cases a barrack block in one half of the sector was opposed by one in the other sector. In all cases with the exception of Housesteads, Stanwix and Maryport, the barracks were laid out *per scamna*. In the case of the exceptions, the barracks were laid out *per strigas*. The barracks at Halton Chesters would appear to meet neither case being set out *per strigas* in the *praetentura* and *per scamna* in the *retentura* (Berry and Taylor 1997, 51-60). It is possible that the barracks at Great Chesters were also laid out *per strigas*; there has been no recent research on the site to throw further light upon this point, but evidence of what appear to be late "chalet-type" barracks can be seen in the south west of the site running *per strigas* (Gibson 1903). All the barracks *per lineam valli* were stone built, with the exception of Wallsend where buildings were constructed to be later replaced in stone.

The layout of the barracks within the fort is consistent with the officers' quarters always abutting the *intervallum* road, with the *contubernia* being laid out towards the centre of the fort. Known double barracks, with the officer's quarters and *contubernia* set out back-to-back, occur only at Benwell and Halton Chesters. With the plan form of the double barracks, the inner rooms to the contubernia would obtain no natural light or ventilation if a double pitched roof was constructed.

A major difference in the plan forms of the barracks is the provision of a covered verandah to the front of the *contubernia,* with the front of the verandah lining up with the front of the officer's quarters. In single barracks this means that the depth of the *contubernia* is less than that for the officer's quarters by the depth of the verandah. Known verandahs occur at the forts of Benwell, possibly Halton Chesters, Chesters, Carrawburgh, Housesteads and Maryport. At Carrawburgh a partition on the line of the dividing walls to the *contubernia* was carried across the verandah (Breeze 1972, 92).

Although in most cases there is a masonry wall between the officers` quarters and the *contubernia*, the officer`s quarters at Maryport are separated from the *contubernia* by a narrow space of 1.000 m. A similar set of circumstances has recently been seen in a third century block in the north west of the *praetentura* at Birdoswald (pers. com. T. Wilmott). In view of this distance it is unlikely that the two blocks were covered by a common roof. A further possible variation occurs at the fort of Birrens where it is suggested (Robertson 1975, 83-7) and further discussed by Davison (1989, 198-199) that, four pairs of long narrow buildings in the Antonine 1 fort, could be four barracks, with the two rooms to each *contubernia* separated by a passage with a possible covered link between each pair of rooms. As a parallel the barrack block in the Flavian fort at Cardean is cited (ibid., 85-86) where a central passage is placed between the two rooms of each *contubernia*. The suggested form of the barracks at Birrens is reminiscent of the hospital at Inchuthill (Pitts and St. Joseph 1985, 91-103), where it is suggested that covered links spanned the spaces between the wards and the corridor (ibid., 96 fig. 17).

A great deal of energy has been spent by many archaeologists in endeavouring to calculate the size of the garrison of a fort by the number of the barrack blocks and *contubernia*, or alternatively the theoretical number of barrack blocks and *contubernia* there should be in a fort. This writer is not going to add to the volume of literature on this subject, except to emphasize the point that the number of soldiers in a fort at any one time is now recognised to have been influenced by a large number of external circumstances. It is most unlikely that at any one time the full complement of soldiers, for which a fort was designed, would have been present (*Tab. Vindol.* 1, 154)

The number of *contubernia* within the barrack blocks is not constant and does not appear to reflect the type of unit thought to have been stationed there. Eight *contubernia* are found in each block at Halton Chesters and Birdoswald, nine at Wallsend and Benwell and ten at Chesters and Housesteads. However, it is apparent that the widths of the *contubernia* where cavalry were known to have been stationed are greater than those used by the infantry. It can, therefore, be seen in table 12 that the widths of the blocks at Wallsend, Benwell, Halton Chesters and Chesters are significantly greater than those at Housesteads. It has been suggested on many occasions that the larger size of the barracks for the cavalrymen was due to the necessity of housing tack and other equine equipment. Whilst this may be so, it is probable that the main reason was a reflection of status and the benefit of a greater amount of floor per man than that allowed for the infantry.

Recent evidence from Wallsend has shown that the four barrack blocks (fig. 2, buildings 9, 10, 11, 12) in the *retentura* were almost certainly shared by the troopers and the horses (site archive). The horse was stabled in the paved front room and the trooper lived in the rear room. Oval soakaway pits were dug in the centre of the stable. This is the only instance *per lineam valli* where horses and troopers have been shown to occupy the same building.

A typical Hadrianic *contubernium* for the infantry can be seen at Housesteads where the unit internally is 7.620 m long by 3.350 m wide, with the inner compartment 4.600 m long and the outer 2.900 m (Wilkes 1961, 282). The door in the internal dividing wall is situated up against the adjacent party wall. It is likely that the outer door was in line, so as to maximize the useable floor space. It has always been assumed that the inner compartment (*papilio*) would be used for sleeping, and the outer one (*arma*) for the storage of equipment and possibly food preparation. Little consideration has been given to how the soldiers actually used a *contubernium*, which must have been impossibly cramped if up to ten persons occupied it as has often been suggested. It is probable that the soldiers slept on palliasses on the floor of the inner room, and using the example from Housesteads, it would have been possible for five men to lie side by side with a fairly minimal width per man of just over 900 mm. The length of the man and palliasse of say *c.* 1.700 would in theory, allow another row to lie up against the opposite wall. However, this would create extremely cramped and unacceptable conditions by today's standards, and gives credence to the probability that around five men was a typical actual occupancy of a *contubernium.* If the bedding was to lie on the floor it would become dirty by foot traffic, and would also become damp due to rising damp through the typical flag or clay floor. It is suggested that the bedding was hung on the internal walls during the day[2]. It is possible if a roof of *c.* 45 degrees pitch was used that a useful sleeping and storage area could have been formed in the roof space (fig. 44). The likelihood is that the outer room would have some nominal furniture such as a table and some benches. A hearth or possibly a brazier was used for heating and cooking. However, there is no fixed position for this which varies considerably in military barracks (Davison 1989, 230-32). Hearths were found against the inner walls of the troopers accommodation at Wallsend. Cooking was often carried out on verandahs when they were provided, together with the ovens sited in the back of the ramparts.

The junior officers of each century had no special accommodation reserved for them unless they shared the officer`s accommodation (Wilkes 1961, 282), which being usually over three times the size of a *contubernium* was generous for one man. A small recess formed to the left hand side of the doorway to the second *contubernium* from the officer`s quarters in the extant southern block at Chesters could be indicative of some special use for that accommodation. The recess is 270 mm wide by 250 mm deep, and raised two courses above ground level (pl. 8). The officer`s quarters were typically divided into two or more rooms, usually with latrine, hearth and sometimes running water.

The form of the building would be that of a rectangular block with an equal pitched roof. Where there was a verandah the eaves to that and the rear of the building would line up (fig. 44) so as to allow adequate headroom to the outer side of the verandah. The pitch of the roof would depend on the cladding materials used. In the case of the double barracks at Benwell and Halton Chesters, the greater overall span of the building would have given rise to a very high roof of *c*. 11.000 m if two equal pitches were utilized; this assumes the use of organic materials. It is possible, due to this very great height, that these barracks were roofed in two pitches (fig. 45). Little is known about the window openings. The wall of a late second century barrack block at South Shields was seen to be *c*. 600 mm wide with a sill 1.300 - 1.400 m above street level (Hodgson, N. 1994, 49-50).

In almost all barracks little remains of the internal divisions to a *contubernium*. It is probable that these walls were of timber and wattle and daub, or less likely built of narrow stonework on minimal foundations. This form of construction would not allow the division walls to extend up to the underside of the roof due to the heights involved without lateral support.

Notes

1 A portico was seen to the front of the *principia* at Ribchester *c.* 2.700 m wide and consisting of eight columns with a channel running to the outside of them (Hopkinson & Atkinson 1928, 15-20).

2 It would not be unreasonable to consider that a platform for sleeping was constructed in the inner room.

3.2 Dimensional Analysis

3.2.1 The Forts

As an introduction to this section it is proposed to consider the comparative sizes of the forts (appendix 3, table 1). The tabulated dimensions of many of the forts take into account recent research which amends many of the sizes stated in the standard works on Wall studies (Daniels 1978; Birley, E. 1961; Breeze and Dobson 1991).

The similarity between the overall dimensions of some forts has been observed by Breeze and Dobson (1991, 69-70), and tentative groupings suggested, e.g. Benwell, Chesters, Birdoswald, and Stanwix which share almost the same common length. One factor which is never fully addressed in considering the sizes of the forts is that the opposing sides of a fort are of unequal dimensions, to a greater or lesser extent, due to inaccuracies in setting out. The dimensions stated, in this work, are usually the greater, or those taken at a point across the width or length during fieldwork.

There is probably only limited value in comparing the fort sizes, but it is evident that there are a greater number of similar widths across the main axes of the forts than along their lengths. The forts of Wallsend, Benwell, Birdoswald, Castlesteads, Birrens and Old Church, Brampton share a width of around 120.000 m, with several more close to this range. Wallsend, Halton Chesters, Carrawburgh and Birrens share a length of around 140.000 m, whilst Chesters, Birdoswald and Burgh-by-Sands are close to 177.000 m.

On a direct comparison, the forts of Castlesteads (121.920 by 120.100 m) and Old Church, Brampton (124.970 by 120.700 m), are of very similar size. It is a possibility that Castlesteads replaced the Stanegate fort of Old Church, Brampton, which was abandoned *c.* 125, and that the new fort was built to house a similar military unit. Castlesteads, Old Church, Brampton along with Maryport (164.900 by 160.000 m) are the only forts where the sides are of almost equal length. The late forts at Carvoran (134.110 by 109.730 m) and Moresby (134.110 by 109.120 m) are of almost identical size. Their width is closely matched by the forts of Carrawburgh (111.700 m), Housesteads (111.860 m) and Great Chesters (108.200 m). It will be shown later in this work that the probability was that Great Chesters was built very shortly after Housesteads.

3.2.2 The *Principia*

The *principia* sited on the main axis of the fort, with its main entrance placed at the junction of the *via praetoria* and *via principalis*, was probably the point from which the fort was set out (Polybius, 73, 12). The depth of the *latera praetorii*, in forts designed to sit astride the Wall, is dictated by the distance apart of the *via principalis* and the *via quintana*. This distance is reflected in the size of the buildings, which in some instances occupied the whole depth of the *latera praetorii.* From table 2 setting out the comparative sizes of each *principia*, it can be seen that no two buildings come close to being of equal size. The length of the *principia* at Wallsend, Chesters and Birdoswald fall within the range 32.200-39.190 m, whilst the lengths of Benwell, Rudchester and Halton Chesters at 39.000-45.110 m are considerably greater than that for the other known buildings *per lineam valli*. This distance for known buildings not astride the Wall, Carrawburgh, Housesteads and Great Chesters, falls into the range

24.800-28.000 m (Birdoswald being designed to be astride the Wall). The width of the *principia* in a large number of the forts is close to 24.000 m, namely Wallsend (23.850-24.000 m), Benwell (24.080 m), Housesteads (23.250-23.500 m), Great Chesters (23.930 m), South Shields (23.800-24.000 m), Chesterholm stone fort 1 (23.380-24.450 m) and Old Church, Brampton (24.380 m). The *principia* at the Antonine fort of Bar Hill (23.480 by 25.320 m), is very similar in size to that of Great Chesters (23.930 by 24.860 m) and close to that of Chesterholm stone fort 1 (23.450 by 26.520 m). The Antonine fort had only one room to each side of the *aedes* in the rear range.

From the limited number of courtyard sizes known (table 4), those at Wallsend (14.170 - 4.360 by 13.040-13.160 m) and Chesters (15.620-15.650 by 15.560-15.610 m) are almost square, whilst those to Benwell (12.190 by 24.380 m) and Housesteads (16.180 - 16.220 by 8.730-8.910 m) are close to the proportion 2:1. The length of the courtyard at Benwell is twice the width, with the width at Housesteads being twice the length. Similar proportions of the courtyard, to those seen at Housesteads, can be found in the Welsh stone forts of Caerhun (*c.* 15.240 by 8.230 m), and Gellygaer (14.320 by 7.310 m). At Chesters the width of the ambulatory is less adjacent to the entrance into the *principia,* than to the other sides of the courtyard.

Comparative spans of the cross-hall over the external walls are shown in table 3, along with the aisle widths and the depths of the rear range. Several of the spans to the cross-halls are around 7.000 m, including those to the *principia* at Benwell (6.680 m, internal span 4.870 m), Rudchester (7.000 m), Carrawburgh (7.050 m), Housesteads (6.970-7.000 m) and Great Chesters (7.010 m).

The width of the aisles (aisle and external wall) varies between 2.300 m and 3.200 m. Where there are no aisles, at Wallsend and most probably Birdoswald, this coincides with a much greater span to the cross-halls of 9.070-9.280 m at Wallsend and *c.* 9.000 m at Birdoswald. This greater span would have resulted in little difference in the net total floor area, when compared with a smaller span of *c.* 7.000 m together with an aisle of average width.

There is considerable variance in the depth of the rear range from 4.990-9.430 m. This latter dimension from Chesterholm stone fort 1 is well above the average depth. There is no obvious pattern to the size of the *aedes* (table 4) where the military regalia and the imperial shrine were likely to have been housed. The *aedes* is normally deeper than it is wide, with the exception of Great Chesters and Birdoswald. The *aedes* to stone fort 2 at Chesterholm and that to periods 7 and 8 at South Shields, projects beyond the wall line of the rear range. This projection could have been expressed in the form of the building, possibly by an alteration in the roof line.

The size of tribunals shows little consistency, that at Wallsend being 3.500 m wide by 3.000 deep with a flight of steps 900 mm wide, Chesters being 4.150 m wide by 3.740 m deep and 640 mm high, Housesteads 1.950 m wide (later extended) by 2.470 m deep and *c.* 1.200 m high and Chesterholm stone fort 2 3.320 m wide (later extended) by 2.840 m deep and 970 mm high. The size of the South Shields tribunals were, period 4, *c.* 2.450 m wide by *c.* 2.500 m deep, period 5, *c.* 2.400 m wide by *c.* 2.700 m deep and periods 7 & 8, *c.* 6.000 m wide by *c.* 2.700 m deep.

The concluding part of this chapter will examine the degree of accuracy to which the *principia* at Wallsend, Chesters and Housesteads were built. This study is based on dimensions taken over extant walls, and will examine whether the standard of setting out was in any way related to the status of the garrison

Wallsend

The building has been set out to a reasonable degree of accuracy; the north and south elevations differing by 150 mm, and those to the east and west elevations by 190 mm. The span of the roof over the cross-hall varies between 9.070 m and 9.280 m; this variation is somewhat greater than one would have expected to find, and its implication is discussed elsewhere (chapter 3.4.1.2). However, the north and south walls are of almost identical in thickness, being 960 mm and 970 mm.

The depth of the rear range is consistent varying between 4.950 m and 4.990 m. The variation in the overall width of the ambulatories is between 4.860 m and 5.085 m, whilst the difference in the width of the courtyard between the north and south elevations is 190 mm, and between the east and west elevations 120 mm.

It is probable that the five rooms to the rear range were set out from external measurements taken from the outside face of the side walls. The corresponding dimensions of the faces of the internal walls, from the external face of the east elevation, are 4.460 m and 8.760 m, and to the west elevation 4.540 m and 8.660 m. These measurements show that the centre line of the *aedes* is positioned 75 mm from a central axis. It is probable that the two original flanking walls to the *aedes* were removed when the strong room was inserted during period 2 (late second or early third century), and subsequently rebuilt in a different position. The discrepancy is far greater, if one calculates that the rear range was set out around a central axis, being a maximum of 230 mm.

The columns to the east and west elevations of the ambulatory have not been set out to equal spacings. The width of the two bays adjacent to the cross-hall are 2.130 m and 2.170 m, which is less than half the width of the remaining two bays to each side of 4.470-4.890 m. It is probable that an intermediate column base has been removed at one time between the existing wider bays. Assuming an average column base width of 700 mm, the distance between the column bases to the east side would have been between 1.885-2.130 m, and to the west 1.875-2.170 m. The excavation records show three column bases to each side of the opening to the north ambulatory, with the centres of the bases to the central opening 4.700 m apart. The centre of the colonnade to the east ambulatory measures 3.650 m from the inside of the external wall, and that to the west 3.460 m; the centres of the columns to the north ambulatory would be 2.525 m to the east of the opening and 2.620 m to the west. The resulting net width of the central opening in the north ambulatory would have been considerable at *c.* 4.000 m (fig. 38).

Chesters

The building has been set out to a good degree of accuracy, the lengths of the north and south elevations differing by 160 mm, and the east and west elevations by 200 mm. The internal span over the roof of the cross-hall is constant over its length at 8.340 m. The north wall is of varying thickness, and was probably subject to reducing courses in its upper levels to bring it to a constant width of 640 mm as at its eastern end. This compares with a width of 620 mm to the south arcade wall. The sizes of the piers to the cross-hall arcade measuring from east to west are 1.100, 1.080, 1.170 and 1.170 m. The sizes of the arcade openings similarly measured are 3.980, 4.000, 4.030, 4.030 and 4.090 m. The depth of the rear range shows only 20 mm in variation.

The variation in the width of the east and west ambulatories is between 5.870-5.920 m, whilst the difference in the width of the courtyard between the north and south elevations is 30 mm, and the east and west elevations 50 mm. The length of the bases to the ambulatory arcade to the east side of the courtyard is between 570-600 mm and on the west 580-630 mm. The spaces between each base are between 2.310- 2.400 m to the east, and 2.280-2.410 m to the west side. The width of the piers is between 540-580 mm.

The *aedes* would appear to have been set out on the central axis of the building, over its external walls, as it is positioned 15 mm outside this axis. None of the rooms to either side of the *aedes* relate dimensionally to each other. The likelihood is that the building was set out on a central axis as the central bay to the arcade can be seen to be 70 mm from the axis, and the main entrance 330 mm. This latter apparently large discrepancy could have been brought about by an error in the setting out of the northern ambulatory openings, the reveal to the westernmost opening being 1.440 m ant the easternmost 940 mm. This unequal width of the reveals is reflected in the elevation to the aisle to the cross-hall.

A limited level survey was undertaken of the site, with particular attention being paid to the top of the splayed plinth course visible to the openings adjacent to the *aedes*, the arcade in the cross-hall and the bases to the ambulatory piers. The plinths are not visible to the western ambulatory, and those to the eastern ambulatory abutting the courtyard lie below the paving. The building, when constructed, was cut into high ground at its western side, and it is probable that the eastern side was filled using the "cut and fill" principle. This is evident in the recorded levels, as those to the east show some settlement, when compared to the ones to the centre and west of the building. The levels on the central axis of the building, taken on top of the splayed plinth course represent minimum divergence. The levels to the *aedes* and arcade show a 50 mm difference and this group, when compared to the main entrance, a 90 mm difference. The levels taken on the cross-hall arcade plinth course over its length, show a variation of 85 mm falling from west to east. It is evident that even allowing for building settlement over a considerable period, the building was set out to a high degree of accuracy and dimensional tolerance.

Housesteads

The *principia* has been set out to a somewhat less accurate standard than the previous two examples, the north and south elevations differing by 300 mm and the east and west elevations by 250 mm. The span to the roof over the cross-hall varies by just 30 mm over its length. The depth of the rear range is consistent to within 10 mm. The width of the rear wall to the cross-hall is 710 mm and the arcade piers 650 mm. The degree of the irregular spacing of the columns to the arcade to the cross-hall is significant, the centres of the bays measuring north to south being 2.460 m, 2.415 m, 2.855, the opening into the cross-hall 3.610 m, then 2.595 m, 2.720 m and 2.765 m. This compares with the colonnades to the ambulatories to the courtyard, which were set out to an equally inaccurate standard. The north colonnade spacing being 2.610 m, 2.790 m, 2.460 m, and that to the south 3.050 m, 2.680 m, 2.530 m, measured west to east. This level of inaccuracy is not matched elsewhere in the building, and gives rise to the probability that the building was started by one gang of workmen whose standards were considerably higher than the gang who completed the building.

The variation in the width of the north and south ambulatories is *c*.. 250 mm, whilst the east and the south differ by only c. 150 mm. The difference between the east and west elevations of the courtyard is 80 mm, and that to the north and south 180 mm.

It is possible that the building was set out on a central axis, the *aedes* is positioned 330 mm outside this axis, the central bay of the cross-hall arcade 400 mm and the entrance to the cross-hall 345 mm. The amount of the variation could be due to the comparatively large difference in the dimensions of the opposing elevations.

There is a strong probability that the three *principia* discussed above were set out around a central axis. This becomes all the more plausible when it is considered that this central axis is also the main axis through the fort, being on the line of the *via praetoria* and the *via decumana*. Walthew (1995, 2), in a recent paper on Roman basilicas, points out that the dimensions of Roman masonry buildings were calculated in relation to their centre lines. The setting out of a building that is symmetrical around a central axis, is much simpler using the axis as a base line than working from an offset base line. This broad conclusion was also reached by Wilson-Jones (1989) in his study of design in Roman architecture.

The dimensional divergence from the centre line of the fort at Chesters is minimal and would seem to reflect the quality of the work; this is also reflected in the level survey. At Wallsend and to a greater degree at Housesteads the amount of divergence would seem to reflect a lesser degree of care. The setting out of the arcades at Housesteads represents careless building practice. The unavoidable conclusion is that the accuracy of the *principia* at Chesters, built for an *ala*, and to a lesser extent that at Wallsend, built for a *cohors quingenaria equitata*, would seem to reflect the status of the garrison. The *principia* at Housesteads, built for the lowest grade of troops a *cohors milliaria peditata,* would seem to have had to accept a building set out to a much lower standard..

3.2.3 The Forehalls

The forehalls at Wallsend and Halton Chesters are of similar dimensions, 46.100 by 9.000 m and est. 48.770 m by an estimated 9.140 m respectively. The overall span of the two forehalls is similar to that of the largest known span of a cross-hall, at Chesters, of 9.600 m. This distance is likely to have been the largest practical span that could be accommodated, taking into account the timbers available for fabricating the roof trusses. The implication is therefore that the forehall was designed to have the maximum width without the provision of internal support.

The spacing of the piers to the arcade at Wallsend is consistent, with an average distance between them of 2.300 m, with the piers themselves averaging 1.500 m square. The intercolumniation is very similar to that between the arcade piers to the *basilica* at Birdoswald of 2.360 m. The spacing of the piers to the arcade at Halton Chesters is irregular, with several openings in excess of 3.000 m wide.

3.2.4 The *Basilica* Building at Birdoswald

The likely length of the building is probably just under 40.000 m (Biggins and Taylor forthcoming), and is slightly less than the dimension put forward by Wilmott of 42.780 m (Wilmott 1997, 81). This length is much greater than any cross-hall *per lineam valli,* the longest of which is at Chesters being 27.540 m. Both these lengths are much shorter than either of the forehalls at Wallsend and Halton Chesters.

The width of the nave of 8.880 m and the aisles at 3.530 m fall within the range of dimensions recorded for each of the *principia.* The distance between the aisle piers of 2.360 m is considerably less than that of Chesters of 3.980-4.090 m, but greater than that of Housesteads at 1.670-2.260 m. The dimension of any intercolumniation reflects the height of the arch above its impost, and the dimension therefore is reflected in the proportion of the nave and aisles. If the average dimension of gate portals is followed whereby the height of the impost was approximately 2.000 m above ground level, then the height of the crown of the arches (assuming a semi-circular arch) to the nave arcade would be *c.* 3.180 m (fig. 39, 40). If the same principle was followed at Chesters and Housesteads, the relative heights would be *c.* 4.000 m and *c.* 2.830-3.120 m. The alternative could be that the height of the impost to the arcades was raised to *c.* 3.000 m, which would give a similar height of the crown of the arch at Birdoswald to that at Chesters. The implication, however, is that the aisles to the *basilica* at Birdoswald were lower than that at Chesters.

3.2.5 The Granaries

The granaries in most cases *per lineam valli* are situated in the *latera praetorii* alongside the *principia* (an exception is the Hadrianic granaries at Birdoswald whose position is not known, and at Stanwix and Drumburgh where their relative siting is unknown). The lengths of the buildings would therefore be expected to be close to that of the *principia* (table 5). The granaries at Benwell (42.670 by 18.290 m), Rudchester (40.030 by 9.750 m) and Halton Chesters (39.00 by 10.400 m) bear a close dimensional similarity when adjustment is made for the double granary at Benwell.

The widths of the double granaries at Housesteads (14.730-14.790 m) and South Shields (14.700-15.700 m) bear a close relationship. It is probable, on dimensional comparison, that the building at Carrawburgh (13.800 m) is also a double granary on account of its width; an overall span of 13.800 m being too great for a single truss without intermediate support. The widths of the Trajanic granary at Old Church, Brampton (7.926 m) and the two early third century buildings at Birdoswald (7.980-8.250 m) are very similar.

The double granary at Wallsend bears little relation to other double granaries in width, being rather narrow, although it is of a similar length to that at Housesteads. The dimensions of the Severan granaries of South Shields show considerable consistency; the known widths of eight known type 1 buildings in the *retentura* being 6.490-6.970 m, and the lengths of two being 29.000-30.400 m. The dimensions of the later type 2 buildings are very similar, the known widths of three being 6.340-6.920 m and the length of one 29.910-30.500 m. The internal widths of the type 1 and 2 granaries are again consistent, falling within the range 4.190-4.890 m in six examples. This width is closely matched in each of the two halves of the double granary at Wallsend (4.500-4.570 m); the overall width of which would closely match those at South Shields if it was a single granary as opposed to a double.

In all known granaries *per lineam valli* the gable walls are extended to form buttresses to the long sides. This configuration also applies at Old Church, Brampton, but not to the mid-Antonine and Severan type 2 granaries at South Shields; it does, however, apply to the Severan type 1 granaries at that fort. At Wallsend the long side walls are also produced to form the end buttresses to the gable wall.

Although some pattern can be seen to the spacing of the buttresses, little consistency can be seen in their width and projection (table 6). The spacing of the buttresses at Benwell, Rudchester and Halton Chesters is close, falling within the range 3.600-3.810 m. The projection of the buttresses is also close falling within 450-610 mm, although the width varies between 550 mm-1.220 m. These dimensions are similar to the granary at Stanwix, whose buttresses are set at centres of 3.600-3.960 m, with a projection of 760 mm and a variable width of 1.060-1.220 m. Close dimensional similarities can be seen between the granary at Carrawburgh and the north granary at Birdoswald. The spacing of the buttresses fall within the range 3.220 -3.420 m, the projection 1.100-1.300 m and the width 1.000-1.230 m.

The spacing and size of the buttresses to the north wall at Housesteads bear little association with each other, with the spacing ranging from 2.760-3.660 m, and the width 560 mm-1.290 m. It is considered that this dimensional irregularity indicates that many of these buttresses could have been added at a late constructional stage, or on completion of the primary building. This is borne out by non-matching courses of some of the buttresses to the north wall, and also the lack of regular bonding courses (pl. 9).

The degree of accuracy in the setting out of the buildings, which can be wholly recorded, is high. At Wallsend both long elevations are equal, with a difference of only 100 mm in the length of the gable walls, and the thickness of the external walls varying between 800-820 mm. Less close dimensions can be seen at Housesteads where the lengths of the external walls differ by 360 mm, the widths by 60 mm and the thickness of the external walls by 780-840 mm. The Severan examples at Birdoswald and South Shields show a slightly less accurate degree of setting out, the lengths of the two granaries at Birdoswald differing by 140 mm and 620 mm, and the widths by 120 mm and 270 mm. At the mid-Antonine granary at South Shields, the difference in opposing wall lengths is 280 mm and 1.000 m., whilst the wall thicknesses are 830-900 mm. The wall thickness of the Severan granaries is generally around 1.000 m and is sometimes in excess of 1.200 m; a wall thickness which matches that of the walls to the third century granaries at Birdoswald of 1.130 m.

3.2.6 The Gates

The comparison of the overall lengths of the gates is dictated by the increase in size of the guardchambers to some forts on certain axes (table 10). The lengths of the south guardchambers to the east and west gates at Birdoswald are significantly greater than those to the north, by a maximum of 870 mm. Both guardchambers to the east and west gates at Chesters are slightly larger than those to the north and south gates by a maximum of 910 mm to the south gate, and 380 mm to the north gate. The probable reason for this, at both forts, is due to the line of the Wall abutting the southern guardchambers[1]. There is a similar possible set of circumstances at Great Chesters in that whilst the lengths of the guardchambers to the south gate and the southern guardchamber to the west gate fall within the close margin of 5.420-5.490 m, the north guardchamber to the west gate measures only 5.040-5.060 m. It could be possible that the line of the Wall, as at Birdoswald when the fort was laid out, was intended to abut the south guardchambers to the east and west gates. This is further supported by the rounded north-west corner of the fort being positioned behind the line of the Wall.

However, taking into account the anomalies of the lengths of the guardchambers, the lengths of the gates at the forts of Wallsend, Chesters, Great Chesters, Birdoswald and South Shields fall within the range 17.500-19.540 m, with Wallsend and South Shields being at the lower end of the scale (table 8). The width of all the guardchambers *per lineam valli* is also that of the curtain wall and earth rampart; as would be expected these widths fall within a close range, 5.480-6.250 m. The exception is Halton Chesters where the width of the guardchamber is significantly wider and falls within the range 6.710-6.930 m. There is little variation in the thickness of the curtain wall *per lineam valli*, with dimensions usually falling within the close range 1.500-1.590 m. The width of the curtain wall at Great Chesters, as recorded at the west gate, measures 1.800 m, which is equal to the usual width of the narrow Wall which forms the fort`s northern boundary, and was shown to be of the same build (Hull 1926, 198).

The width of the gate portals would have been a critical dimension when setting out the gates, and one for which greater accuracy would have been expected. The need for the spans to be of equal width is particularly important, as the height of the portals would have varied, if a semi-circular arch was formed over portals of differing spans. The portal widths at all the main fort gates fall within close limits as can be seen in table 9, and two general groupings can be identified. The widths at the forts of Wallsend and South Shields, falling within the range 2.320-2.700 m, are noticeably narrower than those at Rudchester, Halton Chesters, Chesters, Great Chesters and Birdoswald which fall between 3.050-3.390 m. Particular mention must be made of the widths at Chesters where the dimensions are particularly close, with eight portals ranging between 3.080-3.310 m, six portals of which differ by only 60 mm. A similarly high degree of accuracy is achieved at Birdoswald, where the widths for the three known main gates and two lesser gates fall within 3.320-3.440 m; the six portals to the three main gates differ in width by only 90 mm. By contrast the portal widths at Housesteads fall between the two groups, being between 2.540-3.020 m, and show a much wider degree of error with a maximum variance at the north gate of 430 mm. However, all but two dimensions fall within the range 2.810-2.970 m. These dimensions can be compared favourably with those of the south gate, with double portals and guardchambers, at the fort of Brecon Gaer, where the widths of the portals are 2.770-2.830 m.

It is clear, given the importance of the portal widths that the dimensions of the passage or passages, between the two guardchambers, were critical dimensions in setting out the gates (table 9). It is probable that this setting out took the form of laying out three rectangles on the ground, for the gate passages flanked by the two guardchambers. The passage area of the forts at Chesters and Great Chesters is similar, with the widths falling within 8.210-8.350 m and 8.210-8.230 m and the depths 3.980-4.140 m and 3.960-4.000 m respectively. A further close example can be seen at Birdoswald where the widths fall between 8.260-8.370 m and the depths 4.410-4.610 m. The passage width at Wallsend falls within the same range, although the dimension is narrower due to reduced portal widths. The dimensions to the passage area to the two mid-Antonine twin portal gates at South Shields and the outpost fort at Bewcastle show a similarity to Chesters and Great Chesters, but with a wider range of disparity which may be due to the quality of the data obtained. The depth of the passage area to the fort at Halton Chesters is somewhat deeper, falling within the range 4.870-5.000 m. Once again, Housesteads does not fall within the groupings already stated; the passage widths are close, falling within the range 7.050 -7.190 m, and the depths 5.280-5.460 m. This width bears similarity to the south gate at Brecon Gaer where the dimension is 7.420 m.

The length of the guardchambers has been touched upon at the beginning of this chapter. Excluding the enlargements of the guardchambers for forts designed to be astride the Wall at Birdoswald and Chesters, and an apparent anomaly at Great Chesters, the lengths *per lineam valli* fall within the range 4.170-5.800 m (table 10). There is some considerable divergence in the lengths of the guardchambers, even at the same fort on the same axis, the length of those to the north gate at Chesters falling between 5.360-5.490 m, whilst those to the south gate fall between 4.890-5.050 m. This variance can also be seen at the north gate at Housesteads where the length of the east guardchamber falls within the range of 4.170-4.270 m and the west 4.450-4.590 m. The lengths of these latter guardchambers are significantly less than at other forts *per lineam valli.* The same set of circumstances can be seen at the mid-Antonine fort of South Shields, where there is a 1.000 m difference in the length of the north-west and south-west gates.

The projection forward of the face of the guardchambers from the face of the gates shows considerable consistency *per lineam valli* varying between 1.460-1.800 m (table

10). The two main exceptions to this are the forts at Housesteads where the projection is between 510-660 m, and Birdoswald where it is 1.040-1.115 m.

3.2.7 The Barracks

As the lengths of the barrack blocks are dependant on the number of *contubernia* in a block, it is only possible to directly compare the lengths of the blocks by fort where the blocks have an equal number of *contubernia* (table 11). The twelve blocks from Wallsend, although not all contemporary, form a close grouping between 44.900-48.000 m in length, with six blocks falling between 45.800-46.150 m. The comparable length of the only other block of 9 *contubernia* with known dimensions at Benwell (a double block), relates very closely with this set of dimensions at 45.720-46.010 m.

The length of the blocks with 8 *contubernia* at Birdoswald and Halton Chesters (a double block), must be treated with caution as some of the data from both forts was obtained by geophysical survey and is of low precision[2]. The lengths do appear to be considerably greater if one takes the mid two dimensions of both forts at 45.000-49.000 m, when compared to the lengths of the comparable 8 *contubernia* block forts of *c*. 46.000 m. The lengths of the blocks at Housesteads, with 10 *contubernia*, at 49.150-50.050 m, are the greatest recorded.

The overall widths of the barracks fall within two main groups. Those without a verandah at Wallsend, Bowness-on-Solway, South Shields (B1), and Old Church, Brampton come within the range 7.600-8.900 m. The widths overall the verandah at Wallsend[3], Chesters, Carrawburgh, Housesteads, Birdoswald, Maryport and South Shields (B3, B6), with the possible exception of South Shields, fall within the greater range of 9.500-12.000 m. The double barracks at Benwell and Halton Chesters, if adjusted, would also relate to this grouping.

The length of the officers' quarters, at all the forts, falls within the range 9.450-12.650 m, with the greater lengths being seen at Wallsend. The width in all cases matches the overall width of the barracks. The length of the *contubernia*, as has already been stated, depends on the number of individual *contubernia*. However, the widths (table 12) excluding the verandahs, can be divided into two main groupings with Wallsend, Housesteads, Bowness-on-Solway, Maryport, South Shields (B1) and Old Church, Brampton coming within the range 7.600-8.660 m. The widths at Chesters, Birdoswald, South Shields (B3, B6), and with adjustments for the double barracks at Benwell and Halton Chesters, range between 9.500-10.550 m. It is significant that this greater width occurs at forts where it is known that cavalry were housed, and could reflect on the larger size of *contubernia* than those allocated for the infantry. The differing widths of the *contubernia* at South Shields could reflect the presence of both infantry and cavalry at the fort during its period of mid-Antonine occupation. It is significant that recent fieldwork at Birdoswald (pers. com. T. Wilmott) has shown *contubernia* in the north of the *praetentura* 9.200 m in width, adding further evidence to confirm the presence of cavalry at this fort.

The internal width of the *contubernia* (table 13) to all the forts falls within a narrow range of 3.300- 3.770 m. There would appear to be no significant increased width given to those *contubernia* where cavalry was known to have been accommodated.

Whilst the barracks generally were set out to a reasonable degree of accuracy, comment must be made of the northern block at Chesters. The variation in width over the length of four *contubernia* is 390 mm, if this degree of error is projected over the remaining unexcavated length of the block the difference in width would be *c.* 1.000 m.

3.2.8 Metrology and Design

There has been a considerable amount written in recent years on standard units of measurement in Roman military construction. Walthew (1981, 15-35) suggests that both the *pes Monetalis* and the *pes Drusianus* were used by the military architects. Evans (1994, 143-164) demonstrates that analysis based on proportion tends to give better results rather than that based on units of measurement. Marvell and Owen-John (1997, 181-2) argue that the *praetorium* at Leucarum was designed using the *pes Drusianus*, and that the rooms were laid out in multiples or the major fractions of that unit. Davison however, in his study of barracks, comes to no definite conclusions (1989, 213).

It is evident, from the dimensions quoted by Hyginus, for the laying out of camps, that the dimensions were multiples of the *passus* (5 *pedes*). The Roman preference for decimal and duo-decimal numerical sequences is well documented and outside the scope of this chapter. This is discussed elsewhere at length by Wilson-Jones (1989) and Knell (1984).

The usual value taken for a *pes Monetalis* is 296 mm and for a *pes Drusianus* 332 mm (Millett 1982, 316). The *pes Drusianus*, according to Hyginus, was used in Germany among the Tungri (Hultsch 1882, 693 n.7). According to Hultsch this unit was one eighth greater than the *pes Monetalis*. The difficulty in assuming an accurate value for each unit is that the value of the *pes Monetalis* varied. Crummy (1993, 111-119) considers that the value of the *pes Drusianus* should be taken as between 326.5 and 338.9 mm, or 332.67 ± 1.86 per cent. He also puts forward the suggestion that if the *pes Drusianus* can be demonstrated to have been used in Britain, then it is more likely to reflect the use of a native system of measurement than an imported one. In determining dimensional values below, the *pes Monetalis* will be taken as 296 mm and the *pes Drusianus* at 332 mm. In taking the module to represent a specific value, a margin of error needs to be established. Millett proposes that a value which could express errors in layout and measurement is 75 mm, and when expressed as an error relating to the module is approximately 13% for the *pes Monetalis* and 11% for the *pes Drusianus* (Millett 1982, 316). He suggests that any unit coming within this range could be taken as a whole number, and this proposal is accepted by the author.

Certain dimensions to buildings in the fort were critical for the correct functioning of the fort; such dimensions would be the clear widths of the gate portals. The portal widths of the north and east gates at Halton Chesters (3.250-3.290 m), the main gates and lesser east gate at Chesters (3.080-3.390 m), the west gate of Great Chesters (3.080-3.240 m) and south, east, west and lesser east and west gates at Birdoswald (3.320-3.440 m), give rise to the obvious conclusion that the gate portal width was designed to be 2 *passus* (10 *pes Drusianus* of 3.320 m). It is also likely that the narrower portals to the north and south gates to the later fort at Wallsend of 2.400-2.600 m were built to a lesser width, perhaps in the light of past experience, at one and a half *passus* of 2.490 m. The area containing the gate passages between the guardchambers to the main gates at Chesters can be shown to be 25 *passus* by 12.5 *passus* (8.300 by 4.150 m); the site dimensions being 8.210-8.350 m by 3.980-4.140 m. Similar examples can be seen at Great Chesters, Birdoswald and South Shields. The overall width of the gate passage at Wallsend is reduced by just half a *passus* (7.470 m) to 7.100-7.400 m; this can be seen to be the result of scaling down the width of the *spina,* and possibly responds due to the reduced portal width.

The portal widths at Housesteads, 2.540-3.020 m, fall between those at Wallsend and Chesters. If the assumption is that the width was intended to be 10 *pes Monetalis* at 2.960 m, then this dimension is close to the mid dimension of the range. However, it could have been the intention that the 2 *passus (pM)* portal width was to be slightly reduced to 1.75 *passus* of 2.590 m, which is close to the lower value of the range. The proportion of the gate passage is dissimilar to the other forts being in proportion almost 4:3, compared to 2:1 in the examples discussed above. It is a possibility that the area of the passage was intended to be 18 by 24 *pes Monetalis* (5.350 by 7.100 m) which is close to the actual dimension of 5.280-5.530 m by 7.030-7.190 m.

It is a consideration that the *pes Monetalis* was used at the Trajanic Stanegate fort of Throp (Simpson, F. 1913), where the width of the south east gate is 9 ft 5 inches (2.870 m) and the north east gate 9 ft 9 inches (2.970 m). It may have been that the target width was 2 *passus* 10 *pM* of 2.960 m.

The set back of the face of the portal from the curtain wall at several forts can be seen to have been intended to be 1 *passus* (1.660 m). The set-back at Chesters ranges from 1.520-1.780 m with four dimensions being 1.650-1.690 m, at Great Chesters, 1.460-

1.680 m, with two out of three dimensions being 1.680 m, at the north west and south west gates at South Shields, 1.700, and the north and west gates at Chesterholm 1.550-1.700 m. The set back at Housesteads is much less at 510-660 m and could represent 2 *pes Monetalis* of 592 mm.

Another small dimension that can be linked with the *passus* is the internal width of the *contubernia* in the barrack blocks which, in a great many instances, can be related to 2 *passus* (10 *pD*) of 3.320 m. Many *contubernia* come very close to this width as can be seen at Wallsend, Benwell, Chesters and Housesteads (table 13). It can be no coincidence that this width of 10 feet matches the dimension allocated to a tent by Polybius, 67, 1) in the description of laying out the tentage of a legionary cohort. This dimension can also be seen to have been used in the barracks at Caerleon (Evans and Metcalf 1992, 79-80). Over the five phases of construction (third quarter first century to early third century), it was even found that the barrack block width had remained constant between 3.200-3.400 m, which as the excavators remarked showed essential military conservatism. This could demonstrate the use of the *pes Drusianus* by the *Legio II Augusta*. However, the excavators suggest that as the internal faces of the internal walls across a *contubernia* measure 3.900 m, this could relate to 13 *pes Monetalis*.

At the other end of the scale it is probable that an *actus* of 120 feet (39.400 m *pD*), or a proportion of that unit, was used. The length of the *principia* at Chesters at 38.990-39.190 m comes very close to this, as does the estimated length of the same building at Halton Chesters. The granaries at Rudchester and Halton Chesters were also probably based on the *actus*, being 40.080 m and 39.000 m in length. The likelihood is that the depth of the *latera praetorii* of these last three mentioned forts was based on an *actus*. The dimension 2/3rd *actus* of 80 feet (26.560 m *pD*) could be identified with the length of the *principia* at, Housesteads, (27.280-27.580 m), Chesterholm stone fort 1 (26.520 m) and Old Church, Brampton (27.130 m). The width of the *principia* at Chesters (27.380-27.540 m) and Carrawburgh (26.200 m) might also relate to this dimension, and it could be that the target size of the former was 120 by 80 *pes Drusianus*.

The length of the 9 *contubernia* at Wallsend, 32.800-35.250 m could be identified with 100 *pes Drusianus* of 33.200 m, whilst the length of the officers` quarters at 10.900-12.650 m could relate to 35 *pes Drusianus* of 11.620 m. A similar length can also be seen in the officers` quarters at Chesters of 11.060-11.640 m. However, the dimensions at Housesteads of 39.720-40.230 m being the length of the *contubernia*, and 10.330-10.590 m the length of the officers` quarters, relate very closely to 1 *actus* (39.400 m) and 1/4 *actus* (30 *pD*, 9.960 m). The estimated length of the *contubernia* of Birdoswald (39.000 m) is also close to 1 *actus*. The suggested width of the barracks for the cavalry of *c*. 10.000 m (see chapter 3.2.7), identifies very closely to 30 *pes Drusianus* (9.960 m).

This small sample indicates that, whilst it is certainly possible to equate many dimensions to what was probably their target unit of measure, there are many areas of uncertainty. In particular, at Housesteads where it is possible to argue for the *pes Monetalis* for the gates, and the *pes Drusianus* for the *principia* and the barracks. Millett (1982, 315) points out the difficulty of distinguishing between the two units of measure. However, Millett`s example related to internal dimensions in the civilian settlement at Verulamium rather than to military examples. The key to any further research must, however, be the value of the module assumed for any unit of measure.

It has been shown by Marvell and Owen-John (1997, 181-83) that it is possible to demonstrate that the *passus* and half *passus pes Drusianus* were used in the construction of the *praetorium* at the auxiliary fort of Leucarum, West Glamorgan, almost certainly built by the *Legio II Augusta*. The consistent widths of the barracks at Caerleon tend to support the use of this unit of measure by this legion

A possible tentative conclusion could be that the *pes Drusianus* had been used in Britain for almost 50 years before the Wall was built. There is also evidence that it would appear to have been used by the *Legio II Augusta* and the *Legio VI Victrix* in the construction of the buildings *per lineam valli*. Much more evidence is required on military buildings, particularly those known to have been built by the two legions, before any firm conclusion can be reached. This is a clear priority for future research.

Notes

1 The Stone Wall at Birdoswald was originally intended to be built on the same line as the Turf wall and abut the south guardchambers to the east and west gates. The Stone Wall as built linked up with the northern curtain wall of the fort.

2 The western barrack block at Birdoswald was excavated by Tony Wilmott of the Central Excavation Service of English Heritage who kindly supplied this information prior to publication.

3 A paved verandah was seen to barrack building 1, 2.000 m wide (site archive). There is no evidence to support the likely presence of verandahs to the other barracks.

3.3 Constructional Sequence

3.3.1 Constructional Sequence of the Forts

Once the military surveyors had set out the line of the Wall, it is likely that their first task in its construction, would have been the setting up of a series of construction camps, close to the intended work. This course of action would be identical to the setting up of similar camps for the erection of forts, an association which has long been known, and examined in detail at Inchtuthil (Pitts and St. Joseph 1985, 223-229). The modern analogy, in running what would have been a very large contract, would be the construction of site compounds along its route, each of which would house a site agent, support staff and messing facilities, together with an area where plant and materials could be stored. In the context of the Roman Army such a base, taking the form of a temporary fort, would it is surmised, have probably housed a centurion responsible for a certain length of the Wall, tentage and messing facilities for the builders, and storage areas for the tools and some materials. The size of the fort is speculative but it is unlikely to have held less than around two hundred men of all grades. The suggested distance apart of the camps of some 6-8 miles is not unreasonable, when taking in to account the farthest section of the Wall to be built from the construction camp. In this model it is suggested that the camps were positioned taking due regard of the usual selection criteria for a fort.

In view of the logistical problems in running a building programme on such a large scale, it is inconceivable that construction camps would have been positioned any significant distance from the Wall like on the Stanegate. Any base in such a position would involve unnecessary travel to and from the site, together with double handling of tools and materials, and make communication more difficult. Many temporary camps, which could have been construction camps, have been seen in the central area of the Wall and to the west, although none have been seen to the east (Welfare and Swan 1995, 5, fig. 3). Apart from some small camps of less than an acre, the majority fall within the size of 1.2-3.5 acres (0.48-1.41 hectares). A great many are sited within a few hundred yards of the Wall. Sommer (1984, 55) proposes that the size of a permanent fort could be approximately twice the size a construction camp, although it could be much smaller.

When the decision was taken to construct the permanent forts on the line of the Wall, it is suggested that Roman conservatism played a major part in their siting. The construction bases would have been well positioned, and by the time the Wall was well advanced, it is certain that some significant road infrastructure would have been constructed, due to the requirement to get materials and labour to and from the camps. There is a strong likelihood, therefore, that the permanent forts were sited in the same position, or close to the construction camps.

At Burgh-by-Sands (fort 2, *c.* third century) where the second century forts to the south (Daniels 1989, 23-24), and the Wall diverge, it is suggested that the intended line of the Wall was changed to pass further to the north, once the construction camps had been built. The fort at Castlesteads is positioned on a bluff overlooking the river Cambeck, with the Wall running some 400 m to the north on the opposite side of the river. It is suggested that the original line of the Wall was to run in a straight line from Newtown (turret 57b) to Walton (milecastle 56) passing through the fort, and that a later consideration of site conditions caused the present curving line to be followed. It is surmised that when it came to build the Wall, ground conditions made it either too difficult or impossible to construct a turf wall up the slope from the Cambeck to the west of the fort, and so the easier, more level line, was taken to the north-west.

At Burgh-by-Sands it is proposed that fort 3 was the construction camp, sited on higher ground some 400 m to the south, of the line of the Wall. It could have been the original intention to construct the Wall further to the south in this sector so as to take advantage of the higher ground; the present line is poor as the ground rises to the north at the site of the Wall fort.

When the work on the stone forts began it is suggested that, in most cases, the earlier fort was slighted, and the usual raft of clay placed over the original occupation levels, prior to its construction. In the case of Burgh, where a fort was not constructed on the Wall until the third century, it is suggested that this coincides with the extension and substantial rebuilding of fort 3 when it was enlarged from 2.07 hectares (5.13 acres) to 3.35 hectares (8.4 acres), and a stone built *principia* and bath house built within the rampart (pers. com. M. McCarthy). At Castlesteads possible evidence of a turf rampart from an earlier fort has been seen (Richmond and Hodgson 1934, 160). The fort at Carrawburgh has produced evidence of a *pre-Vallum* earthwork beneath the *principia*, which the excavator considers could have been part of a temporary camp used by the builders of the Wall (Breeze 1972, 87-88).

At Birdoswald there are a number of small pieces of evidence which suggest that there was at least one turf and timber fort predating its stone successor. This evidence is discussed by Wilmott (1997, 42-4) and will only be summarised briefly here. The stone fort overlies the Turf Wall, turret 49a and the Wall ditch. It is likely, therefore, that the earlier fort was built to the south of the Wall, and could well have abutted it. A drain, predating the east curtain wall and rampart, was seen by Richmond (1931, 124). Richmond later concluded that the *Vallum* was laid out first to the south of the turf fort, and the morass seen within the later stone fort was drained and filled before the site could be occupied (Richmond 1931, 123); this morass contained rubbish from an earlier occupation phase. In 1931 the south-east area of the stone fort was examined and produced a spread of rubbish and a stone foundation which predated the fort (ibid., 141-2). Evidence of a clay rampart to the south belonging to the earlier fort was seen in 1931-2 (Simpson and Richmond 1933, 262). A polygonal enclosure to the south of the fort, comprising a pair of concentric ditches and a palisade trench, was seen by Simpson and Richmond (1934, 120). This was thought by them to be a temporary camp, possibly a construction camp, which was consistent with its early Hadrianic date. In more recent times Wilmott (1987, 47-8) found an undated post trench below the northern granary; in addition unidentified stratified deposits were also seen below the southern granary. Any interpretation of the early evidence at Birdoswald can only be speculative, but one possibility is that as the polygonal enclosure was cut by the *Vallum* it could have been an annex to the construction camp, whilst a turf fort housed the main body of men and equipment. It is proposed that this camp was slighted when the later turf and timber fort was built astride the Wall.

Evidence to support this model on the siting of construction camps is not easy to find as, if the hypothesis is correct, the slighted camp would have been overlain by the stone fort, or its *vicus*. A further difficulty in interpretation arises as it is possible that later timber and turf forts superseded earlier forts of the same construction, west of the River Irthing, where the Turf Wall was constructed. As comparatively little total excavation has been carried out within the forts there is little evidence to substantiate this model. The evidence put forward is an alternative interpretation for the siting of the permanent forts, and it is suggested that this is an area where future research might be rewarding.

Once the general areas of the fort had been laid out, it will be shown that the first element to be constructed was the curtain wall. One possible manner in which its position could have been defined, together with other areas in the fort, was by the stripping off of the turves. These were commonly positioned behind the stone curtain, as has been recorded at Halton Chesters (Jarrett 1959, 178), Housesteads (Tait 1963, 37-44), Birdoswald (Wilmott 1997, 95) and South Shields (Bidwell and Speak 1994, 117). At Halton Chesters the turves were laid over a course of whin boulders, whilst at Birdoswald the placing of turf at the base of the rampart to the north wall was seen as a means of stabilising the ground. At South Shields it was thought that they could have been used to retain the earth rampart.

At this early stage the main drainage runs were determined, and their construction commenced. Openings for main drainage outfalls have been seen in the lower courses of the primary curtain wall showing that they were part of the original concept of the fort, and have been recorded at Housesteads (Birley, Charlton and Hedley 1933, 92) and Birdoswald (Wilmott 1997, 71). The drains at Birdoswald were seen to have been constructed as channels with free-standing stone walls to each side, around which the stone base course of the road was laid (ibid., 84). The drain passing through the western portal of the north-west gate at South Shields was seen to have been laid before the construction of the western guardchamber (Dore and Gillam 1979, 13-15). As the drain runs were being formed, work commenced on the curtain wall and gates. It has been shown at South Shields (Bidwell and Speak 1994, 113, fig. 4.7 opp. 115) that the south-west gate and stone curtain were not of one build, and that the gate was commenced before the curtain wall. It is suggested that evidence of a model for the sequential building of the gates might be seen at Chesters. This evidence is based on the variance in the dimensions on each side of the gate passage, between the face of the guardchamber and that of the portals. It is proposed that the building of the gateways commenced with the north gate and continued in an anti-clockwise direction finishing with the east gate. The difference between the projection forward of the guardchamber to each side of the gate portals to the north gate is 40 mm. This is a nominal amount and could imply that the rampart wall to each side was started simultaneously. The same difference applies to the west gate, but has increased at the south gate, where the dimensional difference is 100 mm. However, the difference in the dimensions at the east gate is 260 mm, which probably reflects the joining up of two sections of curtain wall, with the gate, which were not accurately aligned.

As the construction of the curtain wall and gates proceeded, it is probable that the earth rampart was being formed at the same time. The material for the rampart, apart from being made up of turves, would also contain top soil from the site strip. It is unlikely that it contained any great quantity of material from the defensive ditches outside the fort, as there would have been enough material within the fort[1]. Difficulties would have arisen carting the excavated material inside, through or over partly constructed gates or walls. It is considered that spoil from the two defensive ditches of the 4 A/B (mid-Antonine) fort at South Shields was put on the berm between them to form a counter-scarp bank (Bidwell and Speak 1994, 133-4). Miket (1983, 20) found that the spoil had been placed to the side of the ditches away from the fort.

It is unlikely that the stone curtain wall was built with the aid of scaffolding[2]. It would seem that the turf and clay make up of the earth rampart might also have been used as a means of reaching the required height. At Housesteads (Tait 1963, 37-44), South Shields (Dore and Gillam 1979, 9) and Chesterholm (Bidwell 1985, 53), deposits of masonry chippings were seen lying on turf and clay make up layers. This illustrates that the earth rampart and curtain wall were of a single operation. It is possible that the dry stone revetment walls, seen at Birdoswald, formed within the north and east ramparts parallel to the curtain wall were built to stabilise the earth rampart, so that it could be used as a working platform (Wilmott 1997, 94). The volume of material used in the earth rampart at Chesters is *c*. 5637 cubic metres. This assumes an earth rampart 4.140 m wide by 4.500 m high with a 1.000 m walkway on the top, together with a 600 mm high kerb against the *intervallum* road. This volume of earth is the equivalent of a *c*. 243 mm deep site strip over the interior of the fort, assuming the fort was of new build. This quantity of material would easily have been obtained in the removal of top soil, and in the reduced levels for the foundations and drains.

The fort of Carvoran is significant in view of the comparatively large number of inscribed stones found relating to the length of curtain walling built by a century (appendix 1, Carvoran). Three of the six building stones, RIB 1816, 1818 and 1820 respectively, relate to the building of a rampart, and unusually use the verb *vallare* to build a rampart (RIB 1820, 565). This verb is only used in Britain on these three stones, and this together with the elaborate decoration and statement of rampart length, show that the construction work took place in the prefecture of Flavius Secundus within the period 136-8. Of the other three building stones, RIB 1813, 1814 and 1822, the two former refer to a specific length (of walling built), whilst the latter refers to a length of rampart.

RIB 1820, recording the building of 112 feet, was found some 100 yards to the east of the east rampart, and so can reasonably be expected to relate to its construction. If a length of 112 ft or 37.180 m (*pes Drusianus*) of rampart was built by a century, it is possibly worth looking at how the labour could have been divided amongst the various tasks, and how long the stretch of wall might have taken to build. Assuming that the century was nominally 80 men, it is probable that the number actually available for work would have been much less than this. The evidence from the Vindolanda tablets (*Tab. Vindol.* I, 154) shows an instance when only about half a cohort was available for normal duties; the remainder being *immunes*, or on assignment away from the unit, patrolling duties, etc. The work involved by these nominal 50 men would have been the actual building work, and possibly the haulage. Although it is shown that the quarries and kilns were under military control, it is assumed that there must have been some civilian involvement (*Tab. Vindol.* II, 155, 314, 316)

It is probably safe to assume that a building gang would be similar to that of today, made up of a group of masons and labourers. The masons would dress and bed the stonework, whilst one or two labourers would select and bring semi-dressed stones to the mason, together with the mortar. A typical mortar gang of two men would work with a mason, slaking the quick lime and mixing it with sand to produce lime mortar;

this would be a laborious and tiring task. As the curtain wall was probably around 1.500 m wide it is assumed that gangs would work on each side towards the centre, and it is probable that there were three gangs to each side to lay the 112 ft (33.184 m *pD*) making a total of six. As a good modern mason and labourer can lay *c.* 1 cubic yard (0.7646 cubic metre) of walling in three hours[3], it is not too much to think that the Roman builders would have matched, if not exceeded this rate of building. The amount of masonry in the length of walling, assuming a width of 1.500 m and a height of 4.500 m, is 251 cubic metres. Using the rate stated for laying the stonework, the length of time for building the curtain wall is about 985 hours for a man and labourer. If six gangs were used the length of time would be *c.* 164 hours. Assuming a ten hours working day for the purpose of calculation, the length of time to build the wall would be in the region of sixteen or seventeen days. Present day good practice prevents the laying of walling in excess of *c.* 1.000 m in height in one day, so as to prevent the mortar squeezing out of the bed joints[4]. If the wall was *c.* 4.500 m high (Bidwell, Miket and Ford 1988, 192) and of some 20 courses, it is unlikely that more than two or three courses would be laid at one time. It is suggested that the men not involved in the building work were involved in transporting the materials to site, stripping the turves within the fort, reducing levels, laying drains and forming the turf and clay backing to the curtain wall.

These figures can be used to suggest a possible length of time that it took to build the whole of the curtain wall to the fort, excluding the gates and turrets. The total length of curtain wall is 488 m, which includes a length of *c.* 76 m for gates, the nett length therefore is 412 m which, divided by a unit of length of 112 *pes Drusianus,* equals 11.10 units. It is therefore suggested that the time taken to build the curtain wall was in the region of 190 working days, assuming one century and six gangs of 24 men were involved. However, as it is known that three centuries were employed in its construction the figures can be revised to some 63 days. These figures are purely notional and can be revised to take into account variable factors. On the basis of these figures, and that a cohort of five nominal centuries were engaged in the work, there can be no doubt that the major part of a fort and its ditches, could have been constructed within four to six months, assuming that materials and adequate skilled labour was available. These figures can be considered realistic, for Josephus, in describing the erection of a fort (Josephus 1970, 195) states that the work was carried out faster than thought, thanks to the number and skills of the workers[5].

Wilmott (1997, 90-91) demonstrates at Birdoswald, that the west gate had been commenced, except for the *spina,* before the internal streets, ramparts and buildings had begun. The inference must be that the priority was to complete the curtain wall and gates before carrying out any building work (as opposed to setting out and laying drains) within the fort. The only possible exception to this might have been the construction of the *aedes* to house the imperial shrine and other regalia. Bidwell (1994, 58) suggests that a free-standing *aedes* would have provided fitting accommodation in the mid-Antonine fort at South Shields. The building, which was later demolished to provide the site for the permanent *principia,* included two rooms to each side of the *aedes*[6]. Bidwell also draws attention to another *aedes* which was probably built as a free-standing structure at Brecon Gaer (Wheeler 1926, 39, fig. 30). Wheeler describes the *aedes* as being `distinguished by its strikingly superior workmanship and by its structural independence of the adjacent footings`. Webster (1969, 189) states that it was noteworthy that in some timber forts the only stone structure was the shrine of the standards, which would have given fireproof protection to the sacred emblems. It is doubtful if the risk of damage by fire was the reason for stone construction, but more a reflection on the importance of the regalia to the serving troops. Further examples where a stone *aedes*, was incorporated into a timber *principia* can be cited at Newstead (Curle 1911, 43 fig. 2) and Caerhun (Kanovium Excavation Committee 1938, 46-47, fig. 3 opp. 10). At Newstead a small detached building, almost certainly an *aedes*, was recorded beneath the entrance to the *principia*. The orientation of this building faced west whilst the later *principia* faced east. Interestingly, in the courtyard to the later *principia*, a carefully constructed stone detached building measuring 3.400 square metres, was seen (Curle 1911, 47), and was thought to have been a possible shrine. At the Trajanic fort of Caerhun it was seen that the *aedes* was constructed of stone and elaborately decorated with plaster.

The sequence of building within the fort is unknown, but probably commenced with the buildings within the *latera praetorii,* together with the construction of towers and latrines to the curtain wall. At the unfinished legionary fortress of Inchtuthil it is perhaps significant in the central range, that only a small *principia* was built with no *praetorium*. The small *principia* is taken to reflect its temporary nature, being built at the commencement of the work to house the military regalia and essential offices, with a view of being replaced on a larger scale in stone when the other buildings had been completed (Pitts and St. Joseph 1985, 85-87). The absence of the *praetorium* is thought to have been delayed as this was also to have been built of stone, and would have taken longer to construct.

At Chesters it can be seen that where the south-east interval tower abuts the inside of the curtain wall, projecting headers show that the wall was built before the towers (pl. 10). It would seem that when the curtain wall was built, the position of the towers were set out and projecting headers built at alternating courses, or at regular intervals (standard modern day practice) wherever necessary. When the south-east internal tower was built its external walls did not line up with the headers and the course depths did not quite match, so showing evidence of poor building practice. A further example can be seen at the south-east angle tower where the angle of the projecting header does not quite match the angle formed by the wall of the tower and the curtain wall. The presence of straight joints at the lesser east gate at Chesters would tend to indicate that it was not built at the same time as the wall curtain (pl. 11). The same lack of bonding can be seen at Housesteads. Simpson, G. (1976, 126) comments on the lack of bonding of the east wall of the north-west angle-tower with the north wall of the fort. Here the lower three courses are bonded, the next five were not and the ninth was also bonded. All the gates and angle towers show little bonding, except for the occasional header course, which is consistent with the projecting header course being built with the wall curtain and the internal structures added later.

Wheeler (1926, 33-6) found at Brecon Gaer that the corner turrets were not bonded into the fort wall, but concluded that this was to take into account possible differential settlement caused by differing materials, on which some of the towers were founded. This is unlikely as in traditional construction this degree of sophistication was rarely if ever adopted, and is unlikely to have been recognised by the Roman builders. At Gellygaer also, Ward (1903, 44) states that the angle and interval towers were not bonded into the back wall of the rampart. By contrast Wilmott (1997, 179) found at

Birdoswald that the north-west angle tower and the interval tower to the east were bonded into the curtain wall. It might be the case that where there was no immediate threat of attack, the latter course of constructional sequence was undertaken, as the stone curtain at Birdoswald replaced the earlier turf rampart.

In an earlier chapter (chapter 1.5) the hypothesis was put forward that the internal walls of the buildings were set out once the external walls had been laid out. This would have given rise to the builders constructing the external walls of a building before any of the internal walls. Breeze (1972, 97) found in the *principia* at Carrawburgh that the foundations to the internal division walls to the five rooms of the rear range were set at a slightly different level than the external walls. At Wallsend also the internal foundation wall to the room to the east of the *aedes* was set at a higher level than the others (site archive). In the lower courses at least, therefore, these internal walls could not have been built at the same time as the external walls. A similar set of circumstances can be seen in the division walls to the rear range of the *principia* at the stone fort 2 at Chesterholm. From a visual inspection it is probable that some of the walls to the period 4B *principia* at South Shields were constructed likewise. At Housesteads it can be seen that the same construction sequence occurred in the hospital (Charlesworth 1976, 17) and the commandant's house (Charlesworth 1975, 18-9). The external walls to the Trajanic *principia* at Caerhun were seen to follow the same sequence (Kanovium Excavation Committee 1938, 44).

A further general example can be seen in the internal walls to the stone barrack blocks, although examples *per lineam valli* are limited. The internal walls are seen not to bond into the external walls at the extant barracks at Chesters, elsewhere it has occurred in the phase 1 barrack at Caerleon (Evans and Metcalf 1992, 76). The conclusion must be reached, particularly in respect of the more complicated planning arrangements in the hospital and commandant`s house, that standard plans were available whereby all the required accommodation could be fitted within the constraints of the external walls. Once the external walls had been built to a few courses in height there was no need for the remainder of the work to continue in the short term. It could be that this methodology was followed in setting out the position of the principal buildings of the fort, rather than relying on a less permanent method such as timber pegs. One major advantage would be that the roads around such buildings would be able to be completed and not subsequently disturbed for the excavation of foundations; this could have been of particular benefit especially in the *latera praetorii.*

It has already been suggested in an earlier chapter (chapter 2.1.1) that the building stone could have been stockpiled on site prior to the construction taking place. There is possible evidence of clay tiles being delivered to site before the erection of the *principia* at Carrawburgh. Fragments of tile, mainly *tegulae* were seen (Breeze 1972, 102) in the western room of the rear range overlying clay, along with mason`s chippings, up to 60 mm thick. This tile, according to the report, was only seen in this room and in no other rooms of the rear range or cross-hall (ibid., 96-103). Some tile was found in the *Vallum* fill to the western courtyard and ambulatory (ibid., 107-7) but this was considered to be as a result of rebuilding operations. It is likely therefore that the tile was a make-up deposit and not as a result of roof construction, which is unlikely as the tiles would have been laid on boarding. It is usual in traditional construction to make up the levels below any floor to just below floor finish level whilst the structural walls are approximately at that level[7]. This is because it is easier to place the fill before the walls are built, and also it provides a level surface on which to work and erect scaffolding and platforms. In the case of the western room of the rear range, placing fill after the erection of the structural walls would have been made even more difficult as this room was entered from the one adjacent. It is suggested therefore that roofing tile for the *principia* had been delivered by the time work had commenced on site, and that it had probably been placed near to the south west corner of the building. Any tile broken as a result of the delivery is likely to have been thrown into the nearest portion of the building to make up levels, as this was the most convenient way of disposing of broken material that could not be used. The excavator (pers. com.) does not agree with this conclusion as he states that, as the tile was found within rooms but not under walls, it suggests that the roofs were erected before the floors were laid. This response overlooks the fact that the walls are described as being on foundations.

If the model, which has been set out above is correct it would demonstrate that the forward planning of the military builders was such that tiles, and presumably other materials such as timber, lime and sand were on site before they were required. This shows considerable logistical planning and an awareness that, any delay in delivering materials to site would have a serious affect on the completion of the works. The constructional sequence of the buildings themselves will be discussed in the next chapter.

3.3.2 Constructional Sequence of the Buildings

This section will discuss the sequence of construction of the four building types under consideration. It can be confidently assumed that the buildings within the *latera praetorii* would have been erected first.

The *Principia*

It is apparent from what has been and will be discussed (chapters 3.1.1 and 3.4.1), that the *aedes* and flanking rooms were the first parts of the *principia* to be constructed. Evidence from the foundations at South Shields (chapter 3.4.1) would confirm, as expected, that the cross-hall and rear range were completed before the courtyard and ambulatories. From the large quantity of chippings seen in the courtyard at South Shields (Bidwell and Speak 1994, 58), it would appear that roughly dressed stone was brought into the area of the courtyard to receive its final dressing before laying. This would not seem to have occurred at Housesteads (Bosanquet 1904, 212), and probably not Carrawburgh (Breeze 1972, 106-107). It is possible at South Shields, due to the amount of chippings, that the courtyard might have been a masons` yard for various buildings within the fort, whilst at Housesteads and Carrawburgh the stone was dressed near to the point where it was required.

It is likely that the maximum numbers of building operatives were directed to any one building at any one time. An example of this can be seen in the *praetorium* of the Trajanic fort at Caerhun, where the west wall of the building was started at each end by a separate gang on different alignments (Kanovium Excavation Committee 1938, 71).

The Vindolanda tablets record that eighteen men were working on the bath house (*Tab. Vindol.* II, 155). A further reference (ibid., 156) refers to 30 men being sent with Marcus, the medical orderly, to build the residence. This would seem a large number, and clearly the maximum number that can work on site at any one time, is dependant on what stage the works have reached. The contemporary view is coloured by the relatively few men on the traditional building site of today. It must be remembered that the Roman buildings would have had no services (plumbing, heating, ventilation or electrical installations) and therefore the length of time the building would take to complete, and the number of people involved, would be considerably less than that of a building today. This would be reflected in the speed of construction, as delays in completion would be minimised due to the more complicated trades being absent.

As the walls were constructed in the cross-hall, the need for scaffolding would arise. Given the presence of putlogs passing through the thickness of the wall (Wilmott 1997, 114) and their general usage in Roman military buildings, it is suggested that double cantilevered scaffolding (fig. 46) was widely used (Fowler 1982, 126). This form of scaffolding would permit work to proceed both internally and externally, including the application of any wall finishes, and has the added advantage of not obstructing the floor with upright scaffolding poles. It is significant that the cross-hall to the period 4B fort (mid-Antonine) at South Shields has five mortar/plaster mixing pits set *c.* 1.000 - 1.200 m from the face of the internal wall on three elevations (Bidwell and Speak 1994, 61 fig. 3.13)[8]. This distance is adequate for the scaffolding to be comfortably positioned between the pits and the wall. The content of the mixing pits was a fine lime: sand mix, such as would have been used for a finishing coat of wall plaster (pers. com. P. T. Bidwell). In this particular instance the make up of the floor was seen to be approximately level[9], there was no evidence of post holes for any scaffolding; it is possible that cantilevered scaffolding was used on this building.

A major problem in the building of the *principia* would be the erection of the roof trusses over the large span of the cross-hall. It is estimated that each truss weighed up to two tonnes for the *principia* at Chesters. The advantage of the double cantilevered scaffolding would be that at eaves level there would be a working platform twice the width of a scaffold, plus the thickness of the wall, to all sides. It is suggested that this was used as a surface on which the three members of each truss could be assembled. Each member due to its weight would be raised up singly to this level, with the end trusses being erected 2.000-3.000 m away from a gable wall, and the purlins being fixed as the work progressed. It is possible that if the ties to the truss were placed in position first, at centres of 2.000-3.000 m, planks on bearers could be spanned between them, so forming a working platform off which the principal rafters could be fixed. Once the roof carcassing was complete the scaffolding on the outside of the building would form a working platform, for the roof covering of boarding and roofing tiles.

Whilst the roof to the cross-hall and rear range was being erected, the masonry gang could then have completed the walling to the courtyard. Following this the piers to the ambulatory would be formed and the roof erected.

On the completion of the masonry, and probably all the plastering[10], the door thresholds would be positioned and the floor finishes laid on top of any make-up levels. Any joinery, internal fittings and decoration would then follow.

The Granaries

The foundations for the external walls and those for the stone sleeper walls were probably cut simultaneously. Three foundation bases were constructed to the north portico at Wallsend; the central foundation base was cut first and the primary road base abuts the foundation. The two end foundations cut through the primary road bed, so showing that they were constructed last but that all bases were being built at the same time as the *via principalis* was being laid (pers. com. W. B. Griffiths).

It is likely that the external walls, buttresses and sleeper walls were built simultaneously up to ground floor level. In the case of the timber beam slots cut in the ground to the south granary at Birdoswald, it is probable that all the slots were formed before any posts were placed; a sequence seen at Leucarum (Marvell and Owen-John 1997, 121). There would have been some considerable advantage to the flag floor being laid on the sleeper walls before the building of the external walls. Apart from it being easier to place the heavy slabs in position without the limitation of doorways, it would also have provided a level surface off which to complete the rest of the building. The probability is that the timber joists supported by *pilae* and the flagged flooring, were also completed before the external walls, for the same reasons. It also would have been considerably easier to build in the joist ends in the external walls rather than leave pockets for their later insertion.

The external walls would have been constructed using either cantilevered or vertical support scaffolding. At Birdoswald a series of putlog holes are evident to the south wall of the southern granary (Wilmott 1997, 114). A series of putlog holes 140-165 mm square were positioned either side of the ventilation opening, two between each pair of buttresses. The hole was formed through the thickness of the wall and later closed up. Opposite each putlog hole to the south of the building was seen a series of post holes *c*. 200 mm diameter and *c*. 240 mm deep, which would appear to have been the scaffolding uprights to which the timbers housed in the putlog holes were tied[11]. From the position of the putlog holes, the first level of the scaffolding would have been 2.000 m above ground level, with additional levels formed at *c*. 1.500 intervals.

The trussed roofs over the larger spans would have been erected as described for the *principia* roofs. The close couple roofs over the narrower spans could have been erected using the projected first floor as a working surface. With the benefit of a platform, the smaller, lighter timbers could easily have been fixed.

The roof timbers to the double granaries could have been erected from scaffolding against the external and central walls. Purlins were probably positioned over the principal rafters. In all cases the roof carcassing would have been boarded and tiled. In the case of the close couple roof, it is unlikely that a projecting eaves would have been formed as this would require additional labour and materials.

A pit for a possible crane or hoist was seen on the approximate line of the west wall of the granary at Wallsend, some 6.000 m from the south wall.. The pit was formed to house a timber member of *c*. 1.000 m diameter (pers. com. W. B. Griffiths). The emplacements for cranes are rarely encountered on Roman building sites. The possible types are discussed in Bidwell and Holbrook (1989, 121-123).

The Gates

The principal gates were set out, the foundations laid and the six footing courses to the gate responds and the *spina* set in place.

Wilmott has shown that the responds to the gate passage and *spina* were built simultaneously (Wilmott 1997, 57-58), and that they were built into the masonry forming the gate passage. The set-back of the first voussoir from the edge of the impost would have allowed the centering for the portal arch to rest on that moulding. This sequence of construction would appear to have been followed at Chesters, where some of the lowest courses forming the responds pass through the thickness of the gate passage wall. This sequence is a logical one to follow, as in setting out and building the responds first, the accuracy of the portal widths are ensured.

From the excavation of the north-west gate at South Shields it was seen (Dore and Gillam 1979, 13) that the footing courses overlaid a thin spread of masons chippings, so indicating that work had started in dressing the stonework on site before the gate responds were built. They develop the sequence further (ibid., 15) and present the stages of the construction of the gate as follows:

1. The construction of the main drain through the south-west portal.
2. The building of the guardchambers to the point where the stone dressings were required for the portals.
3. The construction of the *spina.*
4. The laying of the road surface.

As will be discussed in chapter 3.4.3.2, it is suggested that the leaves of the gates were set in position prior to the setting of the top pivot stones, with the lower pivot sockets being cut *in situ* prior to the hanging of the gates. Once the top pivot stones were in position they would have been kept in place by the coursed stonework of the *spina* above the pivot stones, and the bonding of the courses into the front wall. The remaining constructional sequence would have following in the normal way. It is probable, as with milecastles and turrets, that in many cases the gates were constructed prior to the curtain wall, as was suggested in the previous chapter.

The Barracks

It is probable that work did not commence on the barracks until the main buildings within the *latera praetorii* were substantially completed. As with many buildings within the fort, the external walls to the barracks were usually constructed prior to the commencement of the division walls to the *contubernia*. This is reflected in the straight joint commonly seen at the junction of external and internal walls. An exception to this is the extant barracks in the *praetentura* at Chesters. In the southern block the rear wall was constructed first, and the dividing walls and front wall would appear to be of one build as there is no straight joint where the cross wall joins the front wall. In the case of the northern block a similar situation occurs to every other dividing wall, set out from the officer`s quarters. The intermediate dividing cross wall is butt jointed at its junction with the front and rear walls.

The low level of the eaves would present no problem with the construction of the simple traditional roof forms as discussed elsewhere (chapter 3.4.4.2).

Notes

1 Richmond proposes that some of the mound content to the *Vallum* at Birdoswald was used to form the earth rampart to the stone fort, and not wholly used to backfill it (Richmond 1929, 310).

2 Alberti comments on the lack of any requirement for scaffolding due to the width of the walls providing a good working platform (Alberti 1955, 53), saying that, `A very thick wall has no need of scaffolding because it is broad enough for the mason to stand upon the wall itself`.

3 Information supplied by Messrs Harry Place and Partners, Quantity Surveyors.

4 Alberti (1955, 52) in considering the building of stonework by "the Ancients" warns against raising the structure too high before what has been completed is thoroughly settled. He states that the work whilst it is fresh and soft is too weak and pliable to bear a superstructure.

5 Trajan`s forum was completed in less than eight years (Claridge 1993, 19)

6 At Wallsend the foundations to two earlier rear ranges with two rooms flanking the *aedes* were seen below the extant *principia*. As the foundations would not seem to have been built upon they could relate to the incorrect setting out of the building, although to get it wrong twice is surprising.

7 The upper surface of this make-up level would be reasonably level and would have accepted the finished floor material, possibly flags in a bedding medium.

8 One mortar pit to the south-east has been omitted from fig. 3.13. The pits are considered contemporary but this was not shown on the drawing.

9 From the limited number of levels the maximum variance in the floor level was seen to be 235 mm.

10 The plastering of the *principia* at South Shields was completed before the floor finishes were laid. This would imply that the plaster ran down the walls below floor level, which would induce rising damp up the wall surfaces.

11 The presence of scaffolding uprights to the exterior of the building does not preclude the use of cantilevered scaffolding to the inside of the building. Both methods can be used simultaneously as long as putlog holes are present. The putlog hole not only supported the horizontal timber member of the scaffold but also enabled any scaffolding uprights to be secured to the building.

3.4 Constructional Techniques

This section will examine how the buildings were constructed, together with the architectural details. Each building type will be considered and the various elements making up the structure will be discussed. A final chapter will draw conclusions from the discussion raised by the four building types. Reference will be made in the chapter to appendix 4 which is a catalogue of the decorated and moulded stonework associated with the buildings.

3.4.1 The *Principia*

3.4.1.1 Foundations, Masonry and Openings

Foundations

The primary purpose of a foundation is to provide a sound level base off which to construct walling, and to distribute the loads over a sufficient area of bearing surface to prevent the sub-soil from spreading, so causing settlement. The use of clay and stone for foundations would have had the same general effect as the weak concrete (1:1:6, cement: sand: aggregate) of today. The Roman foundations are in many cases considerably deeper than those for modern or traditional work, which are normally about 225 mm deep. The only practical reason for the construction of deep foundations is the need to excavate to a greater depth to find a sound base on which to lay any foundation. As Roman construction techniques were based on the empirical tradition the safe option can usually be seen. This contrasts with later examples where less sound principles of construction were used, and minimal foundations laid in some cases.

The final foundation trenches to the *principia* at Wallsend show re-alignment when compared to the original trenches (site archive). This could imply the re-alignment of incorrect setting out of the building, similar to that seen at the Agricolan supply base at Red House, Corbridge (Hanson *et al.* 1979, 1-98).

The foundations on which the masonry was built were substantial and almost without exception adequate for their purpose. The main area where the Roman builders tended to make inadequate provision was over back filled ditches which often had an unsuitable fill. The foundation trenches were generally excavated down to a clay bottom and backfilled with clay and stone. At Carrawburgh the foundations, where seen, were made up of broken sandstone with some whinstones and river worn cobbles, sealed by yellow clay (Breeze 1972, 96). Where they were formed over the *Vallum* ditch the backfill of the mounds was strengthened in strategic places by stones, and sealed with yellow clay. The west wall of the *principia* was not provided with a foundation where it crossed the *Vallum,* the stone packing in the ditch being considered sufficient (ibid., 103, 106). At some time later the general foundations were reformed by adding a layer of less homogeneous stone containing large broken dressed stone, cobbles and sandstone (ibid., 97). At South Shields the foundation to the rear wall of the rear range was seen to be 400 mm deep in a straight sided construction trench, and made up of whin cobbles set in clay (Bidwell and Speak 1994, 71). The foundations to the cross-hall are very similar, being to the north-west wall 410 mm deep by 900 mm wide, and made up of irregular sandstone blocks set in clay, with clay and cobbles above (ibid., 68). That to the north-east gable wall is 450 mm deep made up of clay bonded stone beneath a capping of clay and small pitched rubble. The foundations would appear to be continuous across the openings in the south-east wall to the rear range. Those to the forecourt show foundations of two differing sizes. For a distance of 7.000 m north-west of the cross-hall they were 400 mm deep by 840 mm wide; the remainder of the walling was laid on larger foundations, 640 mm deep by up to 1.200 m wide, made up of two or three rough courses of whin boulders (ibid., 62). It would seem that two gangs had carried out the work to the *principia* at South Shields, one gang being fairly consistent in constructing a foundation *c.* 900 mm wide by 400 mm deep for the cross-hall and courtyard walls abutting. A second gang at some later stage completed the walls to the courtyard and being much more conservative in their work, formed a foundation deeper and wider.

There is no evidence of any of the foundations to the long side walls to the cross-hall at South Shields being greater to one side or the other, as sometimes suggested. Johnson (1983, 109-10) propounded that at some cross-halls the walls fronting the courtyard were more substantial due to the large numbers of openings found in them, or as they supported the ambulatory roof in some instances. This is unlikely as there would have been no need for any increase in foundation size, based on structural considerations, as the loads transmitted to the ground by both walls would have been broadly similar.

The foundations to the internal arcading of the *basilica* at Birdoswald are made up of a single course of faced clay bonded core (Wilmott 1997, 80), slightly wider than the piers themselves, and seen to run continuously for the length of the arcade[1]. The foundation trench is 200 mm deep by 1.260 m wide, and is the only recorded continuous foundation for an arcade *per lineam valli.* The advantage of a continuous foundation is that it facilitates the setting out of the masonry, as there is opportunity to vary the size and spacing of the piers without the necessity of altering the foundations.

The other marginal advantage is that if the foundation is the same size and type any differential settlement will be minimised. The south wall of the *basilica* overlies the Turf Wall ditch and the foundations were seen to be of deep rubble; this rubble was seen to be confined to the edge of the ditch below the external wall.

Separate foundations to piers to the ambulatory were seen at Wallsend and South Shields. Those at South Shields (Bidwell and Speak 1994, 62-4) were seen to be *c.* 1.000 m square by 450 mm deep, and made up of magnesium limestone slabs set upon two layers of whin cobbles capped with stiff clay. The cobbles in the lower layer were seen to be consistently larger than in the upper layer. The column bases to the ambulatory at Housesteads are linked by a structural foundation wall; it is possible that this wall may have acted as a retaining wall between the ambulatories and the courtyard due to the cross-fall over the site.

Due to the natural cross-fall over the width of the building, the *principia* at Housesteads was built on an artificial platform overlying the natural rock, made up of whin and freestone chippings mixed with yellow gravel (Bosanquet 1904, 208). The amount of fill is considerable, as the footings at the south east corner lie as much as 2.100 m below the floor level of the interior. Although the rock would appear to have been removed in some areas, it was not levelled to the northern part of the cross-hall, and the floor level to the north-west room in the rear range was raised by some 450 mm so as to avoid quarrying away the rock in that quarter. Evidence was seen in the rear range for the cutting of the foundation trenches into the natural rock (ibid., 219). The foundations to the majority of the walls running north-south are not known. Many of the walls to the east external wall and portico are shown bearing on the natural rock

(Smith 1954), as are many of the walls to the north of the building and the south wall (Bosanquet 1904, plate XV opp. 210).

The foundations to the main piers to the forehall at Wallsend were *c.* 500 mm deep whilst those of the linking walls were only 50-100 mm deep. These bases were aligned at their western end with the buttresses to the north wall of the granary.

A differing type of foundation can be seen to the Hadrianic[2] *principia* to stone fort 1 at Chesterholm. Here a spread of cobbles was seen to have been laid beneath the whole of the building, with a greater depth occurring beneath the bases to the perimeter walls (Birley, Blake, Birley 1998, 9). This form of foundation would seem to reflect its unique form of construction using *adobe,* which will be discussed further in the next chapter.

Masonry

The masonry walling to all the *principia, per lineam valli,* is generally made up of mortared hammer dressed squared rubble with areas of dressed stonework. The walling is generally as described in chapter 2.1. A variation to the techniques described can be seen at Housesteads where retaining walls were constructed to the *principia,* and other buildings. The south wall and the return walls of the *principia* were constructed of large sandstone blocks, *c.* 900 mm long, laid as header courses, with stretcher courses forming an inner and outer leaf with a mortared rubble core (pl. 12). It is apparent that the original work where one or two stretcher courses were tied in with a row of headers was built to a high standard, and designed to take into account the retained fill. A foundation course of headers was seen at the east elevation to the main wall of the *principia,* the portico and to the rear range. The eastern section of the south wall to the *principia* has been largely rebuilt (Crow 1995, 45), and the difference in the quality of the work is evident.

Elsewhere at Housesteads the same technique can be seen used in the hospital, *praetorium* and building XV. It would appear to have been confined to where the lower courses of the masonry acted as retaining walls, so forming level platforms due to the cross-fall of the site.. A similar detail was used in the walling at the Knag Burn gate, to the east of the fort at Housesteads, where the lower courses were formed using alternate header and stretcher courses; in this instance the walling acted in the main as a retaining wall (Birley, E. 1937 172 - 177, pl. XXIV fig. 1, 2). From the similar form of construction it would seem probable that this gate was built by the same "school" of builders who built the fort; the date of the gate is attributed to the later second century (Crow 1995, 26). A similar set of circumstances was seen at Carrawburgh, where such stones are positioned as the foundations to the east of the *aedes*. It could be that a continuous row of headers was used in this position, to provide a better foundation course to the piers either side of the openings, in view of the concentration of loading.

In contrast to the quality of the masonry to the arcade piers, a clay bonded wall can be seen in the south wall to the aisle of the *basilica* at Birdoswald (Wilmott 1997, 80). The external face of this wall is protected by a stone built *fabrica*. A wall constructed with clay bonded masonry will retain its stability as long as it is in compression, and the clay remains in position. The clay acts in the same manner as mortar in that it separates the individual pieces of masonry to prevent them from rocking. The presence of a building against the external face would have prevented the dissipation of the clay due to weathering. Where a clay bonded wall was not protected externally it would need to have been protected, to prevent deterioration, by the application of a shelter coat.

The quality of the stonework seen in the *principia* is generally of a better standard than seen elsewhere in the forts *per lineam valli*, but this standard cannot always be described as good. The best example of finished masonry can be seen in the plinth to the *Vallum* gate at Benwell (Birley, Brewis and Charlton 1934, 176 - 184) where the standard of the finished stonework can properly be described as ashlar (Hill 1981, 19 - 20); this quality is not matched elsewhere in any fort on the Wall. An attempt to achieve quality in the buildings can be seen in the use of dressed stonework to the openings (pl. 13), and in simple details such as the use of a chamfered plinth course at Chesters (pl. 14). The desire to achieve a good standard can be seen in the accuracy of the setting out of this building type, particularly to the *aedes* and rear range, as discussed in chapter 3.2.2. The thickness of comparable external walls to each of the buildings is rarely constant, although the variation is not great; in the case of Chesters varying between 840-900 mm. This variation probably reflects the work of an individual building gang.

Eight equally spaced buttresses were seen to have been added to support the rear range of the mid-Antonine *principia* at South Shields; it is suggested by the excavators (Bidwell and Speak 1994, 72) that their purpose might be to give additional support to a first floor. Structurally this would not have been required, as the thickness of the external walls would have been more than enough to counteract any lateral forces which may have been present. One possibility is that structural movement occurred to the rear range (it was built partially on the existing foundations of *principia* 4A), and the buttresses were erected to counter this. This could have been exacerbated if the internal walls to the rear range had not been tied into the external wall, as has been seen in instances discussed earlier in this chapter. The movement is shown to have occurred after the completion of the building as the buttresses cut the foundation of the rear wall, and can therefore be seen to be a later addition (pers. com. P. Bidwell). It should be noted that no buttresses were constructed to the rear range during periods 5 and 7, when a two storey height structure might have been erected. Buttresses are shown to both the *principia* and *praetorium* at Birrens, on the plan prepared by Barbour[3], following the 1895 excavations (Christison *et al.* 1896, 81-199, fig. 1).

Although the form of construction is similar to all the known buildings, an anomaly does occur in the wall to the cross-hall abutting the rear range at Chesters. The thickness of this wall to the *aedes* and the two flanking rooms is 850 mm, but this is reduced in the end two rooms to *c*. 640 mm. If this walling was carried up to the eaves level of the cross-hall there would be a break in the wall above the roof to the rear range occurring approximately on the line of the inner wall to the two end rooms. It is likely that the wall to the *aedes* and two flanking rooms reduced at roof level to the lesser thickness, which is approximately equal to the width of the arcade piers. Apart from forming two recesses in the wall in the two end rooms, which would have been useful for storing military records, it is difficult to find a reason for this differing wall thickness. It might be a possibility that the central three rooms might have had a greater floor to ceiling height, or even a second storey, another alternative might be that the *aedes* and two flanking rooms were rebuilt on earlier foundations. It is a consideration, as has been discussed previously (chapter 3.3.1) that an earlier *aedes* and flanking rooms were built, and that these were incorporated at foundation level with resulting differing wall thicknesses in the final form of the *principia*. This is something that can only be determined by excavation.

The Hadrianic *principia* at Chesterholm was excavated in 1932-4 by Birley, Richmond and Stanfield (1936, 229-33). Although the plan of the building, with the exception of the cross-hall, followed the conventional form the construction was highly unorthodox in terms of Roman military construction in Britain. It was described as follows, `The soft sandstone, employed for the decoration and the smaller stonework, is not fitted to bear great weight. So, in the higher portions of the building, namely the cross-hall and the range of five rooms opening off it, the builders employed an old Roman device, described by Vitruvius and Tacitus, of which examples are familiar to students of Roman Spain or Africa, the homes of the *adobe* tradition. The softer material, by this device, is cut up into panels and divided by piers of hard stone. Further, not trusting the softer material even then to carry the required weight, the builders laid only a few courses of ashlar, and set upon the sill, so formed, panels of the soft sandstone ground to powder and mixed with tile and lime, so as to form a hard lime concrete. Masses of this material bestrewed the area of the cross-hall of this building; and though the original demolition and subsequent damp had reduced most of it to formless lumps, it was possible to extract some shaped fragments, which showed that it had been moulded in rectangular blocks' (ibid., 231-2).

Many architectural fragments were found in the debris resulting from the demolition of the building, including fragments of `rich Ionic column bases', complete capitals and `a relief embodying the sun-god in his chariot, together with small statues once attached to a background, as if from panels and pediments' (ibid., 231). The fragments were moved to Housesteads for storage and were unfortunately lost before they could be fully published.

The *principia* at Chesterholm, from the excavators' description, must present one of the greatest enigmas in Roman military building construction in northern Britain (fig. 47). It is hard to understand why this form of construction was used, a technique which would seem to be based on *opus Africanum* and used in dry areas where good stone was at a premium. The wet climate could have caused problems with the formation of the *adobe,* and it is difficult to understand why this was used in preference to stone. This is the only recorded building using this method of construction in Roman Britain. The extant remains on site do offer some possible limited indication as to the construction of the building. At intervals around the external wall of the building, square bases were formed at foundation level. These bases in many instances coincided at the junction of an internal wall with an external wall (pl. 15). Similar bases positioned at regular intervals were seen during the recent re-excavation of the west wall of the *principia*. It must be questionable if the traditional cross-hall with its clerestory was formed, due to constructional considerations. The row of piers to the south of the cross-hall would not seem to represent a conventional arcade, as no responds are formed against the eastern and western external walls to receive an arch; the line of the arcade also coincides with the west door.

Recent work at Chesterholm has confirmed the form of the unique construction as described. Soft sandstone would seem to have been used to build piers off the bases to the external walls, with the intervening space being filled with *adobe* (Birley, Blake, Birley 1998, 8-9 and pers. com. Andrew Birley). The bases to the east wall were set at distances apart ranging from 840 mm to 1.600m, with their size ranging from 720 mm square to 660 by 680 mm and 710 by 630 mm, and up to 400 mm deep (ibid., 8). Tile would also seem to have been used to enclose the *adobe,* both curved tiles for use as columns as well as straight tiles being seen.

Although there are no direct comparables of buildings using the *adobe* technique, it is perhaps relevant to note that buildings with walls of turf and clay blocks have been seen at the late Hadrianic or early Antonine fort of South Shields (Bidwell and Speak 1994, 53-5). Several buildings were seen to have been constructed of close set timbers, with the turf blocks rendered internally with a mud plaster. A similar form of construction was seen in London west of the Walbrook, although the timbers used were less substantial (Perring *et al.* 1991, 81-3).

The south east wall to the period 9 cross-hall at South Shields was seen during the course of its excavation, to have fallen into the courtyard (Hooppell 1880, 129-30). The excavator records that the wall must have been at least thirty feet high, `that extent being in one piece when it was uncovered`. He further states that `The outline of the wall when uncovered was irregular, and it was not easy to conclude where windows or doors had been. It was evident there had been none in the portion which lay unbroken, but the writer thought the appearance not inconsistent with a window at the south-east portion as it lay on the ground, and a door towards the north-west portion.` (ibid., 130). Bruce (1885, 233), writing at a later date and presumably referring to the same piece of masonry, refers to `A wall which had formed part of some lofty building was found lying prostrate and unbroken, except at its base, upon the floor of the *forum* at its western extremity .... The height of this wall as it lay prone, was about twenty feet`.

From an examination of the drawing and plan in the report (Hooppell 1880, plate XIII), it would seem that Hooppell was more likely to be correct, and allowing for some spread of the masonry as it fell, it is probable that the wall could have been in excess of 8.000 m in height. The plan shows a rectangle of masonry absent at the top of the wall as it lies in the courtyard, which could be the window opening.

Calculations have been undertaken (appendix 5A) which show that for a hypothetical reconstruction of the *basilica* at Birdoswald (fig. 39, 40) the walling is proved to be stable with an eaves height of 6.600 m to the cross-hall, and 3.200 m to the aisle. The eaves height of the cross-hall could be raised to 9.000 m without risk of structural failure (pers. com. D. Lingard).

Openings

The evidence from Wallsend, Chesters, Housesteads and South Shields shows that no pivot blocks for gates were placed at the main entrance into the *principia* from the *via principalis*. The "pivot hole" recorded in 1898 by Bosanquet in the threshold at Housesteads can still be seen but this is considered to be a natural feature (Smith 1954, 2). There is no evidence of dressed stone surrounding any of the main entrances and it is likely that the usual squared pitched stone was used. A chamfered plinth course can be seen to either side of the entrance at Chesters.

The square piers supporting the ambulatory at Chesters are in pitched faced stone with a chamfered plinth course to each side. This plinth course extends to the responds at each end of the ambulatories. The piers to the ambulatory at South Shields are made up of sandstone blocks, approximately 600 mm square by 150-450 mm in thickness, and can be firmly associated with period 4B (mid-Antonine), and to be the handiwork of the sixth legion (Bidwell and Speak 1994, 65). At present 71 blocks have been found, most with similar characteristics, and it is probable that many more remain unlocated. The upper and lower surfaces are dressed to a very smooth surface, and about a quarter of the blocks have a lewis hole placed centrally in the upper surface. The sides are dressed with a punch with many blocks having chisel drafted margins to the vertical faces. Many surfaces are finished with diagonal or vertical lines cut with a punch. Three of the blocks re-used in the strong room have diamond broaching, and another block has clusters of opposed chevrons carved in high relief. Three blocks are of special interest; one has an eagle carved on its side (CSIR I, I, 278), another has an ansate panel inscribed with the name of the sixth legion (RIB 1061), and the third has a carved phallus. Although it cannot be proved that all the blocks relate to the *principia* it is probable that many of the blocks, especially those with chisel drafted margins, were used to form the piers to the ambulatory to the courtyard. Columns supported the ambulatory at Wallsend and Housesteads. Those at Wallsend were set on column bases (appendix 4 B) and a re-used capital (appendix 4 A) was used in the period III *principia*. Large well set stones form the responds to the internal angles of the ambulatory at Housesteads which are carefully finished with a smooth pitched face (pl. 16).

The respond in the east aisle wall of the cross-hall and the projecting piers to the cross-hall entrance at Housesteads are of smooth pitched faced masonry. A two piece stone threshold 3.790 m wide by 580 mm deep is extant to the main entrance to the cross-hall from the courtyard and pivot holes 60 mm diameter and trackways have been formed at each end to receive a two leafed door. An upstand *c.* 50 mm high and 150 mm wide is formed to the outside edge. The north elevation of the cross-hall at Chesters is of pitched face stone with a chamfered plinth course adjacent to the openings, projecting nibs are formed either side of the entrance; the threshold is not extant.

The threshold to the east door to the cross-hall at Wallsend is situated close to the north wall. The threshold is *c.* 1.610 m wide by 950 m deep, and is formed out of a single piece of stone. The exposed vertical faces internally and externally show dressing by a light pick or punch (pl. 17). The upper surface is finely dressed with a rebate formed to each side of the opening, 160-230 mm wide by 50-60 mm deep, to receive stone linings. The upper surface of the step is worn. Two small sockets, 70 mm diameter by 50-60 mm deep, have been formed at the edge of the opening up against the rebate, close to the outside edge of the threshold. These socket holes show greater wear around the edge than the centre, portraying a cushion effect, probably indicating that the dowel supporting the door had a metal sleeve. There is some indication of ferrous staining, and iron was found in the southern pivot socket; rough trackways lead up to the sockets. A mortice has been cut in the centre of the threshold on the line of the sockets, 170 by 70 mm by 50 mm deep. There is no evidence that the step or the linings projected beyond the face of the walls.

The east entrance to the cross-hall at Chesters is spanned by a two piece stone threshold 2.440 m wide, with two pivot holes of 70 mm diameter to receive a double leafed door; an upstand 80 mm high by 180 mm wide is formed to its outer edge between the pitched stone reveals. Wheel ruts are formed in the upstand *c.* 1.000 m apart. The west entrance is spanned by a single piece stone threshold 2.390 m wide set at the top of a flight of three steps each of *c*. 160 mm rise, between pitched stone reveals. There is no evidence of pivot holes.

The north entrance to the cross-hall at Housesteads is positioned at the top of a flight of three risers, and is spanned by a single piece stone threshold 1.500 m wide by 550 mm deep. A pivot hole 70 mm diameter is cut into the upper surface at each side to take a double leaf door. Two rebates to receive linings are cut into the ends of the threshold, 90-100 mm wide by 40 mm deep, placed 70 mm from the edge (pl. 18). There is no evidence that the linings projected beyond the face of the walling.

In all instances the thresholds are not built into the jambs of the door openings showing that they had been placed in position after the openings had been formed. This is contrary to present traditional building practice, where a threshold is built into the walling at each side of the opening. The use of rebated thresholds to receive linings can be seen elsewhere at Chesters in the *praetorium* and the bathhouse where many are still extant. In the *praetorium* the rebates are typically 220-250 mm wide by 25 mm deep, and set in 70 mm from the edge. The setting in of the stone lining by 70 mm suggests that the gap between the back of the lining and the walling would have been covered by an architrave on each side. In the *praetorium* bathhouse several thresholds are set forward by *c*. 60 mm, so that the face of the threshold would be on the same plane as the finished plasterwork applied to the walls. Stone linings set into stone thresholds can also be seen at wall turrets 19a Clarewood East to 35a Sewingshields Crag inclusive, and possibly also at 39a Peel Crag and 48a Willowford East (Hill 1997, 34). At turret 34a Grindon West, a rebate is formed in the stonework to the east reveal to the doorway when viewed from outside; this rebate is matched by a further rebate cut in the stone threshold which is 150 mm wide by 760 mm deep. This detail is not matched in the western part of the threshold.

The arcade within the cross-hall, as seen at Chesters and the *basilica* at Birdoswald is structurally the most significant element of the building. It is important that the piers are equally spaced so that the arches are of equal height and profile, whilst at the same time the quality of the workmanship should be high in view of the point loads transmitted through the piers to the foundations. These loads would be considerable as they comprise not only the dead loads[4] of the masonry above, but half the dead and live loads of the roof. The arcade wall in a *principia* and that in a *basilica* would gain very little lateral support from the roof of an adjoining aisle, as it is unlikely that a truss form giving the necessary bracing was used, in view of the narrow width of the aisles. From the excavated evidence at Birdoswald (Wilmott 1997, 80-81), the good quality of the workmanship in the arcade piers reflects these requirements, as do the extant piers at Chesters.

Evidence of the highest quality extant work can be seen in the openings leading from the cross-hall to the *aedes* and the flanking rooms. These openings at Chesters are defined by a splayed plinth course around all sides of the two central piers, and the responds to the two flanking rooms. An extant chamfered block (pl. 14 and fig. 48) is built into the east pier to the *aedes*; the top of the splay is 760 mm above assumed finished floor level. A similar splayed block can be seen in a late nineteenth century unpublished photograph[5] (pl. 19), in a similar position on the west pier to the *aedes*. The present block in this position would seem to have been repositioned (Hodgson, T. 1910, 143) due to at least one course of masonry having been removed. It is also significant that the photograph shows extant masonry (now missing) to the east of the east pier; this would suggest that no further splayed blocks were positioned adjacent. It is put forward that the purpose of the splayed blocks was to set back the respond and voussoirs to the opening to the *aedes* by the depth of the splay 170 mm, so forming two rings of voussoirs. This detail would place further emphasis on the opening and the shrines beyond it (fig. 49). A damaged threshold with a later cut-out lies within the central opening; this stone, not in its original position, probably once housed a stone panel fronting the *aedes* or the flanking rooms.

A two piece moulded threshold 3.870 m long by 520-530 mm wide, with a central joint, spans the opening to the *aedes* at Housesteads (Bosanquet 1904, 273, fig. 18, pl. 20). A slot is cut into its upper surface, 200 mm wide by *c*. 25 mm deep, to receive stone sill panels; the width of the central opening between the panels is 1.490 m. To either side of the opening to the aedes is finely finished pitched face stone. To the north the respond is 610 mm wide in which is found a rebate 190 mm wide by 50 mm deep. To the south there is a single stone in situ 570 mm wide with a face to the cross-hall of 520 mm; no rebate is formed. A similar moulded threshold is found in the Hadrianic *principia* at Chesterholm (pl. 21). The two pieces of moulded stonework with a central joint are 3.200 m long by 470 mm wide. The slot cut into the upper surface for the sill panel is 270 mm wide by *c*. 25 mm deep. The width of the opening between the panels would have been 1.040 m.

The entrance to the *aedes* at stone fort 2 at Chesterholm, together with the flanking rooms, had their openings reduced in width by a stone sill panel to each side of the entrance in a similar manner to those described above. These panels were set in slots in the thresholds and in the adjoining piers. Two of the panels were subsequently used as paving stones in the courtyard (Birley, Richmond, Stanfield 1936, 223). The pier to the west of the room to the west of the *aedes* is of fine quality and stands two courses high above its foundation. The north face into the cross-hall, and the two returns, are finished with a neat punched face, with chisel drafted margins between 40-70 mm wide. The south facing face to the rear has not been finished off to the same standard, having a very rough hammer-dressed finish, although the chisel drafted margins have been formed (pl. 22). The size of the slot cut into the side of the pier described above, is 170 mm wide by 70 mm deep, with the size of the channel cut in the threshold varying where visible between 140-200 mm wide by 40-70 mm deep. The sill panel still extant to the room to the west of the *aedes* is 1.090 m long by 860 mm high, and has a decoration to its north face of a rectangular panel containing a lozenge pattern with a cable mould border. A similar form of decoration has been seen at the Corbridge fountain (ibid., 224). The top of the panels show dowel holes which are considered to have housed a metal screen (ibid., 224). The plain border around the panel is not equal in that the margin adjacent to the opening into the room is approximately twice that of the margins to the other three sides (pl. 23)[6]. The openings into the three central rooms between the decorated sill panels, would have been some 900 mm. The foundation course to the piers either side of the *aedes* is extant, and is formed of carefully dressed and squared masonry. The two central stones on the central axis are approximately square, and are flanked with a single stone with a slot to the east, with two similar stones to the west. The opening into the *aedes* is *c.* 3.530 m. The thresholds to the two flanking rooms are in four pieces. The extant sections of threshold to the *aedes* and the western room adjoining are in five pieces with a joint in the centre of the opening (pl. 24); this is contrary to good modern practice. The centre of the threshold to the *aedes* is uneven for a breadth of some 225 mm on the line of the channel for the panels; this could represent the position of some former type of decorative threshold, or later adaptation. A threshold within the *aedes* in front of the strong room however, is in three pieces with a one piece central slab.

A large sandstone block 1.200 mm long, 580 mm wide and 400 mm high with a coarse pitched face finish forms the base between the two arched openings to the south west of the *aedes* to the mid-Antonine *principia* at South Shields. This block is set on a levelling course of pure clay overlying the foundations (Bidwell and Speak 1994, 71).

A distinction can be made between the treatment of the openings to the *aedes* at the Hadrianic *principia* fort of Housesteads and Chesterholm, and the third century *principia* at Chesterholm. In all instances the thresholds are set in prepared openings. At both the Hadrianic *principia* the thresholds are moulded and are formed in two pieces with a joint approximately at the centre. At the Antonine *principia* the thresholds are not moulded and are formed out of four or five pieces with a central joint in the two piece slab at the entrance to the *aedes*; the exception being the threshold within the *aedes* itself.

There is no evidence of the form or position of windows above ground level. In the Hadrianic *principia* at Chesterholm and Benwell, large openings were formed in a possible aisle adjoining the courtyard. In both instances no details were given by the excavator of any form of screening. It is a possibility that the windows to the clerestory in the cross-hall of the *principia* were of the arcuate type. This suggestion is based on the use of this type of lintel in the early Syrian churches (Butler 1969). It is also pertinent that the range of arcuate lintels to the *apodyterium* at the third century bathhouse at Chesters are re-used, and could have come from an earlier building, possibly a *principia*.

The only parallels for windows in a *principia* are both associated with early third century strong rooms at Benwell (Spain 1929, 126-130) and South Shields (Bidwell and Speak 1994, 80-1). In each case splayed reveals were formed to the sill and jamb. The window opening at South Shields, although opening into the cross-hall, was fitted with an iron grille. It is possible that the windows to the rear range were fitted with metal grilles; a metal grille has been seen at the Antonine fort of Bar Hill (Robertson 1975, 12, 14) which is thought to have come from the rear range. No glass has been seen in a firm context from any *principia, per lineam valli*.

Examples of door heads are unsubstantiated. It is possible that arcuate door heads with moulded decoration were used, as fragments can be seen in the *principia* and *praetorium* at Housesteads which may have come from either building. The north door to the *principia* at Housesteads with slab reveals is likely to have had a matching head; the head could have been rebated to receive the uprights as suggested by the slab reveals to the later bathhouse at Chesters (pl. 25). It has been suggested in chapter 3.1.1 that the main door into the cross-hall from the courtyard in all cases was probably arched. A carved voussoir in the form of the head of a bull (Hooppell 1880, 130 fig. 5) was found from the period 7 *principia* (late 3rd or early 4th century) at South Shields, which Hooppell (ibid., 130-1) considered to have come from this position, and to be the key stone to an arched opening.

3.4.1.2 The Roof

The form of the roof structure can only be based on comparable structures within the Roman Empire, and the meagre archaeological record. The excavated evidence, although limited, does suggest that most if not all of the buildings in the *latera praetorii* of the primary Hadrianic phase, had a clay tile roof covering. This is supported by the findings of Casey and Davies (1993, 230) at Segontium where it is considered that the buildings within this sector were probably roofed with tile. Wheeler (1923,103) also found that the earliest levels at the fort of Caernarfon contained roofing tiles but no slates. There is considerable evidence of the *Legio VI Victrix* being involved in roof tile manufacture *per lineam valli* (RIB II, 2460), but little for the *Legio II Augusta* (RIB II, 2459) and *Legio XX Valeria Victrix* (RIB II, 2463). Evidence of tile making by auxiliary troops is fairly widespread in the third century (RIB II 2464-2480), but less so during the Hadrianic principiate. Tile has been found at Maryport made by the Hadrianic auxiliary garrison of the *cohors I Hispanorum* (RIB II, 2474), whilst tile by the *cohors I Tungrorum*, a pre-Hadrianic garrison at Chesterholm, has been seen at Hare Hill four miles west of Birdoswald (RIB II, 2477). This unit is thought to be the first garrison at Housesteads (ibid., 2477). Tile has also been found within the *principia,* or close by, at Benwell (Petch 1927, 140, 151; Simpson and Richmond 1941, 4), Wallsend (RIB II 2460.50), Carrawburgh (Breeze 1972, 102) and Birdoswald (Wilmott 1997, 82). Its use was postulated on the hospital at Housesteads (Charlesworth 1976, 24) and on the *principia* at South Shields (Bidwell and Speak 1994, 69, fig. 3.24 opp. 72). It is probable that tile was used on the Hadrianic buildings as clay was plentiful and the resulting *tegulae* and *imbrices* were quickly made and easily fixed. By contrast, sources of suitable stone would have been harder to find, and the laying of the slates would have been more labour intensive.

The tiles were laid on close timber boarding, which in turn would be nailed to closely spaced purlins. From the evidence of the early Christian basilican churches in Syria (Butler 1969), it is probable that centres of *c.* 900 mm were commonly used for the purlins. This would suggest that the boarding would have been *c.* 50 mm thick. Butler shows that in the majority of cases two trusses were placed within one structural bay (centre to centre of column or pier). In the case of Chesters, where the average bay length is *c.* 5.130 m, it is suggested that the truss centres were *c.* 2.565 m[7]. At the *basilica* at Birdoswald, the truss centres calculated on the same basis would be *c.* 1.840 m, which is close to many of the Syrian examples. Trusses at these centres are spaced closer together than one would normally consider in present day traditional construction, where it would be usual to place one truss on the column/pier line per bay. However, the close spacing would have reflected in the smaller timber sizes that would have been used, due to the reduced spans. The internal clear span of the nave to the cross-halls, where extant Hadrianic walls can be identified, are Wallsend 7.140-7.470 m, Chesters 8.340 m, Housesteads 8.290 m and the *basilica* at Birdoswald 7.480 m. No deviation occurred in the clear span at Chesters and Housesteads. It was important that the span was constant, as matching trusses would have been made on the ground and then fixed at high level. Any variation in the span could have resulted in a reduced bearing for a truss.

It is assumed that the simplest form of truss, the close couple truss, would have been used, utilizing the simplest of techniques. The joints are assumed to have been formed by halving the timbers and fixing spikes, although it might be that the principal rafters were tenoned into the tie beam. The members are likely to be oversized, taking into account the Roman empirical approach. The tie is likely to have been a greater size than the principal rafters, due to the greater stresses it had to incur.

The principle failing of the close couple truss is that it tends to compress under loading, as there is no king post to give central support and redistribute the loads amongst the truss members. This tendency is lessened due to the close centres of the trusses and the consequential wider distribution of the loads. The main advantage of this type of truss is that it would have been very quick and simple to make.

As close boarding was laid over the purlins it is likely that the masonry was built up to its underside. The consequential eaves detail, to the cross-hall and in similar situations, would have had minimal overhang as no rafters, as in a conventional modern roof, were used. The only overhang would be that formed by the tiles of a nominal 50 mm. It is suggested that the roof to the rear range was constructed on the same principle as the roof to the nave, with the internal cross walls between the rooms taking the place of the truss. The purlins therefore would be set at *c.* 900 mm centres and would bear on the masonry walls. If the floor to ceiling height of the *aedes* was required to be raised this could easily be done by building up the masonry to each side.

It is proposed that the roofs to the ambulatories and aisles were formed of rafters bearing on a beam spanning between the piers, or in the case of the aisle bearing on the external wall, the other ends could have been built into the masonry or rested on a wall plate. The rafters were probably placed at *c.* 450 mm centres which would have been an economic spacing. An overhanging eaves might have been formed to the ambulatory to the courtyard as the rafters could have been designed to project. This overhang could have been as much as 450 mm. In the case of the ambulatory, and that of the rear range, the roof covering of tiles would have been laid on boarding.

3.4.1.3 Floor and Wall Finishes

Floor Finishes

The depth of the make up levels below the finished floor surfaces varied from site to site, but its purpose was to fill any depression between finished floor level, and the reduced levels over the site. The fill at Carrawburgh was made up of clay, mason`s chippings and in one area clay tile[8] (Breeze 1972, 96-106). That at Housesteads was made up of `gravel and chippings` (Bosanquet 1904, 216); it can be assumed that the chippings referred to are those left by the stone masons. This was overlain in the rear range by yellow clay (ibid., 219). Evidence from the *basilica* at Birdoswald (Wilmott 1997, 79-80) shows that the construction levels for the ground floor, for the greater part, were laid down before the structural walls were formed. Deep rubble foundations were laid in the Turf Wall ditch for the south wall of the building, where it was built on the edge of the ditch. The internal area of the building was then formed by spreading a layer of 40-120 mm of hard compacted clay. This was laid on top of the hiatus soil which was laid directly over clay (pers. com. T. Wilmott); a further deposit of similar clay was subsequently laid. The floor construction was then cut to form the foundations of the south wall, and similarly the foundation trench for the sleeper walls for the pier bases was cut. Backfilling of the trenches later took place. It was likely that the primary layer of clay was laid to raise the general levels in the area where the building was to be erected, to match those south of the Turf Wall and the probable area of the earlier fort. At South Shields extensive areas of mason's chippings were seen in two layers up to 450 mm deep in the courtyard (Bidwell and Speak 1994, 69), whilst in the cross-hall the fill comprised mason's chippings, mortar, gravel and building debris (ibid., 68-69).

It is almost certain that the floor finish to rooms and the courtyard of the *principia,* in most cases, would have been stone flags. A lone extant example was seen in the rear range at Carrawburgh (Breeze 1972, 98). Flagging was also extant in the cross-hall at Wallsend laid over a make up of clay, and an eaves drip channel was formed to the perimeter of the flagged courtyard (site archive). The extant areas of flagging in *principia, per lineam valli,* are in many cases of later period or else of unsubstantiated date. *Opus signinum* was seen at Housesteads in a primary context overlying rock in the *aedes* and north-west room to the rear range (Bosanquet 1904, 219, 221). This material was probably confined to use in rooms of special purpose due to its waterproofing properties.

Wall Finishes

Evidence of applied wall finishes to the Hadrianic *principia, per lineam valli,* is limited. Sand: lime plaster or render will readily break up when exposed to the elements, although the lime will dissolve and form a solution, the abnormal quantity of sand as compared to adjacent contexts should be identifiable alongside rendered or plastered walls[9]. It is possible that where lime was scarce a finishing coat of plaster was applied to a clay backing as seen in the *principia* at Bainbridge where a coating of clay 25-50 mm thick was then plastered (Ward 1955, 156). The use of the clay would obviate the need for lime in the dubbing out coats. It is unlikely that any finish was applied to areas of walling where dressed stone was used, such as to the cross-hall wall fronting the rear range, or the external wall abutting the courtyard to the cross-hall. Any applied wall finish such as a sand: lime plaster would have to be applied in a minimum of two or three coats, due to the uneven nature of the stonework, and the necessity to "dub out" the plaster so that an even surface might be achieved. The resulting thickness is unlikely to have been less than 50 mm.

If plaster was applied to the hammer dressed squared masonry adjacent to the pitched faced stonework, then the finished surface would be on a different plane to the latter. This would result in additional labour in forming a stop end abutting the finer finish as well as having an unsatisfactory appearance. There is little evidence of projecting thresholds, as can be seen in the bath house suite in the *praetorium* at Chesters, where projecting thresholds were formed so that the face of the threshold was equal to the finished plaster face. However, it is quite probable that the walls to the *aedes* and flanking rooms were plastered. Collapsed wall plaster was seen at Wallsend in the room to the east of the *aedes* in phase 1 (Hadrianic), and in the easternmost room to the rear range in phases 2 and 3 (site archive). Evidence of plastered and painted walls was seen in the *aedes* to the Trajanic *principia* at Caerhun (Kanovium Excavation Committee 1938, 46). Plaster was also seen in four out of the five rooms to the rear range of the later stone fort (ibid., 76).

The early third century strong room at Benwell was seen to have rendered walls in a coarse cement $1^1/_2$ inches (38 mm) thick, with the east wall still retaining some surface distemper of a plain wash in a bluish white (Spain 1929, 127). The interior of the vault was filled with a loose conglomerate of soil, small stones and lime which could have been used in wall plaster. Considerable quantities of coloured wall plaster were found on the walls of a probable early third century strong room at Rudchester (Brewis 1925, 102). At the outpost fort of Bewcastle the walls to the strongroom were of fine painted cement with the floor finished in a coarser cement; the junction between the floor and walls was finished with a clumsy quarter-round fillet (Richmond *et al.* 1938, 206). The use of painted plasterwork in strong rooms in these instances would support its application, in some if not all of the rooms in the rear range.

The formation of short lengths of plinth courses, to either side of the openings into the courtyard at Chesters, could suggest the use of applied surface decoration in association with them. The plinth courses return for approximately 500 mm to either side of the openings, with the exception of the main entrance in to the courtyard where it is 940 mm. It is possible that these short lengths of plinths were reflected in a band of decorated coloured render applied to the stonework above.

The use of limewash on the masonry has been suggested in chapter 2.2. It is quite possible that this was applied to unplastered walls internally and externally, so providing a shelter coat to protect the masonry, whilst at the same time adding colour to the otherwise drab buildings.

Notes

1 The make up levels below the floor were seen to be laid on clay (T. Wilmott pers. com.). It is therefore apparent that any top soil or turf north of the Wall ditch had been removed, or else the foundation was laid on a mass of clay overlying any earlier fort.

2 The authors question the Hadrianic date of the *principia* to stone fort 1 (Birley, Blake, Birley 1998, 8).

3 Robertson found the plan of one building in the central block, seen during the excavations of 1962-7, to be so unlike that recorded by Barbour that, 'the 1895 Report and Plan as they stand offer little help in elucidation of other buildings in the central block'. It would seem therefore only reasonable to record the probability of buttresses to these buildings.

4 See glossary for a definition of dead and live loads.

5 The photograph is a print of a glass plate being one of many found in the basement of the Department of Archaeology in its former premises in Saddler Street. The plates showed many Wall buildings and views taken around *c.* 1878 by an unknown person, possibly with initials R. J. V. The slides are now in the University of Durham, Palace Green Library.

It is significant that the two voussoirs now positioned to the north of the strong room are shown close to the arcade, and are probably more likely to have come from there than the *aedes* or flanking rooms.

6 The likelihood is that the panel is incorrectly positioned, with the wider margin intended to be placed in the reveal.

7 This compares to *c*. 2.000 m in many of the Syrian examples, and as the span is also usually less than examples *per lineam valli,* both factors could reflect on the better timber supply found in Britain.

8 Broken clay tile was seen to have been used for wall foundations and bonding courses in London west of the Walbrook. (Perring *et al.* 1991, 68).

9 This could be an area where future research could be focused, as it should be possible to quantify and contrast the amounts of sand in various contexts.

3.4.2 The Granaries

3.4.2.1 Foundations, Masonry and Openings

Foundations

The foundations to the external and central walls to the double granary at Wallsend were formed of clay and irregular sandstone pieces, and were seen to be *c*. 1.000 m deep. However, the sleeper walls were constructed on purely nominal foundations. The position of the portico to the south of the building would appear to have been in some doubt at the time the foundations for the bases were formed. Linear foundations *c*. 1.900 m long by *c*. 1.000 m wide were formed, so allowing considerable latitude in the placing of the foundation stones, 910 by 910 mm, away from the building[1].

Simpson and Richmond (1941, 19) describe the foundations to the double granary at Benwell as follows: `Behind the steps came the clay and rubble foundations of the walling, pitched herringbonewise, and then a flagged floor which once carried the ventilating system of the building. The flagging rested upon a mass of yellow clay and pitching over 2 feet deep, a provision which occurred at all points in the building and is thus not to be interpreted as terracing but as true foundation-work`.

A watching brief in 1990 (Holbrook 1991, 41-5) confirmed that a flagged floor was laid to the southern half of the eastern granary, and that this was laid on 350 mm of clay bonded rubble. Foundation trenches for the sleeper walls were seen to be 300-600 mm wide and of approximately equal depth (ibid., 43 fig. 3), being filled with angular rubble or crudely worked blocks set in stiff clay. These foundations, as well as those for the lateral dividing wall to the east granary, were cut into levels below the floor make-up deposit. As the flagged floor was 500 mm above the top of the foundations for the sleeper walls, it seems likely that it was designed to be a solid floor and not a foundation for sleeper walls for a ventilated floor (ibid., 43).

The single granary at Halton Chesters was seen to have been `founded on a massive stone raft of flagging laid on clay, itself resting on packed broken limestone' (Taylor, M. 1961, 164). A stone kerb was seen to retain the clay and stone raft foundation, and in one instance to the west, the buttress was built off the edge of the kerb. The stone sleeper walls were seen to have been built off the flagging (unpublished site archive).

Similarities have been drawn between the granaries at Benwell, Rudchester and Halton Chesters (Breeze and Dobson 1991, 76). Although dimensional similarities exist, and these have been discussed in an earlier chapter (chapter 3.2.5), no similarity can be seen in the known foundations; the excavation record from Rudchester is such that nothing is known about the foundations. A fundamental difference can be seen between the foundations of Benwell and those of Halton Chesters. In the former, foundation trenches were cut and filled with material to receive the external walls and internal sleeper walls; in the latter a raft of stone and clay was laid below the external walls and sleeper walls, which in turn were built off it.

The north granary at Birdoswald would seem to have been constructed off levelled ground, as no foundation trenches were apparent to any of the walls (Wilmott 1997, 111). However, foundation trenches were seen for the southern granary (ibid., 111); that for the north wall was 100 mm deep being made up with stones and clay, whilst the south wall was provided with a shallow foundation with a similar fill. The foundations were stepped, those to the south wall being 390 mm lower than those to the north wall. The buttresses to the south wall had no foundations, and were built directly off the peat sub-soil. The excavator observed that the backfilling of the trenches was always from outside the building. This made it possible for the external walls to be built against the inside edge of the foundation trench.

The foundations to the third century granaries at South Shields show general consistency, and there is no doubt they were erected at the same time (Gillam and Dore 1979, 41). The foundations, which are of minimal depth (pers. com. P. T. Bidwell), are made up of clay and cobble with, in places, a footing of small stone slabs. The foundations of the west wall of granary C 1 were seen to be also those of the westernmost longitudinal sleeper wall. The foundations of the south wall were seen to equal the width of the walling bearing on it.

Masonry

The walls to the granaries are generally constructed of well mortared, squared stonework; the quality of work is not always consistent with the Severan granaries at South Shields being built to a poor standard. At Housesteads a small section of wall to the south and east elevations about the south-east corner is built to a markedly higher standard (pl. 26). This section is at the lowest level of the building, which implies that it was the first part of the granary to be completed, and is made up of a much larger finely pitched masonry than the later stonework. At the south-east angle itself, three courses of quoins have been laid. The implication is that the building was commenced by a construction gang working to a high standard, who were superseded by a gang working to lower standards, perhaps following a change in policy[2]. A straight joint can be seen in the external wall to the east elevation adjacent to the north-east corner to the north of the later buttress. No explanation can be offered for this unless it is connected with the building of the buttress adjacent.

Whilst it can be seen that the external walls of the *principia* are generally of consistent width, this does not apply to the granaries. Two broad divisions can be seen with the thickness of the external walls falling to between 770 - 900 mm and 1000 - 1200 mm. In the former are the granaries at Wallsend, Halton Chesters, Rudchester, Housesteads, probably Benwell and South Shields (A5 mid-Antonine). In the second group are those at Carrawburgh, Birdoswald and South Shields (Severan). It is suggested that the greater width of the external wall could have been caused by the requirement to introduce an upper floor, with the consequential increase in the height of the building. If this assumption is correct, it is likely that there was an offset course to coincide with the bearing of the first floor structural timbers, and a subsequent reduction of the external wall at this point. Examples of reducing courses at an upper floor level are rare due to the extant amount of upstanding masonry; a precedent can be seen in the Colosseum and it was a common detail in medieval architecture[3].

The buttresses, in the majority of cases, can be seen to have been constructed at the same time as the external wall and are fully tied into it. In some instances, as at Housesteads (see chapter 3.2.5), it is possible that some buttresses were added at a later date. There is no reason to doubt that the form of the buttresses followed those of the later medieval period, and that the top was splayed to throw off rainwater. It is quite likely that some of the buttresses with large projections (i.e. Carrawburgh with a 1.200 m projection), included one or two intermediate steps, with splays, over its height. Stones with a splayed face have been found at South Shields in a late fourth century context within a barracks formed out of a Severan granary (Esmonde Cleary 1997, 416). This series of stones are *c.* 250 mm deep by an average of 250-300 mm wide and 100 mm high, with a splay on the face of 60-65 degrees (site archive). If these stones formed the capping to a buttress, then two stones would have been set side by side, with masonry built up behind it bonding into the external wall. Several courses would have been required to complete the splay. A large number of similar shaped stones were found in the alley between the two granaries at Birdoswald (Wilmott 1997, 129-30), which could have come from the buttresses on the south side of the northern granary. The average measurement was 280 by 220 by 170 mm which is very similar to those seen at South Shields. All were very weathered and the distinction between chamfer and fillet was unmeasurable (ibid., fig. 96 no. 4).

Openings

A double door was formed in the gable wall of the granary to provide access from a loading platform into the building. At Housesteads both the north and south doors to the west elevation, 2.030 m and 2.430 m wide respectively, are spanned by a stone threshold, 500 mm deep, with a central joint and upstand 100 mm wide by 60 mm high, with pivot holes and trackways set to each side (pl. 27). A threshold 810 mm deep is positioned at the east door to the south granary at Birdoswald, and a rebate 540 mm long by 60-80 mm wide and 6 mm deep is cut into its upper face 150 mm from the edge. A pivot hole 70 mm diameter is positioned 20 mm to the inside of the rebate, which is set back 120 mm from the external face of the outside wall (pl. 28). A similar rebate is cut in the threshold to the west door; the threshold is 1.040 m deep and the rebate 650 mm long by 60 mm wide and 30 mm deep, with a 70 mm diameter pivot hole set on the inside. A pivot hole can also be seen to the outside of the rebate and conjoins it, this is interpreted as a later addition. The rebate to these two doorways would have housed a stone lining to the opening, being positioned so as to cover the pivot and the outside edges of the doors, which were set behind it, as a means to enhance the security of the building.

Vents were formed, and generally positioned centrally between buttresses where a raised floor was formed; they were not always symmetrically opposed. At Housesteads the vents are *c*. 230 mm wide externally, splaying out to *c*. 400 - 450 mm internally, by 5 or 6 courses high (750 mm maximum). The opening is spanned by lintels the same depth as the coursed stonework on the inner and outer faces. At the later granaries of Birdoswald, the vents to the north are five courses high (720 mm), whilst those to the south are four courses high (620 mm). The width is 800 mm with a minimal internal splay. The vents to the Severan granaries at South Shields vary in width externally from 150 - 280 mm, with the internal width of the splayed openings being 250 - 400 mm; in most cases the vents oppose each other symmetrically.

It has been suggested in an earlier chapter (3.1.4) that the form of the vents below floor level was mirrored at a higher level. Support for this suggestion comes from the period 1 (130-140), granary B1 (west granary) at the fort of the *Classis Britannica* at Dover. Philp (1981, 32) found evidence of a vent in the internal face of the west wall at a height of 2.000 m, with its base being some 1.000 m above the postulated floor level. The vent splayed up through the wall at about 45 degrees, and was 300 mm wide externally and 400 mm wide internally. There was a slight trace of an *opus signinum* applied internal finish.

It would seem sensible that some form of louvre would have been placed within the vent openings, especially at low level, to keep out vermin. From the granaries at Gellygaer quantities of an *opus signinum* fillet were seen below the vent openings (Ward 1903, 64 and fig. 12). This fillet could be interpreted as having filled the gap between the stonework and a timber frame.

An arcade with seven openings was formed between the two halves of the Hadrianic granary at Housesteads. Square bases (appendix 4 B) would seem to have supported simple splayed capitals (appendix 4 A). Although the present position of the bases is such that the spaces between them are irregular, it is considered that they would have been set out equidistant, with an arcade width of *c.* 2.900 m.

3.4.2.2. The Floors

The solid floors in all known cases were formed of flags laid on a bedding of clay and stone. The majority of the suspended floors to the known granaries were constructed with stone sleeper walls supporting stone flags. The granary at Housesteads and the mid-Antonine building at South Shields form the exceptions to this, as it is suggested that timber joists were supported on stone *pilae*.

At Wallsend three sleeper walls 800 mm wide and 500-600 mm apart, run the length of the building (site archive). The transverse sleeper walls in the northern part of the eastern granary at Benwell are not extant, but the foundations were seen to be 300-600 mm wide set at intervals of 500-1.600 m, with 1.000 m being the norm (Holbrook 1991, 42). At Halton Chesters fourteen transverse sleeper walls were constructed at the southern end of the granary for a distance of *c.* 13.000 m from inside the sleeper wall[4]; seven walls were formed in the northern portion running the length of the building. The width of the walls in the southern section was 410-500 mm and they were seen to have been built off a flagged floor (site archive). By calculation the distance between the walls would have been *c.* 500 mm. The late granaries at Birdoswald had a central sleeper wall butted against the inside of the gable walls (Wilmott 1997, 119-20). Midway between the sleeper wall and the external wall was placed a row of timber posts set in a prepared trench. An offset was formed to the inside of the external wall to receive the floor; the offsets were at the same level as the west door in the southern granary. The floor construction to the Severan granaries at South Shields is consistent in its form and comprises four longitudinal rows of sleeper walls 490-620 mm wide (pl. 29). The lengths of the walls are broken on the line of the external wall vents, and a gap is formed at that point in the sleeper walls across the width of the building *c.* 350 mm wide, to ensure full ventilation of the underfloor void.

The arrangement of the supporting sub-structure to the granaries at Wallsend, Halton Chesters and South Shields allowed a simple, strong and economic floor to be constructed. The distance apart of the sleeper walls of around 500 mm allowed stone flags of a minimal thickness and weight (min. 50 mm) to be laid. The arrangement at Halton Chesters, and possibly Benwell, where the sleeper walls were built off a flagged foundation, gives rise to the suggestion that the raised ventilated floor might be a later alteration, as there is no reason to construct the foundation in this extravagant way. It is possible that a full assessment of the site archive might clarify this point. Although there is no evidence to suggest that timber floors were formed, it is significant that at the Welsh stone forts of Gellygaer and Penydarren, where transverse sleeper walls were constructed, timber floors would appear to have been used (Johnson 1983, 147).

The arrangement of the sleeper walls at Benwell, where they are set at an average distance of 1.000 m, apart is somewhat unusual. This greater distance is easily spanned by stone flags but their thickness and weight would have been much greater and consequently they would have been much more difficult to transport and lay[5]. The wider spacing of the sleeper walls can be seen as a fundamental difference between the granaries of this type. Much has been made of the inscription found in the remains of the granary at Benwell, from which it is inferred that it was constructed by the *Classis Britannica* (Simpson and Richmond 1941, 19-21; Breeze and Dobson 1991, 65). Philp (1981) has shown that the period I granaries (B16 and B17) at Dover, the headquarters of the British Fleet, were constructed with timber floors; in both cases most probably bearing on chalk-block piers. It is possible that the construction gang, made up of the Fleet, was unfamiliar with sleeper wall floor construction when it came to build the granary at Benwell, and placed the walls farther apart than normal. Consequently, when the construction of the floor commenced they would have had much greater difficulty in cutting and laying the larger size flags necessary to span the required distance.

The late granaries at Birdoswald follow an unusual form of construction and include an element reminiscent of the floor construction of earlier timber granaries (Marvell and Owen-John 1997). Whilst it has been suggested that the purpose of the central stone sleeper wall was to offer some support to a first floor (Wilmott 1997, 137), the construction of timber intermediate floor supports between the sleeper wall and the external wall, is unusual. The intermediate support was made up of a row of timber posts 300 mm diameter at centres of possibly *c.* 1.200 m minimum (ibid., 119, fig. 82). The span either side of the posts was *c.* 1.300 m. There can be no doubt that the row of timber posts was meant to act in the same manner as a stone sleeper wall, and it is likely that the posts supported a timber joist. The difficulty in interpreting the construction of this floor is that a span of some 1.300 m is greater than one would expect to be economically spanned in either timber boarding or stone flags, without intermediate support. A further problem arises in that as the same amount of floor loading is being shared by the central sleeper wall on the one hand, and a series of timber posts on the other, differential settlement would almost certainly have occurred. Whilst it is easy to devise a system whereby the span is split to an economic distance, this would not seem to work in with the known levels at the door threshold, and would have resulted in the formation of a step.

Known examples of granaries where the floors are supported on the stone *pilae* are few. Apart from the examples of Housesteads and South Shields (pl. 30, 31), the east granary at Dover (Philp 1981, 33, fig. 13) offers probably the best known comparable floor construction. The building at Hardknott has a central row of *pilae*, whilst at Ribchester two granaries of different floor construction were seen (Hopkinson 1928, 14, 15 & pl. III). Here the north granary had a central spine sleeper wall with a row of *pilae* between it and the external walls. Pieces of charred wood were seen among the layers of charred corn suggesting a timber floor (ibid., 14). However, the earlier report (Garstang 1898) refers to stone flags covered by a pile of grain, timber and roof tiles. The south granary floor was supported on two rows of sandstone *pilae* 1.520 m apart and 760 mm from the external walls. Flags from 75 mm to 200 mm thick were seen, many portions of which were still found more or less in position. (ibid., 15). Pieces of charred wood were also found which could have come from the roof. The evidence from this last granary shows that flags of great thickness and weight were used to span between the *pilae*. In this case it could be assumed that the greater thicknesses were used for the larger spans and the lesser thicknesses for the shorter spans. The north granary at Birdoswald, during phase b, had two rows of *pilae* either side of a central sleeper wall.

The floor supports to the Hadrianic granary at Housesteads was made up of six stone *pilae,* to each side of the central spine wall supporting an arcade, in twenty one rows; a *pilae* was set against the external walls and spine walls. The *pilae* were set laterally at 970 mm - 1.180 m and longitudinally at 1.010 - 1.430 m (1.200 mm median) centres. The floor to the mid-Antonine granary at South Shields (A5) was made up of four *pilae* positioned to either side of a central wall and fifteen rows; a *pila* was set against the external walls and the internal wall. The *pilae* were set out laterally at 1.170 - 1.320 m centres and 870 - 940 mm longitudinally, and in both granaries the lateral dimension across the width of the building is the greatest. The spacing of the *pilae* is too great for a stone flagged floor to be economically laid.

The floor construction to the later altered northern granary block at Housesteads was of timber joists, supported on five rows of stone *pilae*. The joists bore on *pilae* set against the external wall, and were set in shallow pockets formed in the inside wall of the northern granary only, which was built against the line of central columns of the earlier phase. Bosanquet (1904, 236) records that the supports to the floor to the southern granary consisted of parallel dwarf walls. He also considered that the floor finish probably consisted of stone flags. It is now established that the floor to both north and south granaries was similar, the floors being of timber joists supported on stone *pilae* (Crow 1995, 52).

It is suggested that the floor of the Hadrianic granary used the same method of construction as the remodelled granaries. The *pilae* to the northern granary are set out in five rows, with *pilae* being set against the external wall to the north, east and west. Whilst it must be accepted that there has been some disturbance in the positions of the *pilae*, particularly to the western section, it is suggested that the existing *pilae* show the general intention and position of the original builders. It is significant that the lateral spacing of the *pilae* adjacent to the later inner external walls (of the later granary) are less than elsewhere. It can also be seen that these later walls were built against and over the bases supporting the central row of columns (Crow 1995, 52). The ends of reused *pilae* can be determined, forming the lowest courses of the two walls (pl. 32); a total of *c.* 25 *pilae* can be seen in both granaries. The distance between the innermost *pilae* and the external wall to each of the remodelled granaries is *c.* 4.090 m; assuming three intermediate rows of *pilae* between them, this represents centres of *pilae* to the original granary of *c.* 1.022 m, which compares favourably with those existing. It is proposed therefore, that the Hadrianic granary was constructed with 13 rows of *pilae* supporting the floor joists; however, it might have been possible that a sleeper wall was built on the line of the centre of the colonnade, rather than a row of *pilae*.

A complication arises in that on the line of the twelfth row of *pilae* from the east in the later northern granary, a step in the joist sockets occurs. This step of *c.* 100 mm must have been reflected in a step in the floor level; it is significant also that the centres of the pockets are reduced at this point to *c.* 850 mm.

The floor to the primary and remodelled granaries would almost certainly have been constructed with two layers of joists laid at right angles to each other[6], and finished with stone flags (fig. 50). A floor of this construction would be extremely strong and stable. If a single row of joists was placed across the *pilae* it is possible that movement of the timbers could occur, making a floor covering of flags uneven. It would also be difficult to level the joists when they were being fixed. Two layers of joists would tend to average out movement in the timbers and would enable packing below the joist to be more securely fixed. The provision of two rows of *c*. 300 mm deep joists at right angles to each other, and a *c*. 50 mm stone flag would bring the floor level above the height of the vents on the north side of the building. This would also tie in with the dimension of *c*. 370 mm being the distance of the bottom of the westernmost wall pocket below the door threshold. The level of the stone foundation bases supporting the column bases on the central arcade is 610 mm above ground level, and the top of the easternmost northern vent is 750 mm above ground level. The depth of the stone flag and bedding on the central bases would have needed to be *c*. 200 mm, so as to line up with the flags on the floor joists. It is significant that all the stone column bases to the central line of columns were unfinished towards their lower edge, as this would have been concealed by the depth of the flags and bedding making up the levels.

The double granary at Wallsend had a clay floor to the primary western part of the building. In the surface of the floor was seen a wider dark band running east-west approximately one third down the length of the building, from the north end. The band was 300 mm wide at its west end and 1.300 m at the east. It is thought that this could be a partition which was cut into the floor surface (site archive).

3.4.2.3 The Roofs

The roof structure to the granaries can be divided into three distinct types. The first includes the single granaries with the thinner walls and greater clear internal spans, and includes Rudchester (7.010 m) and Halton Chesters (est. 9.020 m). The second type is shown in the single granaries with thicker walls and small clear internal spans, Birdoswald (6.000 m) and South Shields (Severan) (4.190 - 4.890 m). The third type are the double granaries with an internal dividing wall as seen at Benwell (*c.* 17.380 m), Wallsend (9.850 m), Housesteads (13.160 m) and South Shields (13.880 m). The three types will now be considered:-

Type 1

The combination of the thinner longitudinal external walls and the greatest span implies the use of a truss (fig. 52). This assumption is based on the span being too great for a close couple rafter to be used, and also that the truss form with its equalised forces used with purlins and boarding would exert the minimum lateral thrust at the top of the walls. A comparison of the wall thicknesses and spans show similarity with the cross-hall of a *principia*. It is unlikely that a first floor would have been introduced into this type due to the thickness of the external walls.

Type 2

The use of a reduced span and thicker walls suggests the use of a close couple roof as the span does not warrant the construction of heavy trusses with the attendant difficulty of erection (fig. 42). The form of the close couple roof with spars running from ridge to eaves could contribute to some lateral thrust from the spar feet with lateral forces being exerted at the top of the wall, resulting in the outward movement of the wall. The thrust would be caused by the spreading of the rafters due to inherent failure in the fixings to the tie. The situation would be exacerbated by the absence of any cross walls giving any lateral tie. The thicker wall also suggests the introduction of an upper floor and the introduction of an offset in wall thickness at that point. (Wilmott 1997, 137) suggests that the spine sleeper wall at Birdoswald is suggestive of a first floor and further states that, `a timber floor would have required central support`. This need not have been the case as the medieval west range at Whalley Abbey[7] (a building very similar in form to the granary), had a ground floor *cellarium* 7.010 m wide, which was spanned at first floor level by a series of joists set on an offset 300 mm wide in the external wall; the external walls at ground level were 1.370 m thick. The presence of a central support, as has been observed in chapter 3.1.4, would have restricted the use of the building.

Type 3

The roof to this type probably took the form of a principal rafter and tie bearing on the external wall and the central wall at mid span and supporting purlins; some form of bracing is likely to have been used (fig. 41, section y y). The centres of the supporting members could have been *c*. 2.000 m. The clear spans are considerable, particularly at Benwell (7.310 and 6.870 m) and are at the limit for this type of roof[8], due to the availability of timber. The alternative roof form for this type of building with an internal dividing wall would be a trussed roof formed over each half of the building as discussed in chapter 3.1.4 and shown in fig. 41, alternative section y y. This arrangement is discounted due to the high probability of water penetration, and the essential need to keep foodstuffs dry.

The covering to all the structural timbers is almost certainly boarding covered by clay roofing tiles. A suggestion has been made that timber boarding was used below the covering to the granary roofs at Birdoswald (Wilmott, 1997, 131). However there was no evidence on site to support this (pers. com. T. Wilmott).

3.4.2.4 Buttressing

The purpose of the buttresses to this building type has been discussed at some length by many writers, and their conclusions are summarised by Wilmott (1997, 137-8). These are also briefly discussed in chapter 3.1.4.

It is likely that a roof truss was placed on the line of the buttresses in granaries with the type 1 roof form. The known two granaries in this category, Rudchester and Halton Chesters, have buttress spacings at *c.* 3.810 m and *c.* 3.600 m respectively, with the buttresses opposing. This spacing of the roof trusses is wider than that suggested in the *principia* (chapter 3.4.1.2), although it is possible that there were intermediate trusses.

In the case of Wallsend the buttresses do not oppose, there being nine to the east elevation and ten to the west. This configuration denies the use of a conventional trussed form of roof, and supports the application set out in type 3. In this form with the principal rafters being set at *c.* 2.000 m centres, the position of the buttresses is immaterial. The same circumstances would apply to the type 2 close couple roof.

The buttresses can have had no part in supporting the roof for, with a truss or principal rafters and ties supporting purlins, it would have been pointless to extend the span on each side of the roof to bear on the buttresses themselves[9] (Gentry 1976, fig. 1). Apart from requiring considerable additional building materials, it would have necessitated the use of longer timbers which were almost certainly in short supply.

The only plausible explanation for the provision of the buttresses is to counter the lateral thrust of the roof, and to prevent outward movement of the walls caused by the lack of lateral tie or possible settlement. It is probable that the height of the longitudinal walls was significant, bearing in mind that the floor level could easily be 1.000 m above ground level, and it is possible that an eaves height in excess of 6.000 m was achieved. It is also likely that the maximum recommended slenderness ratio[10] of some of the thinner walls would have been exceeded without the use of buttresses. The height of the walls would also have a bearing on the rate of any movement in relation to any lateral forces. A calculation is included in appendix 5.B which shows that the south granary at Birdoswald, assuming a first floor and an eaves height of *c*. 5.300, would be stable without the addition of buttresses.

There is no doubt that the Roman builders were aware of the movement occurring to external walls and took steps to counter it by the insertion of buttresses; a course of action apposite today. An example of this can be seen in the period 4 *principia* at South Shields (Bidwell and Speak 1994, 71), where buttresses were added to the rear range. The probability was that the buttresses were built due to the occurrence of past movement in the longitudinal walls at other granaries, and the builders were simply not taking any chances, and were incorporating buttresses into the initial design.

3.4.2.5 Wall Finishes

The question of wall finishes, internally and externally, must clearly be a matter of conjecture. As mentioned in chapter 3.1.4 Columella advocated the internal plastering of granaries to discourage weevils and vermin. There must be a strong possibility that the interior of a granary was plastered, or at the very least whitewashed, in view of the importance the Romans gave to food storage.

Wilmott (1997, 119) found that the mortar which had been applied to the granary walls at Birdoswald had been liberally applied and covered the greater part of the walling stones. The impression gained was that lime mortar had been liberally applied with a trowel, and then brushed over the face of the masonry with a stiff brush. The result was that mortar filled the joints and irregularities of the stonework, creating a flush surface made up of lime mortar and limewash. There is no other evidence of wall coatings applied to granaries *per lineam valli*.

Notes

1 Pers. com. W. B. Griffiths

2 A similar situation can be seen at Birdoswald where the quality of the initial work far exceeded that of the later (Wilmott 1997, 56-60).

3 The use of the offset in a wall thickness was widespread in medieval construction and can be seen in monastic and secular buildings.

4 The first transverse sleeper wall to the south was built up against the inside of the external wall. Transverse sleeper walls have only been identified at the forts of Benwell and Halton Chesters.

5 The weight of a sandstone flag 62 mm ($2^1/_2$ inches) thick, spanning between two sleeper walls 1.000 m apart with a 150 mm bearing at each end, 600 mm wide, would be 118 kg (261 lb.). As stone has a low tensile strength the thickness would have had to be great enough to withstand reasonable impact from the foodstuffs being stored. By comparison the weight of a sandstone flag 50 mm (2 inches) thick spanning between two sleeper walls 500 mm apart with the same bearing and width would be *c*. 63 kg (139 lb.). These weights are for illustrative purposes as it is likely that the flags were considerably thicker.

6 This form of construction with timber joists laid and fixed at right angles to each other, is described by Vitruvius (7.1) and Faventius (Plommer 1973, 67-68) for the laying of pavements on a wooden framework.

7 The dimensional data was acquired as the result of a survey by the author.

8 The roof timbers to the west granary at Benwell, with an internal clear span of 7.310 m would have been considerable. The tie would have been in excess of 8.000 m long and the principal rafters of 9.000 m.

9 In traditional building practice, for a building of this type, the truss bears on the external wall for an ideal minimum of *c*. 300 mm, with the external face of the stonework being built around the end of the tie. If buttresses are used they probably do not rise as high as the truss bearing, but are usually set on the line of the trusses.

10 The slenderness ratio is the ratio of the effective height and the effective thickness of a wall, and for a wall to be stable, the ratio has to fall within prescribed limits. Lateral ties including roof construction, buttresses and window openings are taken into account. The ratio is calculated in accordance with BS 5628 : Part1 : 1992.

3.4.3 The Gates

3.4.3.1 Foundation, Masonry and Openings

Foundations

From the somewhat limited evidence of the foundations to the gates, it is clear that strip foundations, as opposed to a raft foundation, were used. In almost all cases strip foundations were found beneath the walls to the guardchambers and the *spina,* together with the responds. The decision to construct forts astride the Wall, with the east and west gates positioned forward of the Wall, created foundation problems for the east and west gates, as the north guardchamber invariably coincided with the Wall ditch.

The foundations to the north guardchamber to the east gate at Halton Chesters are extremely substantial (pl. 33). The bottom of the wall ditch is filled with two courses of pitched stone. On top of this are built seven courses of stonework, each course being offset above its lower course. This occurs to all the external elevations, as well as the internal elevations of the guardchamber. The lowest three courses span the full width of the ditch and are set into the ditch side. Walling is built up from the side of the ditch between the south wall of the guardchamber and the eastern end of the *spina*, to the north and south elevations. The foundations to the north guardchamber to the west gate are equally substantial (pl. 1). The bottom of the ditch is filled with three layers of large pitched stone but, unlike the east gate, the stone does not fill the whole of the bottom ditch, but stops short on the line of the walling to the south side of the guardchamber. The pitching to the south-west corner is poorly laid. On top of the pitching are five courses of offset masonry, which can be seen to the west and south elevations to the guardchamber, as well as the inside elevations. This masonry does not seem to have been laid to as good a standard as the east gate, as it swings into the south-west corner on the west elevation with the offset to the top course reducing to nil. No excavation has substantiated similar foundations to the east and west gates at Rudchester and Chesters. However, the likelihood is that a similar form of construction was used in the Wall ditch.

The north guardchambers to both the east and west gates at Birdoswald are built over the Turf Wall ditch. From limited excavation it was found that the ditch below the north guardchamber floor to the west gate had been filled with a deposit of hardcore, some pieces as large as 200 mm. It was not possible to confirm that the foundations of the walling to this gate were built up from the bottom of the ditch in offsets, as was the walling to the north guardchamber to the east gate (Gillam 1950, 65). During the course of the excavation of this guardchamber a series of offsets was seen within the inside of the guardchamber itself. The foundations to the west gate were unusual in that strip foundations were laid below to walls to each guardchamber, and on the line of the front and rear portals and *spina*. The form of the foundations represented the outline of four conjoining rectangles (Wilmott 1997, 55, Fig. 27). The strip foundations, made up of large sandstone slabs quarried from thinly bedded material roughly dressed to size, were bedded in hard, pebbly-orange clay. It was seen that the rampart wall and gate foundations were of one build.

Foundations to the south-west and north-west gates at South Shields were formed in the usual way; although the natural ground sloped across the line of the gate. The foundation to the *spina* to the south-west gate was 500 mm deep, and made up of two courses (Bidwell and Speak 1994, 113). The lower course was largely made up of large and small cobbles in a clay matrix, above which was laid a layer of clay 50 mm thick in which were bedded irregular sandstone fragments, *c*. 200 mm by 200 mm by 200 mm. The foundations to the south-east guardchamber were terraced to a depth of 350 mm into the ground. On this level base were laid the foundations made up of two courses. The lower course was made up of small cobbles bonded with clay, with large stones set around the edge of the trench, and an upper course of cobbles 250 mm deep. The foundations to the south-east wall were 300 - 400 mm deep and consisted of a lower course of large cobbles bonded with clay. Those to the north-west guardchamber were *c*. 500 mm in depth and made up of clay and cobble. Due to the slope of the ground the foundation was in some places built above natural ground level. The foundations to the north-west gate (Dore and Gillam 1979, 13) were formed on sloping ground. In all cases the foundations were made up of clay and heavy cobble; those to the south-east guardchamber being *c*. 150 mm deep.

Masonry

The portals and guardchambers are constructed with masonry finished to differing standards. The stonework to the gate portal responds and voussoirs to the front and rear elevations has a pitched finish, usually with chisel drafted margins; many of these stones are very large, with the bed joints being unmortared. On the other hand, the stonework to the guardchambers is the usual squared mortared rubble hammer dressed masonry, set on one or more offset courses. This quality of masonry was used for the walling between the gate passage responds, and almost certainly above the voussoirs to the portals.

The foundation courses to the responds to the portals of all the forts are substantial and form the basis for the setting out of the masonry of the gates. These six bases also usually house the bottom pivots for the gates. From the little masonry that remained unrobbed at Wallsend, one stone of a foundation course to the north *spina* of the north gate remained extant. The upper surface of the stone was smoothly dressed and showed continuous incised setting out lines to two external edges. From indentations in the ground, it could be seen that the foundation for this *spina* was made up of eight individual stones set side by side[1]. Similar bases were seen at Rudchester (Brewis 1925) where the foundation course to the responds to both elevations of the *spina* of the south gate were made up of large flat stones. The foundation course to the south end of the *spina* was made up of five large flat stones; the western one still retained the pivot socket hole, whilst the eastern one appeared to have been broken off, possibly when a new pivot socket stone was inserted. There was a continuous setting out line across two stones to the base to the south of the *spina*. The pivot socket to the east portal at its north end had been cut very close to the edge of the foundation course. The foundation course to the western end of the *spina* to the west gate appeared to have been made up of two very large stones. The pivot sockets seem to have been cut close to the inner edge of the outer stone with a trackway leading to the northern one. A continuous setting out line was cut into the western edge of the outer stone.

The north end of the *spina* to the north gate at Halton Chesters was made up of two stones set side by side. Only the easternmost stone remained which was 790 mm wide by 1.540 m deep. A 100 mm diameter well-worn pivot socket hole was extant, served by a right angled trackway; a piece of stone within the trackway had broken off. The foundation course remained for the north-western respond, which had a continuous setting out line cut into its eastern side. A worn pivot socket hole was extant with a right angled trackway broken off. The east end of the *spina* to the east gate was made up of two large stones set side by side, 1.550 m deep by 1.680 m wide overall. Continuous setting out lines were cut into the upper surface on the south, east and north edges. Pivot sockets, well worn, were cut towards the western edge, one right angle and one curved. Similarly the foundations to the north guardchamber to the west gate were equally substantial. The west end of the *spina* was made up of a foundation course of two large stones set side by side, 1.370 m wide. Two pivot sockets had been cut into its upper surface with a right angled trackway. A continuous setting out line had been cut close to the western edge.

The foundation courses to the responds to the four main gates at Chesters are largely made up of single massive stones, although two stones were used in some instances. The single stones vary in size from 1.620 m by 1.100 m by 180 mm thick to the north *spina* of the north gate, to 1.020 m by 1.870 m by 180 mm thick to the west *spina* of the east gate. The weight of the majority of the bases is in excess of three quarters of a tonne. Of the extant pivot sockets, those to the north gate two have curved trackways, to the south gate one with curved trackway and to the west, three with two curved trackways and one straight. There are several examples of the foundation course having been cut away to insert a new pivot block (pl. 34), as at the north gate. Some foundation courses to the responds of the gates are set at a higher level to the inside, as can be seen at the north and south gates. Setting out points were cut into many of the foundation courses, and took the form of two incised lines 60 - 70 mm long, cut at right angles to each other, indicating the outer corner of a course and outside the line of the masonry (pl. 35).

The foundation courses to the responds[2] to the gates at Housesteads are made up of a series of largely rectangular stones, with a flat pitched upper surface; any irregularities being filled with smaller stones (pl. 36). Pivot sockets are extant in many instances with straight trackways formed in the foundation course. The position of the stonework to the responds and *spina* is indicated on the upper surface of the foundation course with a series of continuous setting out lines. At the south portal of the west gate, and the *spina* to the east gate, it can be seen that the width of the stonework was increased from the original proposals (pl. 36 & 37). The setting out lines to the west gate show that the original proposals did not include for the formation of a reveal and set back to the gate portals.

The foundation course to the inner *spina* to the west gate of Great Chesters is made up of four stones. The north respond to the south portal of the same gate has a pivot hole with no trackway. Continuous setting out lines are extant to the outer east respond base to the south gate. Large deep single stones form the foundation course to the responds to the outer south portal to the west gate at Birdoswald, with two stones forming the western respond to the *spina* (Wilmott 1997, 57, fig. 30). Similar single stones were seen in the same positions at the east gate (Howard 1972, 38, fig. 36). Pivot sockets are extant to the south portal of the west gate; no trackways are cut. The stone into which the socket is cut does not form the foundation course to the responds and differs from all other forts in this respect. The front edge of the stone forms the upstand to the gate threshold (pl. 38), the stone itself being lapped over the primary foundation block (Wilmott 1997, 60, fig. 36), possibly reflecting an error in setting out (ibid., 59). The pivot socket to the western end of the *spina* however, is cut into a foundation course (ibid., 59, fig. 33). The south respond to the south portal to the east gate bears on one stone, having a pivot hole with no trackway, whilst that to the north respond is made up of two stones, one having a pivot hole, which could be a later alteration. The east *spina* is made up of five stones with two pivot holes with no trackways to the responds. The foundation course to the two responds adjacent to the guardchambers to the south gate are in a single piece, being similar to the south portal to the east gate. The pivot holes are extant without trackways. The outer *spina* is set on three stones. The south-west respond to the south-west portal to the north-west gate at South Shields rest on a foundation course of a single flag (Dore and Gillam 1979, fig. 5, 13), with a pivot hole and no trackway. The responds to the *spina* were seen to be built off flat slabs (ibid., 13).

The excavation of the west gate at Great Chesters is fully described by Gibson (1903, 19-64). The excavator distinguished between the masonry of the north and south guardchambers. The stonework to the former is described as being built, `with small well squared stones exactly like those seen in the outer walls of the camp` (ibid., 29). The extant stonework to the latter, and portals of the gate, consisted of, `well squared and very massive stones, many of which pass through the entire width of the walls to which they belong` (ibid., 28), (pl. 40). The first course above floor level to the walls of the south guardchamber was constructed of very large stones which pass through the thickness of the walls, and are set in most cases above a course of headers, *c* 1000 m long. The first three stones of this course of large stones, against the inside of the rampart to the south elevation, are finely dressed with a pitched face, whilst the two adjacent stones to the east are roughly finished, and show evidence of only partial dressing to their upper faces. This course is not bonded into the rampart wall. The stonework above this course is of squared masonry to all elevations and it could be that the large stones were meant to express a plinth course. This course is not expressed in the north guardchamber. Two offset courses are visible to the west elevation below the course of large stones. It could be that the lower projecting course is a plinth course, similar to that seen at Housesteads. A similar detail where a course of headers was set below floor level on an offset course can be seen in the curtain wall to the guardchamber of the east (pl. 39), north (pl. 41) and other gates at Housesteads; these headers extend only for the length of the guardchamber. Gibson likens the masonry of the south guardchamber to the masonry of the early pier to the bridge over the North Tyne at Chesters. In view of the contrasting styles of the masonry, Gibson considers that the two guardchambers were built at different times (ibid., 29). He found a similar set of circumstances at the south gate where the east guardchamber was built of massive masonry, whilst the west gate was built of smaller stones (ibid., 38).

It is probable that a string course was built into the building at approximately first floor level. Evidence of a string cornice mould, which could have come from the gates, has been found at Housesteads, Birdoswald and South Shields (appendix 4 D). The string course from Housesteads was moulded.

Openings

Some considerable care was taken over the dressed stonework forming the responds and voussoirs to the gate portals. However, in many cases the unfinished nature of the work reflects haste, and much of the work is of poor quality.

Only one example of a chamfered plinth course is known and that is from the west gate at Halton Chesters (pl. 42). A length of finely finished masonry, set directly on the foundation course to the west face of the *spina*, has a chamfer formed on its outer face above a bottom margin. It is probable that the chamfered plinth ran across the face of the portals up to the return walls to the guardchamber. The quality of the work appears high, and can be compared with the extant ashlar stonework to the gateway to the *Vallum* crossing at Benwell.

Although there is no evidence of chamfered plinths to the masonry of the guardchambers themselves, they were seen at High House milecastle (MC 50) where a well dressed chamfer was seen to the piers to the north gate (Simpson, F. 1913, 317 and pl. LXIII fig. 1 opp. 327). Brewis recorded an unusual moulding on the Wall itself at Rudchester to the west of the west gate (Brewis 1925, 103). A plinth mould of a curved face with drafted margins above and below was seen some 3 metres from the fort. A further example can be seen in the extant masonry to Bank east turret (52a). Elsewhere a chamfered plinth was seen to the north gate of the stone fort of Balmuildy (Miller 1922, 17). This latter plinth is incompletely dressed on its lower face (ibid., plate VII A, opp 18), suggesting that the stone with its chamfered mould was dressed *in situ*.

The masonry, generally, to the responds to the gate portals is of large hammer-dressed sandstone blocks with some pitched face dressing and chisel drafted margins. Several of the stones are particularly large, as at Chesters and the west gate of Great Chesters, where many of the respond blocks pass through the thickness of the passage walls to the guardchambers, and are up to three courses high (pl. 3). Lewis holes can be seen cut in the upper surface of some of the stonework at Chesters. The masonry, which is unmortared, is block bonded with staggered perpends. Most of the stonework is formed with chisel drafted margins, with the centre portion of the stone finished to a greater or lesser degree. In many cases this central area of stone is only partially dressed suggesting that there was insufficient time to complete the work. Evidence that the stones were set in place prior to final dressing can be seen in many of the respond blocks. The north respond to the north portal of the west gate at Housesteads (pl. 43) shows an external face of pitched stone with fine chisel drafted margins with the edge of the original hammer-dressed stonework level with the return wall to the return passage wall to the guardchamber.

The hammer-dressed masonry, with chisel drafted margins, in stepped courses below the *spina* to the north elevation of the north gate at Housesteads is particularly fine; this was originally covered by the entrance ramp to the gate (pl. 44). The dressing of the stonework shows some variance, for example some of the hammer dressed masonry to the upper foundation course of the *spina* to the south gate has only a deeply cut upper margin. The stonework to the western gate is generally more highly finished than that to the northern gate. This phenomenon can probably be attributed to the lack of time given to finish the work off, and can best be seen in the northern elevation of the northern gate, where contrasting degrees of finish to the stonework can be seen to east and west of the portals. On the lowest course to the inside face of the inner *spina* of the north gate and the eastern and southern face of the western inner portal, can be seen masonry of high quality with a fine pitched finish (pl. 45). These lower courses of highly finished masonry, occurring below much less well finished work, can be seen elsewhere, viz., the granary, the *principia*, the *praetorium* and the probable hospital. Similar high quality work, representing a primary plan of construction work, was seen at Birdoswald (Wilmott 1997, 56-60), where the initial work was of high quality and the latter work much inferior.

The reveals to the inside of the outer portals, at Housesteads and Birdoswald, are formed out of large pieces of stone with a rounded internal angle (pl. 46). The masonry forming the rounded angle is in all instances forming part of the respond, and is block bonded into the passage or *spina* walling. The radius of the rounding shows some degree of variation; viz. the radii to the east portal to the south gate at Housesteads are considerably less than those to the west portal. At the west gate of the same fort there is evidence that the two passage walls have been rebuilt, as the rounded respond returns have been cut off flush with the back of the curtain wall.

The builders were at pains to tie the large blocks of stonework forming the responds to the portals, into the smaller squared masonry of the guardchambers, as well as in the isolated *spina* piers, so as to reduce possible movement. The north inner respond to the north portal to the east gate at Chesters shows how the large blocks forming the respond have been cut back to form a tongue, so allowing the respond to tie in with the masonry to the inner wall of the guardchamber (pl. 47). This wasteful and time consuming detail was also used in the matching respond to the south (pl. 48). Similar detailing is common, further examples can be seen in the outer *spina* to the west gate at Housesteads and to the east portal to the south gate of stone fort 2 at Chesterholm. At Rudchester a detail was used not seen elsewhere *per lineam valli*. This is described by Brewis (1925, 104 & plate XVI fig. 24), `It is a piece of Roman masonry second to none in any fort on the line of the Wall. Each course is a single stone the full width of the pier, 3` 10" (1.170 m), and each stone has a drafted margin and a rock face usually termed "rustic masonry", whilst the west face is checked out to allow of the stones of the divisional wall being housed into those of the pier`.

A probable reason for the bonding detail described above at the east gate at Chesters is the desire for architectural effect to the inside of the gate. From the remaining masonry to the west wall of the south guardchamber it can be seen that long stretcher courses were built which would have tended to give greater expression to the portals (pl. 49). This use of long blocks could have weakened the wall if they had not been tied into the masonry course behind. The general effect of this detail, would have been reduced by the large difference in the course depth to the north and south guardchambers. A possible further example occurs to the east walling to the north of the east gate at Birdoswald. In this case some very large stones, maximum 1.020 m by 1.150 m by 210 mm deep have been used in the return from the outer face of the curtain wall to the portal, and on the face of the curtain wall itself. A similar detail was possibly used at the north gate.

At certain gates the lower course to the responds project to the inside and outside faces, so as to provide protection to the dressed arrises of the responds. Good examples of this can be seen at the north and south gates at Housesteads where the lower stone projects an average 300-350 mm. At the north gate due to the slope up into the fort, two courses of projecting blocks with rounded upper surfaces are found (pl. 50). An alternative detail can be seen at the north west gate at South Shields where a projecting splayed plinth, the width of the respond, is formed with the splay being somewhat less than 45 degrees, and a projection averaging 180 mm with a course height of *c*. 450 mm high. A similar detail to this can be seen at the west gate of the fort of Brecon Gaer, (Wheeler 1926, fig. 13 opp. 19).

Large `L` shaped blocks set side by side, form the primary threshold to the gates[3]. The upstand averages 100 mm high by 150 mm wide. The upstand to the south portal at the west gate at Birdoswald is in part formed out of the stone block in which the pivot socket is cut, being placed next to the respond foundation base. Centrally placed projecting gate stops, *c*. 100 mm high, can be seen at the north and east gates at Chesters, and at most of the gates at Housesteads.

The voussoirs forming the arch over the portals were set on imposts (pl. 51 and appendix 4 F). The purpose of the imposts was to spread the load of the arch onto the passage walls of the guardchamber. It is likely that in most cases the width of the voussoir approximated to the width of the respond[4]. From the dimensions of the extant voussoir at Birdoswald it can be calculated (assuming the length of the intrados was constant), that there were nine voussoirs to each side of the keystone.

A possible window opening can be seen in the west wall to the north guardchamber to the east gate at Chesters. The external width is *c*. 1.000 m reducing to *c*. 550 mm internally, and is *c*. 1.400 m above road level.

Many examples of arcuate lintels, referred to by Bruce (1880, 65) as `one of those arched slabs which are often found near gateways`, have been seen close to gates including Housesteads, Great Chesters, Birdoswald and South Shields (see appendix 4 J). The width of the openings fall within a close range; of 41 fragments from a minimum of 28 windows at Housesteads, the widths fall within the range of 570-600 mm, with one example 420 mm wide. Four arcuate lintels were recovered from the east gate at Birdoswald, one example of which was 660 mm wide (Wilmott 1997, 63). Several examples have also been found at South Shields, one of which had an opening of 595 mm. An example of a bilithic lintel has been seen at Birdoswald for an opening 660-680 mm wide, which could have been used above a door. If this was so it is likely that the door closed up to the rear of the lintel, with a further horizontal lintel to carry the inner leaf of stonework. It is likely that windows to the gates were also formed using voussoirs as found by the west gate at Birdoswald. Similar voussoirs have been seen at Chesterholm and Corbridge (Wilmott 1997, 63, 64 Fig. 39).

3.4.3.2 Gates and Pivots

The gates to the portals closed up against the inside of the ring of voussoirs and were rectangular in shape. They were hung on pivots set in top and bottom sockets. The weight of each leaf would have been substantial. From the pivot sockets at Chesters it can be seen that the internal diameter of the iron sleeve is 90 mm, so it is likely that the diameter of the pivot was 80-85 mm. There is on average 30-40 mm clearance between the edge of the 140 mm stone cut out for the pivot socket and the face of the respond and return wall. Allowing for tolerance, the probable thickness of the gate at that point would have been *c.* 200 mm.

It is probable that the hanging stile was circular in section, being formed out of a small tree trunk into which the top, bottom and middle rails would have been rebated; this would reflect the curved form of the inside of the rebate at some forts. It is possible therefore, that, when boarded out and with protective iron plates or banding[5], the gate leafs were over 275 mm thick and weighed well over half a tonne.

The weight of the door was transferred by a pivot into the pivot socket in the foundation course, whilst the top pivot was held in a pivot socket cut in a stone block spanning across the *spina,* and housing a socket for the two inner doors to each portal. In a great many cases the bottom pivot socket was an iron socket or sleeve set into the stone. At Rudchester an oxidised iron pivot sleeve and socket was found *in situ* at the south end of the south portal of the western gate (Brewis 1925, Pl. XVIII, fig. 29). `The iron shoe for the pivot is 3 inches (76 mm) in diameter and $2^3/_4$ inches (69 mm) in height, much oxidised, and has what appears to be a lug for attachment to the foot of the gate. When found the interior of the socket contained fragments of wood. The cup in which it turned consists of a block of iron 4 inches (101 mm) by $3^3/_4$ inches (95 mm) and $1^1/_2$ inches (38 mm) thick, having in its upper surface a cup-shaped sinking $^3/_4$ inch (19 mm) deep for accommodating the pivot of the gate. The iron cup was let flush into the sill, forming a socket superior to the usual form where the pivot merely turned in a hole in the stone`, (ibid., 105-106). At Chesters the pivot sockets and trackways would have been cut out *in situ*. The average size of the cut out for the pivot is 140 mm diameter by 75 mm deep, the width of the trackway being 130 mm. The bottoms of the trackway and pivot sockets are generally level but some sockets are deeper at the west and south gates by up to 10 mm. The iron sleeves set in the sockets seen *in situ* at the west gate are of 95 mm external diameter by 90 mm deep (pl. 52). The sleeves are set in lead and there is no evidence of wear between the sleeve and stonework. Bruce, when excavating the south gate of the fort (Bruce 1880, 212) found that `these gates have moved on wooden pivots, the lower part of which has been shod with a circle of iron. In this instance the iron cylinders were found sticking fast in the pivot holes, traces of the wood which they had encircled being found inside them`. It would seem that the timber pivots were set in an iron sleeve fixed in the stone socket.

By contrast the pivot sockets at Housesteads, generally 130-160 mm diameter, would seem to have had no shoe, and significant wear is apparent. That the gate pivot itself was iron is borne out by Hodgson`s description of the east gate in July 1833, `The main passage-way had been through its north side, as appeared by the worn state of its threshold and the pivot holes of its doors, one of which formed a true hollow hemisphere, and was still covered with a shining blue coat of iron, from the friction of the pivot upon it`. (Hodgson, J. 1840, 186). A similar detail could have occurred at Birdoswald where an iron pivot 85 mm diameter, was found in the southern pivot hole to the south portal of the west gate (pl. 38). The excavator suggests that the pivot was provided with an iron ferrule (Wilmott 1997, 93); however it is quite possible that the iron pivot has corroded in the stone socket in which it was intended to turn. The amount of wear in the other stone pivot sockets is consistent with wear by an iron pivot in an unprotected socket.

At the north west gate to the mid-Antonine fort at South Shields, it would be expected that the experience gained at the forts *per lineam valli* would be utilised. The stone receiving the pivot is relatively small, *c* 500 mm by 490 mm, and is not set under the gate respond, so anchoring it to prevent a turning moment. This must have been considered unnecessary as the gates to the portals were smaller. An iron socket 140 mm diameter with an upstand to the perimeter of 40 mm, and some 25 mm thick, was set into the stone to receive the pivot. The main difference between this pivot detail, and those previously described, is that the diameter of the pivot socket is much greater, implying a larger diameter pivot. The principle of the detail is similar to that seen at Rudchester.

Further examples of iron pivot sockets have been seen elsewhere on the Wall. At milecastle 13 it was seen that, `the original pivot-holes are sunk in the footing stones. The east pivot-hole contains a flat bed of lead, bearing the impression of a roughly circular iron ring (no doubt the base of the actual socket) which had been forcibly removed; no lead was found in the west pivot-hole` (Simpson, F. 1931, 321-322). The drawing of the gate shows that there were two trackways cut leading to each of the sockets (ibid., fig. 8, 320). A metal pivot socket, set into a foundation block, was seen to the east jamb of the gate to milecastle 17. This was removed and deposited in the Black Gate Museum (Birley, Brewis and Simpson 1932, 257).

Top pivot stones can be seen at Chesters (double and single, pl. 53, 54) and Housesteads (double). The double pivot stones sat astride the *spina* butting up to the rear of the portal, whilst the single pivot stones were built into the passage walls. The size of the double top pivot stone from the south gate of Chesters is 1.500 m by 650 mm by 260 mm deep, with 180-200 mm diameter pivot sockets, one of which is broken. The broken socket shows considerably more wear than the unbroken one, which could reflect the blocking of a portal. The distance between the pivot holes is *c.* 620 mm, which corresponds to the width of the *spina* wall of *c.* 620 mm. That from the north gate[6] of Housesteads is 1.500 m by 440 mm by 140 mm deep, with two worn pivot sockets of *c* 120 mm diameter, one of which is broken. The overhang to each side of the *spina* would have been *c.* 355 mm. The single top pivot stone from

Chesters lesser east gate is 1.000 m by 500 mm average by 260 mm deep. In all cases wear can be seen to be directed towards the *spina* and the portal opening.

Bidwell *et al.* (1988, 213-4) put forward suggestions for the hanging of the gates and their construction. There can be no doubt that the gates to each double portal were placed in position, probably semi-completed, with the bottom pivot in position before the top pivot stone was placed in position over the upper pivot. This is shown by the condition of the extant upper pivot stones, where two holes are drilled of sufficient diameter only to take the pivot, with no tolerance allowed for setting out errors for the position of the lower pivot sockets either side of the *spina*. It is certain that the holes in the upper pivot stone were marked out and cut when the gates and pivots were in position; this is substantiated in that the position of the holes in the pivot stones at Chesters and Housesteads are not on the same line, reflecting that the lower pivot sockets to both portals were not quite in line. It would have been impossible to raise the gate and thread the upper pivot through the fixed upper pivot stone, due to the angle of the gate, and the diameter and depth of the hole.

It is suggested that the trackways were cut to simplify the positioning of the bottom pivot into the correct position. The pivot would be placed into the socket or sleeve, and set in the greased trackway and hammered into position. The alternative method of placing a pivot into a socket cut into the stone foundation block could have caused damage to the pivot, as well as incurring the difficulty of locating the pivot hole. It is likely that the boarding to the door was placed in position after the framing had been hung, due to the total weight of the doors. A late medieval example of a door hung in the same manner can be seen at the Alcazar, Sevilla (pl. 55, 56). The bottom iron pivot is set in an iron shoe positioned in a stone block. The upper iron pivot is set in a projecting stone bracket. Iron banding on the bottom rail is bound round the bottom of the hanging stile.

3.4.3.3 The Roofs

Bidwell *et al.* (1988, 195) found it difficult to understand Richmond and Child`s (1942, 42) proposition that it was more expedient for the ridge of the pitched roof over the guardchambers to run parallel to the curtain wall, as any missile thrown would roll into the fort behind or back onto the attackers rather than onto the defenders on either side of the guardchamber. Bidwell *et al.* therefore propose that a series of roof trusses was built, spanning across the shorter span parallel to the curtain wall with a gable being formed on the line of the curtain wall (Bidwell *et al.* 1988, fig. 7.20, 216). This method of construction is structurally extravagant and unnecessary, as the span across the guardchambers parallel with the curtain wall could easily be accommodated with a series of purlins. This would reinforce Richmond and Child`s proposition for the suggested arrangement of the roof line (fig. 51). Evidence of roof tiles associated with gates is slight and is summarised in Bidwell *et al.* (1988, 193-5). The fact that little tile is associated with the gates does not imply that tile was not used. It is probable that the roofs were tiled, as the buildings in the *latera praetorii*. The absence of tile could reflect its easy removal and reuse on buildings elsewhere.

3.4.3.4 Wall Finishes

There is little information from the excavation records concerning internal wall finishes; the sole evidence, from Chesters south gate, shows that the interior of the guardchamber was plastered and painted. Clayton (1880, 213) describes how, `a quantity of thick plaster was found, with which no doubt the walls were coated. The plaster is covered with fresco painting, the colours used being chiefly brown, black, red and yellow`. Wall plaster was seen in the north guardchamber to the west gate at Brecon Gaer (Wheeler 1926, 19). The considerable quantities of plaster were panelled, and striped with red, yellow and blue paint.

Notes

1 Site excavation archive.

2 There is no respond to the portal openings, inside the fort, to the gates at Housesteads.

3 One stone threshold to the west gate at Housesteads is *c*. 850 mm deep.

4 At the east gate of Birdoswald the depth of the north respond to the north portal is 600 mm, and the depth of the extant voussoir 610 mm.

The depths of the responds to the east portal of the north gate at Wallsend are 1.200 m and 1.400 m (site archive). It is unlikely that the voussoirs matched this depth.

5 Clayton (18810, 212) records that the doors to the south gate at Chesters had been strengthened with iron bars and studded with nails due to large amounts of oxidised iron adjacent to the gates. Bruce (1867, 182) came to the same conclusion having seen similar evidence at Housesteads. Bidwell *et al.* (1988, 213) suggest that bindings were fixed to the gate.

6 The double pivot stone at Housesteads was reused and built into the blocking to the north gate at approximately floor level.

3.4.4 The Barracks

3.4.4.1 Foundations, Masonry and Openings

Foundations

The foundations to the barracks are generally substantially less than those seen to the buildings previously described. Those at Wallsend in the *retentura* were seen to comprise 100-200 mm of stone and clay (pers. com. W. B. Griffiths), whilst those in the north-west of the *praetentura* at Birdoswald were made up of *c.* 100 mm of similar material (pers. com. T. Wilmott). An exception can be seen in buildings in the *praetentura* at Wallsend where the foundations were seen to be of pink puddled clay 800 mm deep (Bishop 1989).

Masonry and Openings

The general apparent reduction in the depth of the foundations, as compared to the buildings previously discussed, could be seen to reflect a lighter superstructure, or be purely as a result of less care and attention being spent on the substructure of this type of building due to its lower status. From the excavations carried out of barracks 9 and 12 at Wallsend in 1998, it was seen that the primary Hadrianic buildings (phase 1A) were constructed of timber with a detatched officer`s house adjacent. Each *contubernium* was subdivided laterally to provide living accommodation and a stable. In a later Hadrianic development (phase B) the barracks were reconstructed in stone, whilst retaining the timber internal partitions, and the officer`s quarters was attached to the *contubernia* with an intermediate stone wall (pers. com. G. Brogan). There is some evidence that timber barracks and other buildings were erected at Bowness where the primary Hadrianic fort was constructed of timber with turf ramparts (Potter, T. 1975, 29-57).

Although it is probable that most of the barracks with stone built lower courses represent buildings with external walls wholly of stone, there is some doubt that all barracks were constructed in this way[1]. The external stone walls of the barracks were generally built of hammer dressed coursed rubble bedded in clay[2]. Evidence for this work has been seen at Wallsend (Goodburn, R. 1976, 306 & 308, Grew 1980, 355), Housesteads (Bishop 1989), Birdoswald (pers. com. T. Wilmott), and in a mid to late third century context at South Shields (Hodgson, N. 1994, 49-50). An exception to this would seem to occur at Carrawburgh where the front wall was apparently constructed of timber (Breeze 1972, 92). The use of clay as a bonding medium between the stones would seem to reflect the scarcity of lime required to make the mortar. This would reflect the lower status of the barracks, which is also seen in the use of organic roof coverings, and in the general lack of accuracy in their setting out.

Internal stone partition cross walls, dividing the *contubernia* and Officers` quarters, were constructed in a similar manner, although the foundations were minimal. In virtually all cases the walls were butt jointed at their junction with the external wall[3] (pl. 57). At Wallsend the divisions between the *contubernia* were seen to be of timber and wattle-and-daub, with the unburnt clay being used to make successive floors (Goodburn, R. 1976, 306, 308). A possible late example was seen at Bowness-on-Solway where a timber partition was identified in a possible barrack block of the first half of the third century (Potter, T. 1975, 38). In all other known cases however, the division walls between the *contubernia* and Officers` quarters were of stone.

At Carrawburgh a substantial stone spine wall was seen to be constructed down the centre of the barracks, parallel to the outer walls (Breeze 1972, 92). This wall had foundations 1.000 m wide, compared to the back wall of 860 mm, suggesting that it was at least as thick as the external wall. The wall was not quite centrally placed, the depth of the rear room being 3.250 m compared to the front of 3.100 m.

Extant remains of openings are few. At Wallsend (Goodburn, R. 1976, fig. 9, 307) and Chesters, the doorway into a barrack is seen to be formed up against a stone dividing wall, with no nib being formed in that wall (pl. 58). At Chesters, in many cases, the dividing wall and front wall can be seen to be of one build. Evidence for window openings relies on a late second century barracks at South Shields. The height of the opening was 1.300-1.400 m above street level, and *c.* 600 mm wide. A possible stone sill and head were seen 400 by 500 by 80 mm deep and 700 by 330 by 60 mm deep respectively. A possible adjacent window was seen 1.900 m apart (pers. com. G. Stubbs).

The supports for the verandah fronting the *contubernia* were made up of stone columns, and timber posts were also used[4]. Stone columns placed on the line of the dividing walls for the *contubernia* were seen at Chesters, and it is possible that stone columns were also used at Housesteads, as the remains of columns and bases were built into later barrack walling (Wilkes 1961, 283). However, Welsby (1989, 20) states that there would not appear to be enough column fragments on site for stone columns to be used to support the verandah; this assumes that all the fragments have been identified which clearly cannot be so. Timber posts have been seen to the verandah to barrack 1 at Wallsend. The verandah was 2.000 m wide and supported by *c.* 200 by 230 mm posts spaced between 1.500 m and 3.000 m apart (site archive). Timber post holes, probably belonging to a primary timber barrack, have been seen at Bowness-on-Solway (Potter, T. 1979, 329). The flooring to the verandah was seen to be lightly cobbled with an eaves drip at Carrawburgh (Breeze 1972, 92), paved at Wallsend and cobbled with a gutter at Housesteads (Wilkes 1961, 283).

3.4.4.2 The Roof

It is probable that the roofs to the barracks, together with the stones and stables, were covered in organic materials. Shingles are known to be a roofing material used by the Romans, especially in Germany (Alberti 1955, 60), and are considered to have been used at Wallsend (site archive). A mass of organic material, identified as shingles, has been seen in a barrack block of period 6 (Severan to late third or early fourth century), at South Shields (pers. com. G. Stubbs). It was considered that the roofs to the stone barrack at Gellygaer were covered in wood or thatch (Ward 1903, 65). The timber barracks at Inchtuthil were also thought to be roofed in shingles or other perishable material, whilst the centurion's quarters appeared to have been roofed with tiles (Pitts & St. Joseph 1985, 151). The use of shingles or thatch would have necessitated a roof pitch of a minimum of 45 degrees. This in turn would have required more timber in the roof carcassing than for a lower pitch. It is possible that the reduced depth of the foundations was due to the reduced loading due to the dead weight of the roof, but this is more likely to reflect the relative unimportance of the barracks. No evidence of tile has been seen on any recorded site *per lineam valli*, although as has been stated previously (chapter 3.1), it is likely that the buildings within the *latera praetorii* and gates were tiled. It is suggested that the demand for tile at the time of the building of the forts was such that there was insufficient for the lower status buildings such as barracks, stables and stores.

The form of construction of the roof would have been dictated by the external and internal walling of a barrack. The possible alternatives are set out below:-

Type 1 (fig. 56)

Where the barrack block was constructed with stone or timber external walls, and timber partition walls dividing the *contubernia*, as at Wallsend, some form of close couple or collar roof would have been used. This is because the partition walls could not be relied upon to support the roof in view of its height due to the steep pitch. It is likely that the partitions were constructed to eaves height and were not full height. It is possible that this form of roof was also used where stone partition walls were constructed, in view of the volume of material which would be required to carry the partition walls up to the underside of the roof.

Type 2 (fig. 44)

In the case of a typical barrack block with stone external walls and well-built stone dividing walls, it is probable that a purlin roof was used. In this configuration purlins were positioned on the cross wall, which was built up to the underside of the roof, and spanned each *contubernium*. This form of roof construction was probably also used on the gates and the rear range of the *principia.*

Type 3 (fig. 45)

In the situation where a substantial stone spine wall was built, parallel to the long external walls along with the cross walls, it is likely that the purlin roof was also used. Alternatively it is a possibility, as at Carrawburgh, that rafters ran from the spine wall to the eaves. In the case of the double barracks, where this could have occurred as an alternative to the purlin roof, this distance would have been considerable, being as much as 7.000 m, and could be ruled out if suitable long lengths of timber were not available. In view of the excessive height, if a double pitched roof was formed, it is possible that a double pitched roof was used over each set of barracks. This alternative form could have been used at the double barracks of Benwell and Halton Chesters. If the interpretation at Carrawburgh is correct, and the external wall to each *contubernium* was made up of a timber partition, the rafters could easily be supported on a timber member spanning the opening. In all cases the roof members would have been boarded to receive the timber shingles, or if thatch was used it would have been fixed to horizontal lathes *c*. 300 mm apart.

3.4.4.3 Floor and Wall Finishes

Floor Finishes

In both phases 1A and 1B at Wallsend, the stables were paved in green sandstone flags, whereas the *contubernia* in phase 1A were paved in beaten earth and charcoal (pers. com. G. Brogan). All the barracks were paved with flags in period 1B. The primary stone barracks at Birdoswald, excavated in 1998, was seen to be flagged (pers.com. T. Wilmott). At Carrawburgh the floor was of grey clay which may have been flagged (Breeze 1972, 92). The floors to the *contubernia* were generally of clay as seen at Housesteads (Wilkes 1961, 282, 283). As at Carrawburgh it is possible that these floors were also flagged, and the flags later removed for re-use.

Wall Finishes

Little is known of the wall finish to the barracks. The clay bonded stone wall to a period 6 barrack at South Shields was seen to have a thin coating of limewash applied externally (pers. com. G. Stubbs). It was not known if the same finish had been applied internally. The limewash would have worked as a sacrificial shelter coat to the clay bedding of the stonework, without which some steady deterioration could be anticipated. Some internal plastering with decoration would be expected to the higher status Officers` quarters.

Notes

1 Daniels suggests that the upper portion of the barracks at Wallsend were constructed of timber (Goodburn, R. 1976, 308).

2 The stone walling to the barracks at Caerhun was bedded in clay (Kanovium Excavation Committee 1938, 33).

3 This same detail can be seen in the extant barracks of the fortress of Caerleon.

4 Evidence for timber supports to the verandahs have been seen at Gellygaer (Ward 1903, 66) and Caerhun (Kanovium Excavation Committee 1938, 32). From evidence at Inchtuthil it was seen that the verandah roof to the timber barracks was carried on timber posts 1.830 m apart; this meant that there was a post centrally placed between the division walls of each *contubernium* as well as on the line of the wall.

3.4.5 Conclusion

This chapter will summarise the findings and opinions set out in the previous chapters of section 3, and endeavour to draw some conclusions.

3.4.5.1 Design and Form

Vitruvius stated that all buildings should take into account strength, utility and grace (1.III.2). The buildings within the forts indubitably reflect Vitruvius` first two precepts, and probably to a certain degree his third. The quality that the buildings do reflect is the fundamental architectural precept that form should follow function, in other words that the shape and massing of a building should reflect its use. The sheer scale of the completed Wall concept expresses the character and confidence of the Roman army, whose conservatism can be seen in the similarity of the design of buildings. Some of these characteristics are mirrored in such details as the grandiose double portals to all the fort gates; a provision which was very soon deemed to be unnecessary in practical terms. The general consistency in the design and layout of the fort buildings shows that the original concept was carried through from start to finish with very little variance; this surely reflects the desire not to deviate from the principles set down by the Emperor himself.

Although the form of the Hadrianic *principia* is consistent in all the forts *per lineam valli*, its plan form does evolve in later phases of the occupation. The function of the ambulatory and courtyard of a *principia* is rarely discussed, but it is likely to have been an area which was used by the soldiers when not involved in military activites. There is no other apparent area within a fort, apart from a barrack, where they could have gone. Stone fort 2 (*c*. 233-5) at Chesterholm, has an internal courtyard which is enclosed on all sides by buildings. The *principia* of period 6 at South Shields (222-35 to late third or early fourth century), and the *principia* at Newcastle-upon-Tyne of Antonine date, both have a cross-hall and rear range, but no courtyard and ambulatory. It is suggested that these three buildings show the development of the *principia* in the military zone. In other words, there was a lack of military need for this space[1], but the courtyard was retained for the purpose of providing access and natural light to the surrounding rooms at Chesterholm. This lack of need is reflected in the smaller buildings at the other two forts, which substantiated by the known small garrison of period 6 at South Shields, whilst it was a supply base (Bidwell and Speak 1994, 24-26, fig. 2.7).

Although some comparisons have been made of the size of the forts, it is considered that the size of the buildings can provide the greatest information. This is tempered by the lack of excavated detail, especially as the plans of many forts with details of the buildings are unknown. The four forts to the west of Newcastle, at Benwell, Rudchester, Halton Chesters and Chesters have many similarities, as might be expected as they are all built astride the Wall. These are that the lengths of the *principia* are greater than at any other known forts *per lineam valli,* with the span of the cross-hall at Benwell and Rudchester being virtually identical, and the likelihood that all the buildings had aisles to the cross-hall. The granary sizes and buttress spacing are all similar, taking into account the double granary at Benwell. The width of the gate portals to the four forts fall within a close range, whilst the projection forward of the face of the guardchamber from the face of the gate is generally consistent. The foundation course to the westernmost *spina* to the west gate at Rudchester is made up of two large stones at its western end; similarly the foundation course to three known *spina* to the north, west and east gates at Halton Chesters were formed out of two large stones. The foundation courses in most instances at Chesters were made up of one large stone, although two stones were used in some cases. A length of splayed plinth was seen to the gate at Halton Chesters, whilst a fragment of splayed plinth is still extant to the V*allum* gateway at Benwell. Double barracks of similar length were constructed at both Benwell and Halton Chesters. These small but significant similarities could lead to the suggestion that the *Legio VI Victrix* not only built Halton Chesters (RIB 1427) but that they were also largely responsible for Rudchester, and possibly Chesters and Benwell[2].

The form of many of the buildings is dominated by the roof, the pitch of which is dictated by the roof covering (chapter 2.4). In the case of a double granary or double barrack block, there is no way of knowing whether the roof was spanned with a single or a double pitched roof. The single pitched roof, due to the considerable width of the building, would be very tall and create a substantial roof void. The alternative double pitched roof would be much less dominant but have an inherent weakness in the form of the internal gutter, which would be likely to allow water penetration.

The fort at Housesteads does not fit comfortably with the pattern of the other forts. Whilst the courtyards to the *principia* at Wallsend and Chesters are almost square, and that at Benwell being twice as long as wide, with Rudchester being probably even longer in proportion, the courtyard at Housesteads is almost twice as wide as it is long. This is a similar probable proportion to that at Great Chesters. Significantly this proportion can also be seen in the Welsh stone forts of Caerhun and Gellygaer (chapter 3.2.2). The gates at Housesteads are unusual as there are no responds to the inner portals, which makes it doubtful as to whether there was an arch in those positions.

This is a similar detail to that seen at the Scottish fort of Balmuidy (Miller 1922, 19). The widths of the portals show a higher degree of variance than at other forts, and are significantly narrower, comparing favourably with those at the fort of Brecon Gaer (chapter 3.2.6), as also does the width of the gate passage. The double granary at Housesteads is the only known example *per lineam valli* to have the floor supported on stone *pilae*, although the mid-Antonine granary at South Shields is similarly constructed. The barracks are set out *per strigas*, a form only seen elsewhere at Stanwix and Maryport, although it is possible that this also occurs at Great Chesters. The length of the barrack blocks is also greater than most of those seen elsewhere, with the exception of possibly Birdoswald and Halton Chesters[3]. This ensemble of detail draws together parallels with the Welsh forts, including the proportion of the courtyards to the *principia* and the dimensional similarities of the gates. As the *Legio II Augusta* was responsible for the forts at Caerhun and Gellygaer, it could be taken as a suggestion that this legion had some involvement with the building of the fort at Housesteads.

As already discussed (chapters 3.1 and 3.2), the fort at Great Chesters shows many similarities with Housesteads. These similarities include the overall width of the fort, the proportion of the courtyard, the probable layout of the barracks the close size of the *principia* and their orientation to the east. However, an anomaly occurs with the gates as the area of the gate passages is virtually identical to that at Chesters, with the overall sizes of the gates being very similar. There is also the intriguing suggestion (chapter 3.2.6), in view of the increased size of the south guardchamber to the west gate, that there was an original intention to position the fort astride the Wall. The unavoidable conclusion would seem to be that this fort was built by vexillation from two legions, both with involvement at both Housesteads and Chesters, one of which might have been the *Legio II Augusta*.

A dimensional study of the *principia* at Wallsend, Chesters and Housesteads (chapter 3.2.2) shows that there was a high probability that the buildings were set out around a centre line. The three buildings were set out to a good standard of accuracy, although the fort at Housesteads, housing infantry, was set out to a lesser degree than the other two forts which housed either all or some cavalry. The setting out of the column bases to the cross-hall and ambulatories at Housesteads to a much less accurate standard than the rest of the building, gives rise to the almost certain conclusion that the work was started by one gang and completed by a much less experienced gang. This is also reflected in the moulded stonework (appendix 4 A B).

It is difficult not to seek for a common unit of measure, and the tentative identification of the *pes Drusianus* with the *Legio II Augusta* has already been made (chapter 3.2.8). There can be no doubt that something of fundamental importance such as the portal widths would have been clearly determined by the *architectus* and instructions issued accordingly. The relationship of a large number of the portals to 10 *pes Drusianus* is indisputable. Moreover the suggestion that the length of the *latera praetorii* was set at 1 *actus*, and shown in the length of the buildings at Halton Chesters and Chesters, is very convincing. The metrology of the buildings is an area of clear priority for future research.

3.4.5.2 Constructional Methodology

The logistical problems in erecting the Wall, its infrastructure, the *Vallum* and the forts must have been considerable, and the fact that the greater part of the concept would seem to have been erected in a little over eight or nine years reflects highly on the Roman administration. It is probable that the Roman army, in view of its strong conservative attitude, would have established a set sequence for the construction of the forts. This, logically, would seem to begin with the erection of the curtain wall and gates, with the gates being commenced before the roads within the forts. The limited archaeological evidence (chapter 3.3.1) confirms such a sequence. From evidence at Wallsend it has been shown that the granary was commenced and was under construction during the building of the *via principalis*, and actually was commenced before it. The inference must therefore be that the granary was probably the first building to be completed in the fort. The sequence would then continue with the buildings in the *latera praetorii,* with the *praetorium* probably being completed last having the lowest priority. It must not be overlooked that a shrine, possibly later incorporated as the *aedes* within the *principia*, could have been erected at a very early stage, maybe at the commencement of the fort building. In the majority of buildings with internal dividing walls, the general sequence of construction was to build the outer walls and then butt joint the internal walls up against them. In some instances a header was left projecting from the outer leaf of the external wall to tie in with an internal wall. The same pattern also occurred with the turrets to the curtain wall, with the former being built after the latter.

The necessity of having the building materials available, particularly those not available close to the site at the appropriate time would, even in the present age, present problems. It is unlikely in many areas, especially the central section of the Wall, that adequate timber would have been available, especially for the larger spans. From the present level of information it is also possible that clay roofing tiles would have to be brought some distance. Suitable lime would have to be found, together with the aggregate for the mortar. Metal fixings would have to be imported, or else manufactured on site. The delivery of material to site at the correct time would have been crucial, as failure to have materials available at the right time could have caused serious delays in the construction programme. The position would have been made more acute due to the forms of communication available at the time. This again is an area where further research could throw further light on the Wall studies as comparatively little is known of the source of material such as stone, lime, aggregate and tile in the construction of the Wall and its forts.

From the evidence available, it would seem that most of the buildings outside the *latera praetorii*, the barracks, stores and workshops were constructed of stonework bedded in clay. It has been suggested (Birley, A. 1997, 133) that this use of clay, which is not affected by frost as is lime mortar, could have been a means of extending the building season, as well as confining mortar to the higher status buildings. There is also a strong possibility that clay was used in bedding the masonry on some parts of the Wall itself, as well as being used in its core; this could account for the significant areas rebuilt about the turn of the second century. As the quality of work was significantly better on the higher status buildings, it raises the possibility that this work was carried out by the legionaries, who could have returned to winter quarters when the building season had ended. During the winter months the work could have continued on the Wall and the lower status buildings using auxiliary troops and conscripted labour under legionary supervision. That the Roman army was capable of rapid construction work is well known (ibid., 133). From the known evidence it is likely that the Wall and the forts were constructed at great speed (chapter 3.3.1), and that the maximum number of operatives was employed. Roman construction techniques were based on empirical principles, and by modern design standards the extant structural elements were more than adequate for their purpose. It can be inferred that the same principles were used in the roof structure, for which there is now no evidence. These empirical standards can be seen in the buildings in the *latera praetorii* where the foundations are well constructed, and far larger than required for their purpose. These foundations mirror the thickness of the walls, which in turn reflect the height of the buildings. By contrast the foundations to the barracks, in most cases, are of purely nominal thickness and may not have been adequate in all instances for the masonry bearing on them. The size of the foundations could reflect the lower status of the class of building, or just lack of care.

Much of the extant masonry to the forts has been finished to a high quality, although a great deal is of inferior workmanship, and much remains unfinished. The quality of the masonry tends to be echoed in the accuracy of the setting out of the buildings. This can be seen in the *principia,* as described in chapter 3.2.2, where the buildings are set out to an good standard and the initial phases of the work are of good quality.

An enigma presents itself in the construction of the Hadrianic *principia* of stone fort 1 at Chesterholm. This building apparently constructed in the form of *opus Africanum* and using *adobe* has recently been partially re-excavated and the method of construction confirmed. It is difficult to understand why this building was erected in this manner, in a situation so unsuited to it climatically, particularly as a good supply of stone was close to hand. It might be a possibility that this form of building has an association with the posting of Africans to the *Legio VI Victrix* (Swan 1992, 3) with their skills being not only reflected in the typology of their pottery but also in the buildings.

The general impression of much of the work is that, it was started with considerable care and completed in haste, with much of the stonework being incompletely dressed. The high quality of the preliminary work to the buildings has been discussed at Birdoswald and Housesteads (chapters 3.4.3.1 and 3.4.2.1). It is possible that three factors can be identified. The first is that the fort and its buildings were laid out and the buildings commenced by an experienced legionary gang, who formed the foundations and built the first course or two setting out the masonry, so as to ensure that the building was in the correct position and of the right size. Secondly, once this had been completed a less experienced gang built the general areas of the walling. Thirdly there is much evidence for haste seen in the unfinished masonry, and this can be seen ubiquitously in the extant masonry, especially the gates, on site. A further slant on this is in the *principia* at Housesteads, where it is built on a platform cut into the bedrock of the site. Although some significant attempt had been made to level the area of the building, there is a marked cross fall, resulting in the bases to the arcading to the southern part of the cross-hall being significantly lower than those to the north. A similar situation arises with the northern and southern ambulatories to the courtyard. These differences in levels would have caused considerable difficulties in construction, possibly involving a longer construction period than it would have taken to level the site, and which would have resulted in a generally unsatisfactory appearance. The levelling of the site for the building would have been well within the capabilities of the builders. It is suggested that the reason why this site was not completely levelled was due to the urgency of completing the building, with any aesthetic considerations being overruled. From the limited evidence that remains today it could be said that generally the buildings within all the forts have been finished to a greater degree than the gates. The implication of this is that it must have been considered that the gates were less important than the buildings within the forts.

Any method of constructing the roofs over the buildings is likely to be subjective as there is no firm evidence of roof construction for military buildings in Britain. However, it is almost certain that the greater spans utilised some form of truss, as this was the most economic and structurally sound constructional form. This supposition is supported by the examples of the early Christian churches in Syria as discussed in chapters 3.1.1 and 3.4.1.2. In the case of the large granaries with central spine walls, it is possible that principal rafters and ties were placed at the same centres which the trusses and purlins utilised. Where lesser spans were experienced, close couple or collar roofs could have been employed as these were simpler to construct, and more economical in their use of timber. In a great many cases where structural walls were placed close together, the roof was likely to be supported on purlins spanning between the walls. This is the simplest and most economic form of roof and carried forward the concept of purlins set at close centres on the trusses. This form of construction was probably the most widely used in a fort with instances of its use occurring in the rear range of the *principia*, gate and barracks. This detail would have precluded projecting eaves as discussed in chapter 4.1.

The status of the buildings undoubtedly determined the roof covering, with the gates, and turrets of the curtain wall, together with the high status buildings in the *latera praetorii,* utilising clay tiles. The roofs to the lower status buildings, barracks, stables and stores were covered in shingles or thatch.

From the small amounts of painted plasterwork found in the *principia* and gates, it is probable that many of the Hadrianic buildings were highly decorated internally and were probably rendered and painted externally. This would reflect the degree of decoration of other buildings of similar status within the Empire, and be a fitting setting for the lost carved wall panel from the *principia* at Chesterholm depicting the sun god in his chariot.

A suggestion has been put forward (Simpson, J. 1998) that stone, until relatively recent times - perhaps the later eighteenth century, was not regarded as something of great value, nobility and beauty, but as a raw building material which required to be finished. He points out that all stonework in the Middle Ages in Europe was limewashed internally and externally, and much was painted in strong colours. From the evidence of the use of colour seen throughout the Roman Empire, it is quite possible that the traditions of the Middle Ages were based on Roman precedents.

3.4.5.3 Decorated and Moulded Stonework

Blagg, in describing the ornament to the building of the northern frontier of Britain, admitted that, "it was scarcely Vitruvian territory" (Blagg 1980, 37). He also states that the rudimentary decoration which is characteristic of most Wall forts bears no close relation to Trajanic material from the legionary fortresses (ibid., 39). Of the material discussed, and set out in appendix 4, some of the most significant pieces of moulded stonework are the capitals from the granary at Housesteads (fig. 58) and their look-alikes at Chesters, together with the Tuscan capital from the *principia* at Wallsend (fig. 57). These pieces were cut by someone who was skilled in his work. It is possible that there was a "school" of craftsmen whose task was to cut the moulded and decorated stonework at the forts. In the case of Housesteads, it could be that they worked on the granary, which was probably one of the first buildings to be erected, and possibly part of the *principia*, leaving site before the arcades to the cross-hall and ambulatories were commenced. Much of the remaining stonework in this fort is of very poor quality, and is obviously the work of someone who had no knowledge of classical proportion and detail, as can be seen in the debased columns and bases. The non-availability of this "school" of specialist masons could account for the use of piers rather than columns in the ambulatories at the *principia* at Chesters.

Housesteads once again differs from the other forts in the detail of the known ornament on two counts. The first is that many of the arcade column bases to the *principia* are attached to square plinths with a large projection and in most cases also to the lower portion of a column, all formed out of one large piece of stone worked on a lathe. Although a column base is usually attached to its plinth, as can be widely seen *per lineam valli,* the projection at Housesteads is much greater as is the amount of the lower portion of column. Secondly, a large number of cornice moulds have a concave sinking cut into the fillet (appendix 4 D), this detail has not yet been seen elsewhere *per lineam valli*. The similarity between the moulded threshold to the *aedes* at this fort and the similar threshold to the Hadrianic *aedes* at Chesterholm is striking (appendix 4 G). This similarity would suggest that they belong to the same "school" of masons.

A considerable amount of string course can be identified from Housesteads and some of it is representative of a well designed moulding. On the other hand, the greater part is of a much debased mould. As matching sections are few, and although the lengths must be from several buildings, the conclusion must be that the lengths of string course were cut *in situ*. This method of cutting moulded stonework is difficult, as the operative would have to work from a scaffold. This would result in a loss of conformity in the section of the mould, as no template would be used. A possible explanation is that the first few sections of the mould were cut by a skilled operative from a template; the normal method of forming a mould. Subsequently different unskilled operatives carried out the work and elected to cut the moulds *in situ* from unworked stone, resulting in the gross variation of the moulded sections. Housesteads is the only known fort where such a quantity of similar mould has been recognised.

Summary

The sequence of construction of the forts will never be known, but it is tentatively suggested that the *Legio VI Victrix*, who probably arrived at Newcastle from Lower Germany, constructed Benwell, Rudchester, Halton Chesters, and possibly Chesters and Wallsend, which all show many dimensional and constructional similarities[4]. The *Legio II Augusta*, probably built Housesteads some years into the construction programme, and at a later date part of Great Chesters. The links between Great Chesters and Chesters in the almost identical sizes of the gate passages, suggests that it is possible that the *Legio VI Victrix* was also involved to some extent. Carrawburgh, apart from the third century fort at Burgh-by-Sands, would seem to be one of the last forts to be constructed *c*. 130-3, based on the dating sequence provided by RIB 1550, and that it was built over the filled in *Vallum*. The forts of Housesteads, Great

Chesters and Carrawburgh were all built contemporaneously with the Narrow Gauge Wall and were set behind it. The true assessment is probably that more than one legion, as well as auxiliary troops, were involved in the construction of any one fort.

The Wall and forts, when at last substantially completed at the end of Hadrian's reign, would, if they reflected the discipline and order of the Hadrianic reign, have been well run and well maintained[5]. This period cannot have lasted any more than a few years before the whole frontier was abandoned, with the move up to Scotland to construct the Wall across the Forth-Clyde isthmus. At this point the slow deterioration and debasement of this magnificent concept began.

Notes

1 The well adjacent to *principia* 5 and 7 at South Shields could still have remained in use for ritual purposes

2 The comparisons of the forts are made primarily on dimensional and stylistic grounds. There is no epigraphical evidence for the *Legio VI Victrix* being at Benwell and Rudchester. A brick RIB 2460.51 stamped by this legion was seen at Rudchester. There is also reference to the presence of the legion at Halton Chesters in RIB 1429 and RIB 1430 along with the *Legio XX Valeria Victrix*. Evidence of the *Legio VI Victrix* at Chesters is strong with RIB 1460, 1461, 1471, and *Tegulae* RIB 2460.48 (viii) and RIB 2460.49 (v-vi) stamped by the legion having been recognised at the fort.

3 The length of the longer barrack at Birdoswald and those at Halton Chesters are based on the results of geophysical surveys

4 A tentative dating for the construction of the Wall, milecastles, turrets and fort is set out in Breeze and Dobson (1991, 82-83). It is suggested that some building was carried on up to the end of Hadrian`s reign in 138, and may in fact never have been wholly completed

5 The Hadrianic deposits in the barracks at Wallsend have been described as being "as clean as a whistle" (pers. com. P. Bidwell) reflecting no deposition of rubbish and other debris.

4.0 RECONSTRUCTION OF THE BUILDINGS

This chapter will put forward proposals for the reconstruction of the four building types under discussion. In the portrayal of the buildings, the dimensions used for the heights are those of modern equivalents for a building of the same use. The reconstructions offered seek to make sense of all the available archaeological data whilst drawing on basic architectural principles; although these reconstructions are hypothetical, it is believed that they will help clarify any interpretation.

4.1 The *Principia*

All the *principia, per lineam valli,* are of similar plan form in that a courtyard and ambulatory front the cross-hall, with the rear range comprising five rooms with the *aedes* in the centre. The only significant difference is that not all buildings have an aisle to the cross-hall fronting the courtyard. The *principia* which is the subject of this reconstruction is that at Chesters (fig. 35).

The entrance to the *principia* from the *via principalis,* on the axis of the *via praetoria,* is shown as 3.330 m high. This is approximately the equivalent height of a gate portal, and so would allow a man on horseback to enter into the courtyard of the building (see chapter 3.1.1), it would also enable the building to be of suitable proportions befitting the headquarters of a fort. This height is echoed in the height of the northern ambulatory and aisle to the cross-hall, so allowing arches on the central axis to be constructed to the height of the main entrance. Matching arches are shown on each side, flanking those on the central axis to the north and south of the courtyard. The entrance into the cross-hall is shown with an entablature, so as to form an impressive entrance into the building. The eaves height to the north and south ambulatories is shown at 4.000 m, so allowing for a voussoir ring depth of *c.* 700 mm, those to the side are shown with a clear height of 2.400 m below the beam spanning between the ambulatory piers.

An alternative solution is put forward for the northern ambulatory of the *principia* at Wallsend (fig. 38). There an arcade of six columns defines the southern edge of the ambulatory adjacent to the main entrance. The columns are equally spaced, except that the central bay is considerably wider than those to each side. This bay is opposite the entrance into the *principia,* but the entrance and centreline of the colonnade do not line up. It is proposed that the wider central bay had a raised roof profile, so as to allow for an entrance the same height as a gate portal.

The top of the roof to the aisle and ambulatories is shown as the same height as the enclosing external wall, and it is likely that a coping was placed on top of the wall covering its junction with the top course of tiles. The *tegulae* and *imbrices* are likely to have been laid on boarding on spars, with the spar feet bearing on the ambulatory arcade external walls, and the beams spanning between the piers. The tiles could have projected some 75 mm forward of the arcade face, and the rainwater would discharge into an eaves drip gutter running around the perimeter of the courtyard. No evidence has been found as to how the Roman builders constructed the valley gutters, which would have been required at the junctions of the roofs at each corner of the courtyard. The most likely way this was formed was by laying overlapping *tegulae* at the intersection of the conjoining roofs to form the gutter, and by bedding the cut *tegulae* in mortar overlapping the upstand to each long edge of the gutter tiles. The *tegulae* would have been easy to cut (pers. com. M. J. Astill), and it would have been possible to form an effective watertight junction of the roofs[1].

The height of the cross-hall would have been dictated by the need to have spatially pleasing proportions, and at the same time have sufficient height to insert clerestory windows above the mono-pitched roof to the rear range, and aisle where it occurred. It is possible that the clear height to the underside of the trusses equalled approximately that of the clear span of the enclosed space; in this case a dimension of 8.200 m is shown.

Due to the significant clear span of the cross-hall, the most practical and economical method of constructing the roof would have been by roof trusses and purlins. It is probable, as already discussed (chapter 3.4.1.2), that trusses were placed centrally on the line of each bay, together with an intermediate, making a total of nine. The purlins spanning between the trusses, in view of their close spacing, would have been of comparatively small size and would have received boarding, on which would have been laid the roofing tiles. As no rafters were used, the eaves would not project beyond the face of the external wall.

The cross-hall would have been lit at high level by clerestory lighting. The size and design of the windows is entirely conjectural, but taking into account the evidence from the *basilica* churches in Syria (chapter 3.4.1.2), it is quite possible that arcuate lintels were used. In view of the consistency in width of this type of lintel (see appendix 4 J), it is likely that the openings were *c.* 600 mm wide, in which case a height of 1.200 m from the sill to the springing of the arch would not be unreasonable. As the cross-hall was likely to be dark, due to the minimal window openings at low level, clerestory windows are shown on the line of each bay with two intermediates. It is probable that additional windows were positioned at high level at each end of the cross-hall. All the window reveals are likely to have been splayed.

The rear range is shown with a mono-pitched roof springing from an eaves height of 2.400 m. This would result in a roof height of *c.* 5.000 m above floor level adjacent to the cross-hall, and *c.* 3.500 m midway between the cross-hall and external wall, allowing for a nominal difference in floor level of 200 mm between the *aedes* and cross-hall. Many reconstructions show a raised roof over the *aedes*, often resulting in a gable to the rear elevation with valley gutters abutting the mono-pitched roofs to the rooms to either side (e.g. Bidwell and Speak 1994, 100, fig. 3.46). This latter reconstruction of the period 7 *principia* at South Shields shows the ridge of the roof over the *aedes* and that of the cross-hall at the same height. Whilst it is appreciated that the floor level of the *aedes* might be raised, even if it were raised a metre there would still be more than adequate headroom to display the military regalia, as this would be unlikely to have been placed at the rear of the shrine. It is considered unlikely that the military builders would have created a space equal in height to the cross-hall, for the relatively small floor area of the *aedes,* as this would result in an enormous volume of space at high level with no function. It is proposed that the solution put forward would have presented an appropriate area for the *aedes,* with more than adequate headroom. The roof over the rear range is likely to have been constructed in the simplest way with purlins spanning between the cross-walls. The purlins would then receive boarding on which the tiles would be laid.

It is probable that all the walling would be rendered or limewashed internally and externally, and the render finished with applied decoration in strong colours. It is possible that the many short lengths of plinths to the openings into the courtyard (chapter 3.4.1.3) related to vertical bands of decoration to either side of the openings. In whatever way the wall finishes were applied it is likely that the finished building would have borne little relationship in character to the present vernacular buildings of the North of England.

4.2. The Granaries

The overall form of the granary would have reflected its function, in that its exterior would have been very plain with the minimum of external openings. These openings would of necessity have been restricted to small openings to provide ventilation (as discussed in chapter 3.1.4), and door openings. The reconstructions show an extension of the roof to provide protection over the loading bay at Halton Chesters and South Shields.

It was put forward in chapter 3.4.2.1 that there were two broad types of the granaries, those with a single floor and those with the addition of an upper floor. This assumption is made as the external walls to the single granaries at Birdoswald and South Shields (Severan) are thicker than those elsewhere in almost every case, falling within the range 1.000-1.200 m. Whilst at the same time the internal spans range from *c.* 4.190-6.000 m - a distance easily spanned by floor joists. These two factors imply the presence of an upper floor.

In all cases it is likely that the treatment of the external walls was similar, with vents placed centrally between the buttresses, and spaced vertically at 1.000-1.500 m intervals, based on the excavated evidence from the granary at Dover (Philp 1981, 32). Above each vent, and often below, would have been a coursed stone spanning the opening. Usually the vents splayed within the thickness of the wall, being wider on the inside. The buttresses would rise up to below eaves height, with the top surface splayed to receive a capping. The larger buttresses, of up to a metre and over projection, would almost certainly be stepped mid-height.

Apart from the postulated two storied granaries, a major factor in any reconstruction is the form of roof construction. The three reconstructions will be based on the roof types discussed in chapter 3.4.2.3.

Type 1 (fig. 52)

This type can be seen in granaries with a large clear span where it is probable that a roof truss was used, with examples at Rudchester and Halton Chesters (figured). The external form of the granary would be as figure 41, except that the eaves height is unlikely to be greater than 3.000 m above floor level. The internal height within the single storied building would reflect the height to which the sacks of grain or other foodstuffs would be stacked. It is unlikely that this height would be much greater than 2.000 m, the additional height within the building being required to provide a free flow of air for ventilation. The relative slenderness of the walls and small size of the buttresses (appendix 3, table 6) are indicative of the lower height of this type of granary.

The roof structure, taking in to account the span of the building and thickness of the external walls, would most likely have been formed using trusses and purlins. It is suggested that the roof line projected to form a cover over the loading bays. This is substantiated by a line of bases forward of the loading bays at Rudchester, which could have supported posts carrying the roof. In the example illustrated in figure 52 at Halton Chesters, a portico is assumed as shown over the loading bays based on the evidence from Rudchester and Benwell (Taylor, M. 1961, 164). It is significant that the projection of the loading bay from the gable wall of 2.430 m, would have probably been equal to the dimension of the truss centres. This dimension is very close to the postulated centres of the trusses to the cross-hall in the *principia* at Chesters, as discussed in chapter 3.4.1.2.

The floors would have been constructed of stone flags spanning across longitudinal sleeper walls. These walls were broken opposite the vents in the external walls. The height of the floor above ground level is likely to have been about a metre.

Type 2 (fig. 42)

The use of a much reduced span and thicker external walls suggests that an upper floor was introduced, as discussed above. Examples of this form of granary can be seen at Birdoswald and South Shields (Severan), where the internal clear spans are 6.000 m at the former, and range from 4.190-4.890 m at the latter. A clear span of 6.000 m is one which can be easily overcome by floor joists spaced at close intervals; no central support would have been necessary[2]. It is likely that the external walls reduced at first floor level to form a bearing of *c.* 300 mm for the joists, with the upper walls still being of a minimum thickness of *c*. 700 mm, an optimum requirement so as to ensure no water penetration.

The reconstruction of a typical Severan granary at South Shields shows a minimum clear height of 2.400 m to the ground and first floors. In view of the short spans, it is likely that a simple close couple roof was used, being the most economic roof form. The extra height of the building and greater possibility of lateral thrust, from the close couple roof, is reflected in the greater size of the buttresses at Birdoswald, which has a greater span than the example from South Shields. The two buttresses to the gable walls were almost certainly added, due to the openings at ground and first floor levels, as a provision by the builders to stop possible outward movement of the walls.

The side elevation would have been similar in form to fig. 41 except that the height of the external walls would have been greater, approximating to 6.000-6.500 m at the eaves. It is likely that access to the first floor was by means of a door in the gable wall, with a hoist positioned above the loading bay. As the granaries at both Birdoswald and South Shields (Severan) had projecting buttresses to the end elevations, it would have been possible, in view of the narrow width of the building, to provide support for an overhang of the roof over the loading doors. There would have been no difficulty in providing structural support for an overhang of *c*. 1.500 m, however, there is no evidence of this.

The twenty granaries in the period 6 fort at South Shields, without the insertion of an upper floor, would not appear to make economic sense. In the design of a building the greatest internal area on plan is contained within a circle. The greater the length of a building in proportion to its width, the greater is the length of external wall in proportion to the enclosed area. In other words, the proportion of the granaries at South Shields do not make any sense unless there is an upper floor, as the total length of the external walls is too great in comparison to the ground floor area enclosed. The reduced width of the building, however, is necessary to provide an economic span for the first floor joists, and this is seen as the only practical reason for the form of the building. Bidwell and Speak (1994, 29-30) calculate the capacity of grain held by the supply base, and suggest that the amount of grain from the single storey granaries would feed 15000 men for 164 days at 1.36 kg per day. In view of the greatly increased capacity provided by the addition of an upper floor, it is suggested that the food storage within the fort has been greatly understated. On the figures already stated, it can be calculated that the stored grain would supply 15,000 men for 328 days at 1.65 kg per day - an increase of 100% assuming, that the same amount of grain or foodstuffs can be stored on each floor.

Type 3 (fig. 41)

The known double granaries occur at Wallsend, Benwell, Housesteads and South Shields (mid-Antonine). In all cases the form of the building is dominated by the roof, due to the large span, if it is assumed that a double pitched roof was used as shown in fig. 41, section y y. In this reconstruction of the mid-Antonine granary at South Shields, the rise of the pitched roof is over 4.500 m. This roof form relies heavily on the central division wall on which the structural timbers for each half of the roof bear.

The external elevations are similar to those already described and it is probable that the roof extended over the loading bays at each of the forts. In the case of Housesteads, where there is no evidence for supports for a portico, the projecting roof could have been supported on the piers to the gable walls. It is possible that a separate pitched roof was formed over each half of the granary as shown in fig. 41, alternative section y y. The weakness of this design lies in the valley gutter, and the likelihood of water penetration due to debris, water, snow or ice causing the gutter to overflow into the building, due to modern methods of construction not being available. It is unlikely that the Romans would risk any such failure, when it could be overcome by means of a single double pitched roof. There is some evidence that the valley gutter was used in military construction, and a reconstruction has been proposed for the third century bath house at Chesters. Stone gutters with lapped lead joints can be seen on site, and these have been tentatively identified as a valley gutter, formed between the vaults to the warm rooms (pers. com. M. J. Astill and T. Wilmott). This suggestion is a strong possibility as it would have been unnecessary to lap the joints with lead, if the gutters were to be set into the ground. The cross sectional area of the gutter would seem to be adequate for the reconstructed roofs, and is similar in section to that used in modern construction.

The suspended floor construction to the double granaries at Wallsend and Benwell was made up of stone flags on sleeper walls as already described (chapter 3.4.2.2). Those at Housesteads and South Shields were made up of stone *pilae* supporting timber joists as discussed in the same chapter.

4.3 The Gates

The only representation of a probable gateway to a fort in Britain comes from Maryport, where a carved stone showing twin portals with fenestration above was found, being first recorded by Gordon in 1726. The stone (pl. 59) shows on the right hand side a double portal gateway with five round headed windows over, separated from a seductive figure of a girl on the left hand side, by two deep vertical grooves. The stone is interpreted by Brian Ashmore (pers. com.) to represent a scene in which one is shown the fort gate, the double ditch defences to be crossed when leaving, and the joy of the girl in the town beyond. The stone is dated by him to the late second century, and it is suggested that it shows the gates in their Hadrianic form before any later alteration. The stone, almost certainly, does not portray a mortal woman, but Venus in her role as protector of men. Her pose is typical of that adopted on pipeclay statuettes of Venus commonly found on the military zone (Allason-Jones 1997, 110). The evidence from the gate stone from Maryport shows that the gate, as well as possibly other gates not on the Wall, had a storey over the portals and towers of three storeys above the guardchambers (fig. 54), as put forward for Wallsend.

The reconstruction of stone fort gates has been considered at length by Bidwell *et al.* (1988), and forms the basis on which the reconstruction of the gate at South Shields was carried out. The first serious study to be undertaken was Richmond and Child`s (1942, 148-54) reconstruction of the gates at Housesteads and Chesters.

The external walls to the guardchambers are generally in the region of 900 mm-1.000 m thick where they are built behind the rampart wall. The external walls above the front and rear portals are likely in most cases to have equalled the depth of the responds, which in turn reflected the depth of the voussoirs, usually *c.* 600-700 mm (*c.* 850 mm Housesteads). From the respective wall thicknesses, it is implied that the building was built to a greater height over the guardchambers than over the portals.

The only known exception to this is at Wallsend where the depth of the responds to the north gate are considerably deeper at 1.200-1.400 m (site archive). It is a consideration that as Wallsend was the easternmost fort on the Wall, the towers over the guardchambers might have been built to the greater height of three storeys.

The floors to the guardchambers would span the shortest distance, that is parallel to the rampart wall, whilst the joists over the portals would span in the direction of the passage (fig. 55). This was usually the shortest span, but the main advantage would have been to give lateral support to both the front and back walls, particularly when the *spina* was not continuous (i.e. Housesteads, Birdoswald). The weakest parts of the building were the gates themselves and the central pier between each portal. In all forts some support has been given to the back of this pier, ranging from a full length *spina* at Chesters to a short return pier as at Housesteads and Birdoswald. Where a *spina* was built the length of the passage it is likely that any opening in it had an arched head, and that the wall was built up to the underside of the first floor, so forming a strong lateral tie at ground level between front and rear portals. A difficulty occurs at Housesteads and Birdoswald in that there is no return or buttress to the pier between the internal portals. The distance of the opening between the portals (the depth of the passage) to be spanned is considerable, 3.130 m at the west gate of Housesteads and *c.* 2.300 m at the east gate of Birdoswald. In the case of Housesteads, the span is greater than the width of the portals, which are 2.810 m and 2.830 m. Assuming a semi-circular arch, this would result in the height of the passage arch being some 160 mm higher than the portal arch, with a subsequent requirement to raise the first floor level. Added to this, the cutting and fitting of the stonework at the *spina* to form the springing for the two portal arches and the passage arch, would have proved a very difficult task (Richmond and Child 1942, fig. 9). Furthermore, even assuming a semi-circular arch, some lateral forces would have been transmitted by the arch onto the almost square *spina*, contributing to its early failure. The solution at Housesteads and Birdoswald must have been that there was no arch or wall between the front and rear walls, on the line of the central piers between the portals (fig. 55). All that was required was for the first floor joists to span the clear opening providing lateral support. The omission of the *spina* wall could have been a means of reducing the work content of the gate, with a subsequent saving of time and materials; the consequence of this would be to weaken the gate.

A further development of this arrangement can be seen at Housesteads where there are no responds to the internal portals. If arches had been constructed, the springers and lower voussoirs would have been built into the rear wall of the guardchamber. This would visually have been unsatisfactory, as well as creating difficulties in tying the rear wall into the passage walls. It is suggested that the rear portals were spanned by timber lintels, and that the rear wall was subsequently built off these, possibly on a course of flags (a traditional detail). It is likely that the first floor joists were notched into the top of the lintels so as to give some lateral tie. This design for the inner arch could have been seen at the inner portal to the west gate at Chesterholm (Birley, Richmond and Stanfield 1936, 235-6 fig. 5) where no responds were seen to the internal ends of the walls at either side of the entrance passage.

It is probable that a course of stone was laid over the keystones to the arch and below the string course (which probably approximated to first floor level) to act as a levelling course. This would enable two courses of stone to be laid above the top pivot stone bearing on the buttress or *spina* behind the central pier between the two portals. Taking into account the size of this pier and buttress at Birdoswald, and the possible eccentric forces applied when both gates were opened and closed, there is no doubt that the member was undersized (chapter 3.1.5). It was probably found that one gate had to be kept shut permanently, so giving lateral support, to allow the other to be used in the normal way. In order to provide adequate vertical forces to the top pivot, to counter any forces applied by the operation of the gate, as much stonework as possible would have been built above them (Hill and Dobson 1992, 49). To this end it is likely that at least an internal projecting pier, built off the *spina* or buttress, was formed over the top pivot stones in the room over the portals. When no room was formed, a pier could have been formed in the rear of the parapet wall.

The two reconstructions show a gate to the fort at Wallsend and the east gate at Birdoswald. The example from Wallsend (figs. 51 & 54) shows a conjectural reconstruction of three storied towers with a storey above the portals; the portals are similar in size to the gate at Maryport but no reconstruction of the gate is possible as the sizes are not known. A gate from Birdoswald (fig. 53) is shown with two storied towers and a platform above the portals.

From the gate stone it is known that there was a room over the portals with five round-headed windows. The windows are set out equally centred on the pier between the two portals, the resulting walling between the openings being *c*. 950 mm wide. From overwhelming evidence it is known that a great many of the windows to the gates *per lineam valli* had arcuate lintels, viz. South Shields, Great Chesters, Housesteads and Birdoswald, the width of these being generally *c*. 600 mm. If the same window spacing was followed in the towers, then only two windows could be fitted in the width available. It is likely that the sills were formed of tile or thin sheets of stone as no one piece sill has been identified. It is possible that some of the stonework identified from South Shields and Birdoswald as string course or merlon capping, could have been used for this purpose (Bidwell and Speak 1994, 148-51). It is likely that the wall to the towers adjoining the room over the portals was carried up with just a door opening connecting the two internal spaces.

A string course could have been built in at around first floor level. This would allow any finely dressed stone, as can be seen to the west elevation of the east gate at Chesters, to finish up against the underside of the mould. It is quite probable that the stonework in the spandrel panels below the string course to the front elevation was finely dressed.

Various arguments have been put forward for roofs over the towers to have the pitch at right angles to the rampart, one of the most persistent being that comparisons can be drawn with gates and towers on Trajan's column. The reliefs on Trajan's column recording the conquest of Dacia, are conventionally seen to have been completed in 113, but this date is challenged by Claridge (1993, 21-22). The forts shown would have been temporary turf and timber camps. It must further be recognised that the reliefs include many errors and misconceptions, as the carvers in Rome were ignorant of many of the people and objects described (Lepper and Frere 1988, 32). When making comparisons with defences shown on the column, it should be borne in mind that the stone forts built by Hadrian were designed to be permanent, and the defences and buildings designed accordingly. It has been pointed out that, as the towers were rectangular with the greatest distance being at right angles to the rampart wall, they were more likely to be roofed with the ridge running parallel with the longest side, as it is usual practice to have the gable wall on the shortest side (Bidwell, Miket and Ford 1988, 195). Whilst this is usual in many cases, as the average external size of the towers was *c.* 5.000 m by 6.000 m, the difference in the dimensions does not make it a realistic consideration. It is probable that the roofs were constructed by spanning purlins across the shortest dimensions, i.e. parallel to the ramparts, on which the boarding was fixed. This is the simplest form of roof, and with a *c.* 4.000 internal span, offers the most economical form of roof carpentry.

Probably the most convincing argument that all the roof pitches ran in the same direction is the way in which they would have been built. In constructing any roof a working platform is required at eaves level, off which to construct the roof timbering, fix the place tiles and materials. If the double pitched roof to the towers was above a roof over the portals, then the latter roof could not be constructed until the former were completed. If the roof over the portals was built it would have been more difficult to construct and raise material to the roofs at the upper level, and there would also be a risk of damage to the lower roof. If the roofs ran in the same direction, work could have been able to be carried out on all three roofs simultaneously, and access to all eaves levels would have been easily achieved.

Many reconstructions show the roofs over both the towers and the portals as being flat, including that over the portals at South Shields. There is no excavated or other evidence from any site in Roman Britain to show that flat roofs were formed. From the technology available to the army, the waterproofing of a flat roof would have been difficult and unsatisfactory in the wet conditions of northern Britain (Bidwell *et al.* 1988, 196 & 200). As pitched roofs could easily have been constructed, it is much more likely that these forms would have been used. A boarded platform directly above the portals would have been acceptable, as any penetrating rainwater would have fallen onto the road below.

With the roof pitches falling to the front and rear of the gate, rainwater would fall to the rear of the gate towers. Water cisterns are often placed in these positions (e.g., the east tower of the north gate at Halton Chesters, west tower of north gate Housesteads and Chesterholm, south tower of west gate), where they are almost the full width of each tower; in these positions they could have been replenished by natural means. In the solution adopted at South Shields, rainwater from the towers would discharge onto the rampart walk and the platform over the gates. If this area was covered with a pitched roof, then the additional rainwater from the towers would discharge over the front and rear portals. The same course would be followed by any missile landing on the tower roofs. There is evidence that both clay tiles and stone slates have been used as roofing materials, with a probability that tiles were used on the Hadrianic buildings in all cases.

The heights of the portals and floor levels to forts *per lineam valli* have been discussed at some length (Bennett 1988, 130, Bidwell 1988, 182, 217, Hill and Dobson 1992, 46-9). For the purposes of this reconstruction it is proposed to use 4.500 m for the height of the rampart walk and 3.000 m for the underside of the portal arch. This latter figure assumes that the arch is a true semi-circle. The arch is made up of a ring of voussoirs *c.* 630 mm high by *c.* 600 mm wide. Access to the first floor is from the rampart walkway via an *acensus* to the side of the tower. It is assumed that the earth backing would be revetted to allow an adequate walkway behind the rampart wall and permit access into the tower.

The reconstruction of the east gate at Birdoswald (fig. 53) takes the form of two towers, each of two storeys, flanking the portals with a timber walkway over the crenellated parapet. The fenestration and spacing of the windows is as the reconstructed gate at Wallsend (fig. 51). The form of the tower roofs is as discussed previously. From the height of the impost and assuming the arch was a true semi-circle, the clear height within the portal is calculated as 3.630 m. The arch is made up of a ring of voussoirs 630 mm high by 600 mm deep.

The floor joists to the platform over the portals could have been laid bearing on the course above the key stone, on the same bed as the string course. Taking into account the clear span between the front and rear portals of *c.* 3.400 m, a timber approximating to 200 by 100 mm might have been used for the floor joists. This would have given a floor level of *c.* 4.600 m above ground level, 100 mm above the rampart walk. The joists could have been covered with boarding or stone flags and might have been laid to falls so as to discharge rainwater through an opening in the parapet wall. Any water penetration through the floor of the platform would have fallen onto the portal passage below.

From the evidence at Chesters (chapter 3.4.3.4), it is likely that the rooms within the gates were plastered and painted. It cannot be discounted that the exterior was also rendered and painted. It is unlikely that the finely pitched masonry was rendered but this could have been limewashed or painted.

4.4 Barracks (fig. 3.4)

There is little evidence of the elevational treatment of the barrack blocks. The only evidence at present to hand from South Shields (see chapter 3.4.4.1), shows that the windows to the inner rooms were probably set at high level just below eaves level. There is no evidence of elevational treatment to the front, but it is possible that the window opening might have been larger, to compensate for the loss of light, caused by the overhang of the verandah, where it occurred. The line of the double pitched roof would continue over the verandah. This roof, which would have been of minimum *c*. 45 degrees pitch (see chapter 3.4.4.2), would have had a large roof space which was almost certainly utilised for either occupation or storage.

As each *contubernium* could in theory be occupied by up to ten men, and it is likely that a fire would have been lit, the matter of ventilation would have been a major consideration. No opening lights are known in Roman buildings, so it is likely that some form of shutter was used. Some form of through ventilation could have been achieved if the central section of the large roof space only, was boarded for occupation or storage (fig. 44)[3]. The open areas adjacent to the eaves would allow trickle ventilation through the roof covering, which would be greatly increased when the external doors were open. This would assist the fumes from any fire to pass through an organic roof covering such as thatch. The amount of useful floor area in the roof space lost by not continuing it to the external walls would be minimal, due to the angle of the roof pitch. A continuous edge to the roof space floor, as opposed to a trap door, would allow easy access by a ladder for men and or equipment.

The various roof types suggested for the barracks, depending on plan form, are set out in chapter 3.4.4.2. However, the various types do not affect the overall form of the building. Figures 43 and 44 show a reconstruction of the southern extant barracks at Chesters, with a verandah running in front of the *contubernia*. A steeply pitched roof of 45 degrees is shown with a light covering; this gives a roof height of *c.* 6.000 m due to a span, overall barrack rooms and verandah, of 12.000 m. This in consequence creates a very extensive area of roof space, which is shown extending up to the front wall in view of the internal height gained by the verandah.

The stone external walls are *c.* 650 mm thick, with the internal lateral walls shown as timber partitions. The purlin roof, with the timbers spanning the *contubernia*, bear on the cross walls, support a thatch roof covering. Stone columns on the line of the cross walls support a timber edge beam, which in turn supports the feet of the spars over the verandah.

The external openings to the rear elevation are based on those seen at South Shields, whilst the front elevation has a much larger window. It is possible the windows were glazed, but timber shutters, as shown to the front elevation, could have been a possibility. The interior and exterior of the building was almost certainly limewashed, or rendered, in which case some form of natural colouring could have been used in the finishing coat. The application of some form of coating at regular intervals, such as limewash, would have been required in the interest of hygiene.

Notes

1 There is very little published evidence of cut *tegulae* which can be related to this application. The detailing of the tiled and slated roofs is an area where future research would be rewarding.

2 The phase 4 western granary at Corbridge, with an internal clear span of 7.620 m has a central row of buttresses. This width is significantly wider than the granaries at Birdoswald and South Shields.

3 The section through the typical barracks (fig. 56) shows stone external walls and cross walls. In view of this the roof is spanned with a collar roof, which is similar to a close couple roof with the tie set mid-way up the height of the pitch. This roof form allows sufficient headroom within the roof space.

5.0 SUMMARY AND RECOMMENDATIONS

This thesis has set out to examine the major Hadrianic stone buildings in the forts on Hadrian's Wall. All upstanding masonry to the buildings has been inspected and measured on site, and these details are included in the appendices; where possible all archival and published reports have been assessed. As a background to the study the introduction reviews the progress of Wall studies and the advances made up to the present time. An overview is taken of the Wall and its garrisons, and the background of the forts and their buildings considered. A subsequent chapter examines Roman military building techniques, a subject which is poorly documented in Britain, and for which much reliance is placed on the work of Vitruvius and other Roman writers. Recent work on timber, especially from Carlisle (McCarthy 1991) is valuable as it is one of the few places in the northern military zone, apart from Chesterholm, where structural timber has been found in good condition. However, little timber anywhere in Britain has been seen which relates to roof carpentry; this is an area where future excavation might throw light on constructional methods.

The main body of the thesis examines the form, a dimensional analysis and constructional techniques of the buildings. The form of the buildings is seen to reflect their function, and this would have been expressed in simple architectural details. This design philosophy was based on empirical methodology which would have enabled the buildings to have been erected quickly, and have ensured that building failures would have been minimal. Drawing on similarities of form and constructional detail, it has been possible to suggest tentative identification of some of the legions carrying out the work. However, it is probable that more than one legion or military unit carried out building work at the same fort. The quality of the finished stonework strongly suggests that the construction was carried out in considerable haste as much of the masonry, especially to the gates, remains unfinished.

It is highly probable that the *architectus* or the *agrimensor* had a “manual” giving guidance on the sizes and disposition of the buildings within any fort. This must have been particularly relevant for the forts on Hadrian`s Wall, as they were conceived as part of an overall concept, and not built piecemeal. The dimensional study of the buildings (chapter 3.2) has shown that there is some correlation with the dimensions of the buildings, both in their parts and their whole. This is an area where future study could provide valuable links with other sites and perhaps identify a unit of measure. Such a study could with justification take in the stone forts on the Antonine Wall, together with others in the northern frontier zone, where they were built by the legions who worked on Hadrian`s Wall.

Whilst the materials and building construction techniques used by the Roman builders have been discussed, together with the sequence of building (sections 2.0, 3.4 and 3.3), the source of the materials is still largely unknown. The natural building materials used, particularly in the central and eastern parts of the Wall, were unlikely to have been brought any great distance, yet comparatively few quarries and lime kilns are known. There are also very few tileries that have been identified in the central area, and there is considerable evidence to show that the Hadrianic buildings within the *latera praetorii* were tiled (chapter 3.4). It is suggested that the source of these building materials for the construction work on the Wall, together with their route to site, would be a fruitful area for further research.

The final section considers reconstructions of the buildings discussed. A study of the dimensional and constructional evidence has enabled reconstructions to be made of the four building types studied. Although there may be some details that are open to interpretation, it is considered that the proposals put forward would bear a close resemblance to the original buildings. The reconstruction of the Severan granaries at South Shields has put forward evidence which shows that the storage capacity of the supply base has probably been understated by some one hundred percent. This could have significant bearing on our understanding of the frontier at the beginning of the third century.

The fragmentation of the archives studied during the research for this thesis has caused some difficulty, and much recent material is unpublished and difficult to source. The English Heritage study of the stone at Housesteads is invaluable, but the single copy of the archive and limited availability of the report, make general access to the contents difficult. Although there is a significant quantity of moulded and decorated stone on site and in the museum at Chesters, some of it from other sites, there is unfortunately no firm provenance for much of it. The limited study carried out for this thesis has identified some stonework *in situ,* which probably relates to upstanding masonry and would not seem to have been recognised. It is desirable that a full study is undertaken of the stonework at Chesters. It is also recommended that the sources of all archival material on the Wall be identified, with a copy of the data kept in the Hadrian's Wall archive at the University of Newcastle.

The stone buildings within the forts on Hadrian's Wall are a field which has been neglected by archaeologists, and unfortunately in many cases, the subject has not received the attention and discussion it deserved in excavation reports. This thesis has been hampered by the lack of site archives from past excavations, as few site records are available for any excavations prior to the Second World War. This is a subject that is receiving more attention at present, but unfortunately much is still being missed, and interpretations are questionable, due to the lack of knowledge of structural form and building construction techniques by archaeologists. It is a paradox that most archaeologists do not understand the buildings which they are excavating, and cannot visualise the three dimensional form of a structure. Even today comparatively few archaeologists obtain specialist reports from a suitably qualified expert on the form and construction of a building under consideration; this is in direct contrast with American archaeologists who would never attempt to excavate any significant building without an architect in the excavation team. Bosanquet (1904) in obtaining a specialist report from an architect on the stonework and masonry during his excavations at Housesteads, was exceptionally far-sighted.

Archaeologists for a large part of their time whilst undertaking fieldwork, are involved with buildings, yet they receive no training in basic traditional building construction techniques, and are not even taught the correct names for the building elements. Wheeler (1954, 133-4) records that he was constantly astonished to find how lacking the average mind was in understanding what, or what was not, structurally possible and recommended that he had no hesitation in urging a systematic course of architectural training upon anyone who proposes to devote himself to field archaeology. Over four decades later these thoughts of Wheeler have still not been put into practice, whilst the lack of basic knowledge in this fundamental field is reflected in the interpretation of structures in many archaeological reports. There is no disgrace in utilising the services of a specialist on sites where significant buildings were being excavated. The time is long overdue when the report on the form and construction techniques of a building should enjoy the same significance that the pottery report has enjoyed for decades.

The scope of this thesis has been limited by the number of forts on the Wall for which the sizes of the buildings were known. In order to extend this scope, the author initiated geophysical surveys of the forts of Halton Chesters and Birdoswald. These surveys were carried out as collaborative projects with students undertaking the MA in Archaeological Survey at the University of Durham. Both surveys were successful and gave useful information on the size of the buildings within the forts. The results have or will be published as, Halton Chesters (Berry and Taylor 1997) and Birdoswald (Biggins and Taylor forthcoming). A further survey took place at Stanwix that was unsuccessful as no archaeological anomalies were located. It is highly probable that if more fort plans had been obtained by geophysical survey, or if archival material had been available, further conclusions would have been made[1]. The author feels that a major advancement of Wall studies can be made by the undertaking of geophysical surveys of the forts where no such plan exists, together with the *vici*. In this manner the plans of the forts could be quickly and cheaply obtained and considered in association with the military settlement and cemeteries. Such a study would throw valuable light on the interaction of the military and civilian on Hadrian`s wall. A programme of research to undertake the surveys would enable Wall studies to make up some of the ground lost since the golden years of the first four decades of this century.

This thesis has brought together for the first time an assessment of the published data along with a dimensional record, of the four building types being studied. This is set in the context of the present understanding of the function and garrisons of Hadrian`s Wall. The material has enabled dimensional and constructional comparisons to be made between the buildings at the forts on the Wall together with other military sites. The analysis has increased our understanding of the design and sequence of the building operations together with constructional techniques. Proposals for the reconstruction of the buildings have been put forward that are based on the data obtained. As more information becomes available in the future this will enable further conclusions to be drawn from the findings set out in this thesis.

Notes

1 It is surprising that at the close of the millennium, and the introduction of geophysical techniques many years ago, the plans of many rural forts *per lineam valli* are not known. The full plans of the forts at Rudchester, Carrawburgh, Great Chesters, Chesterholm and Carvoran are not known. These plans could quickly and cheaply be obtained by geophysical means in a matter of a few days at each fort, and so contribute considerably to our knowledge of Wall studies.

6.0 GLOSSARY OF TERMS

Abacus A slab forming the crowning member of a capital.

Aedes A temple, sanctuary or shrine. The room in the centre of the rear range of the *principia* where the imperial shrine and military regalia was placed. Also known as the *sacellum.*

Arcade A range of arches supported on piers or columns, attached to or detached from the wall.

Architrave The beam or lowest member of the entablature which extends from column to column.

The term also applies to the moulded frame around a door or window

Arcuate Curved like a bow, arched or arched shape.

Arris The sharp edge formed by the meeting of two surfaces.

Ashlar Masonry or squared stones with a fine finish in regular courses, in contradistinction to rubble work.

Capital The crowning feature of a column or pilaster.

Cavetto A simple concave moulding, approximately quarter round.

Chamfer Surface formed by cutting off a square edge, usually at an angle of 45 degrees.

Clerestory An upper stage in a building with windows above adjacent roofs, especially applied to this feature in a *basilica* or church.

Close couple roof A roof form where the spars or rafters are connected by a tie at eaves level.

Collar roof A similar roof form to the close couple roof, but the tie is positioned approximately halfway up the rise of the roof pitch.

Coping	The capping or covering to the top of a wall.
Corbel	A block of stone, sometimes curved, projecting from a wall and supporting a structural member.
Cornice	The crowning or upper portion of the entabulature, projecting to throw off rain water.
Cyma	A moulding with an outline of two contrary curves - either *cyma recta* or *cyma reversa.*
Dead load	The total load of the elements making up a buildings fabric.
Doric Order	The first and simplest order of Greek architecture (Cordingly, 1951, pl. 5)
Eaves	The lower part of a roof projecting beyond the face of the wall.
Entablature	The upper part of an order of architecture, comprising architrave, frieze and cornice, supported by a colonnade.
Entasis	A swelling or curving outwards along the outline of a column shaft.
Extrados	The outer curve of an arch.
Fillet	A small flat band between mouldings to separate them from each other; also the uppermost member of a cornice.
Frieze	The middle division of a classic entablature.
Header	The end face of a block of stone. Roman masonry *per lineam valli* is usually laid in header bond with the end face of the stonework exposed and the long face built into the walling.
Impost	The member, usually formed of mouldings, on which the arch rests.
Intercolumniation	The space between columns.
Intrados	The inner curve of an arch.
Jamb	The side of a door or window.

Joist A timber member used to support the structural floor covering.

Keystone The central stone of a semi-circular arch.

Lap The lap of a slate or tile is the cover which is given to those underneath it.

Lintel The horizontal timber or stone member which spans an opening. Also lintol.

Live load The applied loads on a building fabric such as floor loadings or natural forces applied to the outside of a building, viz. wind or snow.

Opus Quadratum Walling made up of rectangular blocks of stone, with or without mortar joints.

Pediment In classic architecture, a triangular piece of wall above the entablature which fills in and supports the sloping roof.

Per lineam valli Along the line of Hadrian`s Wall.

Per Scamna A strip of land broader than it is long, opposite *per strigas.* In a description of a fort, the buildings would lie parallel with the *via principalis.*

Per Strigas A strip of ground longer than broad, opposite *per scamna.* In a description of a fort, the buildings would lie at right angles with the *via principalis.*

Pier A mass of masonry, as distinct from a column, from which an arch springs in an arcade.

Pilaster A rectangular feature in the shape of a pillar, projecting from the face of a wall and carrying an entablature.

Pitch of Roof The inclination or angle of its surface to the horizontal.

Plinth The lowest square member of the base of a column.

Purlin A horizontal beam in a roof resting on the principal rafters.

Quoin A term generally applied to the corner-stones at the angles of buildings, and hence to the angle itself.

Raft foundation A foundation extending to the whole area of the building whereby all loading is transferred to the ground over the maximum possible area.

Respond Half pillar at end of an arcade. The projecting masonry from the passage walls and *spina* forming the portal openings to the fort gates.

Ridge The apex of a sloping roof, running from end to end.

Span The distance between the supports of an arch, roof or beam.

Spandrel The triangular space enclosed by the curve of an arch, a vertical line from its springing and a horizontal line through its apex.

Spar A timber member used in roof construction, similar to a joist but inclined; usually laid to directly support the roof covering. Also rafter.

Stretcher The side of a block of stone. Masonry is usually coursed with the long side exposed in stretcher bond.

String Course A moulding or projecting course running horizontally along the face of a building.

Torus A large convex moulding used principally in the bases of columns.

Trabeated A style of architecture where beams from the constructive feature, resting on piers or columns.

Truss A supporting structure for the roof made up of principal rafters, and a tie at eaves level. Additional members can be placed between the tie and principal rafters. Trusses are spaced at suitable intervals to receive purlins, upon which rafters or the roof covering can be placed.

Tuscan Order A simpler form of the Doric Order.

Verge The edge of a roof on a gable wall.

Voussoirs The truncated wedge-shaped blocks forming an arch.

Note For the convenience of the research, the glossary of terms draws heavily on Bannister Fletcher (1954, 965-976)

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Abbreviations

AA	*Archaeologia Aeliana,* series identified numerically
CSIR	*Corpus Signorum Imperii Romani*
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	Coulston, J C and Phillips, E J, 1988 *Great Britain* vol 1, Fascicule 6, Hadrian`s Wall West of the North Tyne and Carlisle
CW	*Transactions of the Cumberland & Westmorland Antiquarian & Archaeological Society,* series identified numerically
EHCHS	The English Heritage Catalogue of Housesteads Stone
JRS	*The Journal of Roman Studies*
Polybius	Polybius and Pseudo-Hyginus, *Fortification of the Roman Camp,* trans and ed M C J miller and J G DeVoto, 1993, Chicago
PSAN	*Proceedings of the Society of Antiquaries Newcastle upon Tyne*
RIB	*The Roman Inscriptions Of Britain*
	Collingwood, R G and Wright, R P, 1965 vol 1, Inscriptions on Stone RIB 1-2400
	Frere, S S and Tomlin, R S O, 1992 vol 2, *Instrumentum Domesticum* RIB 2442-2480
SPAB	The Society for the Protection of Ancient Buildings

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