



CLASSIQUES
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Construction and Seismic Culture in Roman Times

How can one build, or rather rebuild, in the wake of an earthquake? There are many possible solutions, ranging from makeshift repairs to technical innovations, whose viability depend on economic and cultural factors but also on the frequency of seismic incidents. Precautions and rules designed to limit seismic effects are now detailed in national recommendations and have been found in various manuals for several decades. The first anti-seismic systems were created in the 15th century by pioneering Italian building projects, at a time when a new ambition to exert influence across the world started to emerge. However, no specific piece of writing on this topic has come down to us from either the ancient or medieval periods. Although ancient literature addresses the origin of natural disasters very extensively, it seems to have focused more on seismic causes than on their material consequences. However, we find a set of eight short passages reflecting on building techniques developed in earthquake-prone areas (Latium, Campania, Asia Minor). Spanning from the end of the 1st century BC to the middle of the 6th century AD, these isolated pieces of evidence correspond to different registers – historical accounts, technical or philosophical treatises (Strabo, *Geographica*, 12. 8.18; Hero of Alexandria, *Mechanica*, 3.12; Pliny the Elder, *Naturalis Historia*, 36.95 and 36.106; Tacitus, *Annales*, 4.55; Aurelius Victor, *De Caesaribus*, 13.12; Agathias, *Histories*, 2.16; 5.6.6-7). They present four types of technical knowledge: observation (changes in the ground, the longevity of buildings and materials), prevention (foundations, the height of elevations, the quality of building materials), repair (replacing part of a damaged building, straightening a sloping wall), and simulation (reproducing the effects of an earthquake on a building).

The exploration of this corpus, in conjunction with archaeological evidence, provides a wealth of data. These texts illustrate a form of knowledge of seismic effects, accompanied by specific, local technical adaptations, and they reflect the practices and skills developed by contemporary builders. A recurring set of technical principles emerges from these

written testimonies. The first principle is the particular importance given to those elements of construction that ensure a building's structural stability, both the foundations and the devices of reinforcement. The second principle is the selection of building materials based on a good knowledge of their resistance. All these elements make it possible to trace the development of a seismic culture during the Roman era, by exploring the relationship between construction and risk.

Hélène DESSALES
École normale supérieure
Université PSL
AOROC, UMR 8546

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Between Adoption and Rejection. The Flying Buttress in 1130s-1150s Architecture

The use of flying buttresses in primitive Gothic architecture has been the subject of numerous publications since the 1970s, and has recently experienced a revival thanks to the studies of the American art historians Andrew Tallon and Stephen Murray. In the light of these several decades of research, it appears that this architectural feature had a less linear history than had initially been assumed. Without revisiting the entire historiography on the subject, this article assesses the conditions that determined the prophylactic use of flying buttresses for the “Romanesque” naves of the Abbey of Cluny III and Vézelay Abbey during the early decades of the 12th century. From this starting point, the study addresses later “Gothic” monuments, built from the 1140s-1150s until the early 13th century. Although many of these were

built with flying buttresses, such as the Abbey of Saint-Germain-des-Prés and the cathedrals of Sens and Senlis, it appears that many others were initially built without flying buttresses. The apses of the Abbeys of Vézelay, Pontigny, Clairveaux and Quincy, the nave and apse of Noyon Cathedral, and even the apse of Le Mans Cathedral were all built without flying buttresses in their initial structures, and therefore help us to understand the multiple reasons that led to their subsequent use in these buildings: fire, masonry movement, and a poor understanding of the effect of wind on roofs. These few examples therefore reveal an inconsistent use of this architectural device. Even though flying buttresses are now a well-established part of visual culture and viewed as an essential feature of the Gothic style, they were clearly less well appreciated by architects in medieval times. Indeed, when they were first used for prophylactic purposes in Vézelay and Cluny, and in many other churches of varying sizes, they were considered as a “crutch” or as a superfluous addition, and consequently, the work of the architects who used them was not held in high esteem. Aside from this cultural reality, it should also be emphasized that flying buttresses surround the monuments in question, and thereby conceal them from the view of the spectator. They also constitute an obstruction that reduces the light entering windows. In short, they were both unappreciated on aesthetic grounds and had shortcomings in practical terms. It is therefore understandable that their use was not a matter of course, and generated a considerable amount of debate.

Arnaud TIMBERT
Université de Picardie Jules-Verne
Laboratoire TrAme UR 4284

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A Process of Construction between Emergency and Planning. The Transfer to the City of the Convent of Poor Clares of Aix-en-Provence in the Second Half of the 14th Century

The withdrawal of many convents to within the city limits in the second half of the 14th century is one of the well-known effects of the insecurity that characterised this period. This episode in the life of these communities is, in many cases, reduced to a date and location that gives a truncated image of that transfer. For most religious institutions, taking refuge within the walls was not a simple matter of moving in. The religious community practically found itself in a new location. It involved obtaining permits, buying or being given property and, finally, rebuilding a monastery. The process of implantation also had to be carried out under the particular conditions of this period of crisis, which affected the convent's income as well as the supply of materials and labour. The Poor Clares, who had been based some distance from the city of Aix-en-Provence since the 1330s, were confronted with this problem when they came to take refuge behind the city ramparts some twenty years later. The preservation of several of the notarial registers in which the nuns recorded most of their acts between 1361 and 1380 allows us to follow in considerable detail the way in which the nuns experienced and managed this transition. These documents allow us to re-examine the circumstances of a process of withdrawal, in which the Counts of Provence played a very different role from the one that historiography has described. Above all, they reveal the dynamics of this implantation in the city. This transfer, in fact, turns out to be a complex operation which cannot be reduced to that of simply choosing a new location. It comprises a series of operations and has different aspects (legal, financial, the acquisition of property, technical matters of construction), which often appear to be closely linked. In order to give the best possible account of this interweaving of elements, without presenting the different facets of the process in isolation, we chose to present the transfer of the Poor Clares into the city in a chronological fashion: step by step. Our observations focus above all, of course, on the constructive aspects of this

undertaking, through the examination of a series of price quotations and construction contracts which allow us to restore a medieval convent in broad outline, most of which has now disappeared.

Philippe BERNARDI
CNRS-LaMOP (UMR 8589)

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Considerations on the Preparatory Marks in the Stone Architecture and Decorative Sculpture of Romanesque Aquitaine (11th-12th Centuries)

The idea for this study was developed after attending the History of Construction seminar entitled “Traces et tracés de chantier”, which took place on 4 December 2017. Starting from the observation that these traces are observed on all continents and in both Antiquity and the late Middle Ages, what was the situation in the High Middle Ages (11th-12th centuries)? Why do we not see the same sort of traces in this period? Did they even exist? Keeping this question in mind, I undertook a study of the construction of monastic buildings, in the context of a doctoral thesis on monastic constructions in western Aquitaine. This article is not intended to be an exhaustive treatment of the question, but is the starting point for a research project, based on a collection of observations made on a few sites in medieval Aquitaine. These marks left on the stone are precious clues helping us to understand the work of the craftsmen and construction sites of the High Middle Ages. The tracings identified and presented in this work all have the same characteristics. Their authenticity as traces left by medieval builders has been verified: they were made with a fine point and then adjusted. These first observations tend to show a high degree of organisation of the construction site,

especially for Saint-Eutrope de Saintes: some traces were used as reference markers for construction, while others related to the manufacture of the blocks, or even served as a modular solution for the construction of special elevations. Without seeking to provide all the answers, my principal aim is to show the profusion of these traces in buildings and to raise awareness of their presence. The main difficulty lies in finding opportunities to observe these traces, and then in understanding how they relate to the construction process and the work of the craftsmen. They are principally found in areas that are not easily accessible. They are not very pronounced, and may be lost in the course of alterations to the stonework and restoration of the facings. Indeed, these lines were not intended to be visible once the building was completed. Some are difficult to observe, and very often fragmentary; their identification can also be difficult. However, in spite of this fragile and fleeting character, they allow us to understand the acts and know-how of builders of the High Middle Ages, in a period when there were few texts on these questions.

Jean-Baptiste JAVEL
 Doctorant IRAMAT-CRP2A
 Université Bordeaux Montaigne

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Popolo, Accounting and Public Works. Administrative Practices and
 Distribution of Resources in Bologna at the End of the 13th Century

Following on from a recent work of historiography, which highlights the relationship between the accounting of construction sites and administration, in this paper we would like to show the administrative management of public construction sites and the distribution of public resources in the municipality of Bologna at the end of the 13th century.

We have set out the systems for the authorisation and audit of public expenditure. The *anziani* and consuls could authorise expenses without any limit (with the agreement of the *Consiglio del Popolo*), which would then be recorded by their notaries on the registers of reforms and commissions and then sent to the treasury. The *podestà* and the captain of the *Popolo*, as specified by the statutes, could authorise expenses up to a maximum of 25 lire, and beyond this sum they could authorise payments only if there were specific provision for it in the statutes. All payment authorisations from these two officers and *anziani* had to be mentioned in every payment made by the treasury (on *libri expensarum et introituum*), in order to facilitate the accounting audit that had to be carried out at the end of the term of office. A judge from the *familia* (staff) of the *podestà*, the *giudice al sindacato*, was in charge of this audit, in which he had to check the work of all the offices and officers who had managed public money, and in the case of fraud, have them sentenced.

We focused on documentary production, in which it is possible to find information about public construction sites, the type of information that was given, and the vocabulary used. In treasury records, and in the records of authorisations for the expenditure of the *podestà* and the captain of the *Popolo*, all transactions are noted: the name of the person who was paid, their office or any other qualification, the reason for the payment, and the name of the person who authorised the expense. The expenses approved by the *Popolo*'s Council are detailed only in the registries of deliberations (the registries of *riformazioni e provvigioni*), and here it is possible to verify the use of a technical vocabulary (materials, structures, measures, etc.).

Finally, we studied the burden of public works expenditure on the city budget, and the people who were paid for these works. We were able to highlight how the municipality implemented a large redistribution of resources among the members of the *Popolo*.

Marco CONTI
Doctorant CIHAM –
Université Lyon 2
Ater Université de Limoges

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Wasserkunst. German Books and Writers on Water and Hydraulic Engineering between 1533 and 1800

Any research into the history of water engineering in the early modern period must begin with a survey of the surviving literature. However, while books on architecture or mathematics have been studied in detail, no such comparative study of books on hydraulic engineering has been undertaken. It is precisely this gap that this paper seeks to fill. This paper thus aims to provide a survey of the works associated with water technology in the period 1500-1800. It provides details of the publications, their various editions, translations of the titles, short summaries and a glossary. Furthermore, details of authors' biographies are included and put into context. The focus is specifically on works in German but includes translations of works into German from other languages. This is a deliberate choice, as German texts are not generally as well-known as contemporary examples in English, French and Latin. The timeframe of 1500 to 1800 offers an insight into the very early beginnings of the emergence of a discipline that is now called civil engineering. The period was chosen in order to cover the first printed books on the subject and the emergence of scientific thought. The study includes roughly 100 publications. Water history is a varied topic and, as the subjects of these books span many different areas, they have been divided here into broad subject themes: books on machinery; books on architecture and the law; books on river regulation and urban development; and technical treatises. In general it can be said that early books mostly relied on illustrations to show techniques, some existing, some new and some purely imaginary. They are based on traditional technologies developed through trial and error. In comparison, later publications show the growing influence of mathematical theories and were written with a more scientific character. Indeed, the basic theoretical equations developed around 1750 and described in these works remain in use today, even though the discipline has changed dramatically. One obvious change is the use of technical terms, but the status

of mathematical modelling has also increased. Theoretical models were originally principally a tool used to explain certain phenomena but were not directly used in the field. Engineers now tend to focus much more on mathematical models and are more reliant on them. This paper therefore provides an opportunity to reflect critically on the history of hydraulic engineering.

James W. CAMPBELL
Queen's College
Cambridge University

Sabine KUBAN
Queen's College
Cambridge University

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Expertise and Power Games in the 18th Century. The Case of the Feydeau Bridge in Nantes (1727-1737)

Authorised by a decision of the Council of State of the King in 1725, the Feydeau bridge was built on the Loire, in Nantes, by a company of shareholders at the initiative of the mayor, who was also sub-delegated by the intendant in Brittany. The three-arched, humped-back stone bridge, modest in size and constructed using techniques of traditional craftsmanship was conceived by the city's engineer, who was a member of the company. Between 1727 and 1737 it was surveyed four times: during the construction, after the collapse of one of the arches at the moment when the temporary supporting structure was removed, one year after the collapse, and, finally, at the end of its reconstruction.

Experts of various sorts were involved: Jacques V Gabriel, the general controller of the King's buildings and first civil engineer of the kingdom, during a mission in Nantes (September 1727); the King's chief engineer in Nantes, appointed by the city after the collapse to assess the damage (July 1728); the King's engineer once again, appointed as a third-party expert, along with an architect-contractor and an engineer from outside the city, to determine responsibility for the collapse (June-July 1730); and two architect-contractors, for the contractor and the city, with the newly appointed King's chief engineer as a third-party expert, when the partners required the release of the re-built construction to the community (February 1737).

The proceedings were opened under the supervision of the successive intendants in Brittany, represented by their sub-delegated officers in Nantes, who were investigating the case. The bridge company, the representatives of the city that would be responsible for it after delivery, the project lead and the contractors were able to participate in the assessments. The minutes, and the controversies that accompanied them, provide details of the actors and proceedings, the sharing of technical knowledge, the implementation of experience and the material used. They also provide information on the relationship between Paris and the rest of the country, on allegiances to different bodies and hierarchies, and on local rivalries, as some expert reports led to contradictory minutes, when the third-party expert – the King's engineer – was suspected of partiality and contradicted the opposing parties, who were in agreement with each other.

The case, which had started productively by questioning the strength of the bridge under construction, ended with the instrumentalisation of technical assessments by a city in search of autonomy, which was eventually repressed by the royal authorities.

Gilles BIENVENU
CRENAU/AAU UMR 1563