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HARD TO OBTAIN, HARD TO TRANSLATE: LIME AND EARTH CONSTRUCTION IN EARLY MODERN PORTUGUESE WRITINGS ON ARCHITECTURE AND FORTIFICATION

Lime masonry and earthwork construction are subjects treated in the earliest written sources related to fortification in the Portuguese empire. Although these texts are not in the form of an architectural treatise, they do evince a noteworthy concern with construction techniques. A group of administrative records related to Mazagan (1541) provide us with a first-hand account regarding new methods of building a fortress, and reveal that good lime, considered more reliable than earth filling for the new ramparts, was difficult to obtain. Another source is an anonymous manuscript from around 1579, written by a fortificateur *playing the role of the architect. Going beyond Vitruvian guidance, the author merges several sources with his own observations. A significant part of his text is devoted to construction techniques, including earthworks, and discusses new materials using new words that are sometimes hard to translate. Both cases show a pragmatic approach and a preference for time-tested knowledge and practical experimentation.*

First notes, first questions

Early modern writings in Portuguese on architecture and fortification – whether theoretical or technical, treatises or notes, handwritten or printed – are not particularly easy to come by as sources, in striking contrast to the construction activity in all of the overseas territories at that time. In fact, the first architectural treatise was printed in Portugal only in 1680, and was a book restricted to matters relating to fortification[1]. Some manuscripts on military architecture may be found dating prior to that, but most of them relate to the same author, royal cosmographer and engineer, Luís Serrão Pimentel[2]. From the period before the 1640-1668 war (when the Portuguese crown was recovered from the Habsburgs), only an incomplete treatise on architecture remains, a manuscript presented as a "lesson read" in 1631 by a royal "master architect"[3]. In addition, no writings specifically focusing on military architecture have been identified before the 1630s[4]. Previously, in the sixteenth century, only fragmentary texts give us a hint as to how architectural writings were produced in Portugal, concurrent with the transformation of the builder into architect or engineer. The scope of this article is to inquire whether construction techniques were a topic included in these first scarce sources, and whether there was any particular concern with the building of military structures, a necessary condition for survival on a transcontinental imperial scale and at a time when fortification was quickly changing.

Construction history is a rather recent field of research in Portugal, but some general works and case studies provide a brief overview. A broad perspective is given by João Mascarenhas Mateus[5], who presents the subject over time and by type; however, the primary focus here is masonry techniques, rather than specifically military features. Nevertheless, some scholars who address the topic in early modern Portugal present other relevant features, especially those relating to the organisational procedures and royal representatives involved[6], mostly from the reign of King Manuel (1495-1521). At that time, a general procedure became mandatory: all royal building works had to be subordinated to an *empreitada* (literally, an undertaking), meaning both a type of contract and a building site management tool. The *empreitada* had to include a prior design (and related drawings) and a regulation document, called a *regimento*, which included a detailed description of the work to be done for a singular case. Other interesting studies[7] demonstrate the relevance of ordinances, regulations and all sorts of legal constraints on the organisation of the built urban environment, at least since medieval times, and underline elements that withstood the test of time. However, beyond a broad treatment of construction management, these studies do not go so far as to examine military building techniques. Still, the unseen face of the material reality points to the very existence of other textual sources besides (and in the absence of) theoretical writings, which must somehow have facilitated the learning of new construction features.

The overarching issue to be addressed is how Portuguese architectural writings actually evince the changes that we might expect in terms of experimentation with fortifications. Common sense would suggest that construction techniques would have been crucial to experimentation in early modern military architecture, and that it should be possible to discuss an equivalent stage of innovation to that which we find in the design of bastioned fortifications[8]. For instance, one of the most obvious cases would be the use of embankments, which required earthen and wooden materials to be mixed together, in a sense creating what could be thought of as new techniques, such as fascine and variations thereof.

In order to approach this topic, two different kinds of sources are explored. Firstly, there are the most direct sources – administrative documents relating to fortification building sites, in particular Magazan, the principal bastioned fortress overseas. Such documents mention technical problems when adapting construction methods to local circumstances. The (new) use of earth construction and the reliable (old) lime con-

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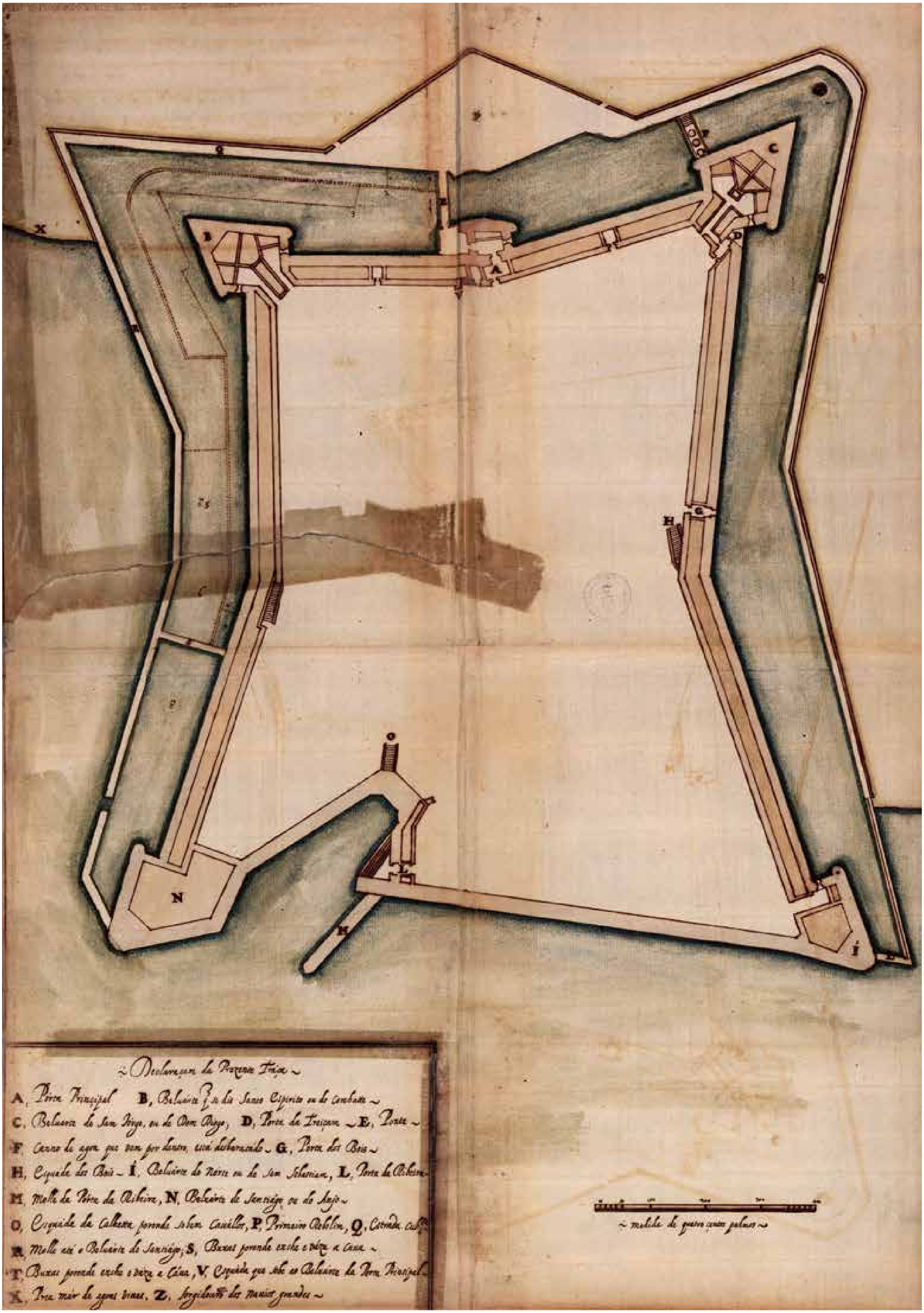
Declaraçam da Prezente Traça
A, Porta Principal B, Baluarte ... do Santo Espirito ou do Combate
C, Baluarte de Sam Tiago, ou de Dom Diogo, D, Porta da Traiçam, E, Ponte
F, Cano de agoa que vem por dentro, está desbaratado, G, Porta dos Bois
H, Escada dos Bois, Í, Baluarte do Norte ou de Sam Sebastiam, L, Porta da Ribeira
M, Molle da Porta da Ribeira, N, Baluarte de Santiago ou do Anjo
O, Escada da Calheta por onde sobem Cavallos, P, Primeiro Rebelim, Q, Estrada cub.
R, Molle até o Baluarte de Santiago, S, Buxas por onde enche e vaza a Cava
T, Buxas por onde enche e vaza a Cava, V, Escada que sobe ao Baluarte da Porta Principal
X, Prea mar de agoas vivas, Z, Surgidouro dos navios grandes
medida de quatro centos palmos

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Fig. 1 *Anonymous, Plan of Mazagan, sent by governor Henrique Correia da Silva to King Philip II of Portugal, 1611 (ANTT, Códice Cadaval, PP/TT/CCDV/29).*

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[1] L. Serrão Pimentel, *Methodo Lusitanico de Desenhar as Fortificaçoens das Praças Regulares, & Irregulares*, Lisbon 1680. The Lisbon editions (1541 and 1542) of Diego de Sagredo, *Medidas del Romano*, Toledo 1526 (R. Moreira, *Arquitectura*, in *Os Descobrimentos Portugueses e a Europa do Renascimento. As Descobertas e o Renascimento, Formas de Coincidências e de Cultura*, Lisbon 1983, p. 345; F. Marías, *Diego de Sagredo, entre Arquitectura y Escritura*, in *Medidas del Romano, Diego de Sagredo*, edición F. Marías, F. Pereda, Toledo 2000, p. 11) are not considered here. An overview of Portuguese early modern architectural writings can be found in M.T. Conceição, *Da cidade e fortificação em textos portugueses (1540-1640)*, Lisbon (2008) 2015, pp. 17-28, 99-118.

[2] Luís Serrão Pimentel trained several engineers in the royal fortification class in Lisbon and some of them left their course textbook manuscript (M. Soromenho, *Manuel Pinto de Vilalobos, da Engenharia Militar à Arquitectura*, Master's diss., Universidade Nova de Lisboa 1991, pp. 4-56; M.T. Conceição, *A Praça de Guerra, aprendizagens entre a Aula do Paço e a Aula de Fortificação*, "Oceanos", XLI, 2000, pp. 24-38).

[3] Mateus Do Couto, *Tractado de Architectura que leo o Mestre e Architecto Matheus do Couto o velho no Anno de 1631*, ms., Biblioteca Nacional de Portugal, Lisboa (henceforth cited as BNP), cod. 946. Details in Conceição, *Da cidade e fortificação...* cit., pp. 347-363. C. Rubão, *"O Eupalinos Moderno": teoria e prática da arquitectura religiosa em Portugal: 1550-1640*, PhD. thesis, Universidade de Coimbra 2006, pp. 281-299.

[4] For instance this first one, related to the Jesuit school: I. Stafford, *La Architectura Militar, in Varias obras mathematicas compuestas por el P. Ignacio Stafford mestre de mathematica en el collegio de S. Anton de la Compañia de Jesus y no acavadas por causa de la muerte del dicho padre*, Lisbon 1638 (BNP, cod. 240, ff. 505-642).

[5] J. Mascarenhas-Mateus, *Técnicas tradicionais de construção de alvenarias. A literatura técnica de 1750 a 1900 e o seu contributo para a conservação de edifícios históricos*, Lisbon 2002; *História da Construção em Portugal. Alinhamentos e fundações*, ed. J. Mascarenhas-Mateus, Coimbra 2011; *História da Construção em Portugal. Consolidação de uma disciplina*, ed. J. Mascarenhas-Mateus, Lisbon 2018; J. Mascarenhas-Mateus, *The Study of the History of Construction in Portugal: Between the Singular and the Universal*, in *L'Histoire de la Construction / Construction History*, éd. A. Becchi, R. Carvais, Paris 2018, pp. 325-356. Research on heritage conservation techniques usually covers the historical context: for example, C.C. Santiago, *Estudo dos materiais de construção de Vitrúvio até ao século XVIII: uma visão crítico-interpretativa à luz da ciência contemporânea*, PhD. thesis, Universidade de Évora 2001.

[6] H. Carita, *Empreitada, regimento e contrato de obras, nas estratégias de actuação da Provedoria das Obras Reais (séc. XVI-XVII)*, in *História da Construção em Portugal. Consolidação de uma disciplina...* cit., pp. 59-75; M. Soromenho, *A Administração da Arquitectura: o Provedor das Obras Reais em Portugal no século XVI e na 1ª metade do século XVII*, "Anuario del Departamento de Historia y Teoria de Arte", Madrid 1997-1998, IX-X, pp. 197-209.

[7] S.M.G. Pinto, *As interacções no sistema das operações urbanísticas nos espaços urbanos portugueses até meados de Oitocentos*, PhD. thesis, University of Coimbra 2012; *Building Regulations and Urban Form, 1200-1900*, edited by T.R. Slater, S. Pinto, London 2017; S.M.G. Pinto, *Behaviours and*

struction are underlined here. These rather administrative and legal texts, which are almost the complete opposite of a treatise, provide us with a manifestation of the real learning in the field and a first-hand reaction to new ways of building a fortress. In short, they tell us how it was achieved – knowledge that would otherwise have been lost. Secondly, we have architectural writings dating from around the 1570s, the first of their kind to be produced within a Portuguese context. We are able to examine these, looking for explanations of construction techniques. The main topics worth addressing here include the interest that this area held for the "architectural writer" and the way in which new materials and words were translated, including descriptions of earthworks. Going beyond the use of Vitruvian *topoi* (despite the fact that this point of reference was mediated to a high degree through contemporary Italian books), we should question whether modern authors were really updating ancient instructions[9] in addressing such building techniques. From at least the fifteenth century, Vitruvian influence in Portugal was disseminated within a broad cultural context[10], but we do not have any architectural text on this subject before the 1570s. Due to this context of an insufficiency of architectural writings, the necessity of exploring sources that fall somewhat outside the theoretical canon also makes it essential to discuss a secondary issue, namely the profile of the "writers". Who wrote about construction techniques and what difficulties arise when attempting to identify their backgrounds? They are variously described as masters of works, or *fortificateurs*, more often than architects or engineers. Coming from different backgrounds, writers use words and expressions that are sometimes hard to translate: words originally in Latin, Italian or French are adapted to Portuguese in different ways, and the use of old vernacular formulations may make the meaning of the text hard to understand and even harder to translate, as its use and meaning in craft practice are lost today.

Building site sources: materials for a new fortress

Certain documents relating to fortification building sites in the first decades of the sixteenth century, when architectural design was changing to resist gunpowder artillery[11], seem to provide the most promising path towards understanding how construction techniques were applied and how they were discussed at the time. In any case, the connection with the existence of a building is very specific. The documents may be signed by different actors, expressing their knowledge and their doubts, and deserve close attention as they state the difficulties being faced in a first-hand account.

One such case that brings together a range of preeminent, professional figures was the fortress of Mazagan (now El Jadida, in Morocco). Construction took place in two different stages: in 1514, when a quadrangular fortress was built (later transformed into a warehouse and cistern); and in 1541, when work began on the new bastioned fortress[12]. The first stage can be connected to two brothers, Diogo and Francisco de Arruda[13]. These royal master builders were at the forefront of important changes in Portuguese military architecture, creating some of the first new constructions to resist firearms. The Arruda brothers were sent to North Africa in 1514 and engaged in work on the fortifications of Azamor and Mazagan. From Azamor, the two wrote the king a long letter reporting construction problems[14] (fig. 2).

Like many similar letters exchanged between local agents and the king's circle, this document shows that the Arrudas' overriding preoccupation was the security of the wall structures in both places and the difficulty of finding supplies of good limestone. Indeed, this was a recurring

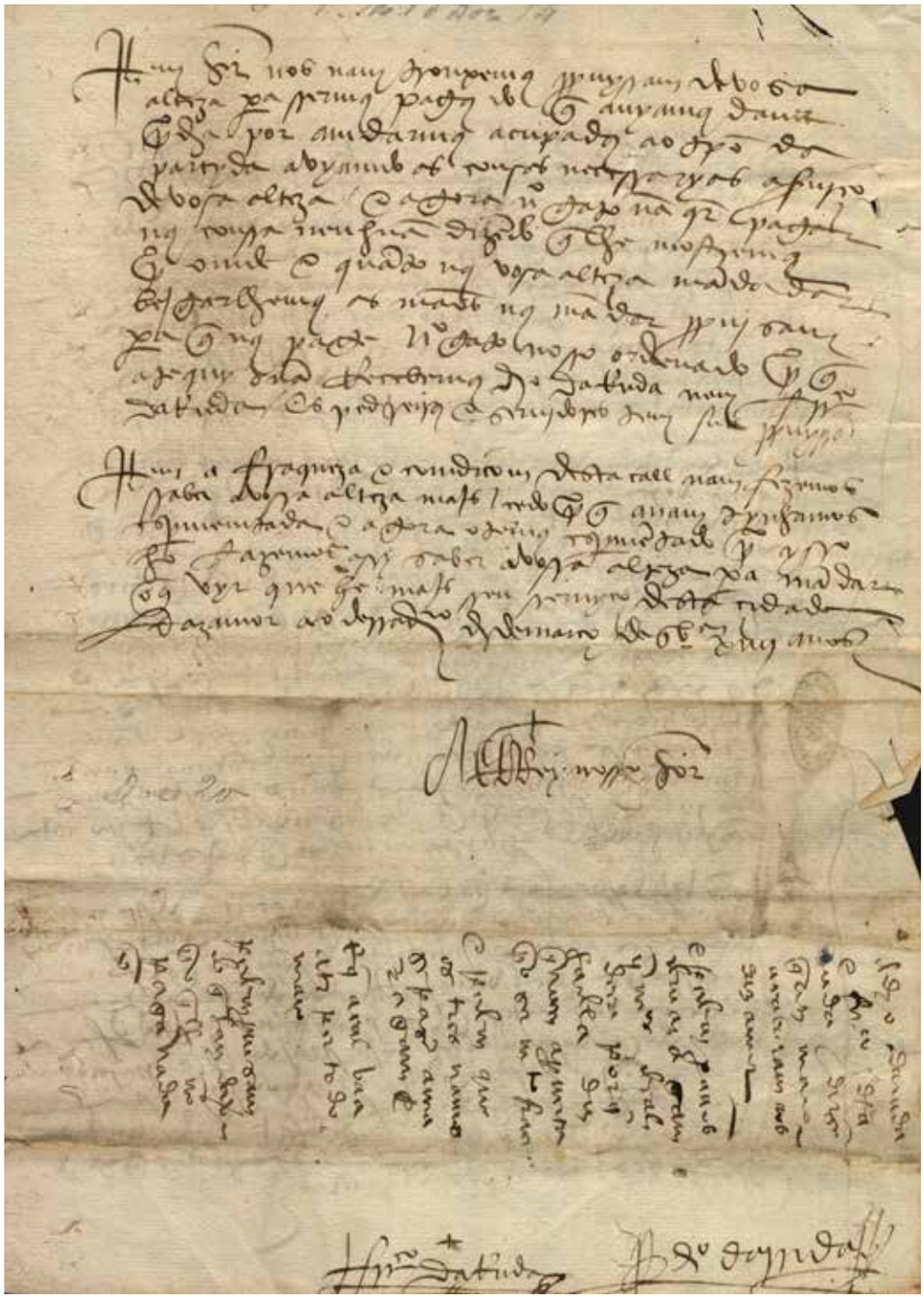


Fig. 2 *Letter addressed to King Manuel, signed by Diogo and Francisco de Arruda, dated from Azamor, 31 March 1514 (ANTT, CC, 1, 15, doc. 14).*

problem[15], as Portuguese limestone (particularly from Portimão on the Algarve coast and areas of the south, such as Évora)[16] was required to get good-quality lime mortar. The reported difficulty mainly related to the walls and bastion foundations facing the sea, which required stronger mortar. For that reason, they claimed to have reserved Portuguese lime for those structures only[17]. The builder-architects explain that they have built lime kilns and tried local limestone to no avail, and stress that they are sure about the lack of viability because they have carried out some experiments. They claim that the local lime they tried to use didn't melt in the same way Portuguese lime does, instead turning to an ashy substance and resulting in a weak, poor-quality material. They also assert this lime is so bad that Moorish builders themselves had to cover the walls with plaster in order "to hold lime inside the wall". This was described by the Arruda brothers, who discovered some points on the Moorish walls coated with less plaster[18]. Over time and across different areas, the production of lime (*cal*) as a binder material relied not only on the quality of the limestone but also on a proper heating, burning and cooling process for it, in accordance with the specific details and recipes later found in most textbooks[19].

Procedures used by Construction Agents of Ordinary Buildings in Portugal during the Late Middle Ages and Early Modern Period: Rules, Regulations and Controls, "Construction History, International Journal of the Construction History Society", XXX, 2018, 1, pp. 49-68. Pinto also studied the case of Valério Martins de Oliveira, a stonemason who also wrote a technical book that was printed in Lisbon in 1739; see S.M.G. Pinto, *As advertências de Valério Martins de Oliveira ou o manual dos mestres pedreiros e carpinteiros portugueses do período moderno*, in *História da Construção em Portugal. Consolidação de uma disciplina*... cit., pp. 77-102.

[8] On the building of fortifications and earthworks, see among others: J.R. Hale, *The Development of the Bastion, 1440-1534, an Italian Chronology*, in *Renaissance War Studies*, London 1983, pp. 1-31 (first edition 1965); S. Pepper, N. Adams, *Firearms and Fortifications. Military Architecture and Siege Warfare in Sixteenth Century Siena*, Chicago 1986; D. Lamberini, *Il Sanmarino. Giovan Battista Belluzzi, architetto militare e trattatista del Cinquecento*, Firenze 2007.

[9] The bibliography of interpretations of Vitruvius and early modern architectural theory and practice is extensive. To quote just the main general works: *Trattati d'Arte del Cinquecento fra Manierismo e Controriforma*, a cura di P. Barocchi, Bari 1960-1962; *Scritti Rinascimentali di Architettura*, a cura di A. Bruschi *et al.*, Milano 1978; *Le Projet de Vitruve. Object, destinataires et réception du De Architettura*, actes du colloque international (Rome, 26-27 mars 1993), éd. P. Gros, Roma 1994; P. Gros, *Vitruve et la tradition des traités d'architecture. Fabrica et ratiotinatio. Receuil d'études*, Rome 2013; M. Carpo, *Architecture in the Age of Printing. Orality, Writing, Typography, and Printed Images in the History of Architectural Theory*, Cambridge 2001; *Sebastiano Serlio à Lyon: architecture et imprimerie. Le traité d'architecture de Sebastiano Serlio, une grande enterprise éditorial au XVI^e siècle*, éd. S. Deswarte-Rosa, [Lyon] 2004; *Les traités d'architecture de la Renaissance*, actes du colloque (Tours, 1-11 juillet 1981), éd. J. Guillaume, Paris 1988; *Paper Palaces. The Rise of the Renaissance Architectural Treatise*, edited by V. Hart, P. Hicks, New Haven-London 1998; F. Lemerle, Y. Pauwels, *Architectures de papier. La France et l'Europe, suivi d'une bibliographie des livres d'architecture (XVI^e-XVII^e siècles)*, Turnout 2013; *Architectvra. Architecture, textes et images, XVI^e-XVII^e siècles*, éd. F. Lemerle, Y. Pauwels, http://architectura.cesr.univ-tours.fr/Traite/index.asp?param, last accessed on 24 February 2020; P.N. Pagliara, *Vitruvio da testo a canone*, in *La Memoria dell'Antico nell'Arte Italiana*, a cura di S. Settis, Torino 1986, III, pp. 5-85; A. Payne, *The Architectural Treatise in the Italian Renaissance. Architectural Invention, Ornament, and Literary Culture*, Cambridge 1999.

[10] Moreira, *Arquitectura*... cit., p. 342; R. Moreira, *A Arquitectura do Renascimento no Sul de Portugal, a Encomenda Régia entre o Moderno e o Romano*, PhD. thesis, Universidade Nova de Lisboa 1991, pp. 286-299. An attempt to translate *De Architectura*, by the mathematician Pedro Nunes, is documented in 1541 (see also M.T. Conceição, *Translating Vitruvius and Measuring the Sky: On Pedro Nunes and Architecture*, "Nexus Network Journal: Architecture and Mathematics", 13, 2011, 1, pp. 205-220).

[11] See Moreira, *A Arquitectura do Renascimento*... cit., pp. 126-195; *História das Fortificações Portuguesas no Mundo*, ed. R. Moreira, Lisbon 1989, pp. 126-195; P. Dias, *Arquitectura dos Portugueses em Marrocos. 1415-1769*, Lisbon 2000; M. Barroca, *Tempos de resistência e de inovação: a arquitectura militar portuguesa no reinado de D. Manuel I (1495-1521)*, "Portvgalia", 2 s., XXIV, 2003, pp. 95-118.

[12] P. Cenival, *Sources inédites pour l'Histoire du Maroc, Série Portugal*, Paris 1934-1953, I-IV; Dias, *Arquitectura dos Portugueses*... cit., pp. 135-153; R. Moreira, *A construção de Mazagão. Cartas inéditas 1451-1542*, Lisbon 2001; J. Correia, *Implantação da cidade portuguesa no Norte de África. Da tomada de Ceuta a meados do século XVI*, Porto 2008 pp. 336-349, 395-402; J.B. Matos, *Do mar contra terra. Mazagão, Ceuta e Diu, primeiras fortalezas abaluartadas da expansão portuguesa*, PhD. thesis, Universidad de Sevilla 2012, pp. 75-227.

Fig. 3 *Baluarte do Raio, Azamor (photo J. Correia).*

Fig. 4 *Torre da Cegonha, Mazagan (photo J. Correia).*

Some construction work took place between 1514 and 1530 both in Azamor and Magazan (figs. 3-4). Problems periodically arose, with Portuguese lime applied to the troublesome spots[20]. Afterwards, around 1540, King John III and his councillors decided to abandon the kingdom's fortifications in North Africa, with the exception of Mazagan, Tangier and Ceuta. In order to secure the Portuguese position, the monarch also decided to build a new bastioned fortress town in Mazagan. By June 1541, the head of the building site, João de Castilho – who was the most important architect in Portugal at the time and already over sixty years old[21] – was already in place when Miguel de Arruda (ca. 1500-1563, probably the son of Francisco Arruda and nephew of Diogo)[22] was sent there to accompany the Italian engineer Benedetto da Ravenna (ca. 1485-1556). At that time, Benedetto was working in Spain for the Emperor Charles V, brother-in-law to John III, and the Portuguese monarch requested the engineer's services via

[13] Diogo (active 1508-ca.1530) and Francisco de Arruda (active 1510-1547) were responsible for Lisbon's new fortifications, including the *baluarte* of the Ribeira palace (since 1508) and the *baluarte* in Restelo (1516-1517, now known as the Torre de Bélem); besides adapting medieval castles and building new fortifications in Alentejo, they both worked in several fortifications in North Africa. Moreover, Diogo de Arruda was appointed in 1521 as surveyor of the Royal Works. F.S. Viterbo, *Dicionário Histórico e Documental dos Arquitectos, Engenheiros e Construtores Portugueses*, Lisbon 1988, I, pp. 51, 60 (first ed. Lisbon 1899); N. Senos, *O Paço da Ribeira 1501-1581*, Lisboa 2002, pp. 54-62.

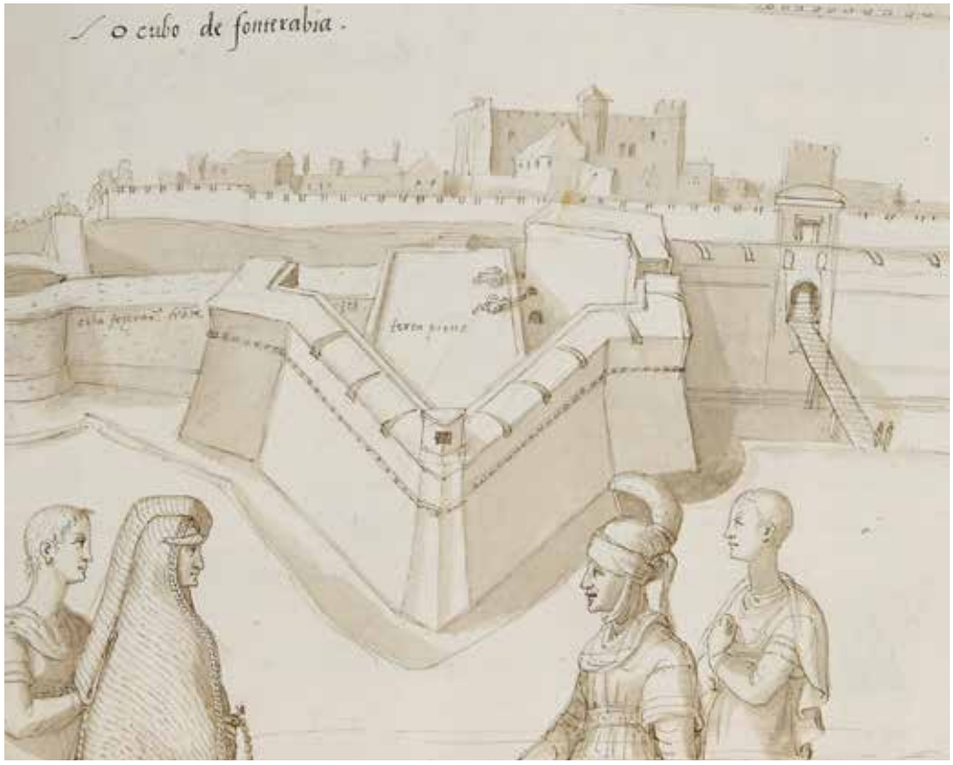
[14] Dated from Azamor, 31 March 1514, Arquivo Nacional da Torre do Tombo (henceforth cited as ANTT), Lisboa, *Corpo Cronológico* (henceforth cited as *CC*), 1, 15, doc. 14, published by Viterbo, *Dicionário...* cit., I, pp. 48-50.

[15] Sources largely published by Sousa Viterbo reveal this issue around the same period, for instance on the north-eastern Portuguese border during the renewal of the castle of Almeida in 1508 (ANTT, *CC*, 1, 17, doc. 46, Viterbo, *Dicionário...* cit., I, pp. 338-340).

[16] Viterbo, *Dicionário...*cit., I, p. 60, refers to Portimão; BNP, cod. 3675, ff. 17*v*-18*v*, refers to Évora. From a broad geological point of view, southern Portuguese regions feature a different kind of limestone.

[17] "[para] fazer obra durauell convem que seja ao menos os alicerces da call de Purtugall [...] como por que he a borda do mar que mais asynha a ade gastar" (Viterbo, *Dicionário...* cit., p. 48); translation: "to create work that lasts, it is important for the foundations, at least, to be made using lime from Portugal […] also because they are at the sea edge, so they are worn more easily".

[18] Longer transcription: "O ponto em que ora estaa o castello dazamor, saberra vosa alteza o que se fez na call que vosa alteza mandou que cá trabalhassemos por se fazer. Cozemos huum forno que nos lamçarya trezemtos cimquemta moyos, o quall forno, se a pedra fomdyra como fumde a de Portugall, ouueramos quinhentos moyos, assy que esta quebra nos parece que jaz na pedra nã ser muyto natural de call e a call em si he fraca [...]. [...] pera que a obra que se com ella fezesse fosse segura e durauel, o que com estoutra, por ser tã fraca como he, nam sera segura a obra com ella começada [...]; por que sabera vosa alteza que quanta obra antyga os mouros tem feyto nesta cidade toda he cuberta de jesso, pera que segure a call de dentro da parede e omde quer que o jesso mimgoa logo a agoa a desfaz como se fosse barro; [...] nem crea vosa alteza que se pode em Mazagão fazer call de que vosa alteza seja seruido, por que parece cimza; assy a faziam os mouros nesta cidade, e a que agora fazemos he de muita avamtagem da que os mouros faziam e comtudo não he boa, como já dizemos. [...] A fraqueza e condiçoens desta call nam fazemos saber a vossa alteza mais ceedo, por que a nam tynhamos esprimentado e agora o temos esprimentado, por yso ho fazermos assy saber a vossa alteza […]" (Viterbo, *Dicionário...* cit., p. 49); translation: "As the castle of Azamor is at this point in time, Your Highness knows what has been done in the lime your highness told us to work with. We burnt it in a kiln which would make three hundred and fifty *móios* [Portuguese old unit of volume measurement, equivalent approximately to 60 *alqueires*, with 1 *alqueire* equal to around 14 litres; the unit was subject to substantial large regional variation], which kiln, if the lime would burn as it does in Portugal, would give us fifty hundred *móios,* so this break that lies in the stone seems to us not to be very natural for lime, so that the lime itself is weak [...]. [...] for the work done with it would be safe and durable, such that for this other one, being as weak as it is, work started with it will not be safe [...]; because Your Highness should know that old work the Moors have done in this whole city is covered with plaster, so that you can hold the lime inside the wall, and wherever the plaster falls, the water



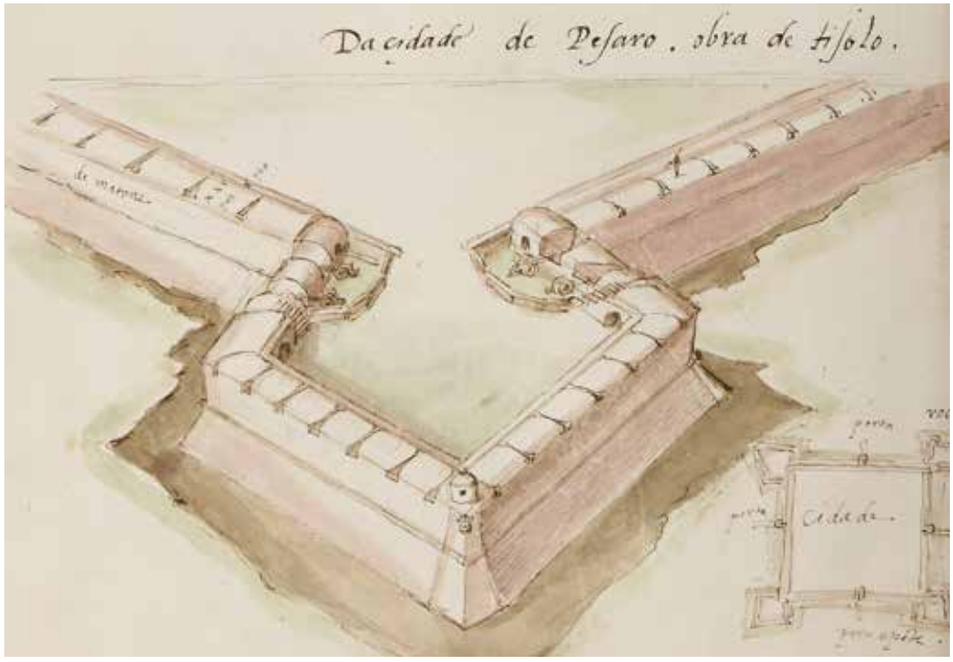


Fig. 5 *F. de Holanda, Detail of the bastion of Fuenterrabía (Real Biblioteca del Monasterio de San Lorenzo de El Escorial, ms. 28-I-20, f. 42r; © Patrimonio Nacional).*
Fig. 6 *F. de Holanda, Detail of the bastion at Pesaro, in brickwork (Real Biblioteca del Monasterio de San Lorenzo de El Escorial, ms. 28-I-20, f. 36v; © Patrimonio Nacional).*

diplomatic channels[23]. Benedetto's mission was to decide on the design of the bastions both in Ceuta and in Mazagan. Building work immediately began in Mazagan and the enceinte was closed by November 1542. Sources[24] relating to the site provide us with far more information than the authorship of the design, revealing the ongoing learning process and aspects under discussion. Such issues were resolved quite swiftly, as the king ordered the Italian's notes to be strictly followed.

These letters reveal new vocabulary in Portuguese, and several sentences are explicit about certain technical changes, such as the transformation of the round or squared *torre* (tower) into the (also round or angular) *baluarte* or *bastião*[25]. One of the most frequently mentioned issues relates to the new type of walls or ramparts: thicker, with embankments, but also with stone cladding shaping the curtains between the new angular bastions. This introduced a differentiation between *muros* (walls) and *reparos* (ram-

soon undoes it as if it were clay; [...] Nor should Your Highness believe that in Mazagan you can make lime so that Your Highness is served, because it looks like ash; that made by the Moors in this city, and that which we are making now are better than that made by the Moors, and yet it is not good, as we have already said. [...]. We did not inform Your Highness of the weakness and conditions of this lime because we had not experienced it, and now we have experienced it, we are letting Your Highness know [...]".

[19] For instance, in Mateus do Couto's lesson (Couto, *Tractado de Architectura...* cit., pp. 36-38, Book 2, Chapter 9, on building materials) or in Oliveira (V.M. Oliveira, *Advertencias aos modernos, que aprendem os officios de pedreiro, e carpinteiro*, Lisbon 1739, pp. 78-81), both following the building techniques outlined in Vitruvio, *De architectura*, a cura di P. Gros, Torino 1997, I, pp. 131-133 (II, V).

[20] Dias, *Arquitectura dos Portugueses...* cit., pp. 117-128; but the building works in Mazagan are documented only between 1514 and 1517; Moreira, *A construção de Mazagão...* cit., pp. 41-42.

[21] The extensive work of João de Castilho (active 1515-1552) is mainly connected to the royal protection of big monasteries; by 1541 he was the leading master-builder of the Convent of Christ in Tomar. See Viterbo, *Dicionário...* cit., pp. 183-184; Moreira, *A Arquitectura do Renascimento...* cit., pp. 406-570.

[22] Over the next two decades Miguel de Arruda, appointed as *Royal Master of the Fortification Works* ("mestre das obras [...] dos muros e fortalezas nos luguares de meus reinos e señorios": Viterbo, *Dicionário...* cit., pp. 72-73) in 1549, oversaw bastioned fortress design in Portugal and overseas (Lisbon, Bahia in Brazil, Diu in India and on Mozambique Island).

[23] Benedetto da Ravenna was a veteran who had worked around the Mediterranean for the Spanish crown since 1511. Around 1540 he was stationed in Cadiz, on the southern coast of Spain, not far from Ceuta; see J. Bury, *Francisco de Hollanda: A Little-Known Source on the History of Fortification in the 16th Century*, "Arquivos do Centro Cultural Português", 1979, pp. 190-198. Id., *Benedetto da Ravenna (c. 1485-1556)*, in *A Arquitectura Militar na Expansão Portuguesa*, ed. R. Moreira, Porto 1994, pp. 130-134; E. Kassler-Taub, *Building with Water: The Rise of the Island-City in the Early Modern Mediterranean*, "Journal of the Society of Architectural Historians", 78, 2019, 2, pp. 145-166.

[24] Moreira, *A construção de Mazagão...* cit. See more in Matos, *Do mar contra terra...* cit.; J.B. Matos, *First bastioned fortifications of Portugal's overseas expansion*, in *Heritages and Memories from the Sea*, conference proceedings (Évora, 14-16 January 2015), edited by F. Barata, J. Rocha, Évora 2015, pp. 208-213; W. Rossa, *1514 El Jadida 1541. Le vicende della fondazione di una città marocchina*, in *Il cantiere della città. Strumenti, maestranze e tecniche dal Medioevo al Novecento*, a cura di A. Casamento, Roma 2014, pp. 103-120.

[25] *Baluarte* or *bastião* are both common equivalents to bastion in English. See M.T. Conceição, *Le langage militaire des ingénieurs et des fortificateurs portugais (c. 1480-1580)*, in *Les mots de la guerre dans l'Europe de la Renaissance*, éd. M.M. Fontaine, J.L. Fournel, Genève 2015, pp. 144-152.

part embankments). It is no mere coincidence that in spring 1540, when the artist Francisco de Holanda (ca. 1517-1584) returned from his journey to Italy, bringing with him drawings of new fortresses, one of them had the subtitle *terrapieno*[26], which highlights this requirement (figs. 5-6).

Mazagan's sources contain several references to the problem of building ramparts in earth *(repairos de terra*), even though everyone recognized the usefulness of this new type of curtain wall against artillery fire[27]. As the king pointed out, building this kind of rampart required a larger area. Moreover, earth was also needed, but the settlement had only rocks:

> [...] you do not have space to make the ramparts nor, I believe, the earth to make them, because I have been told that they are located on rock slabs […][28].

In fact, the moat was tremendously difficult to open, which led to a few piteous complaints by Castilho[29] (fig. 7).

Following the construction of the ramparts, the drawing showing the plan of the fortress in 1611 (fig. 1), as pointed out by João Barros de Matos[30], shows the structure accurately. The perimeter and bastions were not all filled in with earth and rubble[31]: two bastions have stone masonry casemates and another two are filled in. However, on the seafront near the wharf, the rampart is thinner and entirely built using stone masonry (see fig. 7). It is worth looking closer at the discussion between the monarch and master-builder João de Castilho, who complained that he would send the drawings if he had proper sheets of paper. He then justified himself, arguing:

> […] as Your Highness did not send any message regarding what I wrote about the bastion that goes into the sea and the wharf, that I did not do it per your ordination. And believe me, Your Highness, that if we did not make a rampart with dry stonework or stone cladding, no boat or caravel would enter the northern part of the wharf during a storm […]. // I wrote to Your Highness about the wall facing the sea, and what should be ordered to do, because plain earth will cost as much as stone and lime. And to the captain, and João Ribeiro and myself, it seemed that it would be good for it to be made thirty-five palms thick, because with the rubble for the traverses and with the town's wall there will be no more expenses, and plain earth is not needed[32].

Besides the resistance to filling the walls facing the sea with earth and rubble, another issue worth highlighting is the finishing of the parapets, a more visible and vulnerable part of the fortress. The Infante Dom Luís, Duke of Beja[33], the king's brother and his main military adviser, who was also leading the Lisbon board of advisors for the Mazagan works, issued instructions. These detail materials and measures for the parapet on each bastion or front, stipulating the obligation to apply the measurements according to the design. He warned that the walls should not be made thicker than necessary to hold the fill, albeit allowing masonry to be used instead of earthen materials in some specific parts, such as a cavalier facing the sea. He also decreed that no *échauguettes* (or watch turrets) should be built using masonry, but only using tarred wood.

Finally, these instructions distinguish between the materials for the embrasures, with stonework for 'bombards'[34] and brick for harquebuses, and add an exotic touch by ordering that the artillery be covered with palm leaves to provide shelter from the rain. The debate regarding the use of brickwork or stonework against gunpowder impact is absent in these sources. Employing brickwork was indeed among the advice Francisco de Holanda claimed to have given for Mazagan, although it was not heeded[35]. The list of instructions issued by Dom Luís ends with an order to send a large quantity of lime, suggesting that it was still deemed more suitable than rubble and earth filling.

[26] This was the case of Fuenterrabía in the Basque region: F. Holanda, *Os Desenhos das Antigualhas*, ms. 28-1-20, f. 42, Real Biblioteca del Monasterio de San Lorenzo de El Escorial. See Bury, *Francisco de Hollanda*... cit., p. 189; F. Cobos, *Dessins de fortification dans "Os desenhos das antigualhas" du Portugais Francisco de Holanda (1538-1540)*, in *Atlas Militaires Manuscrits Européens (XVI[e]-XVIII[e] siècles)*, actes des journées d'étude (Paris, 18-19 avril 2002), éd. I. Warmoes, E. d'Orgeix, C. van den Heuvel, Paris 2003, pp. 117-132: 124.

[27] "[...] porque aimda que pera artelharia os repairos de terra sejam fortes aveis de ver se vos ficão essas estamçias muito baixas e a cava se he estreita e pouco funda [...]" (Letter from King John III to Luís Loureiro, captain of Mazagan, 13 April 1541, in Moreira, *A construção de Mazagão*... cit., p. 92.). "[...] because even if earth ramparts are strong for artillery, you need to make sure that those platforms are not too low and that the moat is not too narrow and not very deep [...]".

[28] "[...] não tendes espaço pera fazerdes repairos nem creo que terra pera os fazer porque me dizem que estaa sobre lagias [...]." Letter from King John III to Luís Loureiro, April 1541, in Moreira, *A construção de Mazagão*... cit., pp. 86-89: 88. The king also commanded careful checking of the site for making the lime mortar.

[29] Besides the lack of food provisions, João de Castilho, chief master of the building site, states he was working since dawn to sunset (letter from João de Castilho to King John III, 2 September 1542, in Moreira, *A construção de Mazagão*... cit., pp. 137-138).

[30] Matos, *Do mar contra terra*... cit., p. 160.

[31] João Barros de Matos had the opportunity to examine one bastion and confirm its filling materials: earth and small pieces of stone compacted in layers (Matos, *Do mar contra terra*... cit., pp. 147-148).

[32] "[...] posto que Vossa Alteza me não mandou recado do que lhe esprevi açerqua do baluarte que entra dentro do mar e desta entrada da calheta, que eu ho não fizera como estava na hordenaçao pelo que compria a seu serviço. E crea Vossa Alteza que se se não fizer hum reparo de pedra seca hou de chaparia da parte do Norte que na calheta não entrara nenhum batel com tromenta nem caravela [...]. // [...] Eu esprevi a Vossa Alteza açerqua do muro da parte do mar que me mandase o que nele avya de fazer porque terra plana a-de custar tanto como de pedra e cal. E ao capitão he a João Ribeiro he a mym nos pareçia beem que se fizesse de trinta y cynco palmos de grosso porque com hos travezes que levão os entulhos e com ho muro da parte da villa não se faz mais despesa, e escusa terra plana". Letter from João de Castilho to King John III, 2 September 1542, in Moreira, *Cartas*... cit., p. 138. The unit of measurement used here is the Portuguese *palmo* (equivalent to 22 cm), which I have translated here as "palm".

[33] Instructions by the Infante Dom Luís to be sent to Mazagan, undated (ca. 1542), in Moreira, *Cartas*... cit., pp. 155-156.

[34] Here (Instructions by the Infante Dom Luís… in Moreira, *Cartas*... cit., p. 156) and in other documents during this period, the Portuguese word is *bombardeiras*; it refers to the place where the artillery piece was positioned and not to the piece itself. We may suppose that despite this name the embrasures were meant for other, more modern types of cannon.

Fig. 7 *Mazagan, Eastern curtain of the fortress, near the wharf (photo J. Barros de Matos).*

The sources explored here reveal the initial technical reaction to the process of conceiving and building a new fortress with angular bastions according to a design by an Italian engineer, who left drawings and instructions to be strictly followed by the Portuguese. The repeated royal advice not to deviate from these instructions also reflects the reaction towards new procedures for building fortifications, in particular a certain rejection of the use of earth and rubble filling for the ramparts. The Portuguese architects (who in the sources are named as *masters of the royal works*, but who were well acquainted with design) and those who were in charge on the ground seem to have taken a pragmatic approach, insisting on the use of good lime to build strong and lasting walls. This was intended to make the construction viable in the first place, and reliable in the long run.

Hard to translate: architectural writings by a fortification builder

In the late 1570s a very different geopolitical situation emerged. At this time, angular bastioned fortifications were under construction in strategic areas of the Portuguese empire, which would subsequently be united under the same Iberian monarch, Philip II of Spain, son of Charles V and Isabel of Portugal, in 1580. By this time, writings relating to military architecture were being printed and read in Europe (and its colonies) in a much larger number than previously, having seen a particular increase from the 1550s onwards[36].

Roughly coinciding with the start of the reign of the young King Sebastian, grandson and successor of John III, the very first manuscript on architecture to be written by a Portuguese author, albeit anonymous and untitled, dates from around 1576. It appears to meet the standards of architectural treatises published elsewhere and gives building materials a prominent position. Often attributed to António Rodrigues (ca. 1525-1590), Miguel de Arruda's immediate successor as Master of Royal Works[37], it was never printed and remains unfinished, the contents somewhat haphazardly arranged[38]. The codex has 66 *folia*, of which 21 are entirely devoted to construction techniques and the properties of materials, drawing upon approaches by various other writ-

[35] F. Holanda, *Da Ciência do Desenho*… 1571, ms., Biblioteca do Palácio Nacional da Ajuda (BA, Lisbon), 52-XII-24, ff. 43-43*v*. Holanda also claimed that the fortress of Mazagan was made according to his idea and model, but this is not the matter under study here.

[36] J. Bury, P. Breman, *Writings on Architecture Civil and Military c. 1460 to 1640*, The Hague 2000.

[37] BNP, cod. 3675 [*Tratado de arquitectura*]. Attributed to António Rodrigues by Rafael Moreira, who first studied the manuscript in depth and considered it to be the first part of another codex (R. Moreira, *Um Tratado Português de Arquitectura do Séc. XVI*, MA thesis, Universidade Nova de Lisboa 1982; partially published as *Um Tratado Português de Arquitectura do Século XVI (1576-1579)*, in *Colectânea de estudos Universo Urbanístico Português 1415-1822*, Lisboa 1998, pp. 353-398). For more, see Conceição, *Da cidade e fortificação*... cit., pp. 289-338.

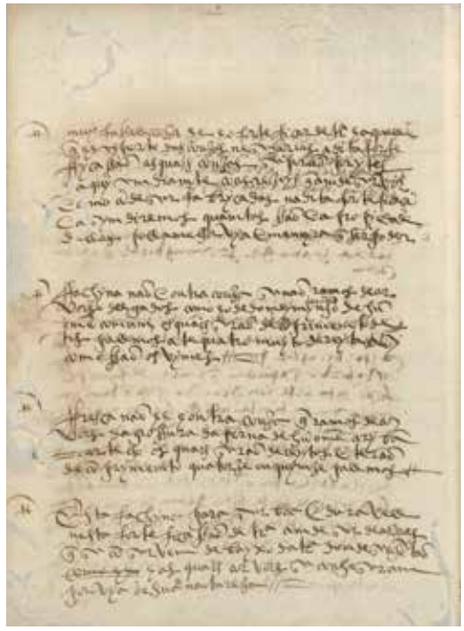


Fig. 8 *Anonymous, Tratado de arquitectura (BNP, cod. 3675, ff. 13v, 14).*

pagina successiva
Fig. 9 *Anonymous, Tratado de arquitectura (BNP, cod. 3675, f. 37v).*

Fig. 10 *Anonymous, Plan of a bastion, from Tratado de arquitectura (BNP, cod. 3675, f. 63).*

Fig. 11 *Anonymous, Plan of a bastion, from Tratado de arquitectura (BNP, cod. 3675, f. 67).*

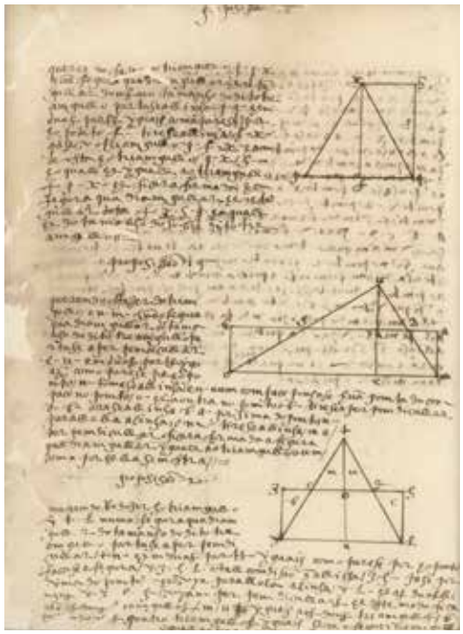
ers while sometimes incorporating the author's own statements. Without delving into the issue of authorship here, it must be said that the vocabulary employed in this work reflects a professional profile in transition: a *fortificateur* trying to play the role of architect, and striving to be seen as such. The manuscript repeatedly features the word *fortificador* struck through and replaced with the word *arquiteto*; in the same way, *fortaleza* is replaced with *edifício*. Although the word *arquitectura* does not occur anywhere and the text makes no reference to architectural orders, it often refers to the *profição de fabricar* (profession of building) or the *profição de quererem ser defemsores* (profession of those who wish to be defenders)[39]. We are, in fact, dealing with the complex metamorphosis from the older, medieval-style role of master builder into the newer, modern-style architect and engineer. These sorts of variations in vocabulary may also be detected in other European regions, such as the Low Countries, where some authors alternate between words such as *fortressaseur*, *ingeniaire* and *architecte*[40].

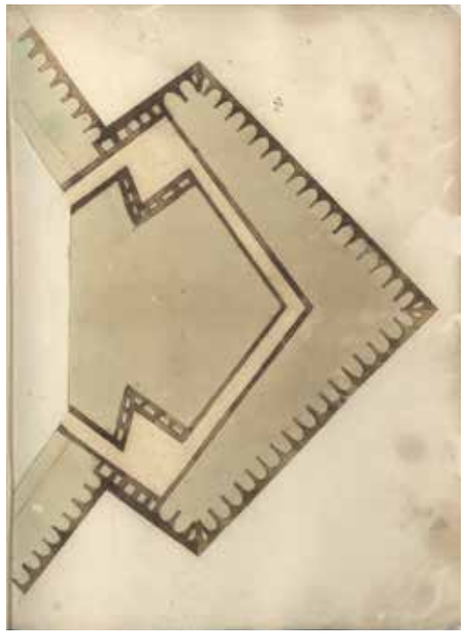
The fact that the aspiring Portuguese 'architectural writer' organised his own notes and started to write about fortifications of his own accord should not be underestimated in the light of other topics included in the manuscript, such as knowledge that architects were expected to acquire or the art of choosing an adequate site for building. To summarise the contents, the manuscript comprises three very different parts. The first section, which lacks drawings, covers various aspects of the art of building, deferring to Vitruvian authority, as is evident from chapters about the disciplines with which the architect should be familiar and the properties of water. The second part consists of a numbered sequence of definitions and propositions on geometry, surveying instruments and perspective, with drawings. The main reference here is Sebastiano Serlio's First and Second Books[41].The last, much shorter part only contains some studies of individual bastion plans (which are not mentioned in the text)[42] (figs. 8-11).

The first part starts with a kind of prologue and with five chapters (ff. 2-13) that may be considered a *résumé* of the initial sequence we find in the Vitruvius's *De architectura*, concerning the choice of a healthy site for the city, air and water quality, and the architect's education[43]. The second half of this first part (ff. 13-24) is mainly dedicated to construction materials, and has not attracted much scholarly attention. It includes two chapters on earthworks and lime production, and another six chapters on sand, clay for making bricks, and the most suitable weather or season for normal building works, earthworks and woodcutting. These chapters also reflect Vitruvius's influence, of course, but constitute a sort of organised compilation rather than direct translation[44].

Such technical writing indicates that the most direct influence was indeed Vitruvius's *De architectura* via the edition by Daniele Barba-

[38] Available since November 2019, but without a full critical edition and not available for direct purchase: *Primeiras Obras de Arquitectura*, ed. J.B. Pinho, J.V. Caldas, Lisboa 2019.
[39] See more in Conceição, *Da cidade e fortificação*... cit., pp. 324-329.
[40] See P. Martens, *Ingénieur (1540), citadelle (1543), bastion (1546): apparition et assimilation progressive de termes italiens dans le langage de l'architecture militaire aux Pays-Bas des Habsbourg*, in *Les mots de la guerre*... cit., pp. 105-140. For the Italian context, see E. Merrill, *The* Professione di Architetto *in Renaissance Italy*, "Journal of the Society of Architectural Historians", LXXVI, 2017, 1, pp. 13-35.
[41] The sequence of the definitions and propositions on geometry, perspective and surveying tools, as well as the drawings, are very similar to Serlio's First and Second Books, but are not a copy or close translation (S. Serlio, *Il primo [-quinto] libro d'architettura... di Sebastiano Serlio, Bolognese*, Venezia 1551; S. Serlio, *L'Architettura. I Libri I-VII e Extraordinario nelle prime edizioni*, a cura di F.P. Fiore, Milano 2001, I-II; or S. Serlio, *Sebastiano Serlio on Architecture. Books I-V of Tutte l'Opere d'Architettura et Prospetiva*, edited by V. Hart, P. Hicks, New Haven-London 1996). Rafael Moreira (*Um Tratado Português*... cit., pp. 168-169) pointed out this Serlio influence and also adds the probable use of Cosimo Bartoli's book (*Del modo di misurare le distantie, le superficie, i corpi, le piante, le provincie, le prospettive & tutte le altre cose terrene, che possono occorrere a gli huomini*, Venezia 1564). For more on the sources used in that part of the manuscript, see J.P. Xavier, *Sobre as origens da perspectiva em Portugal. O Liuro de Prespectiua do Códice 3675 da Biblioteca Nacional, um Tratado de Arquitectura do século XVI*, Porto 2006, pp. 211-242, 315.
[42] The plans of the bastions seem to be studies of different design possibilities for the same "ideal" or hypothetical bastion. As they are drawn on the last seven folios (six bastion plans, a section and half a schematic plan of a regular fortress) without any written explanation and as they are not referred to in the preceding chapters, they may have been produced by a different hand. Previous research on these drawings indicates that they are not copies (Conceição, *Da cidade e fortificação*... cit., pp. 321-324).
[43] Vitruvio, *De architectura*... cit., I, pp. 13-41 (I, 1-4); ivi, II, pp. 127-139 (II, 3-7); ivi, II, pp. 151-163 (II, 9-10).
[44] In Portuguese: *Capitolo dareia e de sua condisam, Capitolo da propiadade do baro pera teyolo, Capitolo do tempo em que se a de fazer o edefisio, Capitolo que trata do tempo convenyemte para se poder fabricar de tera, Capitolo da propiadade das arvores e quais sam boas pera os edefisios* (BNP, cod. 3350, ff. 18*v*-24*v*).
[45] Vitruvio, *I dieci libri dell'architettura di M. Vitruvio*... , a cura di D. Barbaro, Venezia 1556. Rafael Moreira (*Um Tratado Português*... cit., pp. 164-166) points to different passages where the words are very similar, revealing the source, for instance: BNP, cod. 3350, f. 2 refers to three important elements in warfare, "bataria, talhamento de mão e escala", a translation of "la batteria, il tagliamento che fa la man dell'uomo, & la scala" (Leonardi in Vitruvio, *I dieci libri*... cit., ed. 1556, p. 19); BNP, cod. 3350, f. 5 refers to the Vitruvian definition of architecture (without using the word), "portamto entendase ho que dis Vetruvio, que alem de hum omem ser syemtico tenha descurso, porque esta arte criouse da fabrica e do descurso", using a close translation of *fabrica et ratiocinatio*, like Barbaro, *fabrica* and *discorso* (Vitruvio, *I dieci libri*... cit., ed. 1556, pp. 8-9).
[46] P. Cataneo, *I quattro primi libri di Architettura*... , Venezia 1554; Id., *L'Architettura di Pietro Cataneo Senese. Alla quale oltre all'essere stati dall'istesso autore rivisti, meglio ordinati e di diversi disegni, e discorsi arricchiti i primi quattro libri*





ro[45] (1556) and Pietro Cataneo's First and Second books (1554, 1567)[46]. However, the Portuguese author does not go further into Cataneo's books, nor does he demonstrate a deep knowledge of the bastioned system, other than some basic features. As Rafael Moreira has studied, he mentions the "modern artillery" which has led to "new inventions"[47], as stated in the prologue, and later demonstrates that he clearly understands that the architect's main task is to design, to "show his concept through drawings"[48].

When listing the "sciences the architect needs to know", he adds artillery and the quality of gunpowder, lime, sand and how to make mortar, as well as woodcutting (ff. 12-12*v*), setting out some of the subjects he will later explain. When dealing with fortifications, the text provides no explanation of how to outline bastions or the perimeter. Nevertheless, it is curious that the author gives such prominence to earthworks, a type of construction method which (at least according to the current state of research) was barely used in Portuguese fortifications.

Although we cannot connect these *folia* to any specific building, we may try to trace the texts that informed the author. On four *folia*, he organises his notes into topics, explaining the earthworks in a very straightforward manner, listing materials and definitions. He describes fascine (brushwood bound together)[49] and *frasca* (using the Italian word, which today lacks any specialised Portuguese translation)[50], i.e. wooden materials to strengthen earthworks, average measurements and the best trees from which to get the branches (fig. 12). The technique of mixing earth with timber crosspieces is described as the next step in building a strong, lasting fort, making it clear that the explanation does not concern rampart filling. The author states that he is adding a drawing, but does not[51]. He also explains how to use the palisade as a complementary structure (again promising a drawing that does not materialise). This part of the so-called treatise also touches upon the type of earth to be used. The author states that the best type is loam (*greda*). Earth that is too stony, sandy or bumpy (*pedregoza, nem areoza, nem bechygoza*)[52] should be avoided, and he warns that the shape of the fortification, its final appearance[53], can only be realised by the *lota*. This is another word unfit for translation: indeed, the author feels the need to explain that this is a kind of grass[54], common in valleys and marshy fields, with entangled roots, which means it can be used to make sod bricks, the dimensions of which he provides[55]. It is a description that demands close knowledge of different types of grasses and bushes, and the appropriate level of humidity, to assure flexibility and resistance against fire.

Beyond the use of Italian words that do not have a Portuguese equivalent, the length of the explanatory text, when compared to other generally available materials, suggests that the author had access to other texts besides Barbaro's commentaries (and Leonardi's summary)[56] and the works of Pietro Cataneo[57]. Admittedly, the au-

per l'adietro stampati, sono aggiunti di più il Quinto, Sesto, Settimo e Ottavo libro... , Venezia 1567. Rafael Moreira (*Um Tratado Português...* cit., pp. 164-168) also points out different passages where the notes are very similar, despite not being a translation, strictly speaking; for instance: BNP, cod. 3350, f. 2 refers to Cain and Abel in an explanation of the beginning of the world (Cataneo, *I quattro primi libri...* cit., I-2, f. 2); BNP, cod. 3350, ff. 6-7, 9*v*, regarding the properties of the site and the water, like Cataneo (Cataneo, *I quattro primi libri...* cit., I-3, ff. 2-5); BNP, cod. 3350, f. 19, on the sand, follows Cataneo (Cataneo, *I quattro primi libri...* cit., II-4, f. 6*v*).

[47] As previously quoted in note 45, the "bateria, talhamento de mão e escada" was probably taken from G.G. Leonardi (via Vitruvio, *I dieci libri...* cit., ed. 1556, f. 39*v*) or Giovanni Tommaso da Venetia (via G. Ruscelli, *Della Militia moderna*, Venezia 1568, p. 40). For more, see Moreira, *Um Tratado...* cit., p.164.

[48] "É nesesario hao arquiteto saber debuxar porque por hele amostre ho seu cõseito [...]" (BNP, cod. 3350, f. 10*v*); on the evolution of drawing techniques see B. Bueno, *De quanto serve a Ciência do Desenho no serviço das obras de el-rei*, in *Universo Urbanístico Português 1415-1822*, actas do colóquio internacional (Coimbra, 2-6 março 1999), Lisbon 2001, pp. 267-281.

[49] The author writes *fachyna*, from the Italian (and Latin) *fascina*, and not the Portuguese *faxina*. "Fachyna não é outra couza senão ramos de arvores delgados como ho dedo meymynho da mão de hu ome comum, os quais serão de cõprimento de tres palmos ate quatro muyto dreyto, asy como são os vymes" (BNP, cod. 3675, f. 13). Translation: "Fascine is nothing more than tree branches, thin as a man's little finger, which should be three or four palms in length, and very straight, like wicker".

[50] *Frasca* in Italian means literally branch; "Frasca não he houtra couza que ramos de arvores de grossura da perna de hum home aryba do artelho, os quais são dereytos e terão cõprymento quatorze ou quymze palmos" (BNP, cod. 3675, f. 13*v*). Free translation: "*Frasca* is nothing more than tree branches with the width of a man's leg above the ankle, which are straight and shall be fourteen or fifteen palms in length". However, the Portuguese writer does not describe any other kind of branches, such as the *stipa* or the *frasca grossa* that we find in Italian books from that period.

[51] "[...] he nesesaryo que esta terra de que se este forte fas va lygada com grades de madeira emcruzadas huas com as houtras [...]. E a maneira destas grades de como am de ser feytas e asemtadas em seu lugar se [deve] amostrar em debuxo" (BNP, cod. 3675, f. 14*v*); translation: "[...] it is necessary that this earth for the ongoing fort is bound with *wooden railings crisscrossed together [...]. And how to make these grids and to lay them in its place [should] show up* in drawing". In Italian books it is usually called simply "gli alberi per le catene".

[52] BNP, cod. 3675, f. 14*v*.

[53] "A forteficassão de terra para ser boa e perfeita e pareser bem àqueles que a holharem não pode ser bem fabrycada para dar

Fig. 12 *Fascine, from an anonymous translation of G.B. della Valle, Tratado de Milícia, c. 1565-1566 (BNP, cod. 2107, f. 4r).*

thor did borrow his main considerations about the quality of earth from those sources[58]. Regarding the *lota* or sod, a passage from Vegetius (regarding military encampments) comes very close to our codex:

> They then throw up a slight parapet of turf and plant it with a row of palisades or caltrops of wood. The sods are cut using iron instruments. If the earth is held together strongly by the roots of the grass, they are cut in the form of a brick a foot and one half high, a foot broad and one half-foot long[59].

As widespread as readings of Vegetius and Vitruvius were, this consonance reminds us that embankments and earthworks in general were nothing new but were commonly used in earlier times; indeed the use of earthworks for the rapid construction of defences dates back to Antiquity. Sixteenth-century writers (and readers) were surely aware of this heritage. Yet the level of detail in the Portuguese author's text shows that he had read other material, including some Italian treatises on fortification printed before 1579. One of them, the *Duo Libri* by Giacomo Lanteri (1559)[60], essentially specialises in earthworks. This seems to have been used as a reference, although the Portuguese codex is much shorter than Lanteri's and presents only an outline of it. The treatise by Galasso Alghisi da Carpi (1570)[61] could also be a source, as one chapter relates to this topic, but it is somewhat different from the sequence in the manuscript under consideration.

Nevertheless, both of these sources, and Lanteri's text in particular, are in fact plagiarisms of the books by Giovanni Battista Belluzzi, known as "Il Sanmarino", as the comprehensive study by Daniela Lamberini has demonstrated[62]. Belluzzi's manuscripts, both originals and copies, were in circulation despite the fact that his work was only printed in 1598, in a posthumous, incomplete edition[63]. Belluzzi's *Fortificazioni di terra*, written in 1545 (and thus right before the various printed works on fortification), is considered the most accomplished work on the theory and practice of fortification sites[64], and in some ways the original source of many other writings (figs. 13-16).

Other renowned manuscripts, such as those by Francesco de Marchi (1540-1570, printed only in 1599)[65], include chapters about earth construction techniques, but with a less in-depth approach than Belluzzi. So far, however, it has not been possible to connect these treatises on fortification directly with Portuguese sources[66]. Lamberini also mentions that the famous treatise by Giacomo Castriotto, published posthumously by Girolamo Maggi in 1564, includes a rather short chapter – *Dell'ordine, che si debba tenire per fabricare opera di terra*[67] – which, interestingly, reveals that the ancestry of earthen and wooden works was already acknowledged as an *antichissima* invention in existence at least since the time of Homer's *Iliad*. Moreover, Castriotto and Maggi mention the little work by Giovanni Battista della Valle, best known as *Il Vallo Libro*[68], as the first to include earth and wood materials to *fortificare una terra*. Although the Portuguese manuscript does not mention gabions,

boa haparemssea de sy sem ser fabrycada com lota" (BNP, cod. 3675, f. 15); translation: "In order for fortification earthworks to be good and perfect and appear good to those who look at them, they must be made with *lota*".

[54] "Polos campos e vales e pauys nase hua sorte d'erva que em nosa lingoa se chama grama, a qual debayxo de terra crya muytas rayzes e estão tão lygadas huas cõ as outras que se não podem tirar hua que não venhão muytas ymtas. E a mylhor de todas é aquela que tem a folha e a sua folha é como carysso" (BNP, cod. 3675, f. 15*v*). *Cariço* is a Portuguese word for a material used in basketry. Translation: "In the fields and valleys and marshes grows a species of grass that in our language is called *grama*, which under the ground creates many roots that are so connected with each other that one cannot be removed without many coming up together. And the best of all is the one with the leaf, and its leaf is like a reed".

[55] "Esta lota sera cortada he postas nem mais nem menos que hu tijolo que tenha de cõprimento hu pe, e de largura meo pe, e de gorssura três dedos" (BNP, cod. 3675, f. 16); translation: "This *lota* should be cut into pieces, no more nor less than a brick one foot long and half a foot wide and three fingers thick". Lamberini clarifies that *lotta* or *lotte* was used in regions other than Tuscany, where the more common word was *piotte*; some authors present both words (Lamberini, *Il Sanmarino*... cit., I, p. 260-261, 307).

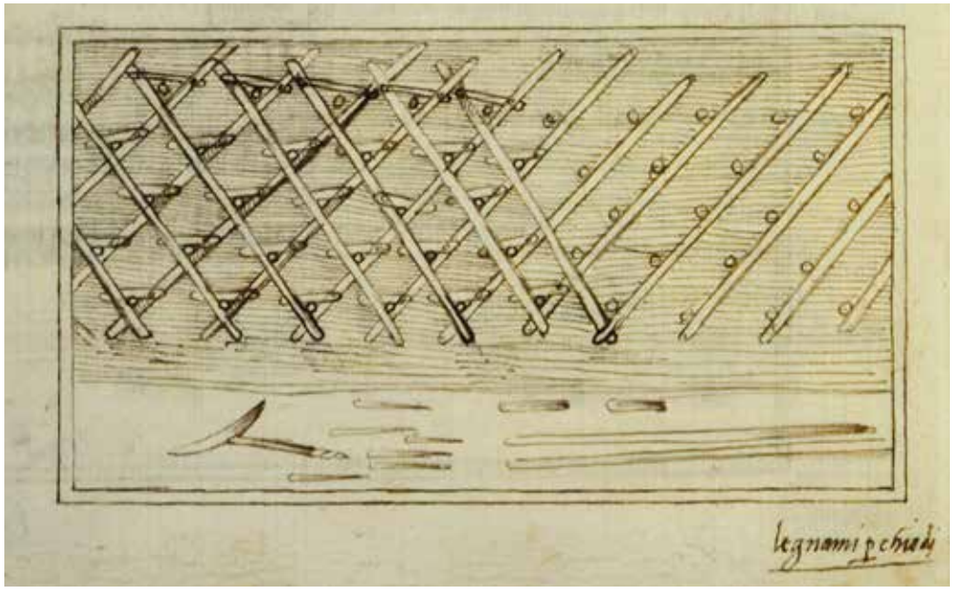
[56] Regarding fortifications, Barbaro includes some indications he gathered from Giovanni Giacomo Leonardi, thus updating Vitruvius's treatise contents; moreover, two drawings and a summary from the *Primo Libro delle Fortificatione del Signor Gianicopo Leonardi Conte de Montelabate* were added (Vitruvio, *I dieci libri*... cit., ed. 1556, pp. 30-31, 38-40). About the disclosure of the new architectural indications, as on Barbaro's edition of *De architectura* the bibliography is vast; see E. Concina, *La macchina territoriale. La progettazione della difesa nel Cinquecento veneto*, Roma-Bari 1983, pp. 135-155; L. Cellauro, *Daniele Barbaro and his Venetian editions of Vitruvius of 1556 and 1567*, "Studi Veneziani", n.s., XL, 2000, pp. 87-134; *Daniele Barbaro's Vitruvius of 1567*, edited by K. Williams, Basel 2019.

[57] Literature about Pietro Cataneo's treatise is scarce, besides references in more general works: G. Nudi, *Pietro Cataneo: trattatista d'architettura del Cinquecento*, Firenze 1968; Y. Pauwels, *Pietro Cataneo*, 2012, in *Architectvra. Architecture*... cit., http://architectura.cesr.univ-tours.fr/traite/Notice/Cataneo1567.asp?param=, last accessed on 24 February 2020.

[58] Vitruvius advises strengthening the walls with olive tree beams and embankments (Vitruvio, *I dieci libri*... cit., ed. 1556, f. 30). Cataneo (*L'Architettura*… cit., ff. 10, 15) also explains some of these construction techniques, how to fill in the ramparts (*terrapianare*) and the use of branches (*frasche*), but he did not dedicate any chapter to this topic in his *Second Book*.

[59] R.F. Vegetius, *Roman Military*, Philadelphia 2004, p. 118 (*Military Institutions of Vegetius*, edited by L.J. Clarke, London 1767). BNP, cod. 3675, f. 16: "Cortamdo desta lota nestes prados hou vales hou pauis a camtidade que for nesesarya pera esta forteficação, e a maneyra do cortar dela he ha seguinte: / Esta lota sera cortada he postas nem mais nem menos do que que hu tijolo que tenha de cõprimento hu pe, e de largura meo pe, e de gorssura três dedos".

[60] G. Lanteri, *Duo libri di M. Giacomo Lanteri di Paratico da Brescia. Del modo di fare le fortificationi di terra intorno alle Città, & alle Castella per fortificarle*, Venezia 1559. Book 1 includes chapters such as "Del modo di Fortificare di Terreno", "Della qualità della terra" (ch. 12), "Del maneggiare la terra" (ch. 13), or "Della qualità della lotta" (ch. 16), "Della stipa, e sue conditioni" (ch. 17), "Della frasca grossa" (ch. 18), "De gli alberi per le catene" (ch. 19). Meanwhile, Book 2 is titled "Del modo di fare I forti di terra intiorno alle città; et alle castella". Lanteri worked as an engineer for the Spanish King Philip II in Naples and the North African coast, which



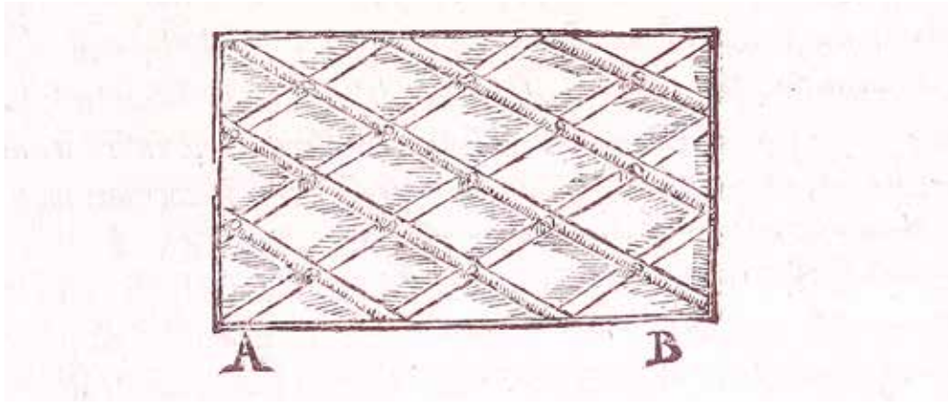


Fig. 13 *G.B. Belluzzi, Legnami per chiodi, from Trattato delle fortificazioni di terra, (Biblioteca Riccardiana, Firenze, Ricc. 2587, c. 19v; © Ministero per i beni e per le attività culturali e per il turismo).*

Fig. 14 *G. Lanteri, Catene, from Duo libri... Del modo di fare le fortificationi..., Vinegia 1559, p. 53 (Biblioteca Nazionale Centrale di Firenze, Magl. 12.5.27/b; © Ministero per i beni e le attività culturali e per il turismo).*

the main device underlined by Della Valle, the author is likely to have known the book, as it was widely publicised, with more than ten editions in thirty years[69], and was commonly found in Portuguese libraries[70].

In short, it is reasonable to assume that the Portuguese writer had direct contact with some or at least one of these treatises, most probably through the mediation of Lanteri's book[71]. He was obviously interested in earthworks and had familiarised himself with the subject, but he simplifies the available material and presents not a copy, but his own summary. When we look at descriptive details, such as techniques for the sod brick (*lotta*), the anonymous writer presents a slightly different version[72]. However, anyone studying his notes alone would have great difficulty in understanding how all the materials should be put together. This is probably why he intended to insert two drawings (for the crosspieces and palisade). The reason for the interest in earthworks in Portugal during that period remains unclear, besides intellectual curiosity in relation to an unusual procedure. In fact, he concludes by voicing doubts as to the actual usefulness of earth construction, suspecting that the Prince would accept this method for reasons of urgency rather than appropriateness[73].

The most noticeable aspect of the other chapters – regarding lime production, sand, clay to make bricks, and the most suitable weather or season for building works and woodcutting – is their brevity in comparison to the preceding chapters. Here the author presents little more than a summary of building materials and basic definitions. In doing so, he comes closer to the Vitruvian structure, which he could have found in both Barbaro and Cataneo, but still adds some personal and local details. For instance, picking up on the topic of lime again, he mentions his own experience in Évora – the source of the best limestone – and the trees most widely used in Portugal[74]. His line of argument seems to follow the sequence of the *De architectura*, explaining how to choose the best kind of stone according to its level of humidity and dryness, how to exer-

may have contributed to his book's dissemination in Iberian lands (M. Pollak, *Military Architecture, Cartography and the Representation of the Early Modern European City*, Chicago 1991, p. 58; Lamberini, *Il Sanmarino*… cit., p. 396 note 10).

[61] G. Alghisi, *Delle fortificazioni di M. Galasso Alghisi da Carpi architetto dell'eccellentiss. signor duca di Ferrara. Libri tre, all'invittissimo imperatore Massimiliano secondo Cesare Augusto*, Venezia 1570. Book 3 includes the chapter "Delle fortificazione di terra, che si fanno nel tempo de la guerra, ò sospetto di quella fatte per brevità di tempo". For an overview on fortification treatises see part of *Los Tratados de Arquitectura de Alberti a Ledoux*, edición D. Wiebenson, Madrid 1988; A. Fara, *Il sistema e la città. Architettura fortificata dell'Europa moderna dai trattati alle realizzazioni, 1464-1794*, Genova 1989.

[62] Lamberini, *Il Sanmarino*... cit., I, p. 288; D. Lamberini, *Il principe difeso: vita e opere di Bernardo Puccini*, Firenze 1990, p. 130. Lamberini underlines that Lanteri took materials from Belluzzi and his pupil and successor Puccini.

[63] G.B. Belluzzi [Belici], *Nuova inventione di fabricar fortezze*, Venezia 1598. From which Moreira (*Um Tratado*... cit., p. 168) mentions a possible source for the Portuguese manuscript, but in relation to another subject.

[64] Lamberini, *Il Sanmarino*… cit., pp. 302-309. The manuscript was presented by Lamberini before, as *Il trattato delle fortificazioni di terra*, in *Il Disegno interrotto. Trattati medicei d'architettura*, a cura di F. Borsi, C. Acidini Luchinat, Firenze 1980, I, pp. 375-401. Pepper, Adams (*Firearms and Fortifications*… cit., pp. 73-76) also mention that earthworks were commonly used in Italy and underline the role of Belluzzi as the author of the best description of building earthworks.

[65] F. De Marchi, *Della architettura militare*… , Brescia 1599. The First Book includes chapters such as "Modo di fortificare di terra" or "Della lotta, e ponerla in opera", and the Second Book includes military construction details. On F. De Marchi see D. Lamberini, *Francesco De Marchi. Ritratto di un cortigiano del Cinquecento, virtuoso e dilettante di architettura militare*, "Storia Architettura", X, 1987, 1-2, pp. 69-88; B. De Groof, G. Bertini, *Francesco di Marchi y la Monaquía Española*, in *Las Fortificaciones de Carlos V*, edición C.J. Hernando Sánchez, Madrid 2000, pp. 388-411; and M. Ng, *New Light on Francesco De Marchi (1504-1576) and His Treatise on Fortification*, "Mitteilungen des Kunsthistorischen Institut in Florenz", LVIII, 2016, 3, pp. 403-410.

[66] Nevertheless, a book on naval architecture, written by the royal chief cosmographer João Baptista Lavanha ca. 1600, contains an interesting quote: "A Architectura Militar he a que ensina a fabricar de tal modo que fortificados nos segura [...], cujos preceitos e regras ensinão em seus escritos Alberto Durero, Hieronimo Maggi, Carlo Theti, o Galarzo, Hieronimo Cataneo, Jacobo Lantero, Battista Zanchi, e outros modernos [...]" (J.B. Lavanha, *Livro Primeiro da Architectura Naval*, Lisboa 1996, p. 2; see F.C. Domingues, *João Baptista Lavanha e o ensino da náutica na Península Iberica*, in *As novidades do mundo do conhecimento e representação na Época Moderna*, actas das jornadas de História Ibero-americana (Portimão, 2002), ed. M.G.M. Ventura, S.J.S. Matos, Lisboa 2003, pp. 115-143; and Conceição, *Da cidade*... cit., p. 230.

[67] G. Maggi, J.F. Castriotto, *Della fortificazione delle città*… , Venezia 1564, Third Book, Chapter XXV, ff. 106*v*-108*v*; see G.E. Ferrari, *Le edizioni venete di architettura militare del Maggi e Castriotto*, in *L'architettura militare veneta del Cinquecento*, Milano 1988, pp. 179-194.

[68] G.B. Della Valle, *Vallo Libro continente appartenentie ad capitanij: retenere et fortificare una cita con bastioni...*, Venezia 1535, ff. 4*v*-8*v* (prima ed. Napoli 1521).

[69] Pollak, *Military Architecture*… cit., pp. 112-113. Bury, Breman, *Writings on Architecture* … cit., p.107.

[70] For instance, the Biblioteca Nacional de Portugal has two editions from the *Vallo Libro continente appartenentie ad capitanij*, Venezia 1531 (BNP, RES. 5973//1 P.), 1539 (BNP, SA 4150 P.), plus a handwritten translation done after 1565 (BNP, cod. 2107).

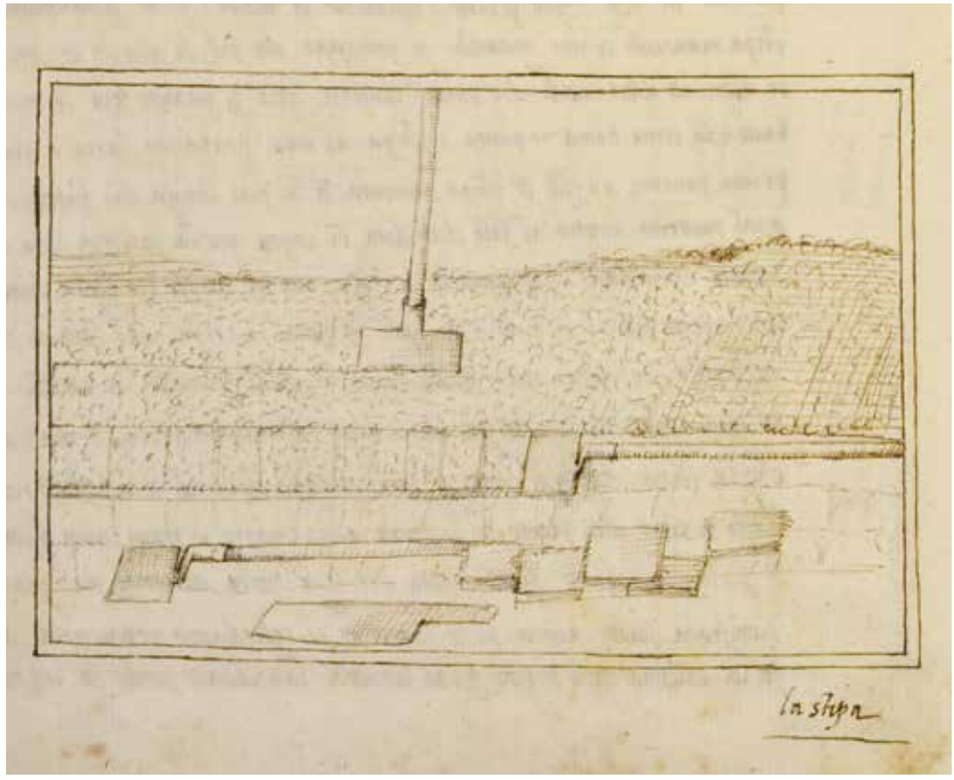


Fig. 15 *G.B. Belluzzi, La stipa, from Trattato delle fortificazioni di terra (Biblioteca Riccardiana, Firenze, Ricc. 2587, c. 17v; © Ministero per i beni e per le attività culturali e per il turismo).*

cise caution during the burning procedures and how much time is needed for the lime to slake[75]. Nevertheless, he also provides a special method for testing the lime. He stipulates that three baskets of sand should be mixed with two baskets of lime. Afterwards, the mason should knead just a small portion and test it; if the materials are not sufficiently intermingled (*bem traçada*), he should add more lime. These specifications do not match the contents or recipe prescribed by Vitruvius-Barbaro or Cataneo[76], who all state the simple rule of two parts sand to one part lime. Notwithstanding their concision, these notes do not evince the slightest hesitation, nor do they require translation (from Italian to Portuguese), and the terms used are fairly familiar. Likewise, the discussion about achieving a good level of humidity for the stone, which must not be too dry, leads him to issue a warning not to use the superficial stone, but to dig between fifteen and twenty palms, where the blueish stone is better than the whiter, as he experienced in Évora[77].

This short chapter ends with the recommendation to leave the lime to slake for at least six months, despite Vitruvius's advice to leave it for two years[78]. The writer concludes,

> But we say, as human life is brief and the appetite of the one ordering building works is big, we cannot wait for so long, and so we say that six months to slake it are enough[79].

Moreover, there is no reference to stonework. Was this topic considered too commonplace, or did the author just did not get around to writing about stonework, or was it perhaps included in a now lost part of the incomplete manuscript? Whatever the answer, this section regarding lime has fewer specifically military features and discusses instead common procedures for both civil and military building. In fact, it is ultimately unclear whether the author wanted to write about architecture or fortification, as the sequence of the chapters is not clearly apparent. In all likelihood, he was simply organising his own compilation of private notes. The chapters on earthworks, their thorny vocabulary issues and the advices on making good lime all to some extent reflect what might be expected of a fortification builder in order to claim architectural intelligence. The writer wishes to demonstrate that he is well read and proficient in basic Vitruvian building knowledge. He is aware that there are certain figures whom he needs to mention, but not without presenting some evidence of his own experience. However, these personal points of reference are not developed enough to support the idea of theoretical knowledge being adapted to local or real practice. Even the summary about earthworks in fortification is presented as an account that is not completely reliable as it relates to the practice at that time.

[71] The bastion drawings included in the Portuguese codex (BNP, cod. 3675 [ff. 62-67]) have a close affinity with one of Lanteri's plans (Lanteri, *Duo libri*... cit., II-15, pp. 100-101), although they are not exactly the same, namely in the design of the flanks and cavalier.

[72] BNP, cod. 3675, f. 16: one foot length, half foot width and three fingers height; Lanteri, *Duo libri*... cit., f. 45: half foot length, but could be more or less, depending on the quality of the earth, one ordinary palm width and four fingers height; Belluzzi (Lamberini, *Il Sanmarino*… cit., pp. 260-261): "mezzo braccio per lungo et larghi un quarto et gross'un ottavo". For the moment it is not clear why there are differences between the measurement units (foot, fingers, palm, and fathom).

[73] "Mas por quamto estes edefisyos de terra quamdo se mãodão fazer he per pura nesesydade do Primsepe que ho mãdar fazer, não se podera esperar este debyto tempo que sera nesessaryo para hele ficar em sua debyta rezão" (BNP, cod. 3675, f. 23); translation: "But as these earthen buildings were ordered to be built by pure necessity of the Prince's decree, it is not possible to wait the appropriate time for the building to take form by the appropriate method".

[74] The writer, presenting the best trees to use for the buildings, such as cedar, chestnut or larch, also points to the most common use (in Portugal) of the oak from Flanders (for doors and windows) and another species of oak, used in Portugal for beams (BNP, cod. 3675, ff. 23*v*-24*v*). For military fascines he recommends chestnut tree, elm, ash, willow, poplar and mulberry.

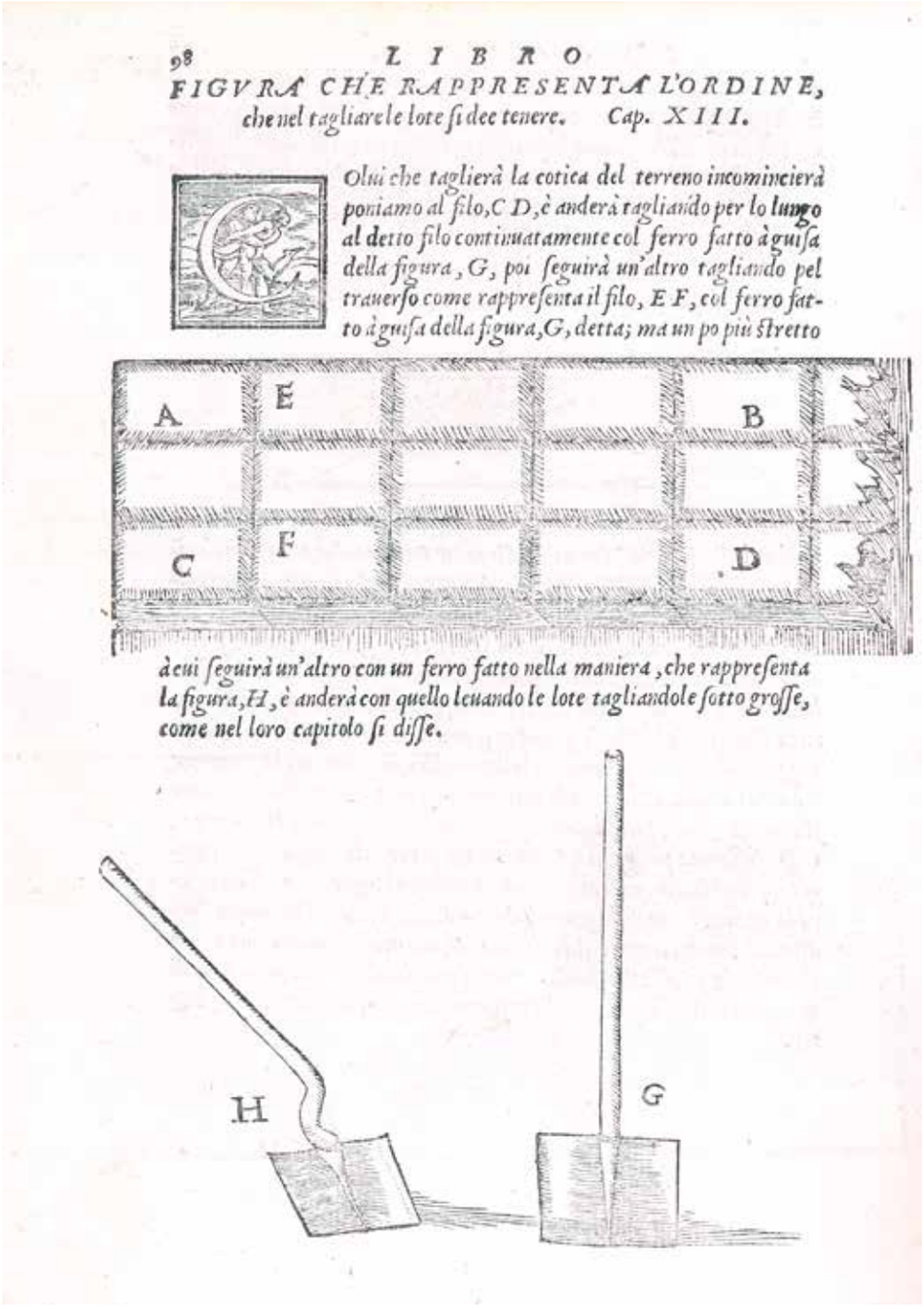
[75] "[...] comvem que declaremos tres couzas a, cõvem a saber: de que pedra a de ser ha boa cal; e quomo se conhesera quamdo he cozida; e depois de cozida quamto tempo avera myster pera se por em hobra" (BNP, cod. 3675, f. 16*v*); translation: "[...] we should state three things, as follows: which stone is needed for good lime; how do we know it when it is burnt; and after being burnt, how much time do we need [to wait before] using it in building work".

[76] Vitruvio, *I dieci libri*... cit., ed. 1556, p. 47; Cataneo, *I quattro primi libri*... cit., f. 29*v*.

[77] "[...] a pedra de que se houver de fazer boa cal não se a de tirar à soprefise da terra senão de quymze hou vimte palmos pelo semtro da terra [...] e quando a partirem paresa mais sobolo azulado que não sobre ho branco. E semdo esta fara boa cal, como se ve por ê por esperyemsy pela cal d'Evora, que por ser feita desta pedra é a mellhor do Reyno" (BNP, cod. 3675, f. 17*v*). "[...] to make good lime we cannot remove the stone from the earth's surface, but from fifteen or twenty palms into the earth [...] and when it breaks it seems more blueish than white. And being so it will make good lime, as I know from experience with the lime from Évora. As it is done with this stone, it is the best in the kingdom".

[78] BNP, cod. 3675, ff. 17*v*-18; the Vitruvian edition by Barbaro (Vitruvio, *I dieci libri*... cit., ed. 1556, II-5) doesn't give this indication and only Cataneo refers to the advice of the Ancients, which recommended leaving three years for the lime to slake (Cataneo, *L'Architettura*… cit., f. 29*v*).

[79] "Mas nós dezemos que por ser a vyda vmana breve e o apetite daquele que māda fabrycar gramde não podemos aguardar tamto tempo, e por yso dezemos que abastão hos seis mezes para se esfryar" (BNP, cod. 3675, f. 18).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FIGVRA CHE RAPPRESENTA L'ORDINE, che nel tagliare le lote si dee tenere. Cap. XIII.

Colui che taglierà la cotica del terreno incomincierà poniamo al filo, C D, è anderà tagliando per lo lungo al detto filo continuatamente col ferro fatto à guisa della figura, G, poi seguirà un'altro tagliando pel trauerso come rappresenta il filo, E F, col ferro fatto à guisa della figura, G, detta; ma un po più stretto

A E B C F D

à cui seguirà un'altro con un ferro fatto nella maniera, che rappresenta la figura, H, è anderà con quello leuando le lote tagliandole sotto grosse, come nel loro capitolo si disse.

H G

Fig. 16 *G. Lanteri, Lotte, from Duo libri... Del modo di fare le fortificationi..., Vinegia 1559, p. 98 (Biblioteca Nazionale Centrale di Firenze, Magl. 12.5.27/b; © Ministero per i beni e le attività culturali e per il turismo).*

Both these architectural notes written by a fortification builder and the letters sent from the building site at Mazagan evince a pragmatic approach. There is no trace of any discussion about the new fortress design; the debates they document relate instead to construction techniques and concern, to put it simply, the question of building either ramparts with earthen embankments or walls with stone and lime. One finds in these writings not so much the introduction of innovative architectural forms or new techniques, but rather a certain reluctance to apply new solutions without the necessary guarantees. The insistence on using reliable materials and previously tested techniques also shows that pursuing secure and immediate results was an integral part of the service to the crown.

Regardless of whether we understand this contact with new solutions as a learning process or not, it is worth observing that the contact existed and was followed by criticism when it came to achieving practical results. These architects or fortification builders were not indifferent to new expertise, but refused to apply it without discussion, even if the interlocutor was their king. They preferred to rely instead on practical experimentation and time-tested knowledge.