

Archaeoseismology in a Mediterranean City.
Siena and the PROTECT Project



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Archaeoseismology in a Mediterranean City

Siena and the PROTECT Project

Andrea Arrighetti

Access Archaeology





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Graphic: Marco Repole

Foreword

Hélène Dessales¹

Since ancient times, Mediterranean cities have continually faced the threat of earthquakes. From Rome to Antioch, from Messina to Skopje, earthquakes have left an indelible mark on both urban landscapes and collective imaginations. But beyond the destruction, these disasters have also revealed essential aspects of the history of cities: the ability of societies to adapt in the face of the unforeseeable, the evolution of living spaces, the methods of restoration, and possible preventive strategies. It is precisely these aspects – often elusive in historical accounts –, that Andrea Arrighetti’s book allows us to explore more closely, through the emblematic case of Siena. The urban stratigraphy of this medieval Tuscan city, the extent of its preserved architecture, and the wealth historical sources make it an ideal observatory for examining the interactions between humans, the city and its environment over time.

This book offers a new perspective on Siena’s urban history in light of earthquake risk, combining geological context, historical sources, archaeological data and architectural studies. It effectively identifies the material traces of successive earthquakes, the first of which is recorded as occurring in 1320, and provides a detailed contextual analysis of their consequences. The book aligns perfectly with the expanding field of archaeoseismology – a specialized branch of archaeology that has seen significant growth in the past decade, and of which Andrea Arrighetti is undoubtedly the leading figure in Europe. We already owe him a highly valuable manual on the subject², as well as the publication of two international congresses, one in the form of a methodological assessment³, the other focusing on the case of Siena⁴. It should be noted that the strong impetus in this field of research is closely linked to the programme that Andrea Arrighetti developed in 2022 and 2023, as part of a Marie Skłodowska-Curie fellowship at the École Normale Supérieure, and for which I had the honour of being the supervisor: PROTECT - Knowledge for PREventiOn. Technique for repairing seismic damage from medieval period To modern era. Carried out with dynamism and passion, the scientific activity was substantial, as demonstrated by the numerous publications resulting from these two years, and it had a significant impact at the European level. The originality of the project lays in its focus on the case of Siena, explored in terms of the relationship between seismic events and urban heritage.

This book is the result of personal field research carried out within this context. It presents the history of the city of Siena from a unique and lesser-known perspective. In fact, it would be more accurate to speak of multiple histories of the city, as they are organized according to a multi-scalar approach, following a zoom effect throughout the volume: at a first contextual level, an overview of the entire city, comparing archival data on earthquake damage (in particular, the very rich 1468 Lira tax records) and archaeological observations of the buildings; at a second macro-level urban approach, a study focusing on the “Terzo di Città” area of Siena’s old city centre, which combines the identification of successive damage, proposing a “stratified disruption map” of the elevations, and the typology of post-seismic repair techniques over time (96 identified features, categorized into four groups: wooden braces and tie rods, buttresses, relieving arches, and buttressing arches); finally, at a third micro-level, a case

¹ École normale supérieure, PSL, AOROC / Université de Lausanne

² Arrighetti 2015.

³ Arrighetti 2018b.

⁴ Arrighetti 2023.

study of the church of Sant'Agostino, whose entire architectural chronology is reconstructed by cross-referencing stratigraphic observations with sources on historical seismicity.

Such a vast amount of data and the relevance of its use are truly admirable, and the example of Siena stands out due to the wealth of contextual sources, both quantitative and qualitative. On the one hand, it is evident that the city has been affected by numerous earthquakes of medium to high intensity throughout its long history, with six of them reaching or exceeding intensity VII on the MCS scale. On the other hand, the preservation of its buildings allows for in-depth analysis, making them particularly well-suited for reconstructing post-seismic damage and subsequent rebuilding efforts. Finally, since medieval times, the city's State Archive has contained a collection of highly detailed texts recording the impact of earthquakes and the municipal measures that followed. Such documentation is undoubtedly exceptional and is a source of envy for any archaeologist interested in this field of study.

A relevant comparison could be a similar programme on Pompeii, which focused on the reconstruction of this small Roman town following the earthquake that struck seventeen years before the eruption of Mount Vesuvius. While the accounts of Seneca and Tacitus provide us with the date of the disaster and present Pompeii — particularly affected — as the epicentre of the earthquake, no textual sources exist regarding the conditions of reconstruction and the strategies adopted. It is only through archaeological and engineering observation, supported by a specific database, that we have been able to map the post-seismic repairs (nearly 260 recorded in about 15% of the excavated portion of the city) and characterise their building techniques, offering valuable insight into the socio-economic conditions of Pompeii during its final years⁵.

The highly innovative method ensures that this book can also serve as a genuine handbook for archaeologists, architects, and all specialists in built heritage. In addition to the multi-scalar and multi-disciplinary approach, we must also highlight the exceptional quality of the field surveys (laser scanning, photogrammetry, stratigraphical analysis, specific database for recording repairs) and all the graphic documentation produced by Marco Repole, which includes striking and highly successful experiments that renew the renderings typically expected in the fields of architecture and archaeology of the built environment. One example is the use of elevation mapping similar to topography, with colour gradients and graphic renderings of deformation data, as illustrated by the example of Via Pendola. In this regard, the image at the end of the book, showing the effects of the 2023 earthquake and the new deformations generated by this seismic event, particularly demonstrates the full potential of this method.

In conclusion, this book — beyond the example of the Siena area — stands out for the study protocol, and it proposes and opens a new path in archaeoseismology. Through the data gathered on the evolution of Siena's city centre over time, it illuminates the complex dynamics between a rich historical heritage and the impact of natural hazards. It encourages us to view seismic risk not as an exogenous or one-off event, but as a factor that is intrinsically linked to urban history, one likely to have a lasting influence on building practices and heritage management. Understanding the impact of earthquakes on cities from a diachronic perspective not only enhances our understanding of their material history but also contributes to contemporary discourse on prevention, urban resilience, and heritage conservation. Furthermore, it raises important questions about the memory of disasters and its appropriation by local populations. In fact, the approach presented in this book is exemplary, as the data has also been made accessible to a wider audience through an exhibition organised in September 2023 at the Palazzo di San Galgano. The exhibition offered the general public a glimpse into the little-known history of Siena — an essential history that must be considered if we are to build cities more resilient in the face of earthquakes.

⁵ Dessales 2022.

Introduction

In the Mediterranean context, the frequency of destructive seismic events continues to be rather high. This is in continuity with the sequence and pattern of earthquakes that took place in Antiquity, and for which we have evidence. The heritage located within this context, including both the built environment and the natural landscape, is subject to a range of different levels of seismic risk. These are determined by the seismic characteristics of each area, on the one hand, mainly linked to environmental and geological factors, and on the other hand, as regards aspects associated more with built structures, by the degree of exposure to seismic risk itself. This risk is introduced both by the recent phenomenon of over-anthropisation of spaces, and by the degree of vulnerability of the historical buildings and structures found in urban and rural centres (Mecca 2022: 30). Whereas it is hard to intervene as regards geological and environmental factors, when it comes to the degree of exposure and, above all, to the vulnerability of buildings and constructions, specific projects can be set up aimed at safeguarding and protecting the built cultural heritage, improving its response to the movements triggered by earthquakes. This is an extremely important factor, requiring specific multidisciplinary analyses aimed at a correct documentation, understanding and assessment of each individual architectural complex that makes up a rural or urban centre. Indeed, following on from this consideration, it is well known that very often ancient masonry structures have intrinsic vulnerabilities in the characteristics of their construction. These correlate to the building techniques used, but they can also include defects in their construction design, or in their execution. Moreover, over time, the constant state of exposure to environmental factors leads to a certain degree of deterioration, and thus to a direct reduction of the original properties of the materials used in their construction. With specific reference to some historical town centres, we should also not overlook the aspect involving ways in which these same buildings have been used and renovated. Indeed, these buildings continue to exist as such inasmuch as they have been constantly used and inhabited over time (Valluzzi 2016: 45), altering their original construction properties. All these factors, when combined with geological, geomorphological and seismological factors etc., may lead to differing seismic scenarios for each study context, not only today but also in the past. As confirmation of this, as regards the impact of earthquakes in history, it has been possible to see that in many scenarios from the past, investigated both by scientific methods and by means of the disciplines that make up the traditional framework of studies on earthquakes¹, also coinciding with seismic events on a moderate scale, huge degrees of damage have been caused. This is an aspect which, once again, but with older chronological horizons, highlights the great vulnerability of buildings and historical contexts in the Mediterranean area (Valluzzi 2016: 45).

Regarding the response of past populations to earthquakes, if we omit scenarios in which sites were abandoned altogether in favour of a different area, a direct comparison between archaeological and documentary sources allows an understanding of the degree of the destructive impact of individual seismic episodes on each site context. While sometimes peoples hit by earthquakes opted for a wholesale reconstruction of their infrastructure and dwellings along the lines of the previous structures², in other situations earthquakes helped to lead to full-scale cultural changes, encouraging the creation and spread of technical expedients and new architectural models that were carefully designed to withstand the effects of earthquakes (Stiros 2016). Two very different scenarios that can be reconstructed from an analysis of historical buildings that have survived down to the present day. Accordingly, as regards

¹ The identification and characterisation of earthquakes define archaeoseismology, as well as paleoseismology and historical seismology, which are vital for enhancing our knowledge of seismicity in the past (Galadini et al., 2006: 397).

² Here the well-known example is cited of the major earthquake at the ancient city of Pergamon: occurring in 1246, the quake prompted local people to intervene with a large-scale reconstruction of civic infrastructure.

archaeology, we must consider the buildings and masonry structures of which they are comprised both as evidence of the material culture and technical knowhow of the master-builders and populations, and as the final outcome of constant transformations that took place over time (Parenti 2002: 73), and that include the historical aspect and also the technical aspect, this latter aspect being linked to the formal and material characteristics of walled features. But how can this type of context be studied from the point of view of archaeology, and what is the correct operational procedure, and what level of detail might be appropriate in our analyses?

The answer to this question is not straightforward. The protection of the architectural cultural heritage in contexts prone to risk, both anthropic and natural, should envisage a territorial-scale form of management that includes strategic plans for specific action, and that fosters the development of predictive analyses based on a deep understanding of the fabric of every building. The studies that up until 2010 have addressed the issue of protecting architectural heritage exposed to seismic risk have seen two parallel lines of research come into being, and become established: on the one hand a large-scale, generic approach, which partially ignores any historical contextualisation, and overlooks an investigation based on stratigraphy and construction history of the complexes where interventions have been carried out, denying the possibility of comprising any understanding of seismic issues on the part of the builders of the past; and on the other hand a practice that takes a more careful and specific look at the history of buildings, and their intrinsic features, and which takes into account the existence of construction systems and expedients that were put in place at the same time as the construction of built features. Since 2010, thanks to national directives in the Italian context, and more in-depth efforts in terms of theory and data collection, the reconstruction of earthquake-damaged buildings has led to the development of concrete para-seismic norms (Dessales and Tricoche 2018: 19). As regards historical buildings, the *Linee Guida per la valutazione e riduzione del rischio sismico del patrimonio culturale* [Guidelines for the assessment and reduction of seismic risk to the cultural heritage] (MIBAC 2011), discussed in more detail in the following chapter, underline the fact that an understanding of an architectural feature derives from an all-encompassing analysis that is the result of the coming together of several different disciplines and approaches (from technical knowledge in the fields of architectonics and engineering, to historical and archaeological studies). Indeed, one of the optimal solutions in terms of a multidisciplinary approach sets out to enhance structural analyses by means of stratigraphic observations aimed at a diachronic interpretation of the phases of life of a particular building that is under investigation (Arrighetti 2015; Brogiolo and Cagnana 2012: 14-15). From a purely documentary point of view, when we turn our attention to the past, both in Antiquity and for the Middle Ages, there do not seem to be any surviving written records of regulations drawn up in a post-seismic context. For this reason, as well as being tools for preferential information regarding the empirical knowledge acquired by the builders that may in some cases be influenced by the recurrence of earthquakes, or that may possibly be associated with seismic events (Dessales and Tricoche 2018: 19), archaeology and archeoseismology make a full contribution, along with other disciplines, to efforts to protect and conserve old town centres where the daily life of local communities routinely takes place within residential spaces and workplaces that are incorporated within buildings founded in the historical past.

Thus these multidisciplinary approaches give rise to a correct approach to the subject of vernacular architecture, the conceptual and etymological origin of which can be suitably rendered by considering the meaning of the Latin term *vernaculus*, corresponding to the terms “indigenous” or “domestic”. By extension, in the context of architecture the use of the term “vernacular” refers to a kind of building technique in a given geographical area, in connection with an ethnic group that populates that same territory. Around the middle of the last century the definition that is now generally accepted and used of vernacular architecture came into common use, in conceptual and ideological opposition to an

academically formulated type of architecture. As regards the Italian context, a systematic approach to the subject of vernacular architecture dates back to the 1970s. The earliest studies addressed the overall structure of buildings and an analysis of their façades (and thus the number of floors, and the positions of doors and windows). Later on, an approach became established that was more based on the conservation and restoration of monuments, with special attention to the materials and building techniques used in historical times, also in relation to areas at risk from earthquakes. Research activities received a considerable new boost in particular from the unfortunate seismic events that have taken place in central Italy in recent years. These have prompted notable insights that have given rise to new approaches and research methods in the field of earthquakes and the conservation of historical buildings³. Interesting projects and research groups are also active in the international sphere. Most often these involve teams drawn from a range of disciplines and specialities. Depending on the area of interest concerned, research studies range between studies looking at masonry structures (especially in the European context) and studies focusing on buildings made from perishable materials (in which case the prime contexts in question are from south-east Asia and the Middle East).

Hand-in-hand with the development of this type of investigation, the concept of “local seismic culture” has come into being, and is taking root. This can be called a veritable cultural response by quake-hit local people, by means of specific building practices which vary from one area to another, in accordance with differences in available materials, construction knowhow, and direct observation of the effects of earthquakes on buildings (Arrighetti 2015: 72-81; Ferrigni et al., 2005; Helly 1995; Pierotti and Ulivieri 2001). The development of these cultures over time was heterogeneous, being mainly linked to advances in scientific disciplines. Indeed, the earliest theoretical discussions of seismic cultures compiled in treatises date to the 16th century, while for a direct application of these practices in the field in a purely empirical and experimental form, through the implementation of solutions that can be described as such, we find numerous examples dating as far back as thousands of years earlier (Ferrigni et al., 2005: 199). Thus here we are dealing with pre- and post-seismic building practices that are not formalised and theorised, but that can be perceived in practical terms within specific construction features or characteristics involving the choice of site, or within a larger territorial reorganisation (Ferrigni et al., 2005: 91-92). The necessary condition for the existence of these seismic cultures is given by the frequency and intensity of seismic phenomena: the more frequent and destructive the event (from level VII to level X on the MCS scale), the more the local population affected by the damage will tend to develop a “culture of seismic prevention” over time; the more the earthquake is of moderate intensity (from level VI to level VIII on the MCS scale), the more the collective response will tend to be geared towards a “culture of seismic repair” (Arrighetti 2015: 73-74). Thus we may take the view that when a seismic culture is found to be well rooted locally in each individual within a given community, this has such an influence that it stimulates the systematic creation of measures designed to safeguard buildings in advance, by seeking to reduce their vulnerability, or else with a view to reconstruction, when they are restored (Ferrigni et al., 2005: 193-194).

These, then, are the factors that allow us to understand the extent to which the role of archaeology applied to contexts exposed to seismic risk, albeit with different concepts and methods, should be regarded as a fundamental operation in analyses of contexts faced with seismic risk. This role includes both the world of research and the professional sphere, and brings tangible material benefits as part of interventions involving historical buildings and the broader planning of urban and rural areas. The PROTECT project, the research aspects of which are described in the present volume, follows these prerogatives: implementing archaeoseismological analyses, previously used in rural areas, in an experimental way in a historic urban centre, Siena, and also covering potential developments and

³ Among the most recent and disastrous were the earthquakes that mainly struck Abruzzo, Le Marche and Umbria: 06/04/2009 (L’Aquila), 24/08/2016 (Amatrice), and 30/10/2016 (Norcia).

problematic factors in every phase of its application. The results discussed here clearly show that this type of approach brings essential benefits to knowledge of the study context as regards seismology, history and architectural history, introducing innovations and new data to explore seismic scenarios in more detail. Scenarios which have been little understood up until now, producing technical material with a view to protecting and safeguarding the architectural heritage, and providing notable improvements and a greater awareness of the risks affecting people's lives.

INTRODUCTION

