The Defences at Saint-Bertrand-de-Comminges: Some Observations on the Mechanics of the Late Roman Building Trade

Jason Wood

INTRODUCTION

This paper takes as its focus the results of a study of the late Roman defences of the upper town at Saint-Bertrand-de-Comminges, Haute-Garonne, France **(fig. 1)** The work formed part of a British initiative, directed by the author and Simon Esmonde Cleary, to document and analyse the construction of the defences and their subsequent development through a combination of architectural survey and archaeological excavation. Additional work was triggered by the completely unexpected discovery of an exceptionally well-preserved length of crenellated wall top; certainly a unique survival in France, and perhaps the best *in situ* example in Europe. The evidence obtained from the excavations places the construction of the defences in the early years of the fifth century (Esmonde Cleary and Wood 2006 – see also Esmonde Cleary, Jones and Wood 1998; Wood 2002).

The research framework for the architectural survey was formulated with the intention of gaining a greater understanding of the form and planning of the defences and the construction techniques employed. The availability of accurate survey data allowed calculations to determine estimates of volumes of building materials designed to help answer questions relating to the mechanics of the late Roman building trade.

OVERALL FORM AND DIMENSIONS OF THE CURTAIN WALL AND TOWERS

The curtain wall comprises four principal elements: the foundations, substructure, superstructure and wall top. The junctions between the foundations and the substructure, and between the substructure and the superstructure, are marked by simple offsets. In some parts of the circuit, a further offset occurs on the internal face of the superstructure.

The maximum external height of the wall is calculated to have been about 5.90m, from the top of the foundations to the top of the merlons. The maximum internal height appears to have been about 5.55m. At the south-west angle, the heights are much lower due to a relatively high spur of rock known as the Rocher du Matacan. The average width of the wall at the base of the substructure is just over 1.70m. The substructure offset and, where it occurs, the internal intermediate offset in the superstructure, reduce the thickness of the wall to 1.50m at its top.

Direct evidence was found for one tower and analysis suggests the position of nine others. Eight of the towers were located on the north-eastern defences and one each flanking the two gates either side of these defences. It is proposed that all ten were solid, projecting, semi-circular towers of a type common on late Roman fortifications. The relatively low overall height of the curtain would suggest that the towers stood only one storey above the level of the wall-walk, estimated to have been about 3m high and about 5m overall to the apex of the roof. As with the curtain, the overall heights of the towers presumably varied due to topographical irregularities but probably did not exceed 10m. In plan, the towers were semi-circular fronted but square at the rear; the rear face being carried over the wall-wall to pick up the line of the internal face of the curtain. The curtain wall towers had diameters of just under 4m. The diameters of gate-towers were probably 6m. They average just over 26m apart.

Figure 1. Present-day view of the upper town at Saint-Bertrand against the backdrop of the Pyrenees, dominated by the medieval cathedral of Sainte-Marie and showing part of the late Roman defences encircling the hill-top. To the left of the picture lie the extensive remains of the Roman lower town in the valley of the Garonne

CONSTRUCTION TECHNIQUES

For the most part, the mortared wall facings are made up of rectangular blockwork or petit appareil, slightly tapered to the rear. The corework is composed of regular bedding planes distinguished by alternating layers of mortar and stone rubble, with occasional pieces of brick and tile. The rubble is sometimes pitched in a herringbone fashion **(figs. 2 and 3)**.

Figure 2. The north-western parts of the defences are well preserved. The Roman fabric is for the most part easily distinguished from that of later periods by its regular, coursed rubble corework or its facing in petit appareil with courses of brick and tile. Note how the foundations are now exposed due to erosion at the base of the wall. Note also how the construction courses follow the natural slope of the ground

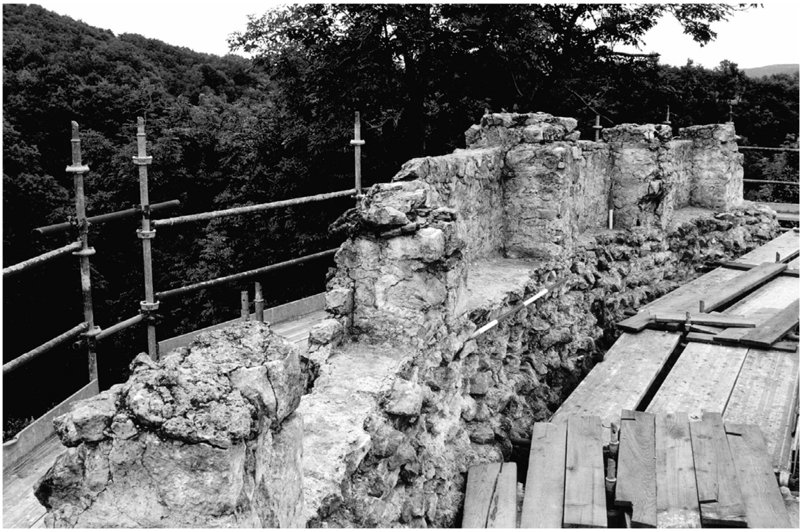

Figure 3. The south-west angle of the defences displays the best preserved Roman fabric. Here both sides of the wall can be seen standing to almost their original heights. Removal of vegetation and later masonry at the top of the wall revealed the exceptionally well-preserved Roman wall-walk, external cornice, parapet and lower halves of five traverses (internal buttresses), as well as evidence for four merlons and three embrasures

The wall appears to have been built one vertical course at a time. The external and internal facing stones were mortared in position to form a shallow trough. The space between was then packed with rubble, laid in regular rows, and a liberal amount of semi-fluid mortar spread over the surface. As soon as this course had dried sufficiently to allow the builders to walk on the surface, the process was repeated. The quantity of rubble was probably too great, and the mortar mix too stiff, to have caused any movement of the facings while the corework was laid. The use of shuttering is therefore discounted. The laying of brick and tile courses is thought to have given the wall facing extra security and additional strength since at intervals they formed a deeper bond with the core than the facing stones themselves.

The walls were originally rendered and lime-washed, both externally and internally. It would appear, therefore, that the modern view of the walls, with rows of petit appareil and brick and tile courses forming an instantly recognisable Roman facing, is far from correct. At Saint-Bertrand, the render and lime-washing might have been intended to give a marble-like appearance.

MECHANICS OF THE LATE ROMAN BUILDING TRADE

With relatively little of the Roman fabric visible at Saint-Bertrand, compared say to some other late Roman defences, it is difficult to make precise statements about the logistics of the construction. The following observations are based on evidence for work-gang lengths and the construction sequence, calculations on the volumes of building materials required, and some thoughts on the related subjects of transport, manpower, technical expertise and the length of the building operation.

Work-gangs

Work-gang divisions are the result of the uneven effects of the builders' efforts to tie in the works of different gangs responsible for the construction. They are identifiable due mainly to changes in the wall alignment, steps in the offsets and other elements of the curtain, changes in the angle of the construction courses, the misalignment of the stone facing and corework courses, changes in the brick and tile courses, and changes in the colour of the mortar.

Evidence for work-gang divisions is clear, especially at the south-west angle and in the north-western defences. In other parts the indications are slight because the Roman fabric is too obscured by later refacing. The divisions average 8.73m long but they are by no means standardised – the longest being 26.80m and the shortest being 2.75m. The projecting towers are not strictly separate work-gang lengths and were probably built with their respective curtain walls, albeit in a slightly different sequence (see below).

Construction sequence

Evidence for determining the construction sequence for the curtain wall is best seen at the south-west angle and in the north-western defences. Examination of the junctions between the work-gang divisions reveals angled or stepped breaks in the construction and also evidence that some superstructure registers oversailed the lower registers of adjacent sections.

As far as it is possible to judge, it appears that the sections of wall erected on sloping ground were built from the top of the slope to the bottom. Evidence from the surviving tower and its adjacent curtain wall sections suggests that the lower stages were built together; those of the tower being deeper than those the curtain because of the slope. The upper registers, however, were built at a common level.

‘Leap-frog’ construction

Since the wall facings did not function structurally once the mortar had hardened, and since shuttering is deemed unnecessary and impractical, the speed with which a layer of newly made structure reached sufficient bearing strength was determined by the stiffening and drying rate of the mortar. This speed was therefore the key factor both in planning the construction and in the actual building.

It is likely that the mortar stiffened fairly rapidly when laid in successive single courses. Even so, the process must have been gradual, the builders being careful not to begin the next layer of corework before the previous layer was sufficiently hardened. The average length of the work-gang divisions (8.73m) suggests that the operation of laying a single course continued for some distance before the wall had gained the necessary strength to carry the additional load safely.

In order to ensure that the workforce was used with efficiency, it is very likely that construction proceeded according to a ‘leap-frog’ method, with work progressing at different rates on adjacent sections of wall. By way of illustration, a typical sequence might have begun with a single course of the facings in section A, followed by a single course of the facings in section B, the corework in section A, the facings of section C, the corework of section B, the corework of section C, the facings of the next layer in section A, and so on. This type of construction might explain the oversailing of certain superstructure registers. It may well be the case, therefore, that a number of adjacent sections were completed by the same work-gang rather than another working independently.

Volumes of material

Estimates are made below of the total amounts of stone, brick and tile, and mortar required to build the curtain wall and towers. In this way we can gain an impression of the total masonry demand. The calculations are based on the known or reconstructed average dimensions of the various component parts of the defences. They do not take account of minor variations to the normal form of the wall or include adjustments for small-scale features and openings. The corework calculations assume that there are no air pockets or bricks and tiles in the rubble.

In calculating the amount of mortar, the figures are based on a ratio of stone to mortar/render of about 70:30 in the facings and stone to mortar of about 60:40 in the core. An arbitrary average of 2.50 tonnes per cubic metre has been adopted.

The calculations suggest that the total volume of building materials demanded for the construction was of the order of 8 537 cubic metres, equating to 21 343 tonnes. 60% of the total was stone, 38% mortar and just 2% brick and tile. Over 92% of the material is employed in the curtain wall; less than 8% is used in the towers. In the circuit as a whole the corework (58%) and foundations (24%) consumed the over-whelming proportion of the materials. By contrast, the facing material accounts for 17% of the total volume. Other components (bricks and tiles for the wall-walk, external cornice, tower floors and roofs) account for only 1% of the total demand.

Transport

A study of the building materials employed in the construction of the defences has demonstrated that most were reused from earlier Roman buildings and monuments in the lower town. Despite the proximity of this supply, some effort would still have been required to transport the material uphill and to distribute it around the perimeter, often on sloping ground and sometimes to precipitous locations.

The following calculations assume that post-wagons (*angaria*) – four-wheeled vehicles drawn by six or eight oxen – were employed to transport the bulk of the material. It is known from the *Codex Theodosianus*, issued in the late fourth century, that the weight limit imposed for a post-wagon was 1 500 Roman pounds (0.49 tonnes) (VIII.5.8; 5.30; 5.47 – see Meijer and van Nijf 1992, pp. 137-8). These restrictions appear to have been designed to minimise the wear on imperial road surfaces and it has been estimated by some – for example Kendal (1996, pp. 142-3) in his study of transport logistics associated with the building of Hadrian's Wall – that the full capacity of a post-wagon might have been 75% above the Theodosian limit (i.e. 0.85 tonnes). This figure has also been adopted by Pearson (2003, p. 94) in his analysis of the construction of the late Roman Shore forts in Britain. It will therefore be used as the basis for the calculations at Saint-Bertrand.

Using the volumes suggested above, it is estimated that transportation of the total amount of building materials for the defences would have required 25 109 post-wagon journeys.

The time taken to transport materials to the construction site was probably not great. Kendal (1996, p. 143) has estimated the speed of travel for a post-wagon over rough ground in the vicinity of Hadrian's Wall to have been 3.20kph. This estimate also seems reasonable for the sloping terrain at Saint-Bertrand. The hilltop is only 0.50km from the centre of the lower town. At a speed of 3.20kph, the return distance could be easily covered in half an hour. However, much more time would have been needed for loading and unloading of the post-wagons. This is estimated at nine minutes per 100kg (Kendal 1996, p. 144) which for a fully loaded post-wagon of 0.85 tonnes equates to about one and a quarter hours. Therefore, the average round journey for one post-wagon, between the commencement of one loading and the commencement of the next loading, was one and three-quarter hours. Assuming a working day of eight hours, and allowing a contingency margin of a quarter of an hour per trip, it is suggested that one post-wagon could have made four round journeys per day and thus moved 3.40 tonnes of material.

Once the post-wagon had reached the construction site, the relatively small size of the building stones meant that movement could be achieved by carrying material on men's backs. Loads transported in this way were limited to about 15kg (Adam 1994, p. 43). For the lower stages of the construction, a chain of workmen throwing each other material from hand to hand was probably employed. For the upper stages, simple pullies may have been used to lift material up to the working platforms.

Manpower

Pearson (2003, pp. 97-8) has calculated that the build-rate for the late Roman fort at Pevensey in Britain was 3.30 man days per cubic metre of wall. (The method used was based on that developed by DeLaine (1997) for the Baths of Caracella in Rome.) This figure takes account of stone quarrying, timber felling, brick and tile production, transport (including loading and unloading), on-site preparation (including sorting of materials, rough-shaping or re-squaring of certain stones, burning and slaking lime, mixing mortar, cutting of timber for scaffolding, etc) as well as the construction process itself (including excavation of construction trenches, all building work, assembly and disassembly of scaffolding, etc).

However, most of the material is reused at Saint-Bertrand and did not require stone quarrying or brick and tile production, only systematic demolition of earlier buildings and monuments. This suggests that the build-rate figure for Saint-Bertrand should be revised downwards. A recent experimental reconstruction of a Roman villa at Butser in Britain has calculated the build-rate to have been 1.50 man days per cubic metre (Morgan Evans 2003, p. 64). As this was for a much smaller project and calculated for on-site preparation and construction only, our figure for Saint-Bertrand should be greater. With the above in mind, the build-rate figure we have adopted for the walls at Saint-Bertrand is 2.75 man days per cubic metre.

Given the total volume of building materials (8 537 cubic metres) the estimated labour requirement at Saint-Bertrand would have been 23 500 man days (to the nearest hundred). Because inefficiencies and other factors not directly part of the construction process have been excluded, this figure must be considered to represent a minimum estimate.

Technical expertise

It is considered that the majority of the construction process did not require skilled labour. Transport of materials and the actual building process were largely physical tasks requiring only unskilled or partially skilled workforces. The use of petit appareil and rubble did not require very qualified masons and the preparation of mortar and the laying of the corework probably only required the minimum of skilled supervision. It is likely that skilled labour would have been mostly focused on the preparatory stages, such as determining the general layout and dimensions of the circuit, and thereafter on supervising the timing and supply of buildings materials. The evidence certainly points to a degree of quality control as there are relatively few building errors and no significant defects.

Length of the building operation

In arriving at an estimate for the length of the building operation we must consider the length of the building season. Lime mortar needs reasonably warm and dry conditions under which to set. The weather and seasonal conditions were therefore limiting factors. Given the Pyrenean climate, the right conditions were probably met during the clement period between April and November, given a dryish autumn. We can therefore suggest a season length of 244 days, of which perhaps 200 days were working days. (Pearson (2003, p. 98) gives a season length of 280 days which seems excessive.)

Dividing the number of post-wagon journeys (25 109) by the daily number of round journeys for one post-wagon (four) gives a figure of 6 277 ‘post-wagon days’. This figure in turn can be converted to ‘post-wagon years’ by dividing by 200 – the estimated number of working days – giving a rounded up total of 32. This indicates that to deliver the required 21 343 tonnes in one building season would require 32 post-wagons; in two building seasons, 16 post-wagons, and so on.

Similarly, by dividing the estimated labour requirement of 23 500 man days by 200 gives a rounded up total of 120 for the average workforce in one season; 60 in two seasons, and so on.

These estimates for transport and manpower do not seem excessive. Even allowing for interruptions and other contingency factors, it would appear that the building operations could have been achieved within one season of work, or two at the most.

REFERENCES

Adam, J-P, 1994. *Roman Building: Materials and Techniques*, London: Batsford.

DeLaine, J, 1997. *The Baths of Caracalla: A Study of the Design, Construction and Economics of Large-scale Building Projects in Imperial Rome*, Portsmouth R I: Journal of Roman Archaeology Supplement 25.

Esmonde Cleary, S, Jones, M and Wood, J, 1998. “The Late Roman Defences at Saint-Bertrand-de-Comminges (Haute-Garonne): Interim Report”, *Journal of Roman Archaeology* 11, pp. 343-54.

Esmonde Cleary, S and Wood, J, 2006. *Saint-Bertrand-de-Comminges III : Le Rempart de l'Antiquité Tardive de la Ville Haute,* Editions de la Fédération Aquitania: Etudes d'Archéologie Urbaine.

Kendal, R, 1996. "Transport Logistics Associated with the Building of Hadrian's Wall", *Britannia* 27, pp. 129-52.

Meijer, F and van Nijf, O, 1992. *Trade, Transport and Society in the Ancient World: A Sourcebook*, London: Routledge.

Morgan Evans, D, 2003. *Rebuilding The Past: A Roman Villa*, London: Methuen.

Pearson, A, 2003. *The Construction of the Saxon Shore Forts*, Oxford: British Archaeological Reports, British Series 349.

Wood, J, 2002. "The Wall Top of the Late-Roman Defences at Saint-Bertrand-de-Comminges: Interim Report", *Journal of Roman Archaeology* 15, pp. 297-309.