Sword and Spade: Military Construction in Renaissance Italy

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Introduction

The growing effectiveness of siege artillery in the fifteenth and sixteenth centuries was the driving force behind one of architecture's more radical responses to technological change. It also provided the impetus for one of Europe's periodic "great rebuildings". The evident vulnerability of medieval defences to gunpowder weapons set in motion a period of redesign from which emerged the squat pointed bastions which proved to be the module of what Sir John Hale aptly called "*the international style par excellence of Renaissance Europe.*"[1] Italy's early lead in this field stemmed from the unwelcome circumstances which made the politically divided peninsula the focus of conflict between France and Spain - the two super powers of the early sixteenth century - as well as part of Europe's front line against Ottoman expansion. The eventual Spanish triumph in the Italian Wars explains the Spanish initiatives and the influence of the Spanish-connected figures mentioned from time to time in the following text. The international character of the Italian Wars also explains the rapid spread of the new fortifications to those parts of Europe (and further afield) to which combattants from Italy returned and to which peripatetic Italian engineers took their skills. By the seventeenth century the face of many of Europe's towns had been transformed. The slender towers and tall battlemented walls of the Middle Ages sometimes survived behind new fortifications, or had been incorporated within them. More often they were replaced by systems of low earthwork ramparts, defended by projecting bastions and a veritable archipelago of detached outworks (the ravelins, counterguards, demi-lunes hornworks and fleches beloved of Uncle Toby) standing in deep ditches and extending the defences far into the surrounding countryside.

Much of the attention given to this revolution has focussed on the early creative role of the Italian Renaissance artist-architect-designers whose ideas on defensive devices survive (and in many cases only ever existed) in their brilliantly revealing drawings. The names of Filippo Brunelleschi, Leonardo da Vinci, Francesco di Giorgio Martini, Albrecht Durer and Michelangelo recur constantly. The first three of those names, together with that of Mariano Taccola, were the subjects of an excellent recent exhibition at London's Science Museum which translated the designers' drawings into large working models of the cranes, pumps, and other equipment used in construction, as well as some of the military machines which are so often used to illustrate Renaissance genius.[2] The thoughts that follow are prompted in part by the continuing emphasis in this field on individual genius, the objects (or more commonly their drawn image) and the connected notion that the field of Renaissance military architecture was at times little more than a dangerous playground for fertile minds.

Here one has to distinguish carefully between the military work of very different designers. Brunelleschi's most important excursion into military engineering ended in failure in 1430 when the dam he had constructed to inundate the approaches to Lucca was breached by the defenders, causing a general collapse which flooded the Florentine camp and forced the besieging army into a humiliating retreat to high ground.[3] Taccola may have campaigned with the Emperor Sigismund

against the Turks in Hungary but his main contribution was theoretical.[4] As a window into the technology and ideas of his period Leonardo's sketchbooks are enormously revealing. However, little substantive fortification work can be attributed securely to the Florentine polymath despite his self-advertisement as a military engineer so often quoted from his famous letter to the Duke of Milan, and some evidence of possible fortress commissions from the Borgia, the Appiani rulers of Piombino, and the Venetians at Gradisca.[5] Michelangelo's fascinatingly eccentric designs for the defence of Florence in 1529 were almost certainly never implemented as drawn.[6] Attempts to make a practical military architect out of Michelangelo are invariably disappointing.

Francesco di Giorgio, by contrast, during the last quarter of the fifteenth century built numerous fortresses, according to some accounts as many as 70 new or extensively modified works, mainly for the Dukes of Urbino and the Aragonese Kings of Naples. Francesco, moreover, was no stranger to the battlefield. His manuscript treatise - although heavily derivative in many areas of architecture - articulates the key military principles of the new fortification, and is illustrated by sketches which describe contemporary design ideas, together with recognisable images of fortresses which he had built or modified himself.[7] Francesco's fortification sketches - together with those of other fifteenth century designers - were still being copied by leading military architects nearly fifty years later.[8] He assisted in the refortification of Naples in the period of tension which immediately preceded the first French invasion of 1494-95, and remained loyal to his Aragonese patrons as they fought their way back into Naples later in 1495. Francesco was probably the "Etruscan Narcissus" who excavated and exploded what may have been the first gunpowder mine in the history of siege warfare under the outworks of the Castelnuovo, which he himself had helped to fortify.[9] The overall scope of Francesco di Giorgio's activity anticipates the scale of some professionals' involvement in the great rebuilding of the sixteenth century.

These points also illustrate some of the difficulties inherent in our topic. An art historical emphasis on the achievement of creative genius quickly runs into difficulty when one has to distinguish between ideas which may or may not have been achieved, but which are in any event often difficult to attribute firmly to the individual authors in whose notebooks they appear. Their credibility is often shaken by the lack of firm evidence for actual building, although clearly those of a figure such as Francesco di Giorgio stand out from the others on this count and gain in authority from their author's military experience. To begin to understand the achievement of the military architectural revolution it is often more helpful to look at the processes by which eventual solutions evolved, and at the range of participants involved. In short, it may be helpful here to employ the methods and agendas of construction history as well as those of conventional art and architectural history, and to ask some basic questions about the nature of the fortification building operations.

Who were the fortress builders and how did they work? The participants in what were almost inevitably teamwork operations often extended from the senior military and political leadership, through the more experienced engineering or architectural experts able to conceive, draw, model and explain complex three dimensional arrangements, to the quasi-professional ranks of master builders, surveyors, foremen and site administrators who got the job done on site and managed the very large numbers of unskilled labourers - men and sometimes women - who did the heavy work. How did fifteenth and sixteenth century systems cope with projects of this magnitude? Often, of course, they did not. The archival record is rich on failure; with a great deal of useful information rising from *post mortem* inquiries, mutual accusations of incompetence or peculation, and shortages of men, money and material. Issues of command and responsibility were complicated by factors such as birth and rank to a much greater extent than would be the case today. All of this needs to be set beside an awareness of the immensity of the logistical task implied by many fortification projects. The comparisons which spring most readily to mind are the canal cutting undertakings of the eighteenth century, or the railway construction programmes which followed them.[10] Fortification

was a serious matter to Renaissance states and correspondingly well recorded, if often frustratingly incomplete in one or more important detail.[11] The surviving records, nevertheless, tell us much about the evolution of design and construction methods, logistics, and the roles of the various artisans and professionals involved at different levels. These issues give us the framework for a paper which seeks to describe the activity of fortress construction, the roles of some of those involved, and the time-scales for the completion of both permanent and temporary works.

Two of the case studies which form the substance of this paper are both unusual in so far as they represent relatively rapid completion. In the case of Siena's mid-sixteenth Spanish century citadel, the completion time was exceptionally fast. The new Florentine fortress at Sarzana took longer, from 1487 to 1492, but this was not long for a major project in a frontier district. Hence, no doubt, the relatively full records in both cases and our ability to describe the salient features in a single paper. Many fortification programmes took very much longer.

The fortification of Lucca and Rome in the sixteenth century

Urban fortifications, in particular, took decades to build. Lucca's renaissance fortifications - probably the best preserved bastion and rampart circuit in Tuscany - began to be modernised in 1513 when the Republic started to "alzare terrapieni alle spalle delle mura," that is, to thicken the medieval walls (whether inside or outside is unclear) with earth-filled ramparts against the impact of cannon balls.[12] Between 1516 and 1525 Lucca further refortified its medieval walls by means of round *torrioni*, substantial brick gun towers which were amongst the last of this type of fortification to be constructed on a large scale in Italy. Already out of date when they were completed, the *torrioni* were seriously outmoded when in 1543 the Consiglio Generale began the search for architectural experts to advise the Republic on a third phase of modernisation. Contact was eventually made with "un certo Frate da Modena" (his name was Jacopo Seghizzi), working for the Duke of Urbino. Seghizzi was released to assist the Lucchesi and prepared a plan for them in the six weeks he spent in the city in 1544, before returning to Pesaro from where he sent further instructions.[13] Another Urbinese, Francesco Bondedi da Pesaro, supervised site works but died in 1546. On Seghizzi's recommendation yet another of the Duke of Urbino's architects, "mastro Baldissera delle Lance," took his place. Baldassare Lanci worked for Lucca from 1547 to 1557 before being summoned to Florence by Duke Cosimo I. Work continued slowly between 1557 and 1575 under the direction of a Milanese architect, Alessandro Resta, with a contribution in 1561 from Francesco Paciotto (then very much the coming man, who was soon to design the much praised citadel at Turin, a project that resulted in a commission to build another six citadels in the Spanish Low Countries).

A gap in building operations followed between 1575 and 1589 when a local architect, Vincenso Civitali, was brought in to advance the programme. Civitali's proposals, together with those of three others, were sent for approval to Alessandro Farnese, the Imperial governor of the Low Countries and an acknowledged expert on fortification. Farnese was unimpressed. In his view any of these schemes would leave Lucca liable to fall within four days, if subjected to a modern attack. Evidently it was the state of the rampart curtains which left so much to be desired. In many parts of the circuit there were still sections of reinforced medieval walls running between the modern bastions. Their replacement by modern ramparts had been postponed by the Republic because of costs, in particular because of the brickwork needed to clad the rampart. Farnese argued that modern ramparts of the required height and thickness could be obtained by building them of rammed earth, without the brickwork *camiciatura* (the outer skin which protected earthworks from the weather). This represented the favoured technique in the Low Countries where siege warfare was by then at its most advanced. Civitali was dismissed when he could not accept this finding and Ginesi Bresciani, who had worked on the citadel at Parma and was trusted by the Farnese family,

was appointed to oversee the works in 1590 on his return from consultations with Alessandro Farnese in Flanders. "L'icamiciatura," in Bresciani's words, served only "per bella mostra." (The brick skin ... served only for show.)[14] Bresciani served the Republic for four years, making two or three visits from Parma every year, and leaving Lucca's service with the gift of a gold chain worth 200 *scudi d'oro*. Seven further architects supervised the work between 1594 and their final completion in 1650. It had taken well over a century to achieve the bastions and ramparts that still surround Lucca.

Lucca, to be sure, was not one of the greatest cities of Italy. Limited resources and over-reliance on foreign advisers certainly did not help to achieve rapid progress in a project that had to be staged as carefully as any contemporary highway rebuilding operation to ensure that the new and old works between them provided at all times a defensible circuit. But the slow pace of these massive schemes was the norm, not the exception. Siena took nearly 150 years to build its final circuit of medieval walls from 1323 to the 1460s.[15] The project was completed just when their inadequacy was becoming apparent and the city - after a period of dangerous inactivity - attempted between 1527 and 1532 to modernise them on a shoestring by adding small bastions at half-a-dozen critical points on the medieval circuit.[16] Verona's bastions and Sanmichele's famous gates in the same city - a showpiece for the new military architecture - were built from the mid-1520s to the 1560s with much better resourcing from a relatively wealthy community as well as strong political pressure from the Republic of Venice, the city's political masters.[17] Numerous ambitious sixteenth-century plans for the refortification of Rome's 18 kilometre circuit (built originally by the emperor Aurelian, and hardly changed through the Middle Ages) ended in the pragmatic decision to concentrate any new work on the Castel Sant'Angelo, the Vatican Borgo and, in the seventeenth century, the Janiculum Hill that overlooked the Papal enclave. Less than twenty per cent of Rome's imperial and medieval perimeter was actually modernised.[18] Indeed, surprisingly few of the very greatest cities of Europe boasted complete bastioned circuits before the end of the sixteenth century. Antwerp was an important early exception in northern Europe, while Palermo and other southern cities in the front line against the Turk moved faster than the average. In the meantime, many Italian and northern European states looked favourably on the construction of self-contained fortresses at strategic points which contributed to the defence of the city without complete reconstruction of the walls.

Even the self-contained mid-sixteenth fortresses, however, represented an enormous increase in scale (Fig 1). This statement is clearly expressed visually by a bird's-eye view of the Castel Sant'Angelo in Rome. The drum of the Roman mausoleum which served as the keep is surrounded by a rectangular medieval curtain wall. One of the cylindrical corner towers built in 1447 survives as a turret inside a later work. The octagonal "bastions" were added in 1492-1495 by Antonio da Sangallo the Elder, steadily increasing in size throughout this building programme. The pointed bastions forming the outer circuit were built in 1561-65 by the then leading papal military architect, Francesco Laparelli, and modified in 1630 to give the curved shoulders known as *orecchioni* ("big ears") which concealed the *traditore* ("traitor") batteries in the flanks. What cannot be seen in this view is the network of underground countermine galleries which ran around the perimeter and extended far out into the approaches, further extending the zone of construction.

The point is made. Growth in the size of sixteenth century fortifications was exponential, even if we leave out of consideration a number of extensive coastal and frontier defence systems that rival in their extent the great frontier walls of the Romans. With this growth, of course, came an exponential increase in the volume of material required for construction and of the labour needed to place it. With it, too, came rapid increases in costs which far outstripped the inflation which was another feature of the century. The largest of Peruzzi's bastions built between 1527 and 1532 at Siena cost 2,000 *scudi*. In the 1540s the first of Sangallo's very much larger bastions in Rome cost

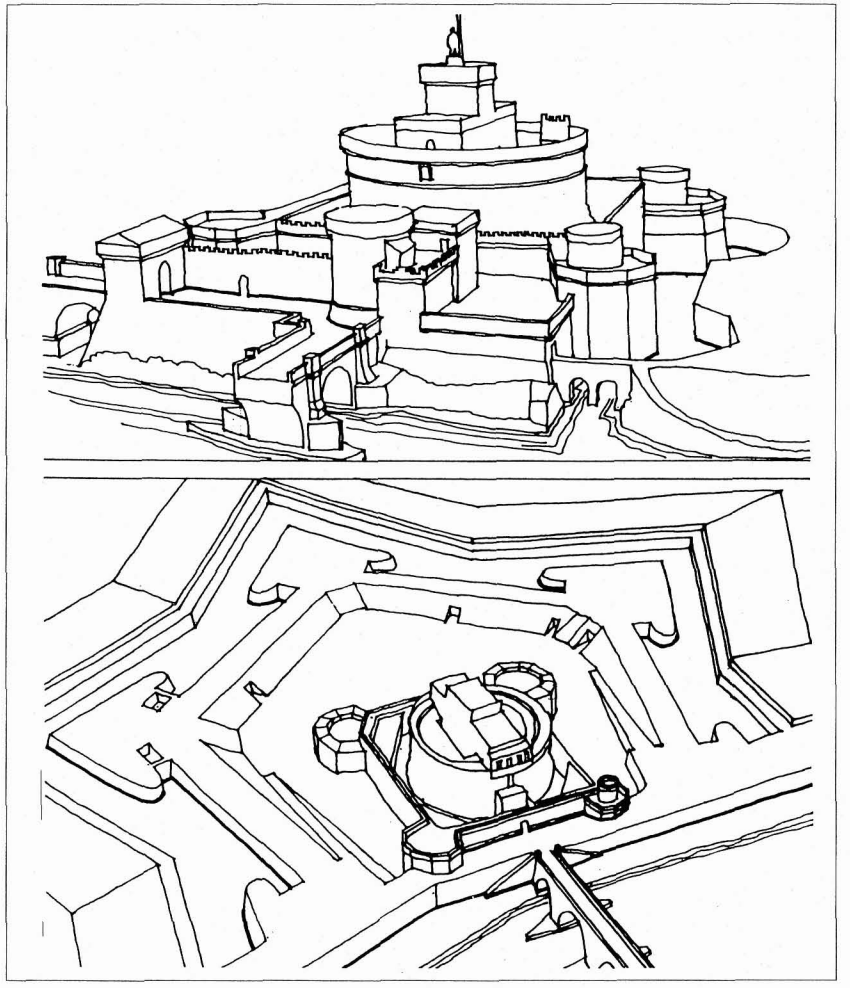

Fig. 1 Two views of the Castel Sant'Angelo, Rome.
Above: Works by Antonio da Sangallo the Elder in 1492-95 involving the addition of octagonal bastions to the smaller cylindrical guntowers of 1447 at the corners of the medieval circuit.
Below: Modern air view showing Francesco Laparelli's bastions built in 1561-65. The curved shoulders (known as orecchioni or "big ears") were added in 1630. The bridgehead defences shown in the upper view were dismantled when the modern Tiber River embankment was constructed. Drawings by the author.

40,000 *scudi*, and the total cost of the 18 bastions needed for the refortification of the papal capital was estimated at 450,000 *scudi*. Not surprisingly the later project was abandoned, but by the early seventeenth century the Papacy of Urban VIII spent some 343,000 *scudi* on the Forte Urbano near Bologna, an average of 85,000 *scudi* on each of the frontier fort's four bastions and their associated rampart curtains.[19]

Design decision-making

The recording and communication of design decisions was also in a state of transition. Drawings were increasingly used for the development of designs as well as communication of construction information. The best surviving collection of Renaissance architectural drawings is that of Antonio da Sangallo the Younger and his circle: dating for the most part from the busiest period of the practice in the 1530s and 1540s. There are few "presentation" drawings, but very large numbers of annotated site survey sketches, quickly-drawn studies of different design solutions or details, and multiple copies of basic layouts for city walls or fortresses. A few sheets could be described as working or assembly drawings; accurate plans and cross sections for the most part, with dimensions and notes on materials. The biggest and most detailed drawings - which involved the joining of numerous sheets of paper to produce sheets as long as two metres - often involve a variety of alternatives, overlaid in increasingly heavy line, suggesting that they formed part of an ongoing design discussion.[20]

Models were also clearly very important. Some Renaissance models (Brunelleschi's brick-built model of the Florence dome, for example, or that of St Peter's in Rome made in timber by Sangallo and Labacco) were so big that they are better described as miniature buildings. Model building on this scale was clearly impractical for the much larger and more extensive fortification schemes, but complex three-dimensional arrangements and difficult sloping sites still required models if they were to be understood by lay committees and patrons. Communication with lay persons was evidently very much part of the agenda when in 1501 Basilio della Scola, an engineer and artillerist in the service of the Republic of Venice, exhibited a wooden model showing "*what is being done in France, Italy ... Germany and elsewhere.*"[21] Models were often transported over great distances. In 1521 the same Basilio made a model of the fortifications of Rhodes, which was sent to the Pope just before the decisive Ottoman attack on the Knights' stronghold.[22] A model of the proposed Spanish fortress at Siena, was sent in 1550 from Italy to Simancas for approval by the Emperor Charles V.[23] In all of these cases the models were viewed by rulers and high-level decision takers, or - in Venice - perhaps by an interested civic aristocracy.[24] Were models also used on site? Were duplicates made? For proper control of long distance construction, some form of duplication was essential and amongst the Sangallo corpus there is ample evidence of a veritable office industry in the mass production of copy drawings. By the middle of the sixteenth century duplication had become an essential aspect of design which allowed the biggest "practices" such as the Sangallo Circle and the Sanmichele extended family to handle numerous different major projects simultaneously over great distances from a main base in Rome or Venice. The issue emerges - together with questions about the authority that was invested in drawings and models - when we look in detail at an earlier fortress construction campaign.

Sarzana 1487-92

In June 1487 the Florentines began construction of a new fortress at Sarzana following their capture of the town from the Genoese (Fig 2). Sarzana was in an exposed position on the far northwest frontier of Tuscany, and at that time was nearly isolated from Florence by the neutral territory of Lucca and traditionally hostile Pisa, all of which lent urgency to the task of fortification. After the immediate patching of the damaged city walls, a contract for what today would be called "design and build" was let in December 1487 by the Otto di Pratica, the Florentine executive committee of Eight under the constitution of 1480.[25] The team of contractors comprised Bernardo di Tommaso Corbinelli, Francesco di Giovanni called il Francione, Domenico di Francesco called il Capitano, and Francesco d'Angelo called La Cecca. Il Francione and La Cecca had established

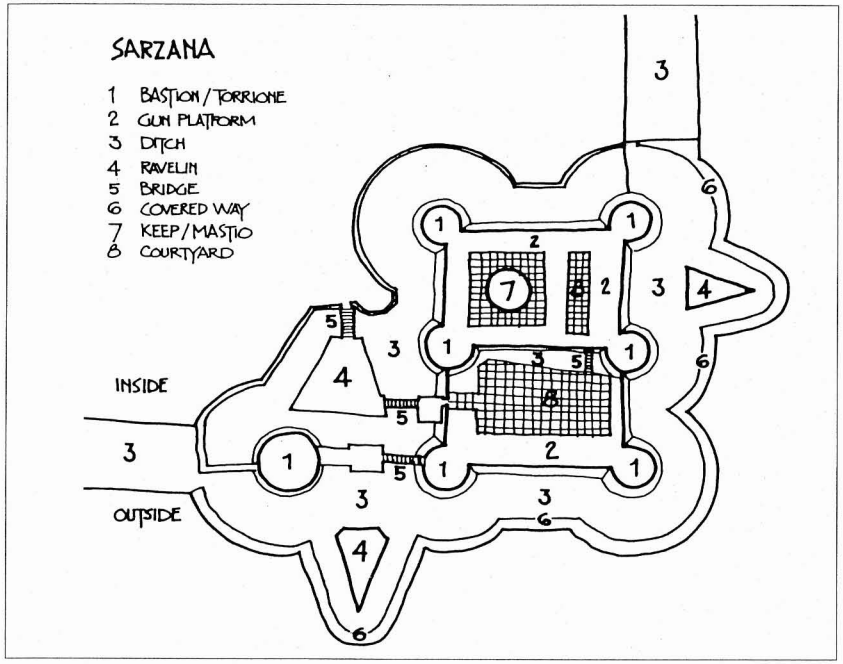

Fig. 2 Sarzana, Florentine Fortress and outworks in the early sixteenth century. Redrawn by the author from reproductions of early survey drawings. The main fortress survives as a prison, but the outworks standing in the ditches are no longer to be seen.

reputations as military architects. Indeed Francione's bottega had trained Giuliano and Antonio da Sangallo the Elder, the leading Florentine military architects of the time, as well as La Cecca. Corbinelli seems to have been the general manager (later in the contract, indeed, it was suggested in correspondence that he was not competent to supervise high quality masonry construction). Il Capitano travelled far and wide to secure materials, as well as supervising all aspects of the contract.

La Cecca and il Francione were clearly regarded as the chief designers. On 17 April 1488, shortly after the solemn ceremonies which marked the placing of the first stones of the new fortress at Sarzana, both of them were appointed at a salary of seven florins a month to the posts of "*architetto e ingegnere della Republica sopra le artiglierie e macchine atte alla espugnazione delle terre e sopra la edificazione e le riparazioni delle fortezze.*"[26] The post of "architect and engineer to the Republic over artillery and machines for the siege of towns and over the building and repair of fotresses" was no honorary position. Il Francione was absent from Sarzana for much of the time on official business for the Republic, which did not protect him from complaints about his lack of supervision. On 26 April 1488, only days after his appointment, La Cecca received a head wound at the siege of the castle of Piancaldoli. He died on 17 May 1488 in Florence, where he had been carried. The four contractors were now three.

The written contract specified prices for excavating ditches, cut and fill to provide a bank outside the ditch, foundation building, and masonry wall construction. All of these works were to be measured in *braccie*, the Florentine *braccia* being about two feet in length. Curved elements - such as the guntowers, which at this stage were still round - commanded a higher rate. Vaults requiring

centering and skilled masonry and the elaborate battlements on the tops of the walls were measured around the outer envelope and costed as if solid, "vano per pieno" - empty for full - as the contract put it. Lime mortar (*calcina*), ironware, dressed stone and *conci* were all to be provided by the Otto under separate contracts. Many of the problems on the contract stemmed from these traditional building elements. Dressed stone components included the framing for gun ports, arrow slits (still very much in use), *merli* (the teeth of the tooth-and-gap battlements), stair treads, window and door architraves and the *conci*, or *becchatelli*, the stone brackets which supported the cantilevered machicoulis (or fighting gallery) which ran around the upper walls and was also still in use at this time. The contract specified matching white marble dressings for all of these components, which would be obtained from the quarries at nearby Carrara and which had to be sculpted to high standards to the satisfaction of the contractors, and of the Florentine inspectors who were not easily satisfied.

The greatest production difficulties at Sarzana turned upon the failure of lime mortar supplies. Traditional solid wall construction between two skins of facing stone consumed enormous quantitites of lime, which had been promised by the Marchese Gabriello Malaspina, lord of nearby Carrara and a newly-acquired ally of Florence. The politics of this situation meant that the contractors were unable to get rid of their main supplier, and were compelled at different stages of the contract to construct their own lime kilns in the ditch of the fortress, using marble salvaged from the demolished towers of the town, and fragments from the ditch excavation as raw material. Timber was needed to fire the kilns as well as for scaffolding, and this had to be collected from a dangerously hostile hinterland until some of the local villages agreed to supply timber in lieu of tax obligations. Other materials were imported by sea or overland by a separately contracted team of carters and pack-mule handlers.

Water supply was another major concern. It was needed for the slaking of lime and the working of mortar, and shortage was acute in the dry summer months when progress should have been most rapid. Once work stopped, for whatever reason, the labour force melted away to the farms from which most of the labourers had been recruited. Early in the contract La Cecca had started the construction of a conduit which ran some 900 metres from a spring between Sarzanello and San Francesco. In August 1488 the project was reactivated and this particular difficulty was solved after three weeks work.

Few of the other problems were so quickly resolved. In additional to supply problems, the team battled with sickness, shortages of labour, and money, and the many political sensitivities in an occupied town where houses (and in one case a religious foundation) had to be demolished to secure the approaches to the new fortress - always an unpopular matter. Pressure to complete the fortress came constantly from Florence, together with an attempt by Guiliano and Antonio da Sangallo the Elder to supplant the Francione/Cecca design with one of their own which not only apparently offered cost and time savings, but commanded the support of the Republic's leading citizen, Lorenzo dei Medici. At the end of August 1488 the Otto di Pratica effectively suspended the original contract and the approved design model, and sent Antonio da Sangallo to Sarzana with the newly approved model. On 3 September Il Francione and Sangallo returned to Florence with the two models - old and new - with strong local backing for the original scheme. Surprisingly in view of Sangallo's political support, the Otto decided on 17 September to stay with the original scheme and it was this typically transitional design - round bastions, pointed ravelins and complex ditchworks - that was completed in May 1492.

The Sarzana contract and the tussle with the older Sangalli brothers sheds interesting light on the role of models and drawings. As early as 2 July 1487 the Florentine officers who had been charged with the emergency repairs to the very recently captured city had expressed their satisfaction with the engineers there and had promised to make a model and to send it to Florence.[27] The original

design contract had been drawn up in December 1487 (six months after the city had been captured) "*secondo il disegno et modello raggionato tra decti otto et decti conductori*"[28] - "*according to the drawing and model agreed between the said Eight and the said contractors.*" In February 1488 requests were made for the model to be sent to Sarzana, where it was "urgently required."[29] On 24 March 1488 the haulier Nicholo di Scarino was instructed to carry "*il modello in legno della fortezza*" - the model in wood of the fortress - from Florence to Piero Tornabuoni, the *capitano* of Sarzana.[30] When the Sangalli tried to get their rival design accepted in August 1488, their own model was sent to Sarzana, and then both models were returned to Florence for the decision. What happened to the old model after that is unclear, but in January 1490 the Otto in Florence were demanding a drawing "*da poter ridurre in modello qui*"[31] - to convert into a model here - which suggests that the model was still in Florence eighteen months later, and was to be revised to take account of changes then under discussion. The language used suggests that an annotated and dimensioned drawing was regarded as a key element with which to reach agreement or decision: "*So that we can better understand how you have designed and determined the dimensions of the said fortress let it be annotated in writing and an exact drawing made with the dimensions marked on it.*"[32] On an earlier occasion il Francione had been instructed to draw "*on paper in detail all that wall, both inside and out, where may be annotated and dimensioned the positions of the gun embrasures, doors, windows, stairs, gargoyles and everything else relevant, with measurements of height and width and the distance from one thing to another, which drawing will remain with you.*"[33] Decisions were also evidently taken by the committee in Florence on drawings prepared at Sarzana, because the Otto di Pratica (3 Nov 1489) instructed Tornabuoni to build the *torre maestra* of the fortress without a scarped base or other embellishments so as to save time. The appropriate section of the letter begins, "... *We have seen the drawing of the keep of the fortress which you have sent us* ..."[34] Many years later, Antonio da Sangallo the Younger - writing from Rome - was angrily urging his colleagues on site at Perugia to be sure to mark the dimensions onto drawings, without which he could not decide anything.[35] Sangallo had carried out the original survey in Perugia and so was familiar with the site topography and felt able to make design decisions at long range. But it seems likely that the Florentine Otto di Pratica were participating actively in the design process at Sarzana by remote control, using il Francione's drawings as the medium of exchange, in addition to the model.

Masonry and earthworks

The works at Sarzana have changed relatively little from the late fifteenth century. The loss of the original model(s) and drawings does not prevent our interpreting an unusually complete documentary record of the construction process. When the works are no longer extant, and accurate contemporary drawings have not survived, the researcher is often confronted with correspondence and other contract records of what were evidently important projects but which are very difficult for us now to understand. These can sometimes be interpreted, however, if one is sufficiently aware of the sequence of construction and the different trades and materials employed in Renaissance fortification. To make sense of this point, something needs to be said about the two most common methods of construction employed in the new fortifications.

The fortress at Sarzana was built with thicker walls than earlier Medieval castles, but in other respects used traditional construction. This comprised a sandwich of brickwork or stone with rubble between. The infill could be either dry rubble, or the rubble and mortar commonly used in the more slender curtain walls. The masonry rampart which was progressively introduced in the sixteenth century comprised a front retaining wall made in the same way, but usually more sharply scarped at the base. The angled-out base helped to resist artillery fire, made it more difficult to place scaling ladders against what were often lowered walls, and provided space for various low level chambers

- in particular the countermine passage that ran around the base of many fortifications giving access to the lower handgun embrasures, sally ports, and the countermine shafts that ran out beneath the ditch. The mechanical strength of the rampart turned upon its being backed by a large mass of earth and supported by internal buttresses known to the Italians as *contraforti*. The *contraforti* could do much to keep a rampart standing even after the front retaining wall had been shot away.

By the middle years of the sixteenth century semi-permanent earthworks were being built to fortify towns and citadels in addition to their long standing role in the field. As we have seen, Lucca was advised to adopt this approach both for its relative initial cheapness, and for its effectiveness in absorbing cannon shot. But this was not simply a question of piling earth into a self-retaining slope. One of the best descriptions of mid-sixteenth century earthwork technology is to be found in the treatise of Giovanni Battista Belluzzi, who had supervised the construction of such ramparts at Pistoia in the 1540s. Belluzzi describes a composite timber, brushwood and earth structure built in the following manner. First a framework of heavy timber uprights, crosspieces, and diagonals would be constructed. Seen in plan the cross-pieces and diagonals appeared as a continuous chain of timber, which was indeed known as the *catena* (chain). Fascines - faggots of long twigs bound together - would be laid in layers across the rampart and built up into front and rear retaining walls. Earth would be mixed with light brushwood and consolidated between the fascines, the brushwood acting as a kind of reinforcing mesh. Layers of clay would be introduced from time to time to form damp-proof courses. Finally the whole structure would be protected from the weather by a layer of turfs, well pegged into the sloping surfaces. A rampart of this kind was stable enough to support heavy guns and was capable of absorbing a great deal of enemy fire (Fig 3 & 4).[36]

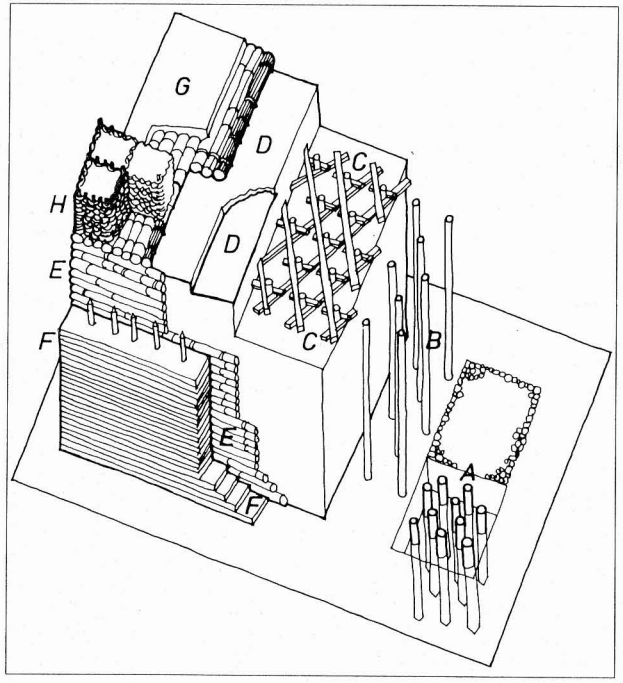

Fig. 3 Earthwork Construction: cutaway drawing by the author based on the account in Belluzzi's treatise.
A: Foundations formed by piles, driven to leave the heads exposed and then packed with rubble.
B: Timber uprights, planted on a 5-foot grid.
C: The chain, or catena, of lateral timber reinforcement, laid at vertical intervals of 3 to 6 feet. The chain must be free to settle under the weight of the rampart: note sliding joint. Outward facing tips are sharpened to deflect incoming shot (not shown here).
D: Sieved earth and brushwood fascine infill, to be laid in 2 to 3 inch layers and well rammed. **E:** Containment of earth infill by revetment of fascines tied back to the vertical timbers.
F: External lining of turfs, laid like bricks and secured by twig reinforcements along the courses and by vertical pegs.
G: Deck formed by rammed clay or mud.
H: Parapet and gun emplacements formed by earth-filled gabions.

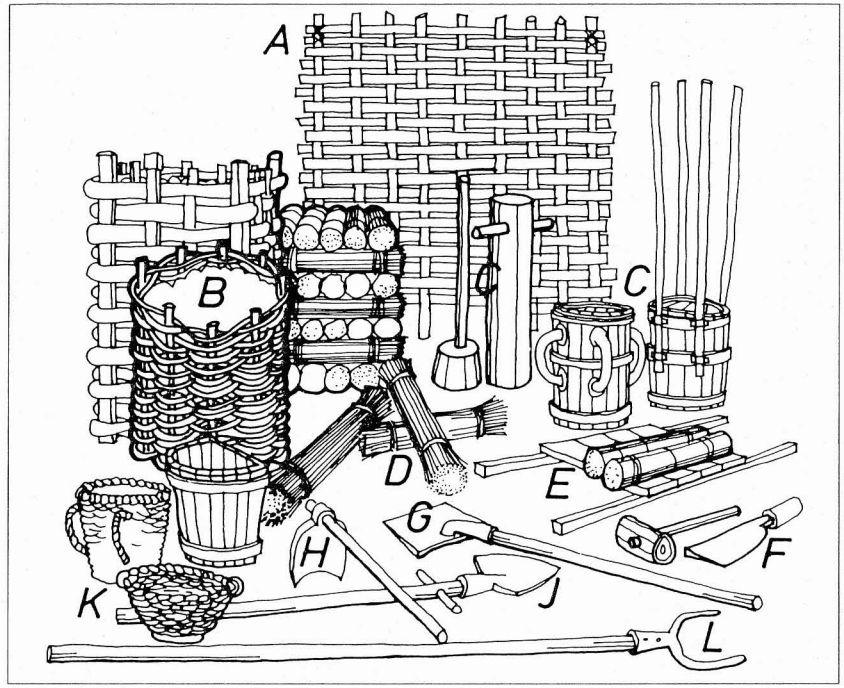

Fig. 4 Earthworks: Tools and Components redrawn by the author from illustrations in Belluzzi's treatise. **A:** Blinds - wickerwork screen used to conceal sappers or gunners. **B:** Gabions: wicker baskets filled with earth to protect gun emplacements (and to repair breaches, or to consolidate retaining walls, as in modern civil engineering). **C:** Rams for consolidating earth and driving the smaller piles. **D:** Fascines, bundles of twigs used to reinforce earthworks and sometimes stacked to construct lightweight gabions (shown at rear). **E:** Tray for moving stacks of fascines. **F:** Fascine cutter and turf trimmer. **G:** Turf lifter. **H:** Mattock. **J:** Spade with footpiece (note most illustrated spades were made of wood, and must have been used in conjunction with mattocks for earth lifting rather than cutting). **K:** Baskets and panier barrels for earth shifting: note shoulder straps. **L:** Forked prop for erecting and supporting heavy timber uprights.

The quality of earthworks turned on the availability of appropriately dimensioned timber - chestnut was considered best for the major structural elements - and loose soil which could be sieved to remove the stones that might become secondary missiles when struck by cannon balls. The forward ends of the horizontal lacing beams of the *catena* were often sharpened to reduce the risk of their becoming a spear when struck end-on by an incoming missile. Consolidation had to be thorough. Those in the field would not forget the fate of Zitolo da Perugia, defender of the Bastione della Gatta at Padua in 1509, whose arm was taken off by a ball which had penetrated thirty feet of loosely laid parapet.[37] External turf faces needed constant attention lest rain find its way into an earthwork and wash out the soil packing and, by waterlogging the interior, increase the tendency of the timber framework and lacing elements to rot. With regular maintenance and a programme of phased renewal, however, earthworks could last almost indefinitely.

The masonry and earthwork systems could also be combined, the lower half or two-thirds being constructed as a masonry system, which lent itself to the complex internal countermine systems and also allowed a wet ditch. (Italians tended to favour dry ditches, which allowed a number of low level pillboxes and protected communication devices to be placed on the ditch floor, but in some circumstances the water table meant that wet moats had to be used.) The upper works would be built

in reinforced earth, which gave an adaptable and shot-resistant area on which to mount defensive artillery. In this case the guns would be housed behind temporary parapets made of gabions. These were enormous wicker baskets (sometimes six or seven feet high and as wide) which when filled with earth provided a good deal of protection against all but heavy shot. *Grati*, or hurdle screens, were also employed on upper works to obscure the view of enemy snipers. Although the *grati* would not stop an arrow, let alone a musket or cannon ball, they were very useful as blinds when guns were being reloaded from the muzzle or moved to different positions. Such a combined system was employed at Siena in the mid-sixteenth century; and the course of these works can be plotted by means of records of the different skilled trades and unskilled labourers used at different stages.

Siena 1549-54

In 1549 the Spanish authorities in Siena attempted to bring order and stability to one of the more turbulent of the Italian city states in their sphere of influence by building a citadel on an area of high ground close to the centre (Fig 5). Besides its internal security function, it was also argued (by the

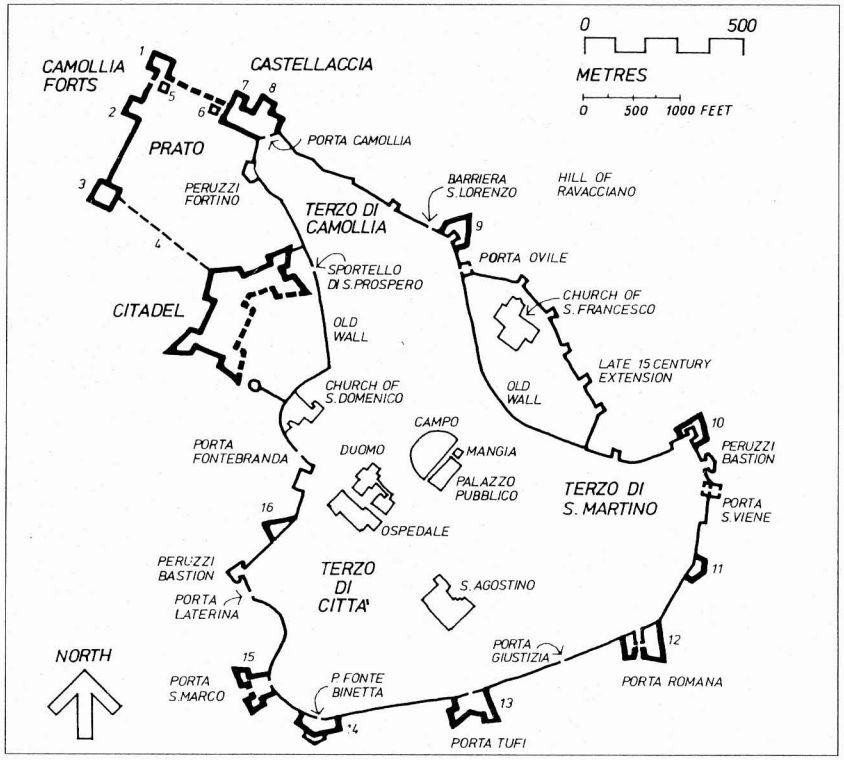

Fig. 5 Siena's fortifications in the Mid-sixteenth century (drawn by the author). Pre-1550 walls in thin line; fortifications built 1550-55 in thick line, incomplete works 1550-55 in broken line. **1, 2 and 3:** Forts built during Spring 1553. **4:** Curtain linking forts to citadel, started in 1553 but unfinished. **5 and 6:** Medieval tower gates and barbicans. **7 and 8:** batteries constructed in Spring 1554 (during siege). **9-16:** Earthworks built in 1553 and early 1554 as shown on a contemporary plan prepared for the besiegers and attributed to Giovanni Battista Belluzzi, who was killed in March 1554.

Spanish) that a well located fortress could add to the defences of a city which - despite the earlier small bastions of Peruzzi - had made relatively little progress toward modernisation. The few very rough plans to have survived indicate that the citadel employed an elongated banana plan, which came close to closing the gaps between the Spanish-held ground and the walls, and which presented four new bastions and their connecting ramparts to the outside world. Here as elsewhere in the dominions of the Emperor Charles V, this was the official justification for Imperial efforts to extract the costs of construction from the Sienese. Against a mounting tide of opposition the project went ahead in November 1550 and in July 1552 a French-inspired revolt broke out. The incomplete citadel was quickly captured and the Imperial garrison expelled. The Sienese and their French allies then embarked on a programme which was described in public as the "destruction of the Spanish citadel" but which quickly evolved into a project to complete the outward facing ramparts and bastions with material salvaged from the demolished inner works. A mixture of paid and pressed labour was involved, making it impossible to calculate the overall cost of the project. But the records of the Committee of Four on the Destruction of the Citadel give an interesting picture of the construction sequence and chronology for what had become a communal civic project.[38]

The Spanish surrendered the citadel on 3 August 1552. On 7 August the Committee of Four held its first meeting and appointed a certain Claudio Bartolucci commissioner general (chief administrator) for the project, assisted by the artist-architect Maestro Giorgio di Giovanni and a certain Maestro Sabbino, who was either an architect or a builder.[39] Since the design already existed, Masters Giorgio and Sabbino were presumably engaged to enforce standards and to coordinate the project rather than to design it.[40] The management and logistical problems were indeed considerable. The first meeting also saw instructions issued to all *maestri* (masters) and *manuali* (skilled workmen) to present themselves on site with their picks and mattocks to dismantle the walls. The emphasis at this stage was on demolition, although the importance attached to the presence of skilled men suggests that some construction (or, at least, the careful salvage of materials) was already much in mind. The guild of bakers was to collect grain from the citadel store and to bake bread for the labour force. Blacksmiths were to bring all of their stocks of iron for the manufacture of pick and mattock heads. Carpenters were to send two *maestri* to make handles for the picks and mattocks. Penalties were fixed for those who did not do their share of the work. On 8 August orders were placed for fifty barrows, baskets were requisitioned from shopskeepers, and anyone wishing to offer catering services on the citadel site was free to do so without sales tax. On 9 August a commissioner was appointed to recruit men from the dominio - able-bodied men between the ages of fifteen and fifty-five years were liable for service. On 10 August an order was placed for 1,000 pick and mattock handles - which may give some indication of the size of the labour force that was envisaged.

There appear to have been two basic kinds of employment. Skilled tradesmen, their apprentices and regular building labourers were hired at a daily rate of pay but were required to work on the fortifications under pain of fines, loss of pay, and corporal punishment. By January 1553, when all the workers on the citadel site were directed toward the completion of the outward-facing sections, there were special musters of the entire able-bodied population to work unpaid for a single day.

Tools were a major preoccupation of the Committee of Four. The pick and the mattock seem to have been the most important iron-headed tools, and until mid-September 1552 the documents contain numerous records of orders placed and payments made for new deliveries, as well as efforts to recover stolen items (often, it seems, removed from the site by drafted peasants on their return home). The next most often mentioned item of equipment was the *corbello*, the same heavy-duty split-twig basket that can still be seen in use on southern European building sites to contain earth and rubble. These were being purchased in bulk at late as December 1552 for use on the citadel, while *corbellai* (basket makers) remained on the payroll for other fortification projects in 1553.

Although contemporary paintings of the partly-dismantled former Spanish works by Maestro Giorgio di Giovanni (one of the two site architects) show brick construction and counterforts to a height of sixteen or even twenty feet (by scaling off against the human figures in the pictures) there are no brick purchases on record. With the thousands already on site and available for salvage, there may well have been no need for additional bricks - although on 28 August some builders' houses were searched for bricks said to have been removed from the citadel site. The records of the Committee, however, show the purchase of materials which together are closely associated with earthwork construction: *legname* (timber), *stipa* (brushwood) and *fascine* (faggots).

Timber, of course, is used for many building purposes, including the scaffolding and boardwalks indicated in Maestro Giorgio's paintings of this site, and the floor and roof structures of conventional buildings such as those built at the citadel site to house the drafted labourers. *Stipa* and *fascine*, however, are bound to be associated with earthwork construction; suggesting that at least a large part of the remodelled citadel was constructed in this way. This suggestion is supported by an analysis of the type of worker employed at different stages. From August to December 1552 the workforce at the citadel comprised *muratori* from Siena and *guastatori* drafted from outside. The *guastatori* (literally "wreckers") were unskilled labourers employed for demolition, levelling and other heavy-duty tasks on site. The *muratori* (literally "wallers") built in stone or brick and were engaged in a variety of heavy construction activity, often leading gangs of labourers and apprentices.[41] The composition of the labour force between August and December 1552 suggests a concentration on the traditional masonry construction needed for the completion of the contraforti (buttresses) and external brick retaining wall of the outward-facing ramparts. After major deliveries of timber, brushwood and faggots in December and January the nature of the workforce also changed. Other specialist trades appear on site: *segatori di tavole* (sawyers of planks), *gratticiai* (hurdle makers) and *corbellai* (basket makers). These trades are intimately associated with earthwork construction. Planks were used for scaffolding and the runways that allowed workers to walk or trolley barrows across loosely laid earth. The other crafts provided the trays and baskets in which earth was moved. On 4 January and again on 23 January 1553, orders were given for all able-bodied citizens to present themselves for work. This kind of muster would have put thousands of workers onto the site, as opposed to the hundreds who had worked there regularly before Christmas. It is the kind of mass unskilled labour force normally associated with large-scale earth movement. And it supports the hypothesis that a combined system of construction was employed for this project: traditional masonry for the lower half; modern reinforced earthwork for the top.

Construction records also allow us to make informed guesses about the nature of the finishes as well as the effective completion dates. Stonemasons were paid in the early weeks of 1553 to dress the marble trimmings for gun embrasures on the cavaliers (high gun platforms built either between or behind the much lower bastions), which confirms that these platforms were also constructed in permanent masonry. The winding gear was fitted to the gatehouse portcullis, and the guardhouses constructed in the Spring of 1553. By then, however, the Committee of Four had already switched their own attention and the efforts of the populace to the construction of a series of detached forts on the approaches to the city. The first meeting to mobilise activity on the forts was on 21 January 1553 and the last muster for mass earth movement on the citadel two days later, on 23 January 1553. By then, it is reasonable to suppose that the heavy construction on the citadel was over, leaving only the professional trades to complete the finishes.[42]

A focus on the construction history of these case-studies conveys something of the time scale and sequencing of operations in these massive programmes. The Spanish construction programme for their citadel at Siena lasted from November 1550 to August 1552, and in 22 months had achieved perhaps as much as two-thirds completion before the revolt of the Sienese changed the direction of the project. Another five months of mass-effort all but completed the outward facing sections, leaving only the marble finishes and associated metalwork to the skilled trades. This was a very fast

programme for a major semi-permanent structure with an original perimeter of at least 1,600 feet. It compares favourably with the 20 months construction of the similarly sized but entirely permanent Fortezza da Basso in Florence between May 1534 (when excavations began) and December 1535 (when the garrison was installed), a feat which was considered remarkable by contemporaries and which involved a site labour force of as many as 1,500 men a day.[43] Two and a half months from the end of January to 13 April 1553 saw the three outer forts at Siena "in large part completed": but these were much smaller and lower than the citadel positions, built entirely in reinforced earth, and constructed against the increasingly frightening prospect of enemy forces massing on Siena's frontiers.[44] During the war which reached Siena itself in January 1554 the defenders of the city built a number of outworks in their attempts to maintain control over the approaches, mobilising hundreds or even thousands of civilians to do so. The fortino di San Marco, located "an arquebus shot" outside the San Marco gate, and with a perimeter of some 400 feet was defensible within three days between 7 and 9 April 1554.[45] For construction of this speed we are almost certainly dealing with a yet simpler form of reinforced earthwork, laced with fascines but not with the heavy timber frame used in "permanent" earthworks. Vauban describes how a work of this kind could be constructed under fire in two days and two nights, behind a protective barrier of gabions (baskets) filled with fascines which could be rolled into position and could absorb ordinary musket fire.[46] Nine days work - without the stimulus of enemy fire, but in the knowledge of a fast approaching enemy - from the much smaller garrison and Sienese civilian population of Port'Ercole made a defensible fort with a garrison of 150 men on a key hill-top position which had to be taken before the naval port could be attacked. Further details and dimensions of the so-called Forte Stella are unrecorded, but the ditch and rampart combination was high enough to demand the use of scaling ladders by the Spanish force which overwhelmed it in a night attack.[47] These examples bracket the fastest construction times that could be achieved for permanent structures, and the much faster completion times promised by the increasingly popular earthworks.

Conclusion: the labour force

There was also a human cost to large-scale construction which is often concealed in object-centred architectural or engineering history. The wartime urgency which mobilised Siena's masses - it has to be said - was often difficult to recreate in time of peace. Even during the War of Siena, works at some sites were characterised by so much inertia that one officer was moved to declare that "*it seemed they were expecting friends, not enemies!*"[48] But these were the words of a frustrated soldier, unable or unwilling to relate to the problems and anxieties of civilians forced to give up their fields or occupations, and sometimes compelled to leave wives or daughters in homes filled with foreign troops. For the peasants or the urban poor chiefly involved, labour on large-scale fortifications represented grindingly arduous activity in the heat of summer or the cold and rain of winter, often far from home, paid (if paid at all) on a subsistence level, inadequately fed and housed in the same squalid conditions which killed many more soldiers in camp from disease than on the field of battle. After heads of households, single wage-earners of families, seamen, soldiers and other key workers had been excluded, the labour draft or the private contractors who scoured towns and country for fortress construction workers tended to select the most disadvanted members of society.

The problem was most acute on the frontiers, where most of the labour had to be imported from far afield and sustained without the infrastructure of an established town. The largest single Italian fortification project of the sixteenth century was Venice's new city of Palmanova, on the Republic's border with Hungarian Slovenia and Croatia and subject to frequent Ottoman incursions. Palmanova, with its nine bastions, radial geometry and centralised planning appears in most textbooks as the quintessence of Renaissance urbanism.[49] When work began on site in 1594 fully

7,000 labourers were needed and much of north-east Italy was scoured for manpower. Six years later, Marc'Antonio Memo, returning to Venice in 1599 from his three-year tour of duty as Provveditore Generale at the then nearly complete fortress, reported on the reasons for the desertions which - despite higher than average pay - ensured a permanent labour shortage on the Republic's key construction site: "*The peasants were fleeing, terrified out of their wits, and holding the name of Palma in dread for the many dead who remained there, and for the many hardships that the living affirmed ...*"[50] For the civilians involved in this great rebuilding, the spade may have killed as many as the sword.

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Notes and References

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2. Paolo Galluzzi, *The Art of Invention: Leonardo and Renaissance Engineers* (Florence, 1999). The exhibition originated in the Istituto e Museo di Storia della Scienza, Florence, and was shown at the Science Museum, London, 15 October 1999 - 24 April 2000.
3. Ross King, *Brunelleschi's Dome* (London, 2000), pp. 127-8.
4. For Taccola's campaign experience, see material in *De machinis libri decem*, trans. Gustina Scaglia, 2 vols, 1971; and *Liber tertius de engeniis ac edifitiis non usitatis*, facsimile and transcriptions by J. H. Beck, 1969.
5. Leonardo literature is vast, but see Carlo Pedretti, "Leonardo da Vinci architetto militare prima di Gradisca," in Daniela Lamberini (ed), *L'architettura militare veneta del Cinquecento* (Milano, 1988), pp.76-81 and Ludwig H. Heydenreich, "The Military Architect," in Heydenriech, Bern Dibner and Ladislao Reti, *Leonardo the Inventor* (London, 1981), pp. 11-71; Pietro Marani, *L'architettura fortificata negli studi di Leonardo da Vinci* (Florence, 1984) and Paolo Galluzzi and Jean Guillaume, *Leonardo da Vinci: Engineer and Architect* (Montreal, 1987) exhibition catalogue, Montreal Museum of Fine Arts, May 22 - November 8, 1987.
6. Charles De Tolnay, "Michelangelo Studies: (1) Newly Found Autographs by Michelangelo in America; (2) Michelangelo's Projects for the Fortification of Florence in 1529," *Art Bulletin* 23 (1940), pp. 127-37; Vincent Scully Jr, "Michelangelo's Fortification Drawings, A study in the Reflex Diagonal," *Perspecta I*, pp. 38-45; William Wallace, "Dal disegno allo spazio": Michelangelo's Drawings for the Fortifications of Florence," *Journal of the Society of Architectural Historians* 46 (1987), pp. 119-34; Renzo Manetti, *Michelangiolo: le fortificazioni per l'assedio di Firenze* (Florence, 1980).
7. Nicholas Adams, "L'architettura militare di Francesco di Giorgio," in Francesco Paolo Fiore and Manfred Tafuri (eds.), *Francesco di Giorgio architetto* (Siena, 1993), pp. 126-62 is an excellent survey. See also Michael S. Dechert, "The Military Architecture of Francesco di Giorgio in Southern Italy," *Journal of the Society of Architectural Historians*, 49, 2 (1990), pp. 161-80.

8. Gustina Scaglia, "Drawings of Machines, Instruments and Tools," in Christoph L. Frommel and Nicholas Adams (eds.), *The Architectural Drawings of Antonio da Sangallo and his Circle* (Cambridge, MA, 1994), Vol. I, pp. 81-97. Scaglia identifies copies by the Sangallo Circle of drawings by Taccola, Francesco di Giorgio, the Anonymous Sienese Engineer, Ghiberti, Leonardo and, of course, Giuliano da Sangallo.
9. Simon Pepper, "Castles and Cannon in the Naples Campaign of 1494-95," in David Abulafia (ed.), *The French Descent into Renaissance Italy, 1494-95* (Aldershot, 1995), pp. 284-5 and sources cited. The "Narcisso Toscano, machinatore d'opere meravigliose ..." was the identification given by Paolo Giovio, *Dell'Istoria del suo tempo di Mons. Paolo Giovio da Como, Vescovo di Nocera* (tradotta [from the Latin original] per M. Lodovico Domenichi, Firenze, 1555), pp. 120-1.
10. Renaissance fortifications were not of course the first to be prosecuted on a vast scale, demanding teamwork and well planned logistical support. The Roman *limes* along the Rhine-Danube frontier and in Africa, the Byzantine long walls outside Constantinople, the Crusader castles in Palestine and Syria, and Edward I's castles in Wales, to say nothing of the Great Wall of China, had all been there before. The biggest Renaissance programmes were probably not urban, but the coastal towers built in their hundreds against Turkish raiders throughout the Western Mediterranean, and the so-called "military frontier" that confronted the Ottomans from Croatia, through Hungary, to the steppe-forest frontier of Muscovy.
11. Most frustrating of all the gaps is that governing costs, and the difficulty of determining the full cost of any project or programme. Venice instituted a magistracy in 1542 to coordinate its terrafirma and overseas fortification programme and this body has yielded one of the best long run cost series (often confused, however, by ambiguity about the parts played by central and local funding in any particular project). John Hale, "The First Fifty Years of a Venetian Magistracy: the *Provveditori alle Fortezze*," in Anthony Molho and John A. Tedeschi (eds.), *Renaissance Studies in Honor of Hans Baron* (De Kalb, IL, 1971), pp. 501-29. For Spain see I. A. A. Thompson, "Money, Money, and Yet More Money! Finance, the Fiscal State, and the Military Revolution: Spain 1500-1650," in Clifford J. Rogers (ed.), *The Military Revolution Debate: Readings in the Military Transformation of Early Modern Europe* (Boulder, CO, 1995), pp. 273-98. Spain expected local communities to contribute to the costs of their own defence (foreshadowing Britain's position with her American colonies) and this often makes a total cost estimate very difficult to determine, given the mixture of paid and unpaid labour employed by many communities - as is shown below in this paper's discussion of Siena's fortification. It has been argued that the fiscal strains imposed by the need to refortify in the mid-sixteenth century contributed directly to the collapse of Siena as an independent Republic. Judith Hook, "Fortifications and the End of the Sienese State," *History* 61 (1977), pp. 372-87.
12. Roberta Martinelli e Giuliana Puccinelli, Lucca: *Le mura del Cinquecento; vicende costruttive dal 1500 al 1650* (Lucca, 1983), p.11. This well-documented volume is my source for the Lucca material. For an English account see Raymond E. Role, "Le Mura: Lucca's fortified Enciente," *Fort* 25 (1997), pp., 82-110.
13. Martinelli & Puccinelli, p.18 citing G. Sforza, "Il Capitano Frate da Modena e le mura di Lucca" in *Riccordi e biografie lucchesi* (Lucca, 1916), p.4.
14. Martinelli & Puccinelli, p.29, n.45.
15. Pepper and Adams, *Firearms and Fortifications*, pp. 32-4 and Duccio Belestracci and Gabriella Piccinni, *Siena nel trecento: Assetto urbano e strutture edilizie* (Florence, 1977), pp. 17-30.
16. Pepper and Adams, pp. 32-57. Peruzzi's bastions adopted the triangular pointed plan which was becoming accepted in the early sixteenth century as the best way to eliminate blind spots on the circuit, but were built more like old-fashioned towers, housing guns at three levels over a much smaller base footprint than would be employed in the fully-matured earthwork bastions.

17. Eric Langenskiold, *Michele Sanmichele, the Architect of Verona* (Uppsala, 1938) is still useful but see the forthcoming book on Sanmichele by David Hemsoll. For specialist fortification sources: Isabella di Resta, "Le fortificazioni di Capua e Verona," in Daniela Lamberini (ed.), *L'architettura militare veneta del Cinquecento* (Milan, 1988), pp. 151-6.
18. Recent work includes P. Marconi, "Contributo alla storia delle fortificazioni di Roma nel Cinquecento e nel Cinquecento," *Quaderni dell'Istituto di Storia dell'Architettura*, 73-78 (1966), pp. 109-30; F. P. Fiore, "Episodi salienti e fasi dell'architettura militare di *Antonio da Sangallo il Giovane," Antonio da Sangallo il Giovane, La vita e opera* (acts of the XII congress of architectural history, Rome, 1986), pp.338-341 and Fiore's contributions to Frommel & Adams, *The Architectural Drawings of Antonio da Sangallo and his Circle* (1994). See also Piero Spagnesi, *Castel Sant'Angelo la fortezza di Roma* (Rome, 1995), pp. 29-55.
19. Figures from Pepper and Adams, *Firearms and Fortifications*, p. 30; Enrico Rocchi, *Le piante iconografiche e prospettiche di Roma del secolo XVI* (Rome & Turin, 1902), Vol. 1, pp. 239-40; and Spagnesi, *Castel Sant'Angelo*, pp. 136-7.
20. Nicholas Adams and Simon Pepper, "The Fortification Drawings," in Christoph L. Frommel and Nicholas Adams (eds.), *The Architectural Drawings of Antonio da Sangallo and his Circle* (Cambridge, MA, 1994), pp. 63-7.
21. David Buisseret, "Modeling Cities in Early Modern Europe," in David Buisseret (ed.), *Envisioning the City: Six Studies in Urban Cartography* (Chicago, 1998), p. 125 quoting the Ventian chronicler and document collector, Marino Sanuto.
22. Nicolas Faucherre, "La Construction de la FrontiËre: De l'Usage StratÈgique des Plans en Relief," in A. De Roux, N. Faucherre and G. Monsaingeon, *Les Plans en Relief des Places du Roy* (Paris, 1989), p. 18.
23. Agnolo Bardi, *Storie senesi*, 1512-1556 (MS A.VI.51 Biblioteca Comunale, Siena), fols. 217v-218v.
24. Venice embarked in the sixteenth century on a formal collection of models recording the fortifications of overseas possessions, although the surviving models in the Naval Museum mainly date from the seventeenth century, as do the important collection in Naples, in the Stockholm Army Museum, and the collections in Les Invalides and Lille. See G. Gerola, "I plastici delle fortezze venete al Museo storico navale di Venezia," *Atti dell'Istituto veneto di scienze, lettere ed arti*, XC, ii (1930-31), pp. 217-21; Teresa Colletta, *Piazzaforti di Napoli e Sicilia, le "Carte Montemar" e il sistema difensivo meridionale al principio del Settecento* (Naples, 1981); Brita Englund, "Fästingsmodeller Fran Eric Dahlberghs Tid: En preliminär undersökning," in *Meddelanden fran Armemuseum* 28 (1967), pp. 11-52; Nicolas Faucherre, "La Construction de la Frontière ...", p.25; and Simon Pepper, "Military Architecture in Baroque Europe," in Henry A. Millon (ed.), *The Triumph of the Baroque in Europe*, 1600-1750 (Milan, 1999), pp. 332-47.
25. My information for the Sarzana contract is from a collection of documents transcribed from the Archivio di Stato, Florence, and published by Franco Buselli, *Documenti sulla edificazione della fortezza di Sarzana 1487-1492* (Sarzana, 1970).
26. Buselli, *Documenti*, p.45.
27. Buselli, p. 20.
28. Buselli, p. 25. The words "disegno" and "modello" can mean literally drawing and model, but can also both mean "design" in a more general sense (i.e. without the presumption of drawings on paper or a three-dimensional model). The use of the two words here, and the later use of the phrase "modello in legno" (model in wood) fortunately clarifies the meaning for us.
29. Buselli, p. 39.
30. Buselli, p. 59.

31. Buselli, p. 63.
32. Buselli, p. 63: "Ma acciò che noi possiamo meglio sapere come voi harete disegnato et fermo le misure di decta forteza ce ne arrecherainota in scriptis et un disegno apunto con le misure superscripte." 29 Jan 1490.
33. Buselli, p. 60: "in su fogli uno disegno particulare di tucta cotesta muraglia cosi dentro chome fuori et dove sia scripto et misurato il luoghi delle bombarde, usci, finestre, scale, doccioni, et di ogni altra cosa occorrente con le misure di alteza et largheza et delle distantie dell'una cosa all'altra il quale disegno rimanga costì ..."
34. Buselli, p. 60: "... Habbiamo visto il disegno della torre maestra di cotesta forteza che tu ci hai mandato ..."
35. Adams and Pepper, "The Fortification Drawings," p. 64. "I cannot finish this unless I know the height facing [that corresponds to] the 17 palmi of the scarp of the bastion. For God's sake make a note of the actual heights of these things and how they measure up one to another."
36. G. B. Belluzzi, "Il trattato di fortificazioni di terra," MS edited by Daniela Lamberini in *Documenti inediti di cultura toscana* (Florence, 1980), Vol. 4, pp. 375-517 and in the posthumous published version *Nuova inventione di fabricar fortezze, di varie forme* (Venice, 1598). Belluzzi had been killed in 1554 in the War of Siena, and the version of his treatise published in 1598 is much less authentic than the earlier manuscript recently published by Lamberini. One of the earliest accounts of Renaissance earthwork construction is to be found in G. B. Della Valle di Venafro, *Vallo: libro continente appertenentie ad Capitanii, retenere & fortificare una Citta con bastioni, con nuovi artificii de fusco aggionti ... et de expugnare una Citta etc* (Venice, 1524), fols. 5v-8v which although not as erudite as Alberti,or as well informed as Francesco di Giorgio Martini, was a very widely distributed pocket-book-sized general military treatise which went through eleven editions in thirty-seven years (more than any other military book of the period) and almost certainly exercised a much greater influence amongst soldiers than many more specialist works. Maurice J. D., Cockle, *A Bibliography of Military Books up to 1642* (London, 1900), number 765, p. 197.
37. The technical treatises are an essential source on works which are no longer available for inspection by archaeologists. Della Valle, *Vallo*, fols.5v-6, illustrates a fortification made entirely of timber and earth, and points out that any stones in the earth will prove dangerous to the defenders as secondary missiles. Girolamo Maggi and Jacopo Fusto Castriotto, *Della fortificatione delle città ... Libri III* (Venice, 1564) stress the need to sharpen the outward-facing tips of timber lacing members. Francesco de' Marchi, *Della architettura militare, Libri tre* (Brescia, 1599) reports the fate of Zitolo da Perugia. After test firings of his own - possibly the first such reported experiments - Francesco de' Marchi found that twenty feet of well consolidated earth was sufficient to stop the heaviest iron balls at 100 paces range.
38. The account is based on Pepper and Adams, *Firearms and Fortifications*, pp. 58-78. The records of the Committee of Four are to be found in two collections of documents in the Archivio di Stato, Siena, *Balia* 141 (the Deliberations) and *Balia* 145 (the Order Book).
39. Sabbino remains a shadowy figure, but Maestro Giorgio di Giovanni achieved prominence in the defence of the last Sienese Republic (1553-55) when he fortified a number of provincial towns and remained in Montalcino throughout the successful 80-day defence of that city against the Spanish and Florentine siege of 1553. Trained as a painter in the studio of Beccafumi, he not only supervised the completion of the "Spanish Citadel" in 1552 but painted the scene on the covers of the city tax registers (the *tavolette* of the Gabella and the Biccherna) which give us an unusually well-informed set of images of the construction site.

40. The authorship of this project illustrates very well the difficulty of attribution in large-scale military architecture, in this case of a project with which no patriotic Sienese architect would wish to be personally identified. The name of Giovambattista Romano (thus not a native of Siena) is given as fabricator of the earth (presumably clay) model sent to Spain for the approval of the Emperor Charles V, and in another source as "architore del Castello." The key decisions on location and form were evidently taken by a commission of military experts, headed by the Marquis of Marignano, a soldier of considerable experience and authority who was to lead the successful Imperial siege of Siena in 1554-55.
41. Richard Goldthwaite, *The Building of Renaissance Florence: An Economic and Social History* (Baltimore, MD, 1980), pp. xiv-xv and 320-1 for the terminology of the Italian building trades. For Siena see the *Statuto dell'arte dei muratori* of 1626. Richard J. Goy, *The House of Gold. Building a Palace in Medieval Venice* (Cambridge, 1992) gives Venetian terminology, of course, but contributes much of general value in this area.
42. The chronology of the work on the forts can be traced by means of the surviving records of one of the three *terzi* into which the city was divided. Each terzo was responsible for its own fort, and the minute book of the Terzo di Camollia (the northern-most part of the city) survives in the State Archive under *Balia* 151.
43. J. R. Hale, "Fortezza da Basso," p.48 and L. Dami, "La costruzione della Fortezza da Basso," *Arte e storia*, Vol. 6 (1915), pp. 165-6. Hale, p.46, reminds us that Nanni Unghero had as many as 2,000 men at a time working on the earthworks at Pistoia, completed in three winter months in early 1545 despite heavy rain.
44. The progress report comes from the minutes of yet another ad hoc body of Four Citizens appointed to organise the construction of a "curtain" (comprising rampart and ditch) between the citadel and the outworks, and another curtain linking the three outworks. "Deliberazioni dei quattro cittadini eletti dagli Otto del Reggimento, deputati sopra la Guerra, per le cortine del forte di Camollia," ASS, *Balia* 153.
45. Here an internal source, an entry in the siege diary of Alessandro Sozzini, is confirmed by an external report from Bartolommeo Concino, the Duke of Florence's private secretary, serving with the Spanish and Florentine outside Siena as secretary to the Council of War. Alessandro Sozzini, "Diario delle cose avvenute in Siena dal 20 luglio 1550 al 28 giugno 1555," *Archivio storico italiano* 2 (1842), p. 203 and Concino to the Duke of Florence, Archivio di Stato Firenze, *Mediceo del Principato* 1854, no. 64.
46. Sebastien Leprestre de Vauban, *A Manual of Siegecraft and Fortification*, trans. George A. Rothrock (Ann Arbor, MI, 1968), pp. 49-51. Originally published as *Mémoire pour servir d'instruction dans la counduite des sièges et dans la défense des places* (Leiden, 1740).
47. Pepper and Adams, *Firearms and Fortifications*, pp. 143-9.
48. Ibid., p. 188.
49. Horst De la Croix, "Palmanova: A Study of Sixteenth Century Urbanism," *Saggi e memorie di storia dell'arte* 5 (1966), pp. 23-41 and 175-9.
50. "... fugivano i contandini spaventati oltre modo, et havendo per cosa horribile questo nome di Palma per i molti morti che vi restavano et per le molte incomodità che affermavano i vivi di havervi provato ..." Maria Grazia Sandri, "Nascita di Palmanova" in Antonio Cassi Ramelli et al, *Palmanova: da fortezza veneta a fortezza napoleonica* (Istituto per l'Enciclopedia del Friuli Venezia Giulia, 1982), p.137.