

# **Books, Buildings, and Construction Techniques: The Materiality of Architectural Knowledge in the Republic of Ragusa after the Great Earthquake of 1667**

Cristiano Guarneri and Ines Ivić

## **Abstract**

This paper proposes a methodological model for reconstructing the architectural knowledge present in Dubrovnik during the renovations that followed the earthquake of 1667. Such renovations are seen as a manifestation of both theoretical and practical architectural knowledge, echoing across various sources and evident in the buildings themselves. The authors advocate for a comprehensive approach that integrates the "know-what" of architectural treatises with the "know-how"

of sources such as building accounts (*libri della fabbrica*). Furthermore, they aim to enrich the understanding of Ragusan construction practices by exploring the circulation of knowledge among different construction sites in Dubrovnik and by comparing them with those cultivated in Rome and Venice. This will shed light on the circulation of architectural knowledge, spatial concepts, and decorative styles between Italy and the eastern coast of the Adriatic.

## Introduction<sup>1</sup>

[1] On the morning of 6 April 1667 a massive earthquake hit the small maritime Republic of Ragusa (today Dubrovnik), destroying most of its houses, palaces, monasteries, and churches, and taking the lives of almost one third of its inhabitants.<sup>2</sup> The earthquake struck during the Cretan War (1645–1669), a politically unfavourable moment in which the Republic found itself buffered between the Ottoman Empire and the Venetian Republic. The following years were the most unstable in the history of the Republic; its survival and sovereignty were seriously threatened.<sup>3</sup> Dubrovnik, like many other locations that suffered similarly destructive earthquakes – such as Val di Noto in 1693 or Lisbon in 1755 – was thus marked by a distinct before/after dichotomy: in particular, textbooks describe the earthquake as the turning point in the urban and architectural transformation of the city, and as the beginning of the transition to Baroque architectural forms.<sup>4</sup> Yet, whereas Noto and Lisbon implemented new urban layouts, in Dubrovnik the earlier medieval arrangement of the buildings and main communication axis were largely preserved, but for a few exceptions.<sup>5</sup>

[2] Previous scholarship has recognized and discussed the formal components that were introduced into the Ragusan architectural tradition, primarily focusing on the new cathedral (1671–1713),<sup>6</sup> which is acknowledged as the main site for the adoption and spread of new Baroque forms and ideas in the city (Fig. 1). The church is noteworthy not only for its innovative design in the development of religious architecture in Dubrovnik, but also for the involvement of Italian

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<sup>1</sup> Although the authors discussed, revised, and agreed on each passage of this paper together, Ines Ivić authored sections 1, 2 and 3, and Cristiano Guarneri authored sections 4 and 5. This article is part of a project funded by the European Union's Horizon 2020 Research and Innovation Programme (GA n. 865863, ERC AdriArchCult). Unless otherwise stated, all translations are by the authors.

<sup>2</sup> Paola Albini, *The Great 1667 Dalmatia Earthquake. An in-Depth Case Study*, Cham (CH) 2015.

<sup>3</sup> Radovan Samardžić, *Borba Dubrovnika za opstanak posle velikog zemljotresa 1667 g. Arhivska građa (1667–1670)*, Belgrade 1960; Lovro Kunčević and Domagoj Madunić, "Venecija i Dubrovnik u vrijeme velikog potresa 1667. godine", in: *Anali Zavoda za povijesne znanosti Hrvatske akademije znanosti i umjetnosti u Dubrovniku* 52 (2014), 173-218; Nikša Varezić, *Dosta je reći u Rimu da bi se reklo čitavom svijetu: Dubrovačka republika i Sveta Stolica tijekom 16. i 17. Stoljeća*, Zagreb/Dubrovnik 2018.

<sup>4</sup> Echoes of Baroque architecture were already present in Dubrovnik in the first half of the seventeenth century (before the quake) in the confraternity church of Our Lady of Carmen and the confraternity church of Our Lady of the Rosary. Katarina Horvat-Levaj, *Barokna Arhitektura*, Zagreb 2015, 135-137.

<sup>5</sup> On the development of Dubrovnik's urban core, see: Lukša Beritić, *Urbanistički razvitak Dubrovnika*, Zagreb 1958; Cvito Fisković, "Barokni urbanistički zahvat sred Dubrovnika", in: *Anali Zavoda za povijesne znanosti Hrvatske akademije znanosti i umjetnosti u Dubrovniku* 19-20 (1982), 91-120; Katarina Horvat-Levaj, "Urbanistička preobrazba Dubrovnika nakon potresa 1667. godine", in: Pavica Vilać, ed., *Stjepan Gradić, otac domovine*, Dubrovnik 2013, 343-353. The most significant alteration of the urban layout occurred on the site where the Jesuit college and church were built, completely cancelling the earlier disposition of narrow medieval streets. See Tanja Trška Miklošić, "Neostvareni projekt isusovačke crkve i kolegija (1659.) u Dubrovniku", in: *Radovi Instituta za povijest umjetnosti* 33 (2009), 125-140.

<sup>6</sup> For a more detailed bibliography and historiographical discussion, see: Katarina Horvat-Levaj, ed., *Katedrala Gospe Velike u Dubrovniku*, Dubrovnik/Zagreb 2014.

architects who oversaw its construction and also contributed to other renovation and rebuilding projects throughout the city.



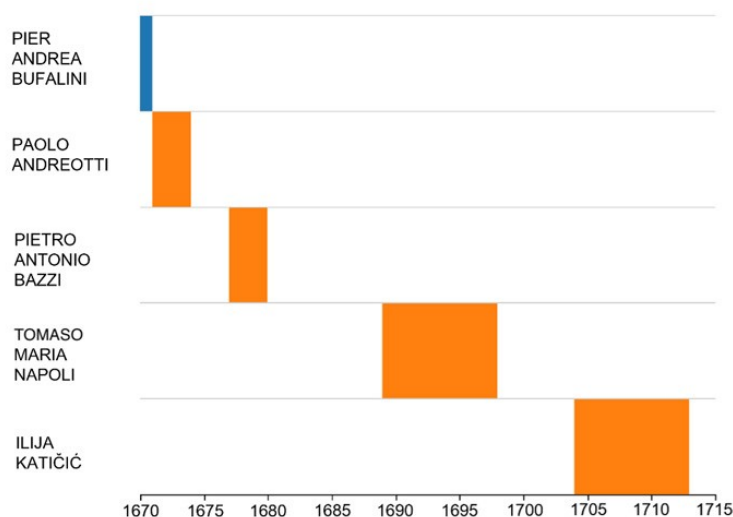
1 Dubrovnik, Cathedral of the Assumption of the Virgin Mary, 1671–1713 (photo: Giuseppe Andolina)

[3] Designed by Pier Andrea Bufalini (1621 – after 1688) in Rome in the years 1670–1671, the commission for the cathedral had come about through the mediation of Stefano Gradi, a Ragusa-born polymath who had settled in Rome in 1653, holding various significant positions within the Roman Curia, including that of custodian of the Vatican library.<sup>7</sup> Despite never returning to Dubrovnik, Gradi maintained strong personal and diplomatic ties with his homeland and served as its official diplomat in Rome. Recognized for his extensive knowledge and broad network, he became the unofficial overseer of Dubrovnik's *renovatio urbis*, advising Ragusan governing bodies by letters and securing international financial and diplomatic support for his homeland. Not only did Gradi provide a detailed plan for the urban reconstruction, particularly of the cathedral, inspired by the Roman Baroque style, but he also personally recruited several architects to carry out the work. Furthermore, he coordinated all the necessary formalities for their employment and their travel from Rome to Dubrovnik.

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<sup>7</sup> Stjepan Krasić, *Stjepan Gradić (1613–1683): život i djelo*, Zagreb 1987; Vilać (2013).

[4] The reconstruction of the cathedral continued on and off for almost forty years under the supervision of the Italian architects Paolo Andreotti (1671–1674), Pietro Antonio Bazzi (1677–1680) and Tom(m)aso Maria Napoli (1689–1698), until the local stonemason Ilija Katičić (Elia Caticich, 1704–1713) finally completed the building (Fig. 2).<sup>8</sup>



2 The architects in charge of the reconstruction of Dubrovnik Cathedral (diagram: Ines Ivić)

[5] Scholars have traced the circulation of architectural forms between the Apennine peninsula and Dubrovnik during this period, and have discussed at length the role of the above-mentioned foreign architects as well as that of the military engineers Giulio Cerruti (in 1667) and Francesco Cortese (in 1668–1670), who advised Ragusan authorities on how to initiate the restoration and contributed their technical expertise to the reconstruction of the damaged buildings.<sup>9</sup> This paper follows a different route: it reconstructs the architectural knowledge in Dubrovnik during this period by asking how Ragusan masters, who ultimately physically rebuilt the city under the guidance of the aforementioned architects, applied that knowledge on the construction sites. In other words, it complements the "know-what" from the architectural treatises, plans, and drawings, with the "know-how" recorded in other primary sources. The process of construction is not seen here as a mere translation of the envisioned project into the foundation-wall-roof paradigm, but as a manifestation of theoretical and practical architectural knowledge that materializes in the building itself and is reflected in all the sources related to it. These mutually intertwined and complementary systems of explicit knowledge, codified in treatises and handbooks, and implicit knowledge, generated and disseminated on the construction sites, are

<sup>8</sup> Katarina Horvat-Levaj, "Arhitektura barokne katedrale", in: Horvat-Levaj (2014), 121-211.

<sup>9</sup> Jasenka Gudelj, "Architettura e diplomazia tra Roma e Dubrovnik: San Girolamo dei Croati e la cattedrale di Dubrovnik nel secondo Seicento", in: *Römisches Jahrbuch der Bibliotheca Hertziana* 40 (2011/2012), 185-239; Horvat-Levaj (2014), 121-211; Katarina Horvat-Levaj, "The Sicilian Architect Tommaso Maria Napoli and the Baroque Cathedral of Dubrovnik", in: *RIHA Journal*, no. 0116 (2015), <https://doi.org/10.11588/riha.2015.0.70065>.

defined by different agents and manifested through diverse media.<sup>10</sup> By exploring their circulation and interaction, we propose a methodological model for reconstructing architectural knowledge in Dubrovnik during the city's renovation after the earthquake. This paper focuses on a few selected examples: the cathedral, the church of Saint Blaise, the church of Saints Peter, Andrew and Lawrence (also known as *Petilovrijenci*), and the Rectors' Palace (Fig. 3).



3 Map of Dubrovnik, seventeenth century. Key: 1 Cathedral | 2 Rector's Palace | 3 St Blaise's Church | 4 Petilovrijenci Church | 5 Sponza Palace (Custom House) | 6 Dominican Convent. Archivio di Stato di Torino, Turin, Sezione corte, Biblioteca antica dei Regi archivi, *Architettura militare*, vol. V, fols. 244v-245r (photo: © Archivio di Stato di Torino)

[6] Moreover, Ragusan construction practices will be compared to the standards established in cultural centres such as Rome, where an advanced experimentation of new techniques and labour management took place on the construction sites of St Peter's<sup>11</sup> and other buildings, such as

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<sup>10</sup> The dichotomy between explicit and implicit knowledge, largely debated in the field of the history of knowledge, has also been adopted in architectural history, particularly in the study of historical construction techniques. See: Hermann Schlimme, ed., *Practice and Science in Early Modern Italian Building: Towards an Epistemic History of Architecture*, Milan 2006. For recent accounts of the history of knowledge, see: Johan Östling et al., eds., *Circulation of Knowledge: Explorations in the History of Knowledge*, Lund 2018.

<sup>11</sup> Nicoletta Marconi, "La Fabbrica di San Pietro in Vaticano per l'edilizia di Roma tra XVII e XIX secolo: officina, innovazione, divulgazione", in: Gaetano Sabatini and Simona Turriziani, eds., *L'Archivio della Fabbrica di San Pietro in Vaticano come fonte per la storia di Roma*, Rome 2015, 95-120; Nicoletta Marconi, "Tecniche e pratiche del costruire nel cantiere di S. Pietro tra XVII e XVIII secolo", in: Francesco Buranelli, ed., *Vaticano barocco: arte, architettura e cerimoniale*, Milan 2014, 217-271; Nicoletta Marconi, *Edificando Roma barocca: macchine, apparati, maestranze e cantieri tra XVI e XVIII secolo*, Città di Castello 2004.

Sant'Andrea al Quirinale,<sup>12</sup> and Venice, historically a cultural hub of the Adriatic Basin.<sup>13</sup> In this paper, we primarily focus on the internal circulation of knowledge among the construction sites in Dubrovnik and the professionals working there. However, we hope that our findings and conclusions will also contribute to contextualizing the position of Ragusan building practices and of the individuals involved in the reconstruction of the city within the broader circulation of architectural knowledge across the Adriatic, or even Europe.

## Knowledge and its sources

[7] Our focus on architectural knowledge rather than on the buildings or their architects stems from the methodological and theoretical concepts established in the field of the history of knowledge<sup>14</sup> and pursues the discussion of the immaterial aspects of construction history, "aiming to reconstruct the systems of knowledge incorporated in the building process itself and their interaction with other knowledge systems."<sup>15</sup> To identify and analyse the circulation of both explicit and implicit knowledge within Ragusan construction sites during the aforementioned period, we have treated all primary sources equally, irrespective of whether they intentionally communicated architectural knowledge through narrative forms such as architectural treatises or unintentionally through building accounts and other documents related to construction containing "confessions that they never intended to give".<sup>16</sup>

[8] Building records, often considered as a marginal source in art and architectural history, illustrate the complexity of the intertwining systems of knowledge included in the construction process, from the administrative framework and the economic conditions to the measurement systems as well as the unwritten rules governing the work of craftsmen on the building site.<sup>17</sup> Due

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<sup>12</sup> Tobias Glitsch, *S. Andrea al Quirinale: die Entstehung von Gian Lorenzo Berninis römischer Ovalkirche*, 2 vols., Aachen 2018, vol. 1, 292-305.

<sup>13</sup> Jasenka Gudelj and Cristiano Guarneri, "Materiali e costruzione nell'Adriatico", in: Francesca Mattei, ed., *Geografia e storia dell'architettura. Il Rinascimento*, Rome 2025 (forthcoming).

<sup>14</sup> Philipp Sarasin, "Was ist Wissensgeschichte?", in: *Internationales Archiv für Sozialgeschichte der deutschen Literatur (IASL)* 36 (2011), 159-172; Simone Lässig, "The History of Knowledge and the Expansion of the Historical Research Agenda", in: *Bulletin of the German Historical Institute* 59 (2016), 29-59; Johan Östling et al., "The History of Knowledge and the Circulation of Knowledge: An Introduction", in: Östling (2018), 9-33.

<sup>15</sup> Claudia Bührig et al., "Towards an Epistemic History of Architecture", in: Schlimme (2006), 7-12; Uta Hassler and Torsten Meyer, "Construction History and the History of Science: An Approach to the Scientification of Building Knowledge", in: Antonio Becchi and Joël Sakarovitch, eds., *L'Histoire de La Construction / Construction History*, vol. 2: *Relevé d'un Chantier Européen / Survey of a European Building Site*, Paris 2018, 921-936.

<sup>16</sup> Marc Bloch, *The Historian's Craft*, New York 1953, 89.

<sup>17</sup> Bührig et al. (2006), 9-10. As Lorraine Daston points out, one of the approaches offered by the history of knowledge focuses on notions that "have historically been denigrated as substandard, including the skills of craftsmen [...] and generally the many forms of knowledge cultivated by non-elites in many times and places". See Lorraine Daston, "The History of Science and the History of Knowledge", in: *KNOW: A Journal on the Formation of Knowledge* 1 (2017), 131-154: 143.

to the multifaceted nature of the subject, building accounts (*libri della fabbrica*) are the proper starting point for reconstructing architectural knowledge and understanding the dynamics of construction. These administrative documents, primarily of an economic nature, detail the payments made to masters and workers, the procurement and costs of construction materials as well as building techniques.<sup>18</sup> The State Archives in Dubrovnik keep a significant collection of such building accounts, spanning from the sixteenth to the eighteenth century and documenting the public buildings, churches, and monasteries that constitute an essential part of our investigation.<sup>19</sup>

[9] This study therefore begins by attempting to tease out implicit knowledge from the *libri della fabbrica*; it then moves on to their interpretation and comparison with expressions of explicit knowledge found in architectural treatises and other sources; finally, these sources are complemented with the physical analysis of buildings and archaeological data. However, one should note that the sources are often a blend of intentional and unintentional forms of communication, conveying both implicit and explicit knowledge. A prime example of this is a series of letters written by Stefano Gradi to the Ragusan Senate,<sup>20</sup> and in particular three letters presented in the form of short treatises: *Discorso sopra lo stato della Repubblica di Ragusa dopo il terremoto et incendio della Città e di quello, che sarebbe da fare in quella contingenza in ordine al sollievo di essa* (1667),<sup>21</sup> *Istruzione per la fabbrica del Duomo di Ragusa* (1672), and *Discorso sopra l'apalto delle cave di travertino* (1672/1673).<sup>22</sup>

[10] In these letters, Stefano Gradi deliberates on the steps necessary to rebuild the city and on the appropriate building techniques for the new cathedral and offers advice on the organization of the construction site. He references notable names in architectural theory and describes techniques he has studied or learned directly from Roman masters.<sup>23</sup> The members of the Ragusan

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<sup>18</sup> For a comparative approach to building accounts, see: Giulia Ceriani Sebregondi, "Un doge sui ponteggi: i libri dei conti di fabbrica del Palazzo Donà dalle Rose a Venezia", in: *Bollettino d'arte*, 7. serie, vol. 103, nos. 37-38 (2018) [2019], 59-98; Petar Strunje, "Blagajnički spisi mletačke Općine Split kao izvor za građevinsku povijest", in: *Vjesnik dalmatinskih arhiva: Izvori i prilozi za povijest Dalmacije* 2, no. 1 (2021), 251-269; Anna Decri, "Tracce di storia del costruire nei conti di fabbrica", in: *Archeologia dell'architettura* 9 (2004), 9-31; Vitale Zanchettin, "Building Accounts as Architectural Drawings: Borromini's Construction Practice and the Role of Francesco Righi", in: Schlimme (2006), 113-124.

<sup>19</sup> The State Archives in Dubrovnik (Državni arhiv u Dubrovniku, hereafter DADU) hold 144 different account books in the series VII *Fabbriche*. These volumes were brought together during the reorganization of the archives in the 20th century.

<sup>20</sup> Đuro Koerbler, ed., *Abatis Stephani Gradii Ragusini ad consilium rogatorum Rei publicae Ragusinae epistolae scriptae: ab anno MDCLXVII. usque ad mortem Gradii*, Zagreb 1915.

<sup>21</sup> Jovan Radonić, ed., *Dubrovačka akta i povelje*, Belgrade 1935, 721-756; Stjepan Krasić, "Obnovitelj našeg grada i slobode", in: Vilać (2013), 290-296.

<sup>22</sup> The latter two texts were published in: Kruno Prijatelj, "Dokumenti za historiju dubrovačke barokne arhitekture", in: *Tkalčićev zbornik* 2 (1958), 117-156. The revised version of the *Istruzione* can be found in: Gudelj (2011/2012), 228-231.

<sup>23</sup> Prijatelj (1958), 143. In the *Discorso sopra l'apalto delle cave di travertino*, Gradi explicitly states: "[...] trasmettendo di qua le notizie che raccolgo dagli esempi delle fabbriche di Roma e degli documenti degli architetti romani [...]".

Senate to whom Gradi addressed these letters were actively involved in overseeing the development of urban spaces and the construction of public buildings in their city and are likely to have been familiar with local architectural practices. One can therefore wonder whether Gradi's addressees actually needed his detailed explanations concerning the types of workers or the specific characteristics of locally used materials.

[11] As a custodian of the Vatican Library, Gradi potentially had access to the whole *corpus* of architectural theory. Additionally, in his role as patron and manager of the new building of the Illyrian College in Rome, he had gained extensive practical experience in construction.<sup>24</sup> A misunderstanding between the architect Paolo Andreotti and the Ragusan Senate revealed Gradi's mindset as well as that of the ruling class of Dubrovnik. After Andreotti's attempt to implement his own ideas and showcase his expertise, Gradi advised the Senate to remind Andreotti of the popular saying: "the main architect is the patron".<sup>25</sup> This incident demonstrates that the Ragusan government viewed the architect primarily as a consultant responsible for executing the client's wishes. Obviously, such a statement did not come from a treatise – no architect would have included it in an explicit articulation of his architectural knowledge – but rather represents a typical expression of implicit and popular knowledge shared among patrons and those involved in construction projects.<sup>26</sup> Yet Gradi's references to seminal theoreticians of architecture, whether actually studied or mere instances of name-dropping, imply that the nobles of the Ragusan Senate to whom he addressed his letters were also familiar with foundational architectural knowledge.

[12] Despite a number of unsuccessful attempts to establish printing in Dubrovnik, the considerable local demand for books, including architectural treatises, was mostly supplied by Venice and Ancona,<sup>27</sup> as evidenced by library inventories from the Early Modern period and present-day collections of early printed books in the region. The 1547 inventory of the Žilković library in Korčula already shows an interest in architecture-related topics.<sup>28</sup> Architectural treatises

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<sup>24</sup> Gudelj (2011/2012), 191-203.

<sup>25</sup> Prijatelj (1958), 143.

<sup>26</sup> Danko Zelić, "Arhitektura dubrovačke Place – projekt 16. stoljeća", in: Jasenka Gudelj and Predrag Marković, eds., *Razmjena umjetničkih iskustava u jadranskom bazenu*, Zagreb 2016, 79-88: 83. Zelić assumes that the proverb was of Ragusan origins. However, our research could only trace it in the writings of Teofilo Gallaccini, who describes it as a "misunderstood and vulgar proverb". Although Gallaccini's work remained unpublished until the eighteenth century, a manuscript copy is preserved in the Vatican Library, where Gradi could have consulted it. Biblioteca Apostolica Vaticana, Ms. Chigi G.I.12, cc. 171r-273r, Teofilo Gallaccini, *Degli errori degli architetti*, 1625: c. 177r-v.

<sup>27</sup> Constantin Jireček, "Beiträge zur Ragusanischen Literaturgeschichte", in: *Archiv für Slavische Philologie* 21 (1899), 399-542: [511-515](#) (Beilagen, I.4.: "Inventar einer Büchersendung aus Venedig nach Ragusa 1549"); Aleksandar Stipčević, "Circolazione dei libri tra le Marche e la Dalmazia nel '500 e '600", in: Sante Graciotti, Marina Massa, and Giovanna Pirani, eds., *Marche e Dalmazia tra Umanesimo e Barocco*, conference proceedings (Ancona/Osimo, 13-15 May 1988), Reggio Emilia 1993, 197-203. On this topic, see also Cristiano Guarneri, *Circulation, Use, Impact. Consumption of Architectural Books in the Early Modern Eastern Adriatic*, Turnhout 2025 (forthcoming).

<sup>28</sup> Among the listed books are Francesco Colonna's *Hypnerotomachia Poliphili*, Pietro Crescenzi's *De agricultura*, and Peckham's *Perspectiva comunis*. Ambroz Kapor, "Renesansna biblioteka Žilković u Korčuli", in: *Bibliotekar* 18, nos. 1-3 (1966), 97-119.



are documented in the possession of the Ragusan aristocracy, such as the Gučetić (Gozze) family, whose library inventory lists works by Vitruvius, Alberti, Palladio, and Scamozzi. Additionally, Frano and Marin Gundulić (Francesco and Marino Gondola) and Šiška Tudizić (Sigismondo Tudisi) respectively owned copies of Palladio's *I quattro libri* and Serlio's third and fourth books.<sup>29</sup> Architectural books were also common in monastic libraries: the Jesuit College in Dubrovnik kept books by the triad Alberti, Vignola, and Palladio; the Franciscan convent had copies of Alberti and Vitruvius, with Philandrier's commentary; and the Dominicans still preserve a copy of Serlio's first five books.<sup>30</sup> There is, in short, sufficient evidence to corroborate the assumption that the Dubrovnik elite in both secular and ecclesiastical milieus were abundantly resourced with architectural treatises.

[13] Gradi evidently thought that the Ragusan ruling class was well-versed in Renaissance architectural theory but needed to be updated on the most recent trends in Roman Baroque architecture. In an attempt to expand their horizon, in 1669 Gradi acquired a copy of Giovanni Battista Falda's *Il nuovo teatro delle fabbriche, et edificii, in prospettiva di Roma moderna* and sent it to Dubrovnik in a wooden box. However, it is not known whether Gradi sent only the recently issued third volume, printed between 1667 and 1669 and containing a plate of the Illyrian College, or the complete three-volume work;<sup>31</sup> a survey of the architectural books currently preserved in the libraries of the eastern Adriatic did not turn up any copies of Falda's volumes.<sup>32</sup> The book, however, did not have the impact on the Ragusan elites that Gradi had hoped for, as no buildings in Dubrovnik appear to be based on or inspired by Falda's etchings of Roman models.

## Architects and the "arenas of knowledge"

[14] Present-day historiography has extensively examined the influence of Italian architects on the development of post-earthquake architecture in Dubrovnik. However, these architects did not contribute in equal measure to the renovations and to the changes in the city's architectural practices. One important factor was the duration of their stay; another was the number of active construction sites where new approaches could be implemented. For instance, Giulio Cerutti arrived in Dubrovnik in the summer of 1667 to inspect the city walls. While his name is often mentioned among those who significantly contributed to Dubrovnik's revival, his impact seems to have been rather limited. At that time, the city was still largely in ruins, preventing substantial interventions beyond the necessary repairs to buildings that had only suffered minor damage, such as the Dominican monastery and the Sponza Palace (Fig. 3). For this reason, Cerutti only

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<sup>29</sup> Jasenka Gudelj and Anita Ruso, "Tiskani renesansni traktati o arhitekturi u Dubrovniku", in: *Peristil* 56 (2014), 101-112: 104, 108.

<sup>30</sup> Jasenka Gudelj and Cristiano Guarneri, "Između teorije i prakse: redovnici-arhitekti i tiskane knjige o arhitekturi u kontekstu samostanske kulture ranomodernoga istočnog Jadrana", in: Slavko Slišković and Ana Biočić, eds., *Dominikanci na hrvatskim prostorima 1221.–2021.*, Zagreb 2024, 171-191.

<sup>31</sup> Gudelj (2011/2012), 206.

<sup>32</sup> Guarneri (2025, forthcoming), Catalogue of architectural books.

spent one month in the devastated city instead of the planned four months.<sup>33</sup> Despite his brief stay, Cerutti could have had a longer-term impact without being physically present in the city; in fact, he promised to deliver plans and projects for a more systematic renovation.<sup>34</sup> Unfortunately, apart from a project for renovating the houses on the main street – initially approved but later rejected by the Ragusan Senate – there is no evidence that he fulfilled his promises.<sup>35</sup>

[15] Another reason for the varying impact of Italian architects in Dubrovnik can be found in the direct control exerted by Ragusan authorities over construction projects in the city. As illustrated by Gradi's comment on Andreotti, they limited the role of the architect to that of a consultant whose task was to technically execute the ideas of the Senate rather than proposing and implementing his own projects. In a letter to Gradi, for instance, the Senate expressed its distrust of Francesco Cortese, an architect who entered the service of the Republic in 1668. They wished to hire someone with more practical rather than theoretical knowledge and who was capable of instructing the local masters.<sup>36</sup>

[16] A shift in attitude as to what was required of an architect is particularly evident in the appointment of the Dominican Tomaso Maria Napoli, a Sicilian architect who spent nine years in Dubrovnik from 1689 to 1698 — a comparatively much longer stay than that of other Italian architects (Fig. 2). Napoli's tenure as head of the cathedral construction marks a period when new architectural concepts and the Baroque style began to permeate ever more intensely major construction sites. Serving the Republic, he also oversaw other significant projects, including the Rector's Palace and minor churches, while also working on private projects, such as the Sorkočević Palace in front of the cathedral.<sup>37</sup>

[17] The Rector's Palace perfectly illustrates the impact of Napoli's presence on the local construction scene. During the first reconstruction campaign in the second half of the 1680s,

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<sup>33</sup> DADU, Cons. Rog. 114, f. 110v. Cerutti was appointed by the Senate on 16 August 1667. DADU, Cons. Rog. 114, f. 125v. By 6 September 1667, the Senate had already decided to grant Giulio Cerutti a gift before his return to Rome. Samardžić (1960), 220-221. In a letter sent from Ancona to Dubrovnik on 13 October 1667, Diodono Bosdari reports that he was hosting Giulio Cerutti, who had arrived in Ancona.

<sup>34</sup> Samardžić (1960), 316-319. DADU, ASMM, 17th century, 1952/55; Katarina Horvat-Levaj, "Strani projektanti i domaća tradicija u dubrovačkoj baroknoj arhitekturi", in: Milan Pelc, ed., *Zbornik 1. kongresa hrvatskih povjesničara umjetnosti*, Zagreb 2004, 75-84: 75. In a letter sent to the Dubrovnik Senate in April 1668, Nikola Gučetić (Nicola Gozze), who was in Rome on an ambassadorial mission, reported that Giulio Cerutti had informed him from Ferrara that he had already completed the reconstruction plans and model for the city. Cerutti had intended to send these along with a young architect he had selected to work in Dubrovnik, but had left for Ferrara before the handover could take place. In the subsequent correspondence, these drawings are no longer mentioned.

<sup>35</sup> Zelić (2016), 79-88.

<sup>36</sup> Katarina Horvat-Levaj and Relja Seferović, "Barokna obnova Kneževa dvora u Dubrovniku", in: *Radovi Instituta za povijest umjetnosti* 27 (2003), 163-183: 165-166.

<sup>37</sup> On Napoli's activities in Dubrovnik, see the previously cited works by Horvat-Levaj (2003; 2004; 2015), as well as Vladimir Marković, "Napolijevo pročelje isusovačkog kolegija u Dubrovniku", in: *Peristil: zbornik radova za povijest umjetnosti* 56 (2013), 155-158.

before Napoli's arrival, local masters including Jeronim Škarpa (Girolamo Scarpa, fl. 1685–1693) and Ilija Katičić (1647–1728) had renovated the courtyard porticos by preserving the earlier Gothic-Renaissance forms (Fig. 4).



4 Dubrovnik, Rector's Palace, courtyard, renovated by Jeronim Škarpa (Girolamo Scarpa) and Ilija Katičić, ca. 1685–1690 (photo: Cristiano Guarneri)

During the second campaign in the 1690s, Škarpa and Katičić, along with Korčula masters Nikola Morosini (Nicola Morosini, fl. 1690–1693) and Jeronim Miroslavić (Girolamo Miroslavich, fl. 1691–1693), who both carved the portals on the upper level of the courtyard, participated in the interior renovation of the upper floor under the supervision of Napoli and his collaborator, Neapolitan sculptor Niccolò dello Gaudio (fl. 1687–1692). On this occasion, new Baroque forms and designs were introduced (Fig. 5).<sup>38</sup>

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<sup>38</sup> Horvat-Levaj and Seferović (2003), 167-173.



5 Dubrovnik, Rector's Palace, upper floor of the courtyard, entrance to the chapel, sculptors Nikola Morosini (Nicola Morosini) and Jeronim Miroslavić (Girolamo Miroslavich), ca. 1690–1693 (photo: Cristiano Guarneri)

In other words, under the supervision of Napoli and other foreign experts, local masters actually expanded their implicit knowledge by participating in projects whose form and expression did not coincide with their own architectural traditions. The construction sites where these innovative ideas, techniques, and forms were applied thus became what Johan Östling classifies as a "public arena of knowledge":

*A place or a platform that, within its given framework, offers the opportunity and sets limits for certain forms of circulation of knowledge. It serves as a site for interactions between knowledge actors and their audiences.*<sup>39</sup>

In this context, Napoli and dello Gaudio served as catalysts of knowledge circulation, and the local masons and stonemasons became their direct recipients or primary audience. However, given the multitude of concurrent construction sites and the circulation of masters among them (well-documented in the building accounts), certain local masters eventually became catalysts themselves, accelerating the dissemination of their newly acquired knowledge to their peers on minor construction sites. Their impact can be further substantiated through comparative analysis of the architectural forms applied to the buildings in which they were involved.

[18] The above-mentioned local masters (Ilija Katičić, Jeronim Škarpa, Nikola Morosini, and Jeronim Miroslavić) are documented to have worked on several sites besides the cathedral, including the now-lost church of Saints Petilovrijenci (1676), which, although construction was never completed, was originally designed on a central plan – a novel feature in the Ragusan

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<sup>39</sup> Johan Östling, "Circulation, Arenas, and the Quest for Public Knowledge: Historiographical Currents and Analytical Frameworks", in: *History and Theory* 59 (2020), no. 4: special issue "History of Knowledge", 111-126: 122.

architectural tradition (Fig. 6).<sup>40</sup> Had this church survived to the present day, it would undoubtedly stand out as a significant instance of Baroque architecture on the eastern Adriatic coast. Unfortunately, the available sources provide little insight into the origins of its central floor plan or the identity of its designer.



6 Dubrovnik, Petilovrijenci Church, built in 1676, destroyed in 1801, archaeological remains of the foundations (drawing: Zvezdana Tolja)

At the time of the project's approval, there were no foreign architects employed in Dubrovnik. While it might be tempting to speculate that such a project arrived in the city through the same channels as the plan for the cathedral church (given the revival of the central plan type in Baroque Rome),<sup>41</sup> it was more likely developed in Dubrovnik, probably inspired by a pre-earthquake project for the Jesuit church: in 1659, Serafino Fabrini (1624–1679), a Jesuit architect and builder, had envisioned a centrally planned church to accommodate the spatial constraints of the densely surrounded location, as evidenced by a surviving drawing.<sup>42</sup> However, after 1667 the project was abandoned due to new space becoming available following the destruction of the surrounding neighbourhood. This shift favoured a longitudinal church design by Jesuit architect and painter Andrea Pozzo (1642–1709), renowned for his work on the vault decorations of the church of Saint

<sup>40</sup> A detailed analysis of the post-earthquake church is currently underway. For an account of its medieval predecessor, see: Ines Ivić, "Crkva i kult sv. Petilovrijenaca u srednjovjekovnom Dubrovniku", in: *Peristil* 59 (2017), 17-25.

<sup>41</sup> Paola Quattrini, ed., *Chiese a pianta centrale: Roma e dintorni*, 2 vols., Rome 2008.

<sup>42</sup> Miklošić (2009), 125-140.

Ignatius in Rome. Apparently, the original plan for the Jesuit church served as inspiration for the reconstruction of Petilovrijenci Church after the earthquake.

[19] The example of Ilija Katičić (1647–1728), a native of Ragusa, well illustrates the exchange and transformation of knowledge experienced by local masters in the arenas of knowledge of the large construction sites. Following the *cursus honorum*, which saw him advance from simple *scarpellino* and *muratore* to *protomagister* of all the public constructions in the city, he oversaw the completion of the Ragusan cathedral, including its most complex element, the cupola.<sup>43</sup> The progress of his skills was undoubtedly shaped by his involvement in these sites alongside Napoli and dello Gaudio, as there is no evidence that he was trained outside Dubrovnik.

## How to reconstruct the knowledge? Case studies

[20] In this section, we apply the previously described methodology of comparative analysis of implicit and explicit knowledge to a number of specific case studies related to critical challenges encountered during the reconstruction of Dubrovnik. While we identified six construction challenges – foundations in marshy soils, selection of the appropriate sand for hydraulic mortar, structural considerations for stone vaults and domes, replacement of columns, resumption of construction after interruptions, and the circulation and use of templates for stonecutters – this paper focuses only on three of them, drawn from the building accounts of the above-mentioned case studies.<sup>44</sup>

### The use of sand in the mortar

[21] According to Gradi, the large extent of destruction in Dubrovnik wreaked by the 1667 earthquake was mainly due to the poor quality of the mortar, which was predominantly made with sea sand or seawater.<sup>45</sup> Gradi devoted significant attention to the properties of mortar in his treatise-like letters: one fifth of the *Istruzione per la fabrica del Duomo* (1672), which accompanied the wooden model of the new cathedral church, discusses the use of proper sand for mortar; so does his *Discorso sopra l'apalto delle cave di travertino* (1672–1673). In the *Istruzione*, Gradi criticizes the use of sea sand for a number of reasons: first, its high salinity makes for weaker mortar, unable to bear the weight of the walls (as he read in Vitruvius); second, sea sand needs to be purified and dried slowly, causing a slowdown in construction; finally, its

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<sup>43</sup> Besides participating in the construction of other churches and private houses in Dubrovnik, Katičić also worked in the Bay of Kotor (Boka Kotorska), where he built the sanctuary and cupola of the church of Our Lady of the Rocks (Gospa od Škrpjela) in 1720. Katarina Horvat-Levaj, "Ilija Katičić u baroknoj obnovi Dubrovnika i Perasta - nove spoznaje o životu i djelu dubrovačkog graditelja i klesara", in: *Anali Zavoda za povijesne znanosti Hrvatske akademije znanosti i umjetnosti u Dubrovniku* 44 (2006), 189-218.

<sup>44</sup> DADU, Fabbriche 117, Fabrica di San Biagio 1667; DADU, Opera pia 152, Libro della fabbrica di SS. Petri Laurentii 1676; DADU, Fabbriche 124, Fabrica del palazzo publico 1686.

<sup>45</sup> Gudelj (2011/2012), 230.

application requires specially skilled stonemasons.<sup>46</sup> Even though architects such as Alberti and Palladio did not share Gradi's opinion on the drying speed of sea sand (both asserted that "sea sand dries fast"), architectural treatises tended to advise against using this material for structural reasons.<sup>47</sup> In this case, however, Gradi's arguments about the time-consuming drawbacks of using sea sand stem from local building practices in Dubrovnik rather than from architectural theory.<sup>48</sup> Nonetheless, his observations on the use of seawater by the Ragusans should be taken with caution, as the practice was not necessarily widespread among local builders: as early as 1410, it was decided that lime should not be slaked with seawater but with water drawn from a well.<sup>49</sup> The urban historian Lukša Beritić already noted in 1958 that the availability of fresh water in the city, following the completion of the water supply system in 1422, significantly enhanced the resilience of structures. He points out that the buildings constructed thereafter, such as the Sponza Palace (1521) and the Monastery of the Holy Apostles (1497), remained nearly intact, while neighbouring buildings collapsed.<sup>50</sup>

[22] Well familiar with the properties and use of *pozzolana* (volcanic ash) in Roman and other Italian construction sites, Gradi became a fervent advocate of its use in the renovation of Dubrovnik.<sup>51</sup> In a letter addressed to the Ragusan Senate accompanying two cargos of high-quality *pozzolana* sent from Naples in 1669, he emphasizes that the material "adheres very firmly and quickly, enabling construction with various types and shapes of materials", and that it is particularly suitable "for the construction of barrel vaults and other critical parts of buildings."<sup>52</sup> To justify the high cost and to assure the Ragusan government that sourcing the material from afar would not compromise its quality, Gradi noted its significant benefits and pointed out that the Genoese were paying a much higher price for *pozzolana* and were obtaining great results in constructions both "outside and inside water."<sup>53</sup>

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<sup>46</sup> Gudelj (2011/2012), 230; Vitruvius, *De architectura*, ed. by Pierre Gros, Turin 1997, II 4. As noted by Beritić, the frequent shortage of fresh water forced Ragusan masters to include seawater in their binding mixtures. Beritić (1958), 28.

<sup>47</sup> Besides Vitruvius (1997), II 4, see also Leon Battista Alberti, *De re aedificatoria*, ed. by Giovanni Orlandi and Paolo Portoghesi, Milan 1966, II 12: "Quella di mare [arena] fa tosto presa"; Andrea Palladio, *I quattro libri dell'architettura*, Venice 1570, I 4; Vincenzo Scamozzi, *L'idea della architettura universale*, Venice 1615, VII 20-22; Giuseppe Viola Zanini, *Della architettura*, Padua 1629, I 15.

<sup>48</sup> The techniques of sea-sand purification are described only in Scamozzi (1615), VII 22, and Zanini (1629), I 15, but Gradi does not mention them.

<sup>49</sup> Ana Plosnić Škarić and Danko Zelić, eds., *Dubrovnik: Civitas et Acta Consiliorum 1400–1450*, Zagreb 2017, 58. DADU, Reformationes 33, f. 156v.

<sup>50</sup> Beritić (1958), 28.

<sup>51</sup> Jasenka Gudelj, "The Circulation of Building Materials: Pozzolana in the Baroque Dubrovnik", in: *Construction History* 31, no. 1 (2016), 61-74: 63-64.

<sup>52</sup> Körbler (1915), 154, Letter 41.

<sup>53</sup> Körbler (1915), 154, Letter 41. For a treatment of *pozzolana* in architectural writings, see Vitruvius (1997), II 6; Alberti (1966), II 12; Palladio (1570), I 4; Scamozzi (1615), VII 21.

[23] As alternatives to *pozzolana* from Naples, Gradi recommends in his *Discorso* to the Senate closer commodities on the Adriatic shores: a red *pozzolana* deposit near Pescara or a higher-quality variant found by Andreotti in Albania.<sup>54</sup> It is interesting to note that no architectural treatise has been found that mentions the Adriatic deposits suggested by Gradi. Recent historical investigations in the trade and use of *pozzolana* between the Apennine Peninsula and Dubrovnik before and after the earthquake do not document them either.<sup>55</sup> Therefore, it seems plausible to presume that these Adriatic deposits of *pozzolana*-like sand were never exploited in the reconstruction of Dubrovnik.

[24] Despite Gradi's best efforts and the presence of a master skilled in its use – who came to repair the water supply system and could instruct the Ragusans on its application – *pozzolana* did not gain traction in Ragusa until much later. This was primarily due to economic reasons rather than a reluctance to experiment with new materials and techniques: the "puzzolana condotta da Napoli" in the summer of 1669 cost the hefty sum of 685 Ragusan ducats for just two cargos.<sup>56</sup> The estimated volume required for the cathedral's construction alone would have necessitated extensive imports from Naples, involving expenses for transportation and insurance that exceeded the Republic's means at that time. Consequently, the Ragusan authorities understandably opted for more affordable local materials, believing that these offered comparable properties. Ultimately, the only recorded use of *pozzolana* in Ragusan construction sites during this period was for the reconstruction of Gradi's own birthplace in 1674, for which he personally covered the expenses of supplying the *pozzolana* from Naples.<sup>57</sup>

[25] Since the Ragusan authorities did not implement the import of *pozzolana* from Naples or the search for it elsewhere in the Adriatic, Gradi recommended a recipe for a fast-drying hydraulic mortar based on a mix of materials that were easily available near the city: "polvere di tuffo di Breno" (tufa powder from Breno), "creta rossa" (red clay), and a small amount of non-sea sand, possibly fossilized sand as suggested by Vitruvius.<sup>58</sup> Gradi's suggestion appears to be an imperfect adaptation of a classic formula again found in Vitruvius. In fact, the Roman author provides two recipes for hydraulic mortar, one with *pozzolana* and one without it. In the first instance, the hydraulic mortar is obtained by adding *pozzolana* and broken vases or bricks as a binder, in the second case by adding tuff powder and red clay. However, the "tuffo di Breno" recommended by Gradi was not the volcanic tuff stone intended by Vitruvius, but rather a porous sedimentary limestone sourced from small rivers and creeks in Župa Dubrovačka (Breno), south of the city.

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<sup>54</sup> Prijatelj (1958), 137, 144.

<sup>55</sup> Gudelj (2016).

<sup>56</sup> To illustrate the high costs, we could mention that skilled masters, builders, or sculptors earned one ducat every three to four working days. A cargo of sand from nearby islands cost 1.5 Ragusan ducats, as recorded in the *libri della fabbrica*. So for the price of two cargos of *pozzolana*, one could have obtained over 450 loads of locally sourced sand.

<sup>57</sup> It was decided that the officials in charge of building the cathedral would supply two or three shipments of *pozzolana* for the construction of Gradi's house. However, the expense for this supply would be borne by Gradi himself and not by the Republic. DADU, Cons. Rog. 121, f. 35v.

<sup>58</sup> Gudelj (2011/2012), 230-231; Vitruvius (1997), II 4.



[26] The ambiguity of the Italian term *tuffo* stems from the similarity in the light and porous nature of these two types of stone, magmatic volcanic tuff and sedimentary calcareous tufa.<sup>59</sup> The consistent and centuries-long use of the term *tuffo* for tufa stone in the sources indicates that the Ragusans recognized its physical features rather than its chemical composition. Therefore, it is plausible that Gradi associated the properties of the tufa stone from Breno with those of the chemically different volcanic tuff suggested by Vitruvius for hydraulic mortar and used more commonly in Early Modern Rome too. Although to a degree inferior to the Vitruvian recipe, the addition of red clay to mortar, as suggested by Gradi and widespread in Dubrovnik practice, really does confer hydraulic properties to the binding agent.

[27] Again, Gradi's writings reflect a blend of explicit and implicit knowledge, based on "the opinion of Vitruvius and all the other authors of architecture, and the daily experience in the city of Rome."<sup>60</sup> Further research is needed to understand how he acquired knowledge of Ragusan practices, especially considering that he spent the last three decades of his life, from 1653 on, abroad. Still, Gradi does not limit himself to championing Roman practices or criticizing Ragusan ones. His claim that only "experience will clarify whether the reasoning is good" shows that he encouraged experimentation in the field of construction:

*But to ensure the success of these things, it would be good to do a test, to deliberately build different, appropriately large pieces of wall, made of the aforementioned sand mixtures, and observe the result after a few months.*<sup>61</sup>

[28] Despite Gradi's considerable efforts to enhance Ragusan construction practices in order to expedite the reconstruction of the city, it appears that few of his insightful recommendations bore fruit. In fact, other sources that provide insights into the implicit knowledge of the masters confirm that the Ragusan craftsmen held on to their traditional practices; in the wake of the widespread devastation, many people were left without a roof over their heads and most public buildings were unusable, leaving little room and will for experimentation in the field of construction. The building accounts of the churches of Saint Blaise and Saints Petilovrijenci document the shipment of sea sand for mortar from the island of Lopud. Whether this sand underwent a process of purification is not clear from the sources.

[29] On the other hand, a payment for the supply of tufa sand from Župa Dubrovačka for the church of Saint Blaise in 1668 indicates that the local masters had adapted the *pozzolana* formula

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<sup>59</sup> There are other instances of Gradi employing ambiguous terminology. For example, when discussing stone extraction, he refers to the local limestone as "travertino", a type of sedimentary limestone widely used in Roman sites but not found in Dubrovnik and its surrounding area.

<sup>60</sup> Gudelj (2011/2012), 230: "Per opinione di Vitruvio e di tutti gli altri autori dell'architettura e per l'esperienza quotidiana della città di Roma [...]."

<sup>61</sup> Gudelj (2011/2012), 230: "Ma per assicurarci della buona riuscita di queste cose sarebbe bene di farne le prove con fabricar a posta diversi pezzi di muri competentemente grandi, fatti di misture d'arene suddette, e doppo qualche mese vedere la riuscita."

long before Gradi suggested doing so, as a result of their hands-on experience on the site.<sup>62</sup> Furthermore, the use of red clay to confer hydraulic properties to mortar was a well-known practice in Dubrovnik and elsewhere in the eastern Adriatic. Although archival documents frequently mention *creta rossa* and archaeological excavations have attested to its use, this use was not extensive but limited to foundations and particularly wet settings. Gradi's recommendation is the only written source recording an attempt to extend the use of mortar with *creta rossa* to the entire masonry structure of the building.<sup>63</sup>

[30] Gradi also refers to traditional building techniques that were transmitted as implicit knowledge when reflecting upon the vaults and the dome of the new cathedral, since the architectural treatises contain no explanation of vaulting techniques but only the geometrical classification of different vault types.<sup>64</sup> The Ragusan masters certainly did not need any advice on how to achieve the light and thin structures of the vaults and inner walls of the church, since the use of tufa stone is recorded from the Middle Ages. The vaulting of the city walls of Dubrovnik and Ston made use of this material both in the original structures and in later repairs. In fact, tufa has been used in this region since ancient times, as can be seen in the vaults of Diocletian's Palace in Split (c. 293 AD).

[31] These examples demonstrate that in his treatise-like letters, Gradi often states the obvious, presumably in order to compile essential information and concentrate it in one place. However, they also reveal that without a detailed exploration of Gradi's sources and an understanding of Ragusan practices, it is challenging to distinguish, as regards the techniques mentioned in the *libri della fabbrica*, between the ones that were introduced following Gradi's suggestions and those that have existed in the region since ancient times.

## Construction of foundations

[32] Several citizens reported in letters after the earthquake that the only buildings that remained standing were the city walls, the lazaretto, and the customs building (Sponza Palace). The greatest damage had occurred along the main street: while the city walls were built on firm rock, the soil along the main street and around the public squares, where the main institutional and ecclesiastical buildings were located, had a different structure as it was once a shallow arm of the nearby sea (Fig. 3).<sup>65</sup>

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<sup>62</sup> Since the origin of the sand is not always indicated in the sources, we cannot yet draw any firm conclusion about the used amount of tufa sand. DADU, Fabbriche 117, n. 172, 224, 268; DADU, Opera Pia 152, n. 1, 22, 100, 121.

<sup>63</sup> DADU, Fabbriche 116, Fabrica delle mura della città, e d'altro 1667, n. 41 (30 August 1667).

<sup>64</sup> Gudelj (2011/2012), 230-231. See Alberti (1996), III 14; Palladio (1570), I 24. Although Scamozzi (1615), VIII 14 mentions the use of tuff for vaults, he finally advocates for bricks: "Le volte si deono fare [...] più tosto fatte di mattoni cotti, che di Tuffi, e Cementi di Monte."

<sup>65</sup> Samardžić (1960), 23. On the damage, see also: Lukša Beritić, "Ubikacija nestalih građevinskih spomenika u Dubrovniku", in: *Prilozi povijesti umjetnosti u Dalmaciji* 10 (1956), 15-83, and Albini (2015).

[33] Most architectural theoreticians emphasize the importance of properly executed foundations, as inadequate ones can cause structural problems already during construction, including collapse.<sup>66</sup> And yet, those responsible for the reconstruction of the city (Gradi included) did not seem to attribute the damage to this element. Moreover, a Senate resolution exempted all homeowners on the main street who decided to rebuild their new house on the foundations of the demolished ones from all the fiscal and juridical burdens attached to the previous dwellings.<sup>67</sup> The reason for this decision is to be found in the pragmatic approach of the Ragusan government, which tried to accelerate the renovation of private houses so as to encourage its citizens to return to the city. With the same aim, Gradi proposed the reuse of the foundations and walls of the previous cathedral to support the nave and aisles of the new cathedral designed by Pier Andrea Bufalini.<sup>68</sup>

[34] Nevertheless, the surviving seventeenth-century *libri della fabbrica* document a few, if rare, interventions into foundation structures. One such example is the Petilovrijenci Church, which was partially built over the foundations of an earlier medieval church, but in a new configuration and following a redesigned plan. To ensure the stability of the building, the masters reinforced the soil with timber piles, applying the piling technique that had been explicitly described in architectural treatises since Vitruvius. This technique was specifically employed when building on loose, marshy, or sandy ground and near bodies of water to stabilize the terrain and enable it to bear the weight of the building.<sup>69</sup> It should be noted that according to the building accounts, the walls of Petilovrijenci Church were built entirely of stone ashlar, presumably with a stone cupola envisioned over them, constituting a quite heavy and statically complex structure on a relatively small parcel of land (ca. 13 m × 13 m).

[35] Piling was commonly used in Venice to reinforce the marshy soil since the very origins of the city, but by the seventeenth century the technique had also become quite common in port structures and hydraulic works elsewhere, such as on the banks of the Tiber in Rome.<sup>70</sup> Vitruvius already recommended using charred alder, olive, or oak wood for the piles, which were driven down by machinery as tightly as possible, filling the remaining space between the piles with charcoal, and constructing the solid foundations of the building over this structure.<sup>71</sup> How

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<sup>66</sup> Vitruvius (1997), III 3, VI 11; Alberti (1966), III 2; Palladio (1570), I 7; Scamozzi (1615), VIII 3-4.

<sup>67</sup> Beritić (1958), 30-31.

<sup>68</sup> Gudelj (2011/2012), 205-209, 229; Horvat-Levaj (2014), 126.

<sup>69</sup> Vitruvius (1997), III 3; Alberti (1966), III 3; Palladio (1570), I 8; Scamozzi (1615), VIII 5; Viola Zanini (1629), I 3.

<sup>70</sup> On the extensive use of *palificate* foundations in Venice, see: Giovanni Battista Stefinlongo, *Pali e palificazioni della laguna di Venezia*, Sottomarina 1994; Mario Piana, "Note sulle tecniche murarie dei primi secoli dell'edilizia lagunare", in: Francesco Valcanover and Wolfgang Wolters, eds., *Architettura gotica veneziana*, Venice 2000, 61-70; Richard John Goy, *Building Renaissance Venice: Patrons, Architects and Builders, c. 1430–1500*, New Haven/London 2006, 63-64; Mario Piana, *Costruire a Venezia. I mutamenti delle tecniche edificatorie lagunari tra Medioevo e Età Moderna*, Venice 2023, 15-25.

<sup>71</sup> Vitruvius (1997), III 3.

common was this technique in Dubrovnik? The question is yet to be thoroughly researched, particularly from an archaeological perspective. What is certain is that it was known before the earthquake: archaeological excavations in the courtyard of the Rector's Palace have revealed the remains of wooden piles under some of the columns, dating from the 1550s to the 1650s.<sup>72</sup> Additionally, the building accounts of the Rector's Palace show that after the 1667 earthquake, the columns in the atrium were reinforced in the same way.<sup>73</sup> The dated timber remains found in the palace, along with the presence of various additives in the lime mortar, including wood ash and *creta rossa*, raise a number of questions. One of them is whether this type of foundation, unlike earlier ones built on arches and also found in the archaeological layers,<sup>74</sup> was directly linked to renovations after the earthquakes of 1520 and 1639 as an attempt to make the building more resistant to future natural disasters.

[36] Among the first payments recorded in the building accounts of the Petilovrijenci Church are the ones (dated May 1677) pertaining to the material for the foundations: 307 timber piles, two cargoes of sand, and two cargoes of *creta rossa*, which were specifically designated as "per fondamento" (for the foundation).<sup>75</sup> Given the relatively small number of piles, we can assume that only the foundations under the walls were reinforced with piles. Again, such a practice was common in Venice, where only the outer walls had pile foundations, while the walls and floors inside the building perimeter were supported by simpler *a zattera* foundations (consisting of a single or double layer of wooden boards).<sup>76</sup> As attested by archaeological excavations, the space between the piles in the foundations of the Petilovrijenci Church was filled with lime mortar enriched with *creta rossa* and stone gravel to create a strong and, more importantly, hydraulic binding that would harden over time in contact with water and thus in complete absence of air.

[37] The choice of this technique was certainly determined not only by the type of soil and the weight of the building, but also by the presence of underground water, which was also observed during recent archaeological excavations.<sup>77</sup> In the aforementioned letter, in which Gradi mentions the successful underwater constructions of the Genoese using *pozzolana*, he draws a parallel to

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<sup>72</sup> Nikolina Topić, Ines Krajcar Bronić and Andreja Sironić, "Rezultati arheološkog nadzora i određivanje starosti drvenih pilota iz atrija Kneževa dvora u Dubrovniku", in: *Portal: godišnjak Hrvatskoga restauratorskog zavoda* 9 (2018), 31-48.

<sup>73</sup> DADU, Fabbriche 124, Fabbrica del palazzo pubblico 1686, n. 140: "per una barca di palli n: 228 per fondamento delle colonne".

<sup>74</sup> Topić, Krajcar Bronić and Sironić (2018), 37.

<sup>75</sup> DADU, Opera Pia 152, n. 7: "doi barche di arena", n. 8: "doi barche di creta rossa per fondamento", n. 11: "per pali trecento sette per fondamenti".

<sup>76</sup> Piana (2023), 22.

<sup>77</sup> The archaeological excavations were carried out in 2009, under the supervision of Ivica Žile from the Conservation Department in Dubrovnik, where the documentation is held (including the excavation diary). *Petilovrijenci excavation field diary* (2009), 7, 15. The archaeological excavation also shows that the terrain between the foundations of the new seventeenth-century church and the earlier, medieval one was consolidated with rough stones bound together with mortar made of lime and red clay.

the use of red clay by the Ragusans for building on water and humid soil.<sup>78</sup> Commonly used in the eastern Adriatic up to our days, this type of mortar is documented in Dubrovnik since the fifteenth century, when it was employed in the construction of the water supply system and of the port's breakwater.<sup>79</sup>

[38] The two examples mentioned above are also significant for understanding the origins of applied knowledge in Dubrovnik. On the one hand, the use of *creta rossa* primarily belongs to the implicit knowledge of Ragusan masters, reflecting their deep familiarity with local materials and their practical application. On the other hand, the addition of ash, found in the mortar used for the foundations of the columns in the atrium of the Rector's Palace, pertains to the realm of knowledge codified in architectural treatises, primarily that of Vitruvius. This demonstrates, once again, that Ragusan masters were also familiar with a number of ancient construction techniques described in architectural treatises.

## Templates for windows and doorframes

[39] The role of important construction sites as "public arenas of knowledge", in which knowledge was transferred, transformed, and further disseminated, can also be understood by observing a more concrete construction element: the profiles of windows and doorframes. The building accounts reveal that skilled stonemasons from the island of Korčula, in Venetian Dalmatia, were regularly commissioned to produce stone parts for buildings, supplying most of the eastern Adriatic coast, including the Republic of Ragusa, with high-quality stone and finely sculpted architectural elements.<sup>80</sup> The process of commissioning and producing stone carved elements fully relied on templates – called *sagome* in Venice and along the Adriatic, instead of *modani* as was the convention in other Italian regions – cut in full scale in paper, cardboard, or even wood by

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<sup>78</sup> Körbler (1915), 154, Letter 41; Vitruvius (1997), II 6; Alberti (1966), II 12; Palladio (1570), I 4; Scamozzi (1615), VII 21.

<sup>79</sup> Krasanka Majer Jurišić and Edita Šurina, *Velika Onofrijeva Fontana u Dubrovniku: Povijesnoumjetnička i Konzervatorska Studija*, Zagreb 2016, 9; Željko Peković, "Valobran Kaše: tijek i način izgradnje, primijenjene antičke tehnike gradnje u renesansi", in: *Anali Zavoda za povijesne znanosti Hrvatske akademije znanosti i umjetnosti u Dubrovniku* 55, no. 2 (2017), 321-373: 331. The use of *terra rossa* as a hydraulic mortar is also documented in Split (Venetian Dalmatia) during the construction of the port and the lazaretto in the first half of the seventeenth century. Strunje (2021), 258.

<sup>80</sup> As the case of Giovanni Battista Fontana demonstrates, Korčula was also a hub for foreign architects and master builders: Cristiano Guarneri, "On the Trail of a Peripatetic Vitruvian Reader: New Insights on Giovanni Battista Fontana in the Late Seventeenth-Century Eastern Adriatic", in: *Ars Adriatica* 14 (2004), 209-240. Ready-made architectural elements of Korčula stone were even exported to the Italian Peninsula, from Mantua to Apulia: Goran Nikšić, "Korčulani u Mantovi – organizacija klesarske radionice za veliku narudžbu", in: *Peristil* 56 (2013), 81-86; Gudelj and Guarneri (2025, forthcoming).

scaling the architect's drawings.<sup>81</sup> As the *libro della fabbrica* of the Petilovrijenci Church shows, the *sagome* made in Dubrovnik were shipped to the stonemasons in Korčula together with the relevant measurements of the commissioned elements. Upon completion, the stone carvings were then shipped back from Korčula to the construction sites in Dubrovnik.<sup>82</sup> Building accounts and other archival sources allow us to reconstruct this practice but provide scarce evidence about the implicit knowledge required in this delocalized production. The authors of architectural treatises from Serlio onwards discuss the production of *sagome* and give examples of how to copy and scale drawings but do not proceed to explain any of the following steps.<sup>83</sup> In fact, their interest in the *sagome* stops exactly where the task of the architect ends and that of the stonemason begins.

[40] The *sagome* were an invaluable – albeit fragile – tool in stonemasons' workshops. The fact that they were transported from Dubrovnik to Korčula, where the local stonemasons often reused them for other commissions and buildings, confirms their role in the dissemination of knowledge across geographically distant locations. The *modus operandi* that enabled the exact communication of the geometrically complex shapes of bases, capitals, column entases, entablatures, windows and doorframes is another example of implicit knowledge in construction. Furthermore, it indicates that the architectural market on the eastern Adriatic coast was not limited by political borders and that further research should include the territories of Venetian Dalmatia that were in close contact with the Republic of Ragusa.

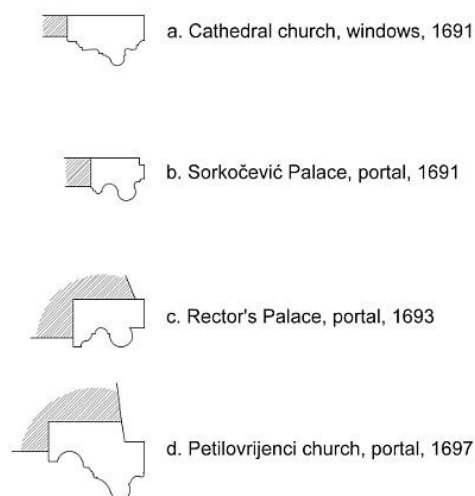
[41] The contribution of *sagome* to the dissemination of new knowledge and forms is particularly evident in the most effective "arena of knowledge" created around Tomaso Maria Napoli during his stay in Dubrovnik from 1689 to 1698, when the construction of the cathedral was making good progress and the renovation of many other buildings was completed. His stay coincided with a new wave of Baroque decorative language, which gradually replaced the earlier Gothic and Renaissance forms, as evidenced by the spread of new and similar profiles. For example, a set of innovative profiles with strongly protruding roll mouldings and slightly oblique surfaces was first introduced by Napoli for the frames of the upper windows of the cathedral's central nave and the portals of the upper floor of the Rector's Place (Fig. 7).

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<sup>81</sup> Tracy Cooper, "I modani", in: Henry Millon and Vittorio Magnago Lampugnani, eds., *Rinascimento da Brunelleschi a Michelangelo: la rappresentazione dell'architettura*, Milan 1994, 494-500; Wolfgang Wolters, *Architettura e ornamento. La decorazione nel Rinascimento veneziano*, Sommacampagna 2007, 37-43; Jonathan Foote, "Tracing Michelangelo's *modani* at San Lorenzo", in: *Mitteilungen des Kunsthistorischen Institutes in Florenz* 61 (2019), 45-74. For a definition of *sacoma* or *sagoma* particularly used in the Venetian context, see Ennio Concina, *Pietre, parole, storia. Glossario della costruzione nelle fonti veneziane (secoli XV–XVIII)*, Venice 1988, *sub voce* "sacoma".

<sup>82</sup> DADU, Opera pia 152, 24 August 1697, payment for "cartoni e una tavola per sagumi"; 5 November 1702, payment for "cartone per sagumi a Curzola".

<sup>83</sup> See Sebastiano Serlio, *Tutte l'opere d'architettura*, Venice 1584, I-II, IV; Jacopo Barozzi da Vignola, *Regola delli cinque ordini d'architettura*, Rome 1562, *passim*; Palladio (1570), I 26; Scamozzi (1615), VI 30.



7 Profiles of windows and doorframes in buildings reconstructed in Dubrovnik after the 1667 earthquake (drawing: Cristiano Guarneri)

Soon, these profiles also appeared on other buildings, such as in the doorframes of the Sorkočević Palace, whose design is attributed to Napoli precisely for this reason.<sup>84</sup> We also find similar profiles on the only remaining architectural element of the Petilovrijenci Church: the portal carved by Nikola Morosini, the same master who had executed the portals of the Rector's Palace in collaboration with Jeronim Miroslavić.<sup>85</sup> The *sagome* were therefore primarily the medium through which the designer conveyed the desired shape to the stonemason. However, once they were stored in the workshop, they became part of sets of templates that the stonemason could reuse in other buildings, thus becoming an active agent in their dissemination.

## Conclusion

[42] Our case studies, combined with the examination of various sources on relevant constructional challenges, allow us to reconstruct a portion of the extensive architectural knowledge of the late seventeenth-century Ragusan masters. The investigation reveals that the construction sites in Dubrovnik were characterized by a rich amalgam of explicit and implicit knowledge. While standardized practices such as the construction of piling foundations or the use of *sagome* are evident, the presence of local techniques such as the use of *creta rossa* or *tuffo di Breno* illustrates that the availability of explicit knowledge – for instance regarding the use of

<sup>84</sup> Horvat-Levaj (2016), 26-27.

<sup>85</sup> Horvat-Levaj and Seferović (2003), 173. The payments for the portals of the Rector's Palace are recorded in the *libro della fabbrica* but also in separate documents stating that Miroslavić and Morosini had to produce architectural elements following the models made by Nicola dello Gaudio. DADU, Fabbriche 124, n. 4 (18 November 1692). Miroslavić delivered a significant number of architectural elements to the Petilovrijenci site in 1688 for the price of 268 *iperperi* (DADU, Opera pia 152, n. 86 (25 July 1688)); in 1697, Nikola Morosini delivered several sculpted pieces for the price of 220 *iperperi*, including the architrave for the portal (25 January 1697).

*pozzolana* – did not always result in its actual application. Moreover, archival documentation clearly illustrates the Ragusan masters' preference for traditional building practices and architectural forms, indicating a continued transmission of implicit knowledge within the stonemasonry workshops and on the construction sites.

[43] Of course, the people of that time did not think in terms of the dichotomy explicit vs. implicit knowledge: this distinction is a historiographical construct. We must therefore assume that the only discernible factor for them was the *medium* through which such knowledge was conveyed. Although the explicit formulation of architectural knowledge in the form of treatises reached the highest levels of Ragusan society and influenced discussions on building, as evidenced by the letters between Gradi and the Senate, it had no significant impact on the community of masters active on the construction sites. In fact, they did not depart from their traditional repertoire until Tomaso Maria Napoli, an architect with a different educational background and a distinct knowledge set, became responsible for several large construction sites.

[44] In other words, the transition to Baroque forms was not primarily due to the circulation of architectural treatises, but rather to the active exchange taking place at a few significant construction sites that we have identified as "public arenas of knowledge". While the Ragusan masters were open to modifying the forms of their architectural language, they showed far greater reservations when it came to altering their construction techniques, holding steadfastly to their centuries-old local traditions.

[45] The approach and examples discussed in this paper have detailed the diverse array of individuals who contributed in various ways to the reconstruction of Dubrovnik after the 1667 earthquake. Administrative officers, commissioners, architects, recognized masters, and even historically marginalized individuals – whose names appear in building accounts and other documents, such as workers, material suppliers, boatmen, and porters – were all part of this complex network. The paper has examined how their different sets of knowledge interacted, from the design stage to the construction site, in the context of a few major public buildings. Given the symbolic significance of these buildings and the abundance of primary sources, the study has focused on a strategic sector, which, however, represented only a small part of the extensive building activity required by the reconstruction. Therefore, extending our methodological approach to other public and private construction projects of the time, as well as to other actors, would enrich and complement the present conclusions. This would bring us closer to a more comprehensive understanding of seventeenth-century Ragusan architectural practices and of their similarities with the ones in use in the broader region of the eastern Adriatic coast and Adriatic Basin. More specifically, it would allow us to better understand the circulation of architectural knowledge in Dubrovnik and to identify its main actors, dynamics, and means of communication, as well as the mechanisms through which knowledge was successfully applied and, in some cases, transformed.



### About the Authors

Cristiano Guarneri is an architectural and urban historian. After obtaining his PhD degree, he held postdoctoral positions at IUAV University in Venice, at the University of Padua, and at Ca' Foscari University of Venice, where he is currently a non-tenured assistant professor. He was the recipient of a starting grant of the Swiss National Science Foundation and of a research library grant of the Getty Research Institute, as well as a visiting researcher at the State Hermitage Museum in St Petersburg. His research interests focus on Early Modern European architectural history, particularly at its intersections with the history of science, the history of knowledge, the history of books, and the history of collecting and museums. His monograph *Circulation, Use, Impact: The Consumption of Architectural Books in the Early Modern Eastern Adriatic* is forthcoming with Brepols in 2025.

Ines Ivić is an art historian and medievalist. After completing her PhD at the Central European University in Budapest, she was a post-doctoral fellow at Ca' Foscari University of Venice. Her research focuses on cultural history and especially on the exchange and adaptation of artistic and intellectual ideas between the two Adriatic coasts in the Late Middle Ages and the Early Modern period. She has worked extensively with archival documents relating to the architectural practices of the Republic of Ragusa, in particular the reconstruction of the city after the Great Earthquake of 1667.

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