Abstracts
4th International Congress on Construction History
3-7 July 2012
The construction industry (in the English sense) constitutes a strategic sector in the world economy, particularly concerning employment. Until 2007, the most important firms were European. This was certainly the case in the Building and Civil Engineering sectors. In 2006, the top five was constituted by Vinci [France], Bouygues [France], Hochtief AG [Germany], Grup ACS [Spain] and Bechtel [USA]. Even if, in 2010, China Railways Construction Corp. Ltd and China Railways Group Ltd passed respectively to the first and second place, Vinci, Grup ACS, Bouygues, Hochtief and Skanska [Sweden] remained among the top ten.

The European hegemony remained strongest in the services connected to the construction industry (property development, public utilities such as water distribution as well as electricity production, transport or distribution) and, above all, in the production and distribution of building raw materials. The European cement industry offers a typical example of advanced globalization: today, there exists a global oligopoly made up of European dominant firms such Lafarge [France], Holcim [Switzerland], Heidelberg Cement [Germany] or Italcementi and Buzzi Unicem [Italy]. However, the distribution of building supplies constitutes also a good example of the European domination with Saint Gobain [France] and its competitors, Wolseley [United Kingdom], CRH [Ireland] and Rockwell [Denmark].

Even if the European hegemony doesn’t exclude spectacular failures (Philipp Holzmann AG bankruptcy in 2002 or, more recently, the financial crisis of Spanish majors), it is interesting to analyze the cyclical or structural reasons for this global European success: What is the part played respectively by technical innovation and by trade and financial strategies? What is the part played respectively by entrepreneurs, engineers and also workers? What is the part played respectively by specifically European practices versus those resulting from technological or managerial transfers, notably from the USA or Japan?

Sessions

Tuesday 3 July, 17:00-19:00 | MALAQUAIS SITE

401. Construction History, Epistemology & Historiography
404. Architectural & Structural Design 1
411. Transfer of Knowledge, Colonial Situations 1
415. Craftsmanship, Gender, Individuals & Communities
420. The Real Estate Market, The Cost of Construction
423. Brick & Tile
440. Industrialization & Rationalization

Cover:

Cruyl Lievin, Preparatory drawing, pen and ink, view of the Pont Royal construction site, 1686. Signed and labeled: Liv: Cruyl auditer delineavit mense Octobri 1686 - Four or eight horse mill to pump water with a scoop. Wheel of [missing] diameter. Heisser © Cecilia / Nationalmuseum, Stockholm.
**Knut Stegmann**
Institute of Historic Building Research and Conservation, ETH Zurich, Switzerland

Analyzing Historical Timber Structures – A Case Study on Ernst Gladbach [1812–1896] and His Research on the “Swiss Style”

The professor of structural theory and construction materials at the Swiss Polytechnic School in Zurich, Ernst Georg Gladbach [1812-1896], is today, still one of the overlooked protagonists of construction history. His most important works, such as Der Schweizer Holzzeit [1868 and 1883] or Charakteristische Holzbauten der Schweiz [1893] have been mainly regarded as templates for the internationally recognised motif of the “Swiss Style,” especially because of their painterly manner of representation. Though, the artistic presentation and contextualisation of Gladbach’s research on historical timber structures accords to his concept of the “researcher artist,” which he himself practiced. This paper illuminates more precisely Gladbach’s methods of analysis, documentation and presentation of historic timber constructions and demonstrates its connection to contemporary research and, in particular, to the teaching at the Swiss Polytechnic School.

**João Mascarenhas-Mateus**
CES – University of Coimbra, Portugal

Ethnographic Studies and Their Contribution to Construction History in Portugal

The classification schemas of historical construction processes in Portugal are established in important ethnographic studies, which have been undertaken since the end of the 19th century. In works by figures such as Leite de Vasconcelos [1858-1941] or Schauder Holzbauten der Schweiz [1893] have been mainly regarded as templates for the internationally recognised motif of the “Swiss Style,” especially because of their painterly manner of representation. Though, the artistic presentation and contextualisation of Gladbach’s research on historical timber structures accords to his concept of the “researcher artist,” which he himself practiced. This paper illuminates more precisely Gladbach’s methods of analysis, documentation and presentation of historic timber constructions and demonstrates its connection to contemporary research and, in particular, to the teaching at the Swiss Polytechnic School.

**Torsten Meyer**
Institute of Historic Building Research and Conservation, ETH Zurich, Switzerland

The Science of Building as a Polytechnic Discipline in the 19th Century

In the 19th century, the process of scientificization initiated within polytechnic schools transformed and enriched contemporary knowledge on building. The genre of building textbooks written under the aegis of these schools illuminates this development most clearly. This paper focuses on the genre and its historical context; aiming to outline principally the emergence and relevance of the constitutive discursive process of “historicism,” and to briefly outline the nature of its parallel process, “economization.” The central thesis of the paper is that the process of “historicismisation” can be considered as evidence of a method or a theory of invention.

**Sascha Roessler**
ETH Zurich, Switzerland
Architectural Anthropology: A Knowledge-Based Approach

In the discipline of architecture to date, hardly any approaches exist to integrate into architectural education knowledge of construction as it is found in vernacular and informal building. The following remarks are intended as a plea for the establishment of a new academic discipline that comprehensively addresses such vernacular building traditions, commonly referred to as “architecture without architects” [Rudolfsky 1964]. The discipline will be entitled “architectural anthropology”: subject matter of this discipline would primarily consist of domestic, non-European building phenomena. Architectural anthropology comprises an interdisciplinary field of knowledge, in which architects – as well as anthropologists – play a crucial role. The following considerations deal only with the (possible) contribution of architects to this new discipline.

**Richard A. Ellin**
School of Architecture, Planning, and Preservation, University of Maryland, College Park, MD, USA

Toward an Iconography of Stereotomy

Since the history of art has been filled with symbolic meaning, there is no reason to imagine that stereometric vaulting would have been exempt from the universal human tendency to assign religious, political, and cultural significance to its forms. Most of the paper is devoted to symbolism of Christ and the Evangelists and/or references to Solomon’s Temple as found in French Romanesque architecture: rompre carrying octagonal vaults in churches, the vis de St.-Gilles with circular window in the eponymous church in Gard, the crypt of Montmajour, and skew doorways in Angévin churches; in Valencia: the Serrano [1392-1398] and Quart [1444] city gates, the Royal Chapel [1433-1463], Santo Domingo Convent, and the Cathedral. The paper ends with a brief discussion of Philibert Delorme’s Hôtel Bullioud [1536], Lyon, considered as a purposeful creation of a Roman ruin, with references to pagan and Christian antiquity, as well as to French Romanesque antecedents.

**Maria Antón Barco, Eva J. Rodríguez Romero, Juan Tejela Juez**
CEU ‘San Pablo’ University, Institute of Technology [EPS], Madrid, Spain
Builders’ Inventiveness in Madrid’s Baroque Convents: Construction Invariables

This research focuses on the constructive and design invariables recurrent in Madrid’s Baroque religious buildings. The study focuses on two representative examples: the Convent of the Holy Sacrament, known as Sacramento; and the Convent of the Immaculate Conception, known as Sacramento. These invariables can be found by analyzing the architectural volumes, their spaces, geometrical traces, building techniques and construction materials. Throughout this analysis, the manner in which the city takes shape can be easily understood. The main sources of investigation have been historical cartography and pictures, construction treats and similar architectural projects designed by the same architects who constructed these two examples.

**James W.P. Campbell**
University of Cambridge, UK

The First Complete List of All the Models Made for the Construction of St. Paul’s Cathedral, London 1675-1720

It is commonly assumed that there are only two models for St. Paul’s Cathedral [built between 1675 and 1720]. By careful re-examination of the surviving building accounts, this paper provides details of all the models, which were made during the period of construction. By so doing, it clearly shows the crucial part played by architectural models in the design process. It also shows the extraordinary range of materials from which the models were made and gives a clear idea of their different sizes and functions. The paper is accompanied by a complete list of references to models in the archives, which will hopefully be of use to future researchers. The models for St. Paul’s provide an invaluable insight into the working practice of a design office in the late 17th century, but the practices probably differed little from those used in the construction of the gothic cathedrals centuries before.
These architectural transformations have generally been from Mauritius and France, and artisans from the London capital of Antananarivo, Madagascar from 1820 to 1860. During this 40-year period in Malagasy history, Merina architectural forms and construction techniques into the architectural forms and construction techniques of the British State.

In this paper I investigate the involvement of architects Maxwell Fry and Jane Drew in West African building projects supported by the British Colonial Office from the 1940s through to the early 1960s. Much of the technical knowledge for this work came from studies by the Building Research Station, the first state-run research institution dedicated to problems of building and construction. There was some tension between a growing recognition of the colonial subject and the idea that technical expertise provided a neutral means of intervening in colonial territories. The very material presence of the architecture stemmed from investigations of the state, usually serving British commercial interests and subject to patterns of global trade. A form of reflexivity is visible in the technological and aesthetic transfer between the British and African contexts.

In the early 21st century it is still considered unusual to find a woman working as a housepainter and decorator. Tradewomen, in these most domestic of building trades, were working throughout Scotland during the 19th and 20th centuries. These were women who worked, not middle class women, but women working with their husbands and fathers in the building trades, widows continuing the workshops of their deceased husbands, and women supplying building materials for particular sites.

In the light of their production, they have traditionally been considered as artisans of limited artistic background and low economic position, with the weight of the guilds behind the development of their trades. The motivation behind Els of the construction to Girona 1419-1833 was to prove the validity of this historically accepted premise. In this study, we examined some 90 wills and post-mortem inventories of master craftsmen residing in Girona during the 16th and 17th centuries, together with the statutes and regulations of the confraternity [later known as the guild] that united them for over four centuries. After our portrait of the professional members of the building trade working during the modern era in Girona and, by extension, all over Catalonia, we now turn our attention to the role of craftsmen coming from outside the area.

One of the lesser-known aspects of Catalan art history in the modern era is the social and cultural status of its craftsmen. In the light of their production, they have traditionally been considered as artisans of limited artistic background and low economic position, with the weight of the guilds behind the development of their trades. The motivation behind Els of the construction to Girona 1419-1833 was to prove the validity of this historically accepted premise. In this study, we examined some 90 wills and post-mortem inventories of master craftsmen residing in Girona during the 16th and 17th centuries, together with the statutes and regulations of the confraternity [later known as the guild] that united them for over four centuries. After our portrait of the professional members of the building trade working during the modern era in Girona and, by extension, all over Catalonia, we now turn our attention to the role of craftsmen coming from outside the area.
How Much did Greek Temples Cost? Economic Issues of Construction in Greek Cities [4th -3rd C. B.C.]

Some cities in the ancient world made official documents public by transcribing them into stone, which is why building accounts were found in the Delphi, Epidaurus and Delos sanctuaries 4th-3rd centuries B.C. This evidence allows us to understand in what economic and financial contexts Greek cities worked on and carried out construction projects. Several issues will be discussed: Which funding sources supported the development of these out-of-the-ordinary building sites? What practices and regulations [contracts, fines, payments by installments, etc.] were used by those involved in the project [sponsors, accountants, architects, craftsmen and suppliers]? How were prices defined? Did they actually reflect the market? Was this market local, regional or Mediterranean? Finally, what was the status of this accounting data? Is it possible to exactly evaluate the cost of public construction by studying them?

Construction Financing in Late Medieval Portuguese Towns [14th-16th c.]

Our goal is to provide answers to numerous questions regarding the different modes of construction financing in late medieval Portuguese towns from the 14th to the 16th centuries. For that purpose, we selected four approaches or perspectives: the issue as to who commissions and pays for the construction work: the king, lords or the municipality [concelho]; the typology and functions of the construction: military, religious or others; the identification of who contributes, and how, to finance the construction work; and lastly the modes of financing the different production costs. In order to reach our goals, we will apply a multidisciplinary methodology, crossing various types of sources, such as written, iconographic and material evidence through the use and application of specific concepts and methodologies derived from distinct fields of knowledge that usually focus on construction, such as history, archaeology and computer science.

Between Market and Architecture: The Role of the College of Engineers, Architects and Land Surveyors in Real Estate Pricing in 16th-18th Century Milan

This paper provides empirical evidence on mechanisms leading to real estate pricing in early modern Milan [16th-18th centuries]. More specifically, it focuses on the moment of valuation, when conventions on houses' worth become explicit through the estimate operation. Milanese appraisals and contracts in the long run show that home pricing involves three major qualitative and non-economic factors [i.e. material, social and legal factors] and implies a double degree of valuation: a valuation of objects' qualities as well as a valuation of subjects' qualities of transactions. Regarding this double mechanism, we show not only the evolution of the estimate methods, but also the role played by the stima [in both senses of evaluation and reputation] of the experts of the College of Engineers, Architects and Land Surveyors of Milan in evaluating houses, workshops, and flats distributed all over the urban space.

Building Expropriation Process for the Construction of the New Dock at the Port Of Cartagena [Spain] in the 18th Century

During the 18th c., the Bourbon monarchy mandated the building of a Naval Base in the Spanish Bay of Cartagena. To do so, different actions had to be implemented on the surrounding environment in order to prepare it for the construction of the new port. One of the priorities was the transformation of the watershed of the streams that flowed into the blocked Sea of Mandarache. This was achieved through the design and building of a dam in the northern part of the city. The design of this massive construction, which would also serve to fortify the city of Cartagena, was fraught with doubt. Its proximity to the city would result in the demolition of several buildings in the San Roque neighborhood. Therefore, the number of affected buildings and the value of the fair compensation for their expropriation would become decisive factors in determining whether or not the construction project was a viable option for the Royal Estate.
This paper explores three aspects of brick construction in Scotland from the 18th and 19th centuries. These are the use of brick to line ashlar walls, the choice of brick to construct early cotton mills and various uses of the material in tenement construction. Whilst there are many developments that have contributed to the evolution of brickwork, the choice of brick to construct early cotton mills led to a greater sophistication in Scottish architecture.
Keynote Lecture

Tuesday 4 July, 9:00-10:15  MALAQUAIS SITE [AMPHI BINET]

Ledlie Klosky
Professional Engineer, United States Military Academy, West Point, NY, USA

*Men of Action - French Influence on the Founding of American Civil and Military Engineering*

It is difficult to overstate the debt owed by the Continental Army to the French military engineers, largely volunteers, who provided essential support during a pivotal period in history. Equally important is the influence of the French scientific approach during the growth of American engineering practice in the early 19th century. Influential engineers and educators such as Duportail, Crozet, and Mahan were educated in French schools, and the methods they learned played an important role in early American engineering and construction practice. The resulting union of the French scientific theory, British methodology, and American need resulted in a unique combination of immigrant and homegrown engineers building the new nation.

This lecture traces the beginnings of formal engineering practice and military construction in the United States from the coming of the French engineers to the establishment of the Army Corps of Engineers and West Point. Early American engineers and professors are discussed, as is the strong connection between French and American engineering education in the early 19th century. The capstone to the early growth of engineering as a discipline in the United States came with the founding of the American Society of Civil Engineers in 1852.

Sessions

Wednesday 4 July, 10:45-12:45  MALAQUAIS SITE

402. Construction History, Education & Diffusion
405. Architectural & Structural Design 2
416. Contractors
424. Structural Bricks & Tiles
432. Vaults & Stereotomy 1
436. Wood Structures 1
441. Prefabrication 1
443. Hydraulics
This paper presents an educational experience held at the ETH-Bibliothek. The Pier Luigi Nervi System of construction is a combination of technical solutions used to define a new way of building that is both economical and rapid. Economical because it eliminates the wooden formwork required to pour reinforced concrete, both costly and impossible to reuse, and because it reduces the costs of materials, limiting the thicknesses of the load-bearing elements (thus diminishing dead loads). Rapid because it divides the building yard into two autonomous sectors, where workers can operate in parallel: on the one hand, the building site, with the excavations, foundations, pillars and all site-cast elements; on the other, the prefabrication yard, used to prepare the pieces applied to complete the structure. The pieces are small and lightweight and easy to move from the storage area to the adjacent building site. One example of the application of the system is the construction of the Palazzetto dello Sport for the Rome 1960 Olympic Games. A model-game, designed by the authors on the occasion of the Nervi exhibition held in Maxxi, National Museum of 21st Century Arts, in Rome, from December 2010 to March 2011, helps us to understand the Nervi System.

The lack of degree programs in construction history motivated the CH.ESS. Jointly organized by universities in Brussels, Cottbus, Madrid, Munich and Wroclaw, the first of these events took place in Cambridge in 2011. In keeping with the transdisciplinary character of construction history, the two-week course brought together students and teachers from a variety of disciplines. The experiences gained with CHESS could be of interest to any university teacher who is planning to set up a degree program in construction history. With that in mind, the authors [members of the central CHESS organ] will end this report with some remarks about the main problems that arose in trying to teach construction history in an international and multidisciplinary context.
industrialists who introduced, whether successful or not, examples of such companies. Their leaders were clever Aerschot workshop in Herentals are two well-known for heavy iron industry whereas Flanders was far less large-scale production. In Belgium, the Walloon provinces and large machines provided sufficient power and volume for in Belgium evolved to a small number of large companies. Industrial Revolution, the large number of small ironworks frequentin Collette a sizeable contribution to the architectural heritage in all of exceptional documentation shows the know-how and spirit their use and destination [principally to France and England] and on the administrative management of the firm. The exceptional documentation shows the know-how and spirit of enterprise of these marble-masters. Their work provided a sizeable contribution to the architectural heritage in all of Europe.

Joëlle Petit HTTP-CNAM, Paris, France Private Archives of the 18th and 19th Centuries: Sources for the History of Marble-Working in Belgium Even today, relatively little is known of the work of marble-masons, but owes much to the skill and knowledge of the marble-workers of French-speaking Belgium. An essential contribution to the history of marble-working is to be found in the study of the outstanding documentation from one Belgian marble-works [quarriers and marble-masons]. The company books we have at our disposal [dispatching ledgers and account books] come from two periods: 1769-1784 and 1843-1889. These private archives relate to the marble industry in the region of Rance, in the Hainault and provide important information as to the technical organisation of work, the technical characteristics of marbles employed, their use and destination [principally to France and England] and on the administrative management of the firm. The exceptional documentation shows the know-how and spirit of enterprise of these marble-masters. Their work provided a sizeable contribution to the architectural heritage in all of Europe.

Koen Verswijver, Inge Bertels, Ine Wouters, Quentin Collette Vrije Universiteit Brussel, Belgium The Development of Belgian Ironworks in the 19th Century: Case Studies and Reflections on Sources and Historiography During the 19th century, especially after the second Industrial Revolution, the large number of small ironworks in Belgium evolved to a small number of large companies. The introduction of steam engines, the Bessemer converter and large machines provided sufficient power and volume for large-scale production. In Belgium, the Walloon provinces with the cities of Liège and Charleroi were the home base for heavy iron industry whereas Flanders was far less industrialized, only housing a limited number of foundries and forges. The Marcellis ironworks in Liège and the Van Aerschot workshop in Herentals are two well-known examples of such companies. Their leaders were clever industrialists who introduced, whether successful or not, small castings, machines, bridges and spans.

Maria Luiza de Freitas Federal University of Pernambuco [UFPE], Recife, Brazil Architecture and Reinforced Concrete in Brazil: The Action of the Largest Construction Companies in Brazil, Christiani & Nielsen and Ways & Freytag We investigated the development of reinforced concrete structures as one of the key drivers of the modernization of Brazilian architecture between 1920 and 1940, based on the performance of large construction companies in the country. The urban modernization was characterized by the concentration of the main modern activities in urban centers, the restructuring of cities’ spaces to accommodate new workers, and changes to the perception of the environment introduced by new media, transportation means, and infrastructure. This scenario allows for us to analyze the arrival of two foreign construction companies in Brazil: Ways & Freytag, one of the most important companies specializing in reinforced concrete systems, and Christiani & Nielsen, a Danish construction company. These firms were a true experimentation field, and consequently contributed to the formation of professionals capable of creating a new aesthetic arising from this technique in Brazil.

Javier Martínez-Gonzalez, Marta García-Alonso School of Architecture, University of Navarra, Pamplona, Spain Building Modern Spain: Some Notes on Huarte y Cía The construction company Huarte y Cía was created in 1927 in Pamplona, a small city of northern Spain. The creative and skilful management of Félix Huarte, its founder and president, together with the highly qualified staff of its Technical Office, made it one of the most relevant Spanish contracting firms. When Félix Huarte died in 1971, Huarte y Cía, was the head of an industrial corporation composed of 45 companies, while the Huarte family had become one of the most generous patrons of the arts and culture in Spain.

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Jennifer Zessin, John Ochsendorf Massachusetts Institute of Technology, Cambridge, MA, USA Efficiency in Form: Thomas Jefferson’s Serpentine Walls at the University of Virginia Thomas Jefferson, founder and architect of the University of Virginia, included a number of innovative building systems in his design of the school. In particular, Jefferson designed a series of undulating brick walls, known as serpentine walls, to enclose the gardens at the University. This paper describes the history and origins of serpentine walls, as well as the development of Jefferson’s walls, in order to track the transfer of technology to the United States. In addition to understanding the intent of the design, particular attention will be paid to the performance of the walls, with a cursory discussion of the effects of curvature on the lateral stability of walls. A preliminary analysis of the walls based on Jefferson’s original description of the walls is included. This analysis, combined with new information regarding the history of the serpentine walls, provides a new understanding of a major work of American construction.

Esther Redondo Martínez Department of Building Technology, Universidad Europea de Madrid, Spain Tests on Tile Vaults in France in the 19th Century Throughout the 19th century the construction of tile vaults experienced enormous development and the use of these vaults spread to new types of buildings, as well as to areas where they had not traditionally been constructed. In addition, cement started being used as a binder instead of plaster. In this context numerous tests were carried out on these vaults, in order to validate a construction system that was considered new for these reasons. This paper studies a series of strength tests carried out in France between 1837 and 1865, all of them on vaults of similar size and geometry, with spans between four and five m. and a rise of 1/10 of the span. This type was new for these reasons. This paper studies a series of strength tests carried out in France between 1837 and 1865, all of them on vaults of similar size and geometry, with spans between four and five m. and a rise of 1/10 of the span. This type was frequently used in Italy for construction of industrial basins at that time. The first test aims to measure experimentally the thrust of one of these vaults, to end a debate on whether or not tile vaults exert thrust. The tests seek to obtain the failure load of the vaults to be used in the design of similar vaults.

Nan-Wei Wu University of Edinburgh, UK Structural Morphology Presented on Surface Cladding: From Structural Brick to Ornamental Tile in the Westernised Far East The determination of the surface cladding of architecture often resulted from the availability of constructive techniques and materials as well as the cultural and social perspectives that architects would like to express, while the latter element is sometimes potentially more crucial. In this paper, the skeuomorphic link between structural brick and ornamental tile for the surface cladding of architecture and construction and for buildings in the westernised Far East is the focus. The social and cultural perspectives will be considered in significant examples, since these perspectives have strongly affected this structural morphology. This practice concerns the diffusion and transfer of knowledge and of political power. Several architectural projects are examined in order to illustrate how these influences have played significant roles in the cladding of constructive elements, that is walls, in the construction history of the westernised Far East.

Gemma Muñoz Soria Universitat Politècnica de Catalunya, Spain Load-Bearing Wall Structures in the Works of Lluís Nadal Until the introduction of the first brick masonry standards in 1972, construction in Spain traditionally used load-bearing walls in all types of dwellings. Lluís Nadal, a Catalan architect, was one of the last architects to combine the design of dwelling interiors with load-bearing brick structures. His most significant works are the apartments at 307, Carrer Lepant [1963-1968] and 44-50, Carrer de les Tres Torres [1970-1974]. Nadal designed the interior layouts using load-bearing walls. These walls functioned to ensure the basic structural concept, strength and stability by means of structural elements and ties. The design included various nuances that increased the inertia of the overall construction and formed a series of spaces that, structurally, functioned independently. His work is, then, based on specific knowledge of constructive processes, in which the essence of the Mediterranean provided the basis of the balance needed to posit his architectural discourse.
Building with large stone blocks, also called opus revinctum, was a method frequently used in the architecture of Roman Asia Minor. Vertical connections were established with dovetails, horizontal joints were secured with clamps. Mortar essentially was not applied. This paper presents examples for dome and barrel vault construction carried out in this technique. Unfortunately only a few monuments have been studied in detail. This paper aims to present some of these examples and to discuss their design. However uniform their appearance might seem at a first glance, the underlying structural principles are surprisingly manifold: They include true dome construction as well as corbel vaulting and flat arches. Our goal is to attract attention to these monuments and the neglected questions of their structural design.

Marina Simunčič Burić
Faculty of Architecture, University of Zagreb, Croatia
Construction of Early Rib-Vaults in Croatia

The preserved early rib-vaults in Croatia belong to the period of experimentation with a new structural element, diagonal arches, which opened the path to the Gothic rib-vault. Like in other European regions, the first rib-vaults built in Croatia at the beginning of the 12th century are characterised by massive diagonal arches, rectangular in cross section. The geometry of the vaults ranges from hemispherical domes with diagonal arches to rib groin vaults with horizontal ridges; from unusual combinations of progressive elements within traditional forms of vaulting, to the original solution of rib-groin vaults with horizontal ridges in the bell-tower in the Benedictine convent of Zadar. The construction of the vault in the Zadar bell-tower, begun in 1105 and completed by 1111, is documented by the original donor’s inscriptions, which makes it one of the earliest precisely dated rib-vaults in Europe.

Alberto Sanjurjo Alvarez
Universidad CEU-San Pablo, Madrid, Spain
The Chambiges and the Construction of Vaulted Stone Spiral Staircases

Martin Chambiges, the most representative architect of the Flamboyant Gothic Style, is known as the architect of the transepts of Sens and Beauvais Cathedrals and of the main façade of the Cathedral of Troyes. In these constructions he designed and built, assisted by a group of collaborators and disciples, very singular stone spiral staircases. These are the so called vis de Saint Gilles with circular or polygonal plans, that may be considered real wonders from the point of view of stereotomy. This paper deals with the study of the geometry and construction of these staircases and tries to enlighten the debate about the attribution of some of his possible works.
Francis Guillemand
CNAM, Paris, France
Charles-Henri Besnard de Quelen: A Precursor of Prefabricated Construction
This French architect [1881-1946], a disciple of Anatole de Baudot and Viollet-le-Duc, expressed an early interest in construction processes. Already in 1917, he had filed a patent with the CNAM for constructing in molded concrete and foam cement. Named Chief Architect of Historic Monuments, he applied his inventions to numerous edifices such as the Saint Quentin Hospital, the National Office of Tourism on the Champs-Elysées and the Pouliain Chocolate Factory in Blois.
In 1919, at the Foire de Paris, he presented a reinforced concrete house for the first time, which was, moreover, the first entirely prefabricated dwelling. His inventive contribution is evident in the building of St. Christophe de Javel Church. The edifice, entirely in reinforced concrete, is composed of molded components fabricated on the construction site and then directly integrated into the assembly of the building.

Rafael García García
Universidad Politécnica de Madrid, Spain
Concrete Meccano: Precast Constructions after the Second World War in the Netherlands
This paper deals with prefab constructions in utility buildings in the Netherlands' reconstruction years after the Second World War. Specifically, housing and non structural buildings during the post Second World War period in Italy, through the example of the first ENI-SNAM headquarters. The application of industrialization in office buildings often produced “hybrid” configurations, where inclination towards traditional and modern techniques merged with the preservation of more traditional construction aspects. The ENI-SNAM building in San Donato Milanese [1954] – A Case Study of Japanese Bridge Construction in the Edo Period
Yasuhiro Honda
Miyazaki, Japan
This research clarifies the construction process of the Tsujunkyo Aqueduct Bridge, constructed in 1854 in Yamato province during the Edo Period, just before the introduction of occidental techniques. This aqueduct bridge improved the agricultural situation of a small plateau where the farmers had much difficulty irrigating their rice fields. Thus, the construction process and its current status. Specifically, by organizing previous studies and historic records, observing the irrigation channel’s structure and maintenance work by field survey and making records of the system of self-government for operation and maintenance and the many unwritten rules.

Hernando Vargas
Universidad de los Andes, Bogota, Colombia
RetCel: The Development of Floor and Roof Assemblies of Precast Concrete Cells in Colombia, 1949-1989
Based on archival, primary and published sources around concrete prefabrication industry development in Colombia [1946-2006], this paper focuses on a proposed staging of this innovation and adoption experience as an outstanding case of local professional and industrial organizations offering modern building systems for an expanding market. Started in 1948, after direct observations on the Brazilian experience of open plan architecture, among other proposals for new construction procedures, the RetCel patented system accumulated 40 million ft2 of licensed built slabs in six countries as of 1985 when it was considered to be introduced in the United States. Colombian modern building architecture registered for decades a marked influence of this technology down to the 1980s and 1990s new seismic resistance-oriented construction codes.

Laura Greco
University of Calabria, Cosenza, Italy
The ENI-SNAM Headquarters in San Donato Milanese: Some Features of Industrialization in Construction Techniques Applied to Office Buildings in the Post Second World War Period in Italy
This paper analyses some features of industrialization in office buildings in the Post Second World War period in Italy, through the example of the first ENI-SNAM headquarters. The application of industrialization in office buildings often produced “hybrid” configurations, where inclination towards traditional and modern techniques merged with the preservation of more traditional construction aspects. The ENI-SNAM building in San Donato Milanese [1956-1958], designed by Marcello Nizzoli and Mario Oliveri, stands out as an example. The building has a steel structure, curtain walls and prefabricated partition walls. In the office building, on one side, the attention to advanced construction processes is evident, while on the other side, the building stands out due to its curtain wall design, which proposed an original interpretation of industrialized products. In fact, the figurative features of the facade reduce industrialization, highlighting the link between architecture, figurative arts and industrial design, developed by Nizzoli.

Anna Decrè
Institute for the History of Material Culture [ISICUM], Genoa, Italy
The Historical Aqueduct of Genova: Materials, Techniques and History - A Way to Know
This contribution is part of a work commissioned by the Municipality of Genova to ISICUM [Institute for the History of Material Culture] concerning the cataloguing of the historical aqueduct, a significant architectural structure that extends for about 40 km. The work consists of cataloguing all the constituent elements of the structure of the aqueduct [bridges, galleries, arcades and simple channels] and also includes the cataloguing of manufactured accessories for the channel, such as sluice gates, blowholes, milestones, fountains. The data collected is the result of spot investigations and bibliographic research and is managed through a database specifically developed for this purpose. This database also allows the inquiry and facilitates the cross-comparisons and the knowledge of relationships between phenomena, materials and construction techniques. This paper describes the approach used and the first results of this collaboration.

Naoto Tanaka
Center for Policy Studies, Kumamoto University, Japan
The Role of the Tsujun Irrigation Canal’s Construction and Maintenance in the Creation of a Cultural Landscape [Shiraito Plateau, Kumamoto, Japan]
The Tsujun irrigation canal is an agricultural irrigation canal built in 1854 to supply water to Shiraito Plateau in Kumamoto Prefecture, Japan. Since then, the canal system has been supplying water to the terraced rice paddies on the plateau for about 160 years. In the background of the continuously used canal, there is a local rule to distribute the precious water evenly, which has been protected from the time of construction to today. This study focuses on the system and technologies and has the objective of making known the transition of operational management of the Tsujun system and its current status. Specifically, by organizing previous studies and historic records, observing the irrigation channel’s structure and maintenance work by field survey and making records of the system of self-government for operation and maintenance and the many unwritten rules.

Carlo Togliani
Politecnico University of Milan, Italy
Water Pumping Plants for Land Drainage in the Po Valley: A Case Study of The Mantua Region [1866-1940]: People, Techniques, Materials
For centuries, the area around Mantua was largely at the mercy of water’s whims, of flooding and stagnant water. Traditional gravity drainage systems remained in use until the mid-19th century. It was only then that new mechanical techniques, and revolutionary new building materials and construction techniques were introduced. With Milan becoming Italy’s major industrial cities and universities recruited leading-edge engineers and workers. Iron and reinforced concrete made a wider range of hydraulic parts possible; monumental structures were built to house the massive machinery of the thermal power stations and thermoelectric power plants [initially propelled by steam, later by diesel and electric engines]; and pumps composed of turbines, horizontal centrifugal pumps and vertical screw pumps began to be used. The Mantua region was exceptional in terms of the complexity of its hydraulic structures and the quality of the technical and architectural solutions it employed.
Sessions

Wednesday 4 July, 14:00-16:00    MALAQUAIS SITE

403. Construction History, Heritage & Restoration
406. Applied Sciences 1
413. Transfer of Knowledge, Political Initiatives
417. Organization of the Construction Site
425. Stone
433. Vaults & Stereotomy 2
444. Infrastructure & Public Works, Bridges
306. Rules & Standards, Building Regulation Compared
Use of Modern Materials in the Conservation of Traditional African Buildings

Africa's architectural and built heritage has adapted to, and incorporated, new technologies and materials. Most of these efforts have taken place within the informal, traditional sector, with cultural meaning serving as the basis for conservation choices. “New” materials and technologies are increasingly applied to meet the challenges of keeping African traditional architecture alive. This paper, through selected case studies, identifies the plusses and minuses of the adaptations, and discusses the challenges that the borrowing poses. It identifies the factors that contribute to the obsolescence of indigenous construction technologies and the loss of local knowledge systems. It further establishes the existing expertise for the conservation of these technologies as well as what adaptations have been made, with modern materials, in current restoration practice. It concludes with a synthesis of the dominant trends and recommends steps necessary for the emergence of African conservation expertise to ensure adequate preservation of this architecture.

The Interpretation of Palladio’s Building Techniques: Palazzo Chiericati and the Restorations of the 19th c.

Palazzo Chiericati represents a true ‘experimental worksite’ where Palladio introduced a series of formal and technological innovations, which will later become a trademark of his work and of the building tradition in the Veneto region. He created architectural elements typical of the classical culture [columns and stone-like architraves] with simple material [plaster-coated bricks and wood]. The building was completed only in the last part of the 17th century, while the first restoration dates back to the 19th century, when it was perceived as an opportunity to bring the building back to its “original conditions,” according to the Neoclassical perspective. The construction, completion and restoration of the palazzo help us to understand how Palladio’s technical skills were interpreted and modified according to the evolution of the critical views and building traditions that had spread throughout the Veneto region over the centuries.

Material History and Conservation of Contemporary Building Fabric

This essay will deal with the relationships in play between construction history and architectural design and will attempt in particular to specify what kind of construction history architects and/or historians of architecture working on existing buildings should be making use of. Can the built architectural object, a primary documentary source, also become an active component in the way we practice architecture? To what extent does the “as found” material identity of architectural objects determine maintenance, repair, renovation and restoration strategies? An historical understanding of 20th-century construction materials, methods and practice – the “material history” of contemporary building fabric – and monographic studies on representative works provide us with the essential methodological tools we need when designing for existing structures, as well as being subjects of research relevant to modern and contemporary architecture and vital instruments for the teaching of architectural practice.
In the interplay between the development of construction and of mechanics, and more in general of modern scientific thinking, the question about the status of firmitas – whether it is necessary or contingent – runs across different ages and different philosophical and scientific universes. In this paper we put into perspective this question in the context of the evolution of classical mechanics, from Enlightenment to 20th century developments. We first consider the question posed by the Berlin Academy for its competition on necessity and contingency of the laws of statics and mechanics. In the light of the independence of predictability from determinism for sensitive to initial conditions systems, we then try and evaluate the status of firmitas in the recent developments of digital architecture. In this field, in fact, morphological research is often based on the properties of unstable systems. Francois Fleury

ENS A de Lyon, France

Some Aspects of John Wallis’s Structural Mechanics

Albeit not a construction practitioner, the mathematician John Wallis (1616-1703) shows a clear interest in statics and structural mechanics in the “Mechanica: Sive, de Motu, Tractatus Geometricus.” The present contribution focuses on chapter six in the third part of the treatise. In this chapter, some fundamental structural problems, such as the study of the curve of the catenary and the arch, are investigated. The study of the catenary curve is important for several reasons. First, it is a well-known example of a non-trivial curve that can be described in terms of elementary functions. Second, it is the first non-trivial example of a curve that can be used to model physical phenomena. Finally, it is a curve that has been studied by several mathematicians and physicists, including Leibniz and Newton.

In this section, we will focus on the role played by the problem of the catenary at the beginnings of the process of mathematicalisation of elasticity. We will also discuss the role of the catenary in the development of the calculus of variations. We will conclude with a discussion of the modern applications of the catenary curve in engineering and architecture.
exist in Aomori, Sendai, Nagoya and Shibata. The Army’s architectural system has not yet been sufficiently studied. So far, the architectural prototype for Army buildings has not been found, but we can describe the architectural planning process and the prototypes both for garrisons, which were built on the site of ancient castles, and for barracks, which mixed the traditional Japanese carpentry and the positive introduction of new techniques from France. This paper intends to clarify the planning method for military garrisons and the early stages of the barracks’ construction process by way of field surveys and archival documents.

Lia Barelli
Sapienza Università di Roma, Italy

Construction Methods in Carolingian Rome [Eighth-Ninth Centuries]

In the city of Rome, the Carolingian period was marked by an exceptional volume of building activity due to the favourable political and economic conditions of the papacy. All the buildings of this period reveal the same construction characteristics: the attempt to imitate the techniques of classical antiquity is evident, but the norm in these structures, which differentiate them from the Roman ones, is the irregularity of the laying. The technical characteristics are only partly justified by the use of non-homogeneous materials as a result of their recovery or of hurried workmanship or even of a presumed loss of technical capacity. Among the principal causes one must also consider the possible employment of unskilled labour: some works are known to have been carried out through public tender and also using forced labour, made possible by the political and economic structure of the Papal State.

Andrea Bonavita
Università Iuav di Venezia, Italy

Building the New Prisons of Venice and Their Bridge [1591-1604]

Despite traditional construction techniques in the lagoon, the structure of the New Prisons of Venice, with their walls of massive Istrian stone and barrel vaults in masonry, remains really unique. In this paper several aspects of the building site are analyzed by means of the documentation held in the Archivio di Stato di Venezia: salaries and wages, the management of masons and the supplies of building materials. Particular attention is paid to the activity of stonecutters and the provision of Istrian stone, without forgetting to follow the operations for the erection of the “Bridge of Sighs.”

Matthieu Pinon
GSA-ENSA Paris-Malaquais, France

The Building of the Arsenal of Le Havre in the 17th and 18th Centuries

This paper draws upon PhD thesis research currently underway, which is dedicated to the study of construction works that occurred within the Graville fortress close to the port of Le Havre in the 17th and 18th centuries. More exactly, our objective is to understand the conversion of the castle’s 13th century outbuildings into a cannon foundry, which began in 1627. Even if nothing remains of these buildings today, this study is possible thanks to rich archival sources, notably quantity surveys and other established prices from the repair of the building in the 17th and 18th centuries and a recently discovered archaeological survey conducted before its demolition in 1949. This constructive analysis, which we will call "an architect's reading of the archives," strives to understand how this modest-looking Norman building participates in the development of the perfect arsenal as embodied by Cherbourg in the 18th century.

Anne Conchon
Université Paris 1-IDHE, France
Katherine McDonough
Stanford, University, CA, USA

Road Construction Sites in 18th Century France: Labor and Administration in Action

Historians remember that the French monarchy was able to construct a vast road network during the 18th century, while they forget a little too quickly how construction work in many places lingered on for decades, how some roads were never completed, and how others’ alignments were subject to heated debate. The finished product represented an Enlightenment-era political initiative, a success story for the reforming royal ministers. The contrast between these politicized accounts of the road network and contemporary representations of the inefficiency of the corvée raises the following question: If the corvée presented such difficulties suggested by its detractors, how do we explain the results of this unprecedented public works project? Part of the response may be found in the study of the corvée – in its work practices on the road construction sites. Our paper outlines technical specifications as well as the social dynamics and labor constraints of these road construction worksites.
Wednesday 3 July, 14:00-16:00  MALAVQUA SITE, Room 308
425. Stone
Chair: Jacques de Mandat-Grancey, Fondation du Patrimoine, France

Dimitris Theodossopoulos
University of Edinburgh, UK

John Barber, Graeme Cavers, Andy Heald
AOC Archaeology Group, Lisburne, Midlothian, UK

The Achievement of Structural Stability in the Drystone Iron-Age Broch Towers in North Scotland

There is a growing need in architectural literature to focus more on the fabric and direct insight derived from field monuments, in the case of brochs, going beyond typological analysis or speculations about the purpose of certain features. This study attempts to discuss the complexity of this type of Atlantic roundhouse in the construction and planning processes, combined with their structural design and performance, and also to treat brochs like architectural structures. Such focus can provide further valuable information on how stability was achieved in dry stone built structures of this scale. It can also augment what we learn about the technological culture and corresponding intellectual achievements of the period.

Turgut Saner, Kaan Sağ
ITU, Istanbul, Turkey

The Aeolian-Style Polygonal Masonry in Larisa [Baruncuk] and its Regional Context

Larisa [on the river of Hermos] is located in ancient Aeolis – western Asia Minor. Excavations held on the acropolis [1902, 1932-1934] by Swedish-German teams brought to light sixth century buildings of monumental character. They are constructed in polygonal work with masonry skills on stone built structures of this scale. It can also augment what we learn about the technological culture and corresponding intellectual achievements of the period.

Wido J. Quist
TU Delft, Netherlands

Timo G. Nijland
TNO, Delft, Netherlands


Mining engineer A.L.W.E. van der Veen was the first scientist to become involved in material research on natural stone in monuments in the Netherlands. The paper provides a first brief overview of his life and activities in the field of natural stone research as a ground for interventions on monuments and discusses his legacy.

Angelo Bertolazzi
Department of Civil, Environmental and Architectural Engineering, University of Padua, Padua, Italy; GSA-ENSA Paris-Malaquis, France

Stone Cladding Techniques in French Modern Architecture [1920-1940]

The research studies the evolution of construction techniques in stone in France during the 20s and 30s related to new industrialized construction. It begins with the study of technical manuals and French journals [La Construction Moderne, L’Architecture d’Aujourd’hui]. This evolution begins from the French tradition of block masonry that has been improved upon in the 19th century. During the modernization and the industrialization of the 20s, it began to evolve towards a mixed construction [stone and reinforced concrete], where modernity and tradition give rise to an unusual and experimental constructive solutions. In the 30s, instead, the stone cladding grows as a model of constructive rationality, where “modern” building techniques slowly converge toward new solutions. The modern cladding in stone of the 50s has a central role in France, where dialogue is possible, without contradiction, between modernity and tradition.

Wednesday 3 July, 14:00-16:00  MALAVQUA SITE, Room 206
433. Vaults & Stereotomy 2
Chair: Jacques Heyman, University of Cambridge, UK

Rosa Senent Domínguez, Miguel Ángel Alonso Rodríguez, Enrique Rabasa Díaz
Polytechnic University of Madrid, Spain

José Calvo López
Polytechnic University of Cartagena, Spain

The Irregular Ribbed Vault of the Sacristy of the Cathedral of Saint-Jean Baptiste in Perpiñan

The vault of the sacristy of the Cathedral of Saint-Jean Baptiste in Perpiñan (France), constructed by the Majorcan architect Guillem Sagrera between 1433 and 1447, is an outstanding, yet strikingly unknown, example of rib vaulting. This paper analyzes the overall construction of the form of the vault, characterized by its highly irregular perimeter, with particular attention to an isolated decorated corbel that solves the problem of the wall support of a group of six ribs and is in stark contrast with the rest of the supports, which are completely unadorned. Given the extreme rigour of Sagrera in all his works [and this one in particular], this apparent “capriccio” must be justified not only by decorative or formal requirements, but also by the constructive logic of the Gothic vaulting system.

Rafael Martín Talaverano, Carmen Pérez De Los Ríos, Rosa Senent Domínguez
Polytechnic University of Madrid, Spain

Late German Gothic Methods of Vault Design and Their Relationships with Spanish Ribbed Vaults

The classification schemas of historical construction processes in Portugal are established in important ethnographic studies that have been undertaken since the end of the 19th century. In works by figures such as Leite de Vasconcelos [1858-1941] and Rocha Peixoto [1868-1909] we can find an extensive mapping of the relationship between material resources, social traditions and construction technology throughout the country, During the 20th century, this body of research was developed by other scholars such as Orlando Ribeiro [1911-1997], who applied the Human Geography methodology to establish the first clear distinction between the stone culture of the North, and the earth culture of the South, integrating them in a universal context. This paper shows the importance of these studies to the establishment of a comprehensive view of Construction History in Portugal and highlights research areas opened up by such seminal works.

Stefania Petralia
Faculty of Architecture, Polytechnic of Bari, Italy

Safavid Ribbed Vaults as a Masterpiece of Iranian Construction Techniques

Spanning with ribbed vaults is largely diffused in several countries. In Iran they represent a primary element in local architecture and have been realized with techniques never developed abroad. The restoration of this vernacular methodology is strictly connected with the materials, consisting in bricks and suffering for the shortage of timber. The first examples of these structures spread in Persia during the tenth century and reached new levels of achievement under the Safavids. The method for constructing these ribs was developed in several ways until this high-performing period when elaborated ribbed vaulting, made with complex patterns of intersecting brick arches were created, as a structural and a decorative device. From this moment on, a big variety of spaces is covered using this system. This shows the ability of brick-workers who articulated several formal potentialities for addressing a structural problem, turning a weakness into a masterpiece.

Giuseppe Fallacara
Facoltà di Architettura, Dipartimento ICAR, Politecnico di Bari, Italy

The Lecce Vault: History, Construction Techniques and New Design Perspectives

In the region of Puglia in southern Italy, from the late 16th century onward and continuing to today, one finds the tradition of a particular type of composite vault called the Lecce Vault [volta leccese]. This vault is found in the geographical region of Salento and particularly in the cities of Lecce and Brindisi. Historically this zone was called the Terra d’Otranto. The Lecce vault, which derives its name from the eponymous city, is also designated as a “star vault,” because, when viewed from below its form resembles a star. As a composite vault, the Lecce Vault combines features of all the canonical vaults: barrel vault [semi-cylindrical], sail vault [portion of a sphere], groin vault [composed of the intersection of two barrel vaults whose wedge-shaped parts are called in Italian angulus], and cloister vault [composed of sections of a cylinder called in Italian falli].

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The paper describes innovations by the John A. Roebling's Sons Company in the design and construction of suspension bridges in the period from the late 1920s to the early 1950s. Specifically, the contributions of Charles Sunderland and Blair Birdshall are discussed. Sunderland devised an efficient method for the assembly of in-situ spun main cables that was adopted worldwide. The pre-stretching technology pioneered by Roebling enabled the assembly of main cables using pre-stretched, pre-socketed strands. Roebling engineers designed innovative anchorages, saddles, and decks for pre-manufactured small suspension bridges for erection in remote locations. In response to the failure at Tacoma Narrows, Sunderland developed a cable truss suspension bridge stiffened by prestressing.

Eberhard Pelke
Hessen Mobil – Roads & Traffic Management, Wiesbaden, Germany
The Development of Multi-Cable-Stayed Bridges

The work of Hellmut Homberg embraces all the materials and structural forms of modern bridge-building. It is even broader than he himself realized, even though his great passion was major bridges. Homberg reached the pinnacle of his art of bridge-building between 1962 and 1967. Within a short space of time he developed, patented and built the two fundamental types of multi-cable-stayed bridge. And his last main patent [1967] points the way forward for multiple-span multi-cable-stayed bridges: the Rhine crossing at Neuwed -Weissenthurn became the prototype for the Millau Viaduct. It remains a tragedy that Homberg's pioneering designs and studies for stringing together multi-cable-stayed bridges were not pursued during his lifetime. This trilogy is a first attempt to document Homberg's work, publications and relevant literature. This is the first systematic appraisal of his contribution to the development of the multi-cable-stayed bridge. It includes previously unpublished designs and concludes with a Catalogue Raisonné of his multi-cable-stayed bridges.

Ivan Ferrari
University of Salento, Lecce, Italy
The Roman Bridges of the Via Traiana: An Innovative Building System

In the historical perspective, the development of masonry arch bridges in the 19th century was somewhat eclipsed by the rise of iron bridge construction. However, the present contribution shows that the processes of masonry arch bridge construction underwent a radical and unprecedented change during the 19th century, and that early concrete bridges were unthinkable without this development. The change involved the usage of completely new lifting gear and cranes, a switch unthinkable without this development. The change involved the usage of completely new lifting gear and cranes, a switch unthinkable without this development. The change involved the usage of completely new lifting gear and cranes, a switch unthinkable without this development. The change involved the usage of completely new lifting gear and cranes, a switch unthinkable without this development.
Keynote Lecture

Wednesday 4 July, 18:30-19:30    CNAM SITE, AMPHI PAUL PAINEVÉ

Shigeru Ban
Architect, Tokyo, Japan

Works and Humanitarian Activities

Shigeru Ban, born in Tokyo in 1957, is an architect, designer and set designer. After attending the Southern California Institute of Architecture and Cooper Union School of Architecture, he founded his firm in 1985. Ban is considered one of the most innovative architects of his generation and is, in particular, known for his development of paper as a construction material.

Among his best known projects, there are notably: the Curtain Wall House in Tokyo [1995], the Japanese Pavilion for the Hannover World Exhibition in collaboration with Frei Otto [2000], the Nicolas G. Kayek Center in Tokyo [2007] and the Centre Pompidou in Metz [2009]. He is also known for his commitment to humanitarian causes and, in particular, to disaster relief initiatives. Among his works in this domain, we find: the Paper Log House and Paper Church built after the Kobe Earthquake [1995], Paper Emergency Shelters for the Byumba Refugee Camp in Rwanda [1999], Emergency Shelters built after the Gujarat Earthquake in India [2001], the reconstruction of the fishing village of Kiranda after the Sri Lankan Tsunami [2004] and a temporary school in Chengdu, China after the Sichuan Earthquake [2008]. In 2011 he was awarded the Auguste Perret Prize in recognition for his mastery of integrating technical knowledge into innovative architectural design.

Sessions

Thursday 5 July, 9:00-11:00    LA VILLETTE SITE

410. Structural Analysis & Modeling I
414. Technical Literature, Images & Representation
418. Scaffolding and Machines
426. Reuse & Recycling
427. Earthen & Plaster Structures
434. Shells & Thin Vaults
442. Natural & Technical Risk, Earthquake Design
445. Infrastructure & Public Works, Transportation
Thursday 5 July, 9:00-11:00  LA VILLETTE SITE, Amphi 4

410. Structural Analysis & Modeling 1
Chair: Patricia Radelet-De Grave, Université catholique de Louvain, Belgium

David Wendland
TU Dresden, Germany
Arches and Spirals: The Geometrical Concept of the Curvilinear Rib Vault in the Albrechtsburg at Meissen and Some Considerations on the Construction of Late-Gothic Vaults with Double-Curved Ribs

An analysis of the geometric design of a late Gothic vault with curvilinear ribs is carried out interpreting the 3D measurement data, formulating hypotheses on the design directly from the built artifact, with a working method not common in surveying until now. It is demonstrated how the geometric definition of the arches in the vault can be characterized. The general methodological problems regarding the interpretation of the geometric features of surveyed buildings and the interpretation of design processes in architecture are discussed. Further, the necessity of revising the current state of knowledge on Gothic vault design is underlined. Some final remarks discuss the design and construction of the masonry shell in vaults of this kind.

Thierry Ciblac
ENS Architecture Paris La Villette / MAP-MAACC CNRS UMR 3495, France
Analysis of Philippe de la Hire’s Arch Theory Using Graphic Statics

In Proposition CXXV of his 1695 Traité de mécanique, Philippe de la Hire gives a graphic method for studying arch equilibrium that is considered the first scientific approach to this subject. With some restrictive hypotheses such as frictionless contact and radial joints, he gives a particularly simple geometric construction by which to determine the weight of the stones. This paper analyses this method using graphic statics – another graphic method, formalized by Culmann in 1864 – in order to point up the reasons for its simplicity and the role of each hypothesis. The first part deals with the relationship between some of the other propositions in de la Hire’s Traité and the graphic statics method. An equivalent duality between force polygon and funicular polygon is then brought out. In the second part, the proposition on arch theory is analysed using graphic statics. A generalization of the method, which was touched upon but not illustrated by de la Hire, is proposed.

Javier Suárez, Laura Cirera
School of Architecture, University of Granada, Spain
Structural and Constructive Analysis of the Acequia Real Aqueduct in the Alhambra, Granada

This work presents a documental study of the historic beginnings, the constructive description and the analysis of the mechanical behaviour of the Acequia Real Aqueduct in the Alhambra of Granada. This historic structure is the keystone of the Nasrid Palace’s hydraulic system. Construction of the Acequia Real was commissioned by King Muhammad I in 1238, when he decided to build the new palatial city of the Alhambra. The entry of the Acequia Real into the citadel of the Alhambra is found by passing through an aqueduct dating back to the beginning of the 18th century, built with ashlar, on a semi-circular arch eight m. in diameter and 11m. in height. The work shows: the geometric modelling of the aqueduct, the study of the stone material, through investigation of its origin, petrographic analysis and stereotomy; the pathologic inspection of the building and the modelling of its mechanical behaviour through application of the Fundamental Theorems of Limit Analysis, according to J. Heyman and S. Huerta, including detailed graphical diagrams on the position of the thrust line. Finally, we will draw conclusions on its stability and security level.

Santiago Huerta
Universidad Politécnica de Madrid, Spain
Structural Analysis of Thin Tile Vaults and Domes: The Inner Oval Dome of the Basílica de la Virgen de los Desamparados in Valencia

The inner oval dome of the Basílica de la Virgen los Desamparados, built in 1701, is one of the most slender masonry vaults ever built. It is a tile dome with a total thickness of 80 mm and a main span of 18.50 m. It was built without centering with great ingenuity and economy of means, thirty-three years after the termination of the building in 1667. The dome is in contact with the external dome only in the inferior part with the projecting ribs of the intrados, the lunettes of the windows and, in the upper part, through 126 inclined iron bars. This unique construction was revealed in the 1990s in the studies previous to the restoration of the Basílica and has given rise to different theories about the mode of construction and the structural behaviour and safety of the dome. The present contribution aims to provide a plausible hypothesis about the mode of construction and to explain the safety of the inner dome that has stood, without need of repairs or reinforcement, for 300 years.
Maria Grazia D'Amelio
Università Tor Vergata, Rome, Italy

Fabrizio De Cesaris
Università La Sapienza, Rome, Italy

Jean-Sébastien Cluzel
Institut national d’histoire de l’art, Paris, France

414. Technical Literature, Images & Representation
Chair: Chen Zhao, Nanjing University, China,

Thursday 5 July, 9:00-11:00  LA VILLETTE SITE, Room 114

The process of moving St. Peter’s obelisk [1586] was immortalized in two famous engravings by Giovanni Guerra and Natale Bonifacio, which were produced at that time. Four years later the creator of this memorable enterprise, Domenico Fontana, published his work Della Trasportazione dell’Obelisco Vaticano [1590], which describes how the monolith was removed from the original location, transported and then erected in St. Peter’s Square. Historiography has always considered this volume as a means for spreading highly specialized technical knowledge, a reference when undertaking similar enterprises. The illustrations were certainly much admired, though they attracted less technical interest. In fact, they still had to be proved in the context of the debate between mechanical theory and practice, which was as yet in an embryonic stage. Moreover, one wonders if the images contained sufficient information to pass on the very specialized “science” of moving large monoliths. This paper aims to analyse the technical scope of the illustrations, and their effectiveness as spreaders of knowledge.

Jean-Sébastien Cluzel
Institut national d’histoire de l’art, Paris, France

Hokusai Manga as a Reference Construction Book

Two of the illustration books of the master painter Hokusai Katsushika [1760-1849], are dedicated to architecture: The fifth book of Hokusai Manga [1816], and New Models Illustrated for Craftsmen [1836]. Therefore it appears a little strange that those two albums are still not considered as a “valuable pieces” among construction books of the Edo period [1603-1868]. Proceeding from a short structural analysis of a representative variety of 17th, 18th and 19th century Japanese publications related to construction, this paper will explain some relation between construction books and Hokusai’s albums, showing the necessity of including them in the bibliography of construction books. This conclusion allow the author to discuss the limits of the field of construction history in Japan, and to question the “non existence” of architects in pre-Meiji Japan. By this paper, the author hopes to shed light on Hokusai’s work as well as contribute to the elaboration of a transnational construction history.

Javier Girón
Universidad Politécnica de Madrid, Spain

A Review of the Depiction of Ancient Construction by Charles Chipiez in L’Histoire De L’Art

This paper critically reviews the analytical drawing of construction in the prominent Georges Perrot’s and Charles Chipiez’s Histoire de l’Art dans l’Antiquité, which has not yet been thoroughly studied. The chapters devoted to architecture, for which Chipiez was responsible, cover from Egypt [1882] to Greece [1898]. Chipiez, with a rationalist approach, analyzed and recreated ancient design using perspective and axonometric projections to represent construction details that in earlier literature were drawn in planar projections. This approach can be compared to that of Choisy in his Histoire de l’Architecture [1899]. A comparison between both works has enabled us to understand the value of Chipiez’s contribution to architectural literature and drawing. It seems Chipiez’s work anticipated some of Choisy’s drawings and subjects he discussed in his first chapters [Egypt and Assyria]. The influence of authorities such as Hittorf is evident in both Chipiez’s and Choisy’s studies of Greek architecture, especially in the depiction of the construction processes.

Hilary Bryon
School of Architecture+Design, Virginia Tech, VA, USA

Construing Construction with Drawings: Robert Willis’ and Auguste Choisy’s Axonometric Representations of Vaulted Structures

English engineer Robert Willis extended his mechanical-analytical approach and graphic methods to architecture and archeology in the early 19th century. His unprecedented graphic demonstrations used isometric projection to clearly convey his construing on construction. Willis constructed his graphic thoughts in two different ways, in Remarks on the Architecture of the Middle Ages [1835], the drawings articulated an abstraction of arcuated building components that form the whole and in “On the Construction of the Vaults of the Middle Ages,” [1842] the representations appear as less analytical while making manifest a mechanical relationship between the stones, as component parts, and their assembly, as vaulted structures. This paper examines the methods employed by Willis to reveal and embody vaulted construction, but also how Willis’ rational, analytic practices and graphic axonometric constructions influenced those by French engineer Auguste Choisy in his L’art de bâtir chez les Romains [1873] and L’Histoire de l’architecture [1899].
Rationalization of the building processes on site. How various actors tried to ameliorate the mechanization and suggests further methodological procedures and questions. Based on this analysis, this paper brings a first ‘typology’ of safety, with the minimum of trouble and expenses. As such, The Study of Medieval Lifting Machines Thanks to Iconography: An Example in Mediterranean Machinery The paper presents a study of medieval lifting machines on construction, based on the use of iconography as the primary and main source of research. Traditionally, the discipline has been used as a visual support in other subjects, but in my research the iconography is used as a primary resource because it provides a wealth of information per se. The analysis of it joins the multidisciplinary work of comparing the results with disciplines such as architecture, physics or engineering research proving unique in its field and so far the only jobs that have seen the iconography have done so from a standpoint of repertoire, without further visual importance. Inge Bertels Vrije Universiteit Brussel / FWO & Universiteit Antwerpen, Brussels/ Antwerp, Belgium Scaffolds: 19th Century Discourses on Innovative Scaffolding Techniques within Architecture and Construction Journals This paper focuses on innovative scaffolding techniques within the second half of the 19th century and is based on a profound study of a selection of contemporary architectural and construction journals [discourse and iconographic presentation and promotion]. The image these journals clearly puts forward is that contractors and trades evolved toward a strong focus on the discovery of new machinery and tools capable of performing the maximum of work and safety, with the minimum of trouble and expenses. As such, these journals offer a first glimpse of what innovators of scaffolding techniques and construction tools were seeking. Based on this analysis, this paper brings a first ‘typology’ and ‘evolution’ of innovative scaffolding techniques, suggests further methodological procedures and questions how various actors tried to ameliorate the mechanization and rationalization of the building processes on site. Richard C. Ryan University of Oklahoma, Norman, OK, USA Development and Use of Mechanized Heavy Construction Equipment in the United States Since the mid 1700s, U.S. construction history can be divided into four basic earthmoving, excavating and hoisting equipment development time spans or eras: canals, railroads, highways and high rises. Fundamental mechanical and operating principles for earthmoving, excavating and lifting equipment were proven and documented well before 1800. The challenge of the 19th century was to mechanize crude human, horse, or ox-drawn construction. The invention of the steam engine as a power source started the rapid evolution of heavy construction equipment design, manufacture and use and began the change from tools to machines. Discussion focuses on the evolution of earthmoving, excavating and hoisting machines from barges to rails to wheels and tracks. A timeline highlighting the construction eras is intended to show the relationship of equipment developed for construction of United States infrastructure and building projects, significant events or inventions and the equipment needs of the different types of work. Niccolëta Marconi Università di Roma Tre,Vigata, Italy Innovation and Tradition in the Reconstruction of the Basilica of St. Paul Outside the Walls in Rome [1825-1928]: Technologies, Procedures, Protagonists The decision to rebuild the ancient Basilica of St. Paul Outside the Walls, destroyed by a fire in 1823, was taken immediately. The work began in 1825 and continued for 100 years. There have been many studies about the project and the stages of the reconstruction from the 19th century on. Less frequent have been the contributions supplied by the methods used to raise the multitude of columns that were placed at regular intervals around the interior of the Basilica and the monumental four-sided portico. This paper focuses on this last aspect, illustrating the technical contributions offered to the San Paolo work yard by the Fabbrica di San Pietro in the Vatican, the papal institution responsible for overseeing the worksite of the new Vatican Basilica from the 16th century, whose role was crucial in the execution of the technically delicate and complex operations in the reconstruction of St Paul’s. Stéphane Büttner Centre d’études médiévales d’Auvergne, CNRS / Université de Bourgogne, Auvergne; France The Use of the “Already There”: Reuse and Recycling for Monumental Building in the West in Late Antiquity and the Medieval Period Historians of building have always wondered about the practice of reuse, focusing mainly on obvious cases, such as the reuse of Gallo-Roman carved blocks to build city walls at the end of Antiquity. The sometimes ostentatious character of the rework has been interpreted as a manifestation of the desire to anchor some symbolic buildings in a long history. Nevertheless, the discrete recycling of materials has undoubtedly occurred in a far higher proportion of buildings. It is necessary to evaluate this proportion in order to take it into account in reflections on the technical and economic organisation of construction during Late Antiquity and the Medieval Period. The issue of reusing materials [stone and architectural terracotta] and even entire walls, as new architectural components [mortars, components for foundations and elevations, or roofing], opens up a whole field of reflection on the functioning of construction but also deconstruction, as the two operations sometimes appear nested. Emanuela Montelli Università degli Studi “Roma Tre”, Italy The Reuse of Granite Columns in Rome, 15th-16th Centuries Between the second half of the 15th and the early decades of the 16th centuries, Roman architecture was characterized by the presence of reused columns in various different types of marble [bigio antico, breccias, cipollino, granite, travertine], reworked in accordance with their new function in contrast to what occurred during the Middle Ages. Initially, column shafts were reused without any distinction between the types of materials available; later, especially after the construction of Palazzo della Cancelleria, monolithic granite columns [grey and red] were sought out and these took a primary role compared to other materials. Only in the works of Bramante is the reworking of the granite columns, already problematic due to the hardness of the stone, further complicated by the execution of the entasis. The preference for granite can be explained by both technical reasons and the desire to make reference to Antiquity; this material made it possible to create shafts of the desired size, much appreciated during the Imperial period, without running the risk of breaking the stone. Martin Bachmann German Archaeological Institute, Istanbul, Turkey The Revival of Classical Building Techniques in Late Ottoman Architecture in Bergama, Turkey This article discusses the buildings of the Greek middle class in Bergama, Turkey, dating from the late 16th to the early 19th century. To understand what this style of building represents, an awareness of the social and historical background behind its emergence is of great importance. In addition to questions of typology and design, we must also pay special attention to aspects of construction technology, which to date has not been studied at all. It turns out that ancient architecture and building practice served as a model. The adoption of construction techniques was accompanied by large-scale recycling of building materials from ancient ruins. The townhouses and civic buildings of the Greek population of Bergama were erected upon the intellectual and material substratum of ancient Pergamon. They bear witness to a keen interest in the legacy of antiquity, which was most likely deepened by the German excavations beginning in 1870. Alongside the revival of classical building techniques, surprising innovations are also to be encountered, such as stone-iron bracing methods and adhesives that betray a boldly experimental approach within the building industry of the period. Sachiko Okada, Ichiro Kobayashi Department of Civil and Environmental Engineering, Graduate School of Science and Technology, Kwansei Gakuin University, Kwansei Gakuin City, Japan A Study on Distribution and Reuse of Tram Line Paving Stones in Japan Trams used to be seen in most major cities in Japan between early 1900 and the 1950s. Stone slabs were generally used for the track paving at the time. Since then, quite a few tramslines have fallen into disuse, and their slabs have been...
as it was reminiscent of cities in bygone days. Of use diversion, the texture of the old flagstones was popular among flagstones, they were sold and reused. According to one case study, re-use was a common practice. 3) As there was a large quantity of disused flagstones, they were sold and reused. According to one case study, re-use was a common practice. Therefore, the flagstones were a standard distribution product following three points on the distribution and use of the flagstones.

In the second part of the paper, a brief synthesis of the persistence of the perishable; wattle-and-daub architectures in the Roman period: a census of the archaeological findings in Gallia Cisalpina and the persistence of the perishable. The pre-Columbian site of La Joya, on the Mexican Gulf coast, is extremely valuable due to its size, antiquity and historical relationships, but above all, its building materials, because it was entirely built using raw earth, though located in an admittedly adverse environment for this type of building. However, ancient settlers developed strategies that made it possible for the city to remain standing through the first millennium A.D. During the 20th century, the site has suffered a dramatic process of destruction by brick manufacturers. This situation gave rise to an archaeological project that has produced hitherto unknown data about the construction of earthen living spaces that are remarkably adapted to their natural environment. The findings are important because there are no similar studies in this region; they provide knowledge about the effective use of raw earth that could support the design of new buildings to meet growing demands for housing.

This paper aims to provide a tool for a systematic study of perishable material building techniques in Northern Italy. The research considers findings from published excavations. This work identifies five different building techniques, where perishable materials are employed. The results are presented in synoptic tables relating the type of findings, place of discovery, archaeological context and chronology. This census is the first step in the analysis and understanding of construction methods of perishable material buildings. In the second part of the paper, a brief synthesis of the case of Mediolanum is presented: this work identifies five different building techniques, where perishable materials are employed.
In the winter of 1923, just after having finished university, Ulrich Finsterwalder entered the building enterprise Dyckerhoff & Widmann, which recently had developed a groundbreaking method for the construction of thin concrete shells. Within the company he soon established himself as the second driving force besides another mastermind: Franz Dischinger. In less than a decade, both engineers would provide the theoretical and practical basis that enabled thin concrete shell constructions to conquer the whole world. The article takes a closer look at their complicated collaboration. As a result, it aims to raise questions about originality and authorship in engineering – questions that normally are ignored in a research field whose objects of investigation usually arise from collaborative endeavors.

Maris Suits
Estonian Academy of Arts, Tallinn, Estonia
Reinforced Concrete Shells in Estonia during the Soviet Period: Science and Practice

This paper presents a discussion of the Estonian school of concrete shell research, led by Professor Heinrich Lau. The school was characterised by a strong experimental emphasis and a drive to practical application. New calculation methods were developed [e.g. the shear stress approximation method], which allowed engineers to determine [with relative ease] the forces present in a reinforced concrete shell. Experimentation on scale models was widely used in research. Paradoxically, although this scientific research was aimed at finding practical methods for engineers, only a few reinforced concrete shells were constructed in Estonia. The paper introduces the built shell structures and discusses the reasons why shells were inappropriate in Soviet Estonia.

Giovanni Fatta, Tiziana Campisi, Calogero Vinci
Dipartimento di Architettura, Università degli Studi di Palermo, Italy
Titled Works from Western Sicily: Originality and Continuity of an Imported Building Technique

The search for alternatives to wood for floorings has led to very interesting experiments on vaulted structures, with diffusion in specific areas. We analyze the Sicilian ones consisting of three layers of tiles with plaster, introduced in the mid-18th century, reintroduced with local materials and building culture, with original and ingenious solutions as to the seismicity of area. The oldest examples in Palermo date back to the period following the earthquake of 1726, considered a good solution because of their lightness and presumed monolithic structure, able to reduce the pressure on walls. This paper is an assessment of this building system, that we found during many restoration works. Totally ignored by official current technical culture, tiled vaults usually are demolished or transformed into decorative ceilings. A comparative examination of several cases has enabled us to properly assess the actual possibility for maintenance, rehabilitation or re-proposal, whilst preserving the structural function.

Thursday 5 July, 9:00-11:00
LA VILLETTE SITE, Room H2B

442. Natural & Technical Risk, Earthquake Design
Chair: TBA

Hélène Dessales
École normale supérieure, AOROC, UMR 8546, Paris, France
Not Built in a Day: Awareness of Vulnerability and Construction Techniques in Roman Times

This paper tackles two issues that have never really been raised before in the history of Roman construction. Firstly, we shall try to interpret the factors of architectural vulnerability as they are set out in a selection of different texts: literary narratives, inscriptions, juridical sources. Two major categories can be identified, the first is human, featuring construction mistakes that lead to architectonic defects; the second is natural, covering a variety of manifestations ranging from erosion to violent episodes such as earthquakes. Secondly, we investigate the reasoning added in the choice of construction techniques, which sought to avoid instances of fragility and ensure stability and durability of fabrisc and perpetuas.

João Caldas, Rita Lisboa
Instituto Superior Técnico–Universidade Técnica de Lisboa, Portugal
The Use of Vaults in the Reconstruction of Pombaline Downtown Lisbon

Usually, the system of construction used in the rebuilding of downtwon Lisbon after the Great Earthquake of 1755 is described as having vaulted ground floors. Some writers mention three types of structures used to support the first floor: vaults, wooden beams on stone arches and wooden beams supported just by pillars and/or walls. However, we still did not know whether the three types coexisted from the start of the reconstruction, or whether they resulted from the vicissitudes of construction methods over time. After our research, we may conclude that the three constructional systems coexisted from the outset. Moreover, differently from what was once presumed, the vault was the least used constructional system to cover the ground floor and support the first floor of rentable buildings in Pombaline downtown Lisbon.
Matteo Porrino
ENSAT Strasbourg/GSA ENSA Paris-Malaquais, Paris, France
Notes on Technological and Architectural Aspects of London Transport Power Stations and Substations, 1880-1915

Through the analysis of several London buildings, this text aims to highlight transformations in architecture and construction associated with the electrification of public transport and the creation of the London Underground at the end of the 19th century. Power plants, the shape of which crystallised in the form of juxtaposed twin halls, can be considered magnificent building exceptions – for their unprecedented steel frame, for example. They are also interesting as a starting point to reflect upon the functional limits of major installations on the edge of cities. During the same period, electrical substations were an exercise in reinterpretation and adaptation of industrial buildings to the existing urban surroundings both in terms of language, which goes from historicist eclecticism to architectural rationalism, and in terms of construction modalities, especially regarding the implementation of technologies aiming to reduce nuisances or the management of the life cycle of productive units.

Ted Shelton
University of Tennessee, Knoxville, TN, USA
The Highway Comes to the American City: Automobility, Urbanity and the Functioning of City Streets

Near universal individual automobility, when extrapolated to the scale of a city, overwhelms existing street networks and spurs the creation of dedicated urban highways. The search for workable urban highway typologies in the United States throughout the 20th century was burdened by a focus on the functioning of the system as a whole, romantic ideals of the rural highway and utopian ideals that largely discounted the functioning of the traditional city street. Accordingly, the resulting construction had profound and largely negative implications for the American city. This paper examines the pressures that led to the construction of American urban highway and chronicles the development of early and midcentury American urban highway typologies as well as strategies used in their construction.

Evelynia Chatzikonstantinou, Paschalis Samarinis
National Technical University, Athens, Greece
Areti Sakellarioudou
Rheinisch-Westfälische Technische Hochschule, Aachen, Germany
Road Construction in Greece during the Interbellum: The Makris Project

The paper discusses aspects of road construction in Greece during the Interbellum and it analyses the inscribed social and spatial ideas within road infrastructure planning and construction. It focuses on the most important national road scheme of that period, known as the Makris Project and it aims at contributing to the transnational discussion on mobility infrastructure construction through a site specific, spatial and sociotechnical approach. Geographical, economic and cultural asymmetries characterise the transfer and appropriation of technology; the cross-national process of technological circulation regarding road construction and the role of actors and networks as agents of change are the main theoretical starting points of the analysis. In this context, the paper is organised in three parts. The first one relates road infrastructure construction in Greece to other national traditions. The second narrates the chronicle of the contract, while the third canvases its spatial implementation.

Yuju Hoshino, Sachiko Okada
Department of Civil and Environmental Engineering, Graduate School of Science and Technology, Kumamoto University, Kumamoto City, Japan
Daijiro Kitagawa
The Agency for Cultural Affairs, Tokyo, Japan
Historical Research for the Planning and Construction of Misumi Port

The port of Misumi is one of the oldest Japanese modern ports, built by the initiative of the Meiji government. In spite of its historical importance chronologically speaking, the appreciations by historians are rather divergent: a beautiful masonry work realized thanks to the marriage of traditional and Western techniques, the badly selected site where commercial activities stagnate with the passing of years, etc. In order to validly define the historical value of this realization, this paper analyzes the archives, known or not, and clarifies the process and the ideas of the planning and construction of this port.
Thursday 5 July, 11:30-13:00  LA VILLETTE SITE, Room H10

303. Transfer of Knowledge, Colonial Situations 2
Chair: Margareth Da Silva Pereira, Universidade Federal do Rio de Janeiro, Brasil

Jorge Galindo Díaz
Universidad Nacional de Colombia, Manizales branch, Manizales, Colombia
Barbetti Serafín: Builder of Vaulted Bridges in South-Western Colombia [c. XIX]

During the second half of 19th century, in southwest Colombia, at least 30 arch bridges were built in brick, a complex structural typology that doubtless required an ensemble of specific technical knowledge for its execution. How was it carried out and was there one constructive tradition able to reach a maturity that allowed the achievement of works of significant importance? Through an investigative process that combined field work and documentary archives research, it was determined that the origin is in the figure of an Italian priest who arrived to Popayan City in 1859, and whose practical teachings to workers and local foreman served as a base in a process of singular technology appropriation. Through the historiographic report of the work of Serafín Barbetti and the analysis of his work positioning it among the technical culture of his epoch, his role was determinant as a transmitting agent of knowledge and the adaptations that made it successful. This work is framed in an investigation intimately connected with the history of the constructive technique and its mechanisms of assimilation and diffusion.

Hsin-Yao Hsu
Graduate School of Engineering, University of Tokyo, Japan

Most research concerning the modernization process of architecture in Taiwan during the Japanese colonial period tends to focus on the architects’ ideas and the transformation of the “architectural style.” In light of this, this paper shifts the focus of study to the “construction process” of government buildings that were the main constructions first performed under the “modernized” construction system. The purpose of this study is to try to shed light on the mutual interaction among all involved participants in the entire course of a building project, by analyzing the construction records retrieved from the Archives of the Bureau of Monopoly of the Taiwanese Government-General. A conclusion can be generalized that with greater power given on the construction site, the supervisor became the most crucial person in the building construction, which has consequently led to a construction site supervisor-based realization of design in the transitional period of modernization in Taiwan.

Thursday 5 July, 11:30-13:00  LA VILLETTE SITE, Room H11A

304. Rules & Standards, Specifications
Chair: Brian Bowen, Georgia Institute of Technology, USA

Beatrice Maria Fracchia
Politecnico di Torino, Italy
History of Construction in the 18th Century through the “Istruzioni” Written by Filippo Juvarra

Filippo Juvarra’s works are documented in “Istruzioni” [instructions], which prove the existence of a technological culture developed in the 18th century. The term “instruction” refers information issued by the First Architect who was in charge of all the architectural works commissioned by the House of Savoy. The content of this information highlights skills and practices of the entities involved in the technical aspects of construction sites. The instructions outline the relationships between professionals and workers on the site and they give us an insight into Juvarra’s planning skills and his construction techniques. The “Istruzioni” always contain sketches and drawings that complete the written description of buildings to be constructed on the site. These are useful in explaining Juvarra’s technical writings and drawings. This study is an essential aid in understanding the techniques that characterize the history of constructions in the 18th century.

Katie Lloyd Thomas
Newcastle University, UK
Describing Construction: Building Specifications and the ‘Process-Based’ Clause

This presentation explores the description of construction and materials in United Kingdom building specifications. Although there is some acknowledgement that a range of forms of description are used in specifications, the differences between them and the conditions which give rise to the various forms has yet to be investigated. Here, I focus on the ‘process-based’ clause, which details how materials and construction elements are to be made up. This form of specification appears in the late 18th century and reaches its peak in the 1960s before, with the rise of performance specifications, descriptions of process almost disappear, and this form of knowledge is no longer available. While to some extent the use of one form of clause over another is informed by the kind of material or process being prescribed, selection is largely determined by more general shifts in procurement, manufacture and contractual organisation. The history of construction, then, shapes the documents through which that history can be known.

Jeroen Cornilly
Catholic University of Leuven, Belgium
Contractors of 19th Century Public Works in Belgium: Looking for a Research Approach for the Rural Areas

In the course of the 19th century, public works strongly altered the image of Belgian villages. Rural communities outsourced their construction works to the private sector. Although not legally obliged, works were generally put up to public tender. In this practice, building specifications became crucial documents in the relation between the public client and the contractor of public works. The specifications also indicate that the contractors of public works in rural areas had to be able to execute the totality of the building project and that they weren’t necessarily recruited locally. They appear as a heterogeneous group of local craftsmen and general contractors, located in the city as well as in the countryside.
these books to discuss their origins, their aims and usefulness, useful, but orderly form. The aim of this paper is to dwell on building process by providing the necessary knowledge in a form the body of research in this field. The aim of the genre of handbooks on construction site supervision – novel transforming the structure of knowledge on building. The result of new and modified materials and building techniques; In the 19th century typical building processes changed as a Century Switzerland Institute of Historic Building Research and Conservation, ETH Zurich, construction of the cofferdams required to construct the new drawing of the construction of the Pont d'Orleans guided his in Belidor's Architecture Hydraulique Semple was unfamiliar with French. However, the illustrations and Serlio did not provide Semple with the technical advice between Ireland, England and France at this time. The traditional architectural texts of Alberti, Palladio, Scamozzi and Serlio did not provide Semple with the technical advice he needed, nor did visits to Labelye and others in England. Semple was unfamiliar with French. However, the illustrations in Belidor's Architecture Hydraulique [1753] and a perspective drawing of the construction of the Pont d'Orleans guided his construction of the cofferdams required to construct the new foundations for the bridge. Christoph Raubut Institute of Historic Building Research and Conservation, ETH Zurich, Switzerland Handbooks on Construction Site Supervision in the 19th Century In the 19th century typical building processes changed as a result of new and modified materials and building techniques; moreover, specialised craftsmen were increasingly required to execute work on construction sites. At the same time the process of scientification initiated within the polytechnic schools was transforming the structure of knowledge on building. The genre of handbooks on construction site supervision – novel for the time – reflects both developments. Sixty different German books on construction site supervision from the 1840s to the 1910s formed the body of research in this field. The aim of this book was to give guidance on an increasingly complex building process by providing the necessary knowledge in a useful, but orderly form. The aim of this paper is to dwell on these books to discuss their origins, their aims and usefulness, their dependency on the 'Praxis' and their inherent constraints. Emmanuelle Minnaert-Richomme Bibliothèque du CNAM, Paris, France The Conservatoire Numérique: A Reservoir of Digitized Resources for Construction History The purpose of this paper is to present the Conservatoire numérique (Digital Conservatory), that is to say the online heritage library of the Conservatoire National des Arts et Métiers, founded in 2000. The library now has 600 titles in French on the History of Science and Technology, published between the 16th and the 20th century. The CNUth follows the consultation of scholarly journals, catalogs of manufacturers, encyclopedias and monographs organized in thematic corporuses such as world fairs, théâtres de machines, electricity, construction history, etc... Thus, about a hundred books on construction history have already been digitized and put online, illustrating techniques for shaping territories, cities and architecture.
The use of reinforced concrete during the first decade of the 20th century is an important topic in Mexican architecture, especially considering that the first experiences with the Hennebique system were dated from 1892 and the later supplements made to them. Applying the methodology of an epistemic history of architecture and basing this study on the Mercato Orientale, a patented technology on site. 

Hermann Schlunme
Bibliotheca Hertziana, Max Planck Institute for Art History, Rome, Italy

François Hennebique’s Patents as Applied on the Building Site: The Mercato Orientale in Genoa [1896-1899] and the Creation of a Local Construction Network

This paper deals with François Hennebique’s patents for reinforced concrete dating from 1892 and the later supplements made to them. Applying the methodology of an epistemic history of architecture and basing this study on the Mercato Orientale, a patented technology on site. One aim, for example, was to reduce to a local context Hennebique’s mode to conduct international projects by correspondence.

Chair: Paul Acker, Lafarge, France

Thursday 5 July, 11:30-13:00 LA VILLETTE SITE, Amphitheatre 7

316. Reinforced Concrete, The Hennebique Companies

Chair: Paul Acker, Lafarge, France

Where the Hennebique system was used to achieve the longest reinforced concrete beam of that time in Mexican architecture.

Stephanie Van De Voorde
Ghent University / Centre for Flemish Architectural Archives [CVaA], Antwerp, Belgium

Rika Devos
Ghent University / University College of St. Lucas Architecture, Brussels, Belgium

The ‘Scientification’ of Reinforced Concrete in Belgium during the Interwar Period: Development and Dissemination of Scientific, Theoretical and Technical Knowledge

Through the work of François Hennebique, Belgium played an important role in the early history of reinforced concrete, yet forfeited this pioneer position when the theoretical dimension of the material was to be developed. Before World War I, Belgium contributed little to the theory of reinforced concrete, especially in comparison with nearby countries. It was not until the interwar period that the ‘scientification’ of the material did gain momentum in Belgium. Yet, despite the late start, impressive headway was made during the 1920s: Belgian engineers and industrialists in various fields: regulations; theoretical knowledge in academia, laboratories and professional organisations; specialized press; international conferences. This paper presents a detailed and critical analysis of this scientific activity and illustrates how the various fields were developed simultaneously and, consequently, interlinked and strengthened each other, mostly through the wide involvement of a rather concise number of engineers, scientists and contractors.

Mónica Silva-Contreras
Universidad Iberoamericana, Mexico City, Mexico

Belém Arme à in a Sinking City. Mexico 1902-1914

The use of reinforced concrete during the first decade of the 20th century is an important topic in Mexican architecture, especially considering that the first experiences with the material in Mexico City were contemporary with significant structural tests made in Europe and some other places by Hennebique representatives. Performance of new materials and critical analysis of this scientific activity and illustrates how the various fields were developed simultaneously and, consequently, interlinked and strengthened each other, most often through the wide involvement of a rather concise number of engineers, scientists and contractors.

Chair: Paul Acker, Lafarge, France

Thursday 5 July, 11:30-13:00 LA VILLETTE SITE, Amphitheatre 7

317. Metal Structures I

Chair: Werner Lorenz, Brandenburg University of Technology, Germany

Lara Slivnik
Faculty of Architecture, University of Ljubljana, Slovenia

A Prefabricated Cast Iron Three-Hinged Arch Bridge in Ljubljana

This paper is an overview of the Hradecky Bridge [1867] across the River Ljubljanica in Ljubljana, the first three-hinged arch bridge built in the Habsburg Monarchy and the oldest three-hinged cast-iron bridge in Europe [excluding the British Isles] still in use. The supporting structure is a prefabricated three-hinged arch with a total span of 30 m. It is made of cast-iron pipes that are joined together with screws to make one cantilever truss. Three cantilevers from one side of the bank are connected together with I beams and linked up with another three cantilevers from the opposite bank. Both groups of cantilevers are joined together at the crown of the arch with hinges. The prefabricated structure of the bridge permitted it to be moved three times to three different locations, each time bearing the same name, i.e., the Hradecky Bridge.

Volker Wetzk
Brandenburg University of Technology, Cottbus, Germany

Historic Bridge Bearings: Material Research on Cast Steel

This paper gives a review of the history of cast steel and presents results from material analyses performed on sliding bearings from the first decade of the 20th century. All bearings were made from cast steel, which had become the material predominantly used for bridge bearings by the end of the 19th century. The analyses provide insights into the metallurgical development for the practice of casting steel at the turn of the 20th century and yield a broader and more reliable base for the structural assessment of historic bearings still used in historic bridges.

Chair: Werner Lorenz, Brandenburg University of Technology, Germany

Bernard Espion
Université Libre de Bruxelles, Belgium

The Vierendeel Bridge at its Heyday: Rational Design, Experiments and Brittle Failure

The purpose of this paper is to document the evolution of the Vierendeel Bridge, from its inception in 1896 up to its heyday in the 1930s. The use of this kind of bridge, mainly in Belgium and Congo, matured very slowly between 1902 and 1930. However, the number of Vierendeel bridges increased very rapidly with the construction in Belgium, between 1932 and 1937, of more than 50 spans in steel, mainly welded. This was certainly favoured by extensive research efforts in Belgian universities with the structural analysis of this kind of girder and on the welding mode of the connection of steel elements. But the fast introduction of the new welding technology in bridge steelwork building led to the failure of the Hasselt Bridge in 1938 and to serious damages to at least two other Vierendeel type bridges in 1940. These accidents mark traditionally the beginning of the brittle failure story.

Volker Wetzk
Brandenburg University of Technology, Cottbus, Germany

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Keynote Lecture

Friday 6 July, 9:00-10:15     MALAQUAIS SITE [AMPHI BINET]

Antonio Becchi
Max Planck Institute for the History of Science, Berlin, Germany

Looking for an Equilibrium Point: A Moonwalk with Vitruvius and Gyro Gearloose

The talk investigates the ideas of ‘invention’ and ‘equilibrium’ in construction history, with particular focus on Vitruvius’ De architectura and on the Vitruvian tradition. We follow the historic evolution of two notions that encapsulate the tension between the attractiveness of ‘artistic’ liberty and the rigor of ‘scientific’ method. The history of construction includes a rich collection of ideas and debates on this topic; this talk presents some examples of the role played by ratio, cogitatio, inventio in the evolution of the idée constructive.

Sessions

Friday 6 July, 11:00-13:00    MALAQUAIS SITE

407. Applied Sciences 2
408. Structural Analysis & Modeling 2
419. Management of the Construction Site
421. Institutions
428. Mortar
429. Reinforced Concrete, Reception & Dissemination
435. Wood Structures 2
438. Interior Environment, Heating
The evolution of the theory of structures has a missing link: its relationship to practice in the first three decades of the 19th century. The publication of scientific literature about the theory of structures intensified in the years around 1800 and shortly afterwards. Bridge building is the forerunner and leads to the elaboration of new methods in dimensioning. Using archival material about the Berlin Bauakademie in the 1820s, this paper will show how, under the leadership of Johann Albert Eytelwein, new concepts of a theory of structures were firstly fully applied in teaching. The newly appointed professor Johann Friedrich Wilhelm Dietlein put the approach of uniting beam statics and theory of elasticity into practice. He gave examples of sizing wooden structures as in bridge calculation, bending of simple and continuous beams, and buckling. Eytelwein’s experimental data gave the basis for a safety concept.

Federico Foce
Dipartimento di Scienze per l’Architettura, Università degli Studi di Genova, Italy

Same Title, New Contents: Saint-Venant’s Revised Edition [1864] of Navier’s Résumé Des Leçons Sur L’Application De La Mécanique [1826, 1833]

Following previous papers on Saint-Venant’s early unpublished studies of applied mechanics, elaborated during 1837–1853, this paper will be devoted to the improvement given by Saint-Venant to the third edition [1864] of Navier’s Résumé des leçons sur l’application de la mécanique, first published in 1826 and reprinted in 1833 with few additions by Navier himself. Despite the great importance of Navier’s treatise and its international success, a comparison of the original textbook with Saint-Venant’s ‘revised’ edition shows the limits of the former through the advances of the latter. For the first time in the history of structural mechanics, Saint-Venant was able to transfer the fundamental results of the mathematical theory of elasticity from the specialized journals read by few scholars to the world of practical engineering. This paper will offer a synthetic sketch of this contribution, which still represents an exemplary case of the interaction between pure and applied sciences.

Andreas Kahlow
University of Applied Sciences Potsdam, Germany

Theory and Practice in Timber Construction 1800–1850

Guarini’s Flat Vaults and Thin Vaults on Wooden Beams in the Duchy of Modena

Guarino Guarini repeatedly insisted upon the originality of his own contribution on vault construction. Recent literature has generally confirmed his claim. However, less attention has been paid to the fact that he codified and improved construction techniques that were already very common and popular in northern Italy. His “flat vaults” and thin vaults on wooden beams in the Duchy of Modena – where Guarini came from – and Emilia offer a significant example. They clearly reflect a ‘know-how’ acquired with time, since the 16th century when more and more alternatives to timber floors were frequently proposed. In the same buildings – as in Correggio – it is possible to find flat vaults and more complicated and sophisticated versions of light vaults, built before 1730. In Guarini’s work this dualism arrived at a better synthesis, an original and cultured expression and, therefore, rightly “my own method.”

Carlo Bianchini
Dipartimento di Storia, Disegno e Restauro dell’Architettura, Sapienza-Università di Roma, Italy

The Role of Stereotomy in Guarino Guarini’s Space Research

This paper presents the work of Guarino Guarini in the fields of Stereotomy and Representation Geometry. Beyond his activity as an architect, in fact, Guarini should be considered as a versatile intellectual who discussed the above topics in two books (Euclides adauctus and Architettura Civile) which are complementary and together represent part of a modern Descriptive Geometry Treatise. In the former, Guarini discusses the fundamentals of geometric representation which, in the latter, become the tools for solving the problems of accurate intersection and unfolding concerning cylinders, cones, spheres, conesoids and other solids. This is why Guarini’s role should be considered one of the most relevant in the field of 17th century science, especially in that of Representation Geometry. In fact, his way of explaining and using orthogonal projections should be considered as a mature codification of common, well-known “technical” proceedings rather than a simple anticipation of Monge’s method.

Friday 6 July, 11:00-13:00 MALAQUAIS SITE, Room 103

407. Applied Sciences 2
Chair: Antonella Mastromarili, ENSA de Lyon, France

408. Structural Analysis & Modeling 2
Chair: Bill Addis, Co-Editor, Construction History, UK

Friday 6 July, 11:00-13:00 MALAQUAIS SITE, Room 206

Andreas Kahlow
University of Applied Sciences Potsdam, Germany

Theory and Practice in Timber Construction 1800–1850

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Dipartimento di Scienze per l’Architettura, Università degli Studi di Genova, Italy

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Friday 6 July, 11:00-13:00 MALAQUIS SITE, Room 308

419. Management of the Construction Site
Chair: Arnaudo Melo, University of Minho, Portugal

Raúl Romero Medina
Universidad CEU-Cardenal Herrera, Valencia, Spain

Manuel Romero Bejarano
Universidad de Sevilla, Spain

Building during the War of Granada: The Project for Reconstructing Fuengirola in 1485

In 1485 the Castilian troops conquered Fuengirola [Malaga]; it was then that the Catholic Monarchs commissioned the reconstruction of both the bastion and the town walls of the city of Jerez de la Frontera [Cadiz]. The local authorities sent a committee to evaluate the cost of the works in question, and a report with all the details was written. The information included in this document has allowed us to envisage those parts that needed to be reconstructed – using the formwork technique in the majority of cases. Furthermore, the record provides also detailed information with regard to the number of workers, materials, tools and specific utensils. The reconstruction was not carried out in the end due to financial problems, and the population in Fuengirola decreased dramatically; it was not until contemporary times that the area was populated again. The report gives us a clear idea of the way in which Christian buildings were edified by the end of the War of Granada and also of the manner in which Christians faced the Muslims using Moorish architectural elements.

Catherine Isaac
Université Toulouse II – Le Mirail, France

In 1782, Jean-Rodolphe Perronet [1708-1794], Director of the École des Ponts et Chaussées, criticized the "considerable expense" involved in building the bridge in Lavaur [1769-1791]. This paper focuses on a single building profession – the Institution of Civil Engineers – and considers how the institutional headquarters building located in Great George Street, London SW1, visually represents the authority of the profession and what meaning can be given to the “things” or “paraphernalia” contained inside. A relatively large number of primary sources can be found in the ICE archives on the design and construction of the headquarters building. These include original drawings, specifications, tender documents, correspondence, accounts, Building Committee and Council minutes, all made available by a welcoming and knowledgeable library staff. The paper considers the Great Hall of the Institution building and forms part of a wider study of the building that will be published shortly.

Christiane Weber
Karlsruhe Institute of Technology, Germany

Volker Ziegler
Universitätsarchiv Stuttgart, Germany

In 1884, the Institute for Materials Testing was established under Richard Baumann of the Stuttgart Polytechnical School. Under Richard Baumann and Otto Graf, the Institute for Materials Testing was quickly developed into one of the most important institutions of the National Housing Bank [Banco Nacional da Habitação]. Since the 1920s, Otto Graf’s role in that institution continuously increased. This contribution illuminates where and in what context the engineers of the Institute for Materials Testing were involved in national socialist planning. It therefore draws on material treasured in the Universitätsarchiv Stuttgart.

Alícia Gzowska
Institute of Art History, University of Warsaw, Poland

In post-war Poland, during a time of particular political, social and economic circumstances an unusual design office was created which gathered the best Polish structural designers. The Office for the Study and Design of Industrial Building Types [BISTYP] enabled the ambitious constructors and researchers a multilateral development opportunity by supporting and encouraging them to conduct research, experiment and implement the newest structural technologies in practice. A broad scope of issues and the atmosphere of close and creative cooperation with architects resulted not only in numerous interesting and innovative construction solutions for industrial objects, but also in spectacular public buildings, which thanks to their exceptional formal and construction qualities quickly gained appreciation. This paper offers an insight into the conditions and labour organisation of the BISTYP.

Ana Paula Koury
São Judas Tadeu University, São Paulo, Brazil

Brazilian Construction Center: Initiative for Management of the Brazilian Housing Construction Industry [1969-1972]

The current paper presents the creation context, objectives and actions of the Brazilian Construction Center [Centro Brasileiro da Construção], an institution geared towards the management of the Brazilian housing construction industry. The initiative, composed of technical institutions, plus industrial and financial sectors, allowed for a coordinated action performed by major players involved in civil construction oriented towards large-scale housing. This perspective was introduced mainly on account of the creation of the National Housing Bank [Banco Nacional da Habitação] in 1964. The study of this initiative allows us to revisit the part played by the state, class institutions, private enterprises, and technical staffs, with the objective of re-proposing the technical innovation agenda oriented to solving the housing problem, thereby contributing to building economic development and social alternatives within a context of returning to a nationwide development project led by the Brazilian state.

Friday 6 July, 11:00-13:00 MALAQUIS SITE, Room 306

421. Institutions
Chair: Tricia Meehan, ACS-ENS Paris Malaga/Malaga / UIUC-SAPV, France

Malcolm Dunkeld
London South Bank University, London, UK

The Great Hall of the Institution of Civil Engineers Headquarters Building

This paper focuses on a single building profession – the Institution of Civil Engineers – and considers how the institutional headquarters building located in Great George Street, London SW1, visually represents the authority of the profession and what meaning can be given to the “things” or “paraphernalia” contained inside. A relatively large number of primary sources can be found in the ICE archives on the design and construction of the headquarters building. These include original drawings, specifications, tender documents, correspondence, accounts, Building Committee and Council minutes, all made available by a welcoming and knowledgeable library staff. The paper considers the Great Hall of the Institution building and forms part of a wider study of the building that will be published shortly.

VOLKER ZIEGLER
Universitätsarchiv Stuttgart, Germany

Construction Material Testing at MPA Stuttgart during the Third Reich

In 1884, the Institute for Materials Testing was established by Carl Bich, professor of Mechanical Engineering at the Stuttgart Polytechnical School. Under Richard Baumann and Otto Graf the Department for Materials Testing quickly developed into one of the most important institutions of this kind in Germany. Since the 1920s, Otto Graf’s role in that institution continuously increased. This contribution illuminates where and in what context the engineers of the Institute for Materials Testing were involved in national socialist planning. It therefore draws on material treasured in the Universitätsarchiv Stuttgart.
60

Friday 6 July, 11:00-13:00 MALAQUAIS SITE, Lenoir 2

428. Mortar
Chair: TBA

Frédéric Davidovits
Geopolymer Institute, Saint Quentin, France
Geological Origin of the Reagents Constituting Roman Mortar, According to Vitruvius

It was established that the volcanic sands, around Rome, have physical properties that make them correspond to the harenae fossiculae described by Vitruvius [II, 4]. However, Vitruvius states that the best of all sands extracted from volcanic tufts is what he calls the tuft carbunculus “carboncle” or materia excocta, which is a “soft volcanic tuff calcined by underground fire.” He also claims that it is found geologically in Etruria, in the volcanic area located to the north of Rome. Vitruvius uses this volcanic sand exclusively for concrete masonry, whereas regular pozzolana from Napoli [puluis] refers to a pyroclastic rock traversed by formations called “fossil fumaroles.”

Barbara Thuswaldner
Institute of History of Art, Building Archaeology and Restoration, Department for History of Architecture and Building Archaeology, University of Technology, Vienna, Austria
The Use of Mortar in Late Hellenistic Construction: The Case of the Octagon in Ephesus

The use of mortar in combination with ashlar masonry during the Hellenistic and Roman period has been considered uncommon. The recent study of a tomb monument in Ephesus shows that probably mortar was already used in late Hellenistic times as a leveling course as well as an ashlar binding material. The technical construction of the walls of the cella was analysed by using a virtual stone by stone reconstruction of the entire building, which was compiled from 3D models of all remaining building blocks. According to the evidence derived from this reconstruction it seems very likely that mortar was used as a leveling course in its ashlar masonry. This paper will address these unexpected findings and furthermore tries to depict that mortar was also used in the context of various Late Hellenistic and presumably even older buildings due to efficiency reasons within the construction process.

Reinhard Heinz
Vienna, Austria
The First Verifiable Application of Cast Mortar in Prefabricated Construction in the Cofferered Ceiling of the Early Hellenistic Mausoleum of Belevi

The Mausoleum of Belevi is the first known example of the Early Hellenistic Mausoleum of Belevi. The creation of the mausoleum and its architectural design are related to the architectural style of the period. The mausoleum was built in the 5th century BCE and is located in the city of Verona, between the end of the 18th century and the beginning of the 19th century. The mausoleum is an example in hollow core slabs, whose elements are connected to a constructive unity with a circumferential grid, and where the weight is reduced by means of cavities. The application of such a mortar jointing technique is first evident at Belevi.

The offsetting of the blocks, and their dowelling, was only guaranteed, together with clamps and dowels a shear rigid construction, which found the ideal technique in reinforced concrete. This application was employed in all reinforcement lattices. This application was employed in all construction experience. As this happens, the production constructive types will be developed, was sustained on those prototypes, on scientific research on materials and on direct construction experience. As this happens, the production techniques of architecture kept changing. The evolution of concrete at the beginning of the second half of the 20th century will have an impact on institutions such as the Spanish Association of Prestressed Concrete [AEHP] created in 1949, the International Association of Prestressed Concrete created in 1951, or the International Association of Laminar Structures [IASS] chaired by Edoardo Torroja from the Technical Institute of Construction [ITCC] and founded in 1959.

429. Reinforced Concrete, Reception & Dissemination
Chair: Thomas Leslie, Iowa State University, USA

Cédric Avenier, Anne Coste
Laboratoire Cultures constructives, ENSA de Grenoble, France
Auguste Perret: The Grenoble Orientation Tower – Architecture, Art and the Press

The Orientation Tower of Grenoble is an important project in Auguste Perret’s career and also in the history of cement and reinforced concrete in France. The reinforced concrete tower of Grenoble was designed and built by August Perret for the 1925 International Exhibition on hydroelectric power and tourism. The main goal of this paper is to explain the way in which August Perret was awarded the contract for this project and why it is one of Perret’s favourite works, the first building he erected as an architect. This paper shows the particular role of art and literature critic Marie Dormoy, his mistress, at this particular stage of the architect’s career. It also shows the link between this project and the conferences on concrete and architecture that August Perret gave at this time.

Eduardo Currà
Department of Civil, Building and Environmental Engineering, University of Rome Sapienza, Italy
Manual Abilities and Modern Constructive Techniques in a Building by Arturo Hoerner: The S. A. Supertessile Plant and the System Baroni-Liling, Rieti, Italy, 1926

The study of the Supertessile complex at Rieti has brought to light the application of the Italian Baroni-Liling patent and some of its effects on the development of constructive techniques in reinforced concrete, especially in the field of the planning and construction of light components for large covered structures. A notable impulse towards the rationalization of construction can be attributed to this system and to its applications by the firm ing. H. Bollinger. Above all, this came about through the innovative system of spacing the reinforcement bars with bolts, to create semi-rigid reinforcement lattices. This application was employed in all of the pavilions of the Supertessile plant, perfectly integrated with the architectural solutions of the architectural designer Arturo Hoerner. His plan reinforces certain invariants shared with the architectural solutions of the architectural designer Arturo Hoerner. His plan reinforces certain invariants shared with modern architecture; for example, a plan simplified of ornamentation and qualified through the geometry of the construction, which found the ideal technique in reinforced concrete.
Friday 6 July, 11:00-13:00  MALAQMA site, Room 102

435. Wood Structures 2
Chair: James W.P. Campbell, University of Cambridge, UK

Zeynep Eres
Istanbul Technical University, Turkey
A New Approach in Studying the Structural Systems of Prehistoric Wooden Post Buildings: A Case Study from Aşağı Pınar in Eastern Thrace

A preliminary assessment of the structural details of the Neolithic architecture discovered at the prehistoric site of Aşağı Pınar will be presented in this paper. The site, located in Eastern Thrace, is considered as one of the major archaeological sites in understanding the transmission of sedentary village life from its homeland in Anatolia to Europe, via the Balkans. In their original homeland, Neolithic communities developed the basic principles of architectural structuring, developing from round hut-like structures to multi-story rectangular buildings. In the area of its origin, the main building material was stone or mud-brick. But while this new way of life was expanding to the Marmara region, they had to adapt to a new habitat. In particular, the region where Aşağı Pınar is located is within the forest zone and the new settlers had to develop new building strategies using wood and wattle. From the setup of the ground plan to the roofing every structural detail had to be adapted to the new building material.

Dietmar Kurapkat
German Archaeological Institute, Berlin, Germany
A Roof under One’s Feet: Early Neolithic Roof Constructions at Göbekli Tepe, Southeastern Turkey

The ongoing excavations at the site Göbekli Tepe in southeastern Turkey have revealed a number of monumental buildings, which were erected between the late tenth and early eighth millennium B.C. Some of these special buildings are much bigger than the usual Neolithic huts and houses and are equipped with monolithic T-shaped pillars. Not only for the history of construction but also in view of functional questions, it is an important matter of discussion whether these buildings were roofed or if they remained open to the sky. A detailed examination of all the archaeological data has led to the conclusion that most probably the buildings were covered by earthen roofs on wooden supporting structures. The key to the acceptance of this thesis is the convincing reconstruction of the construction design to span rooms of up to nearly 20 m. diameter with the means of early Neolithic craftsmanship.

Alexandra Harrer
Tsinghua University, Beijing, China
Fan-Shaped Bracket Sets and Their Application in Different Building Materials: A Discussion of the Chinese Fangmu Tradition and Jin-dynasty Tomb Architecture in Southwest Shanxi Province

It is a well-known characteristic of “non-timber architecture” in China, such as stone bridges, pagodas adorned with glazed ceramic tiles, or brick tombs, that they imitated their timber counterparts in a different material. The paper discusses the application, function and reliability of such “quasi-architectural evidence” and raises the question of possible deviation and distortion of the wooden sample. It specifically addresses the thrilling phenomenon of “fan-shaped bracket sets,” an unorthodox construction method that has been popular in Central China, Shanxi province since the 11th century, and explores their reflection in the Jin-dynasty brick tombs of the Du family in the southwest of the province. Whereas regular bracket sets usually consisted of bracket-arms that were perpendicular and parallel to the wall plane, such corbelled clusters added horizontally slanting brackets projecting at a 45 or 60 degree angle.

Christof Krauskopf
Brandenburg State Office for the Preservation of Monuments and Sites, Wünsdorf, Germany
Medieval Timber Structures in Eastern Germany: Archaeological Evidence from Eberswalde

Very few medieval timber-framed buildings survive in Brandenburg, the region around Berlin. The earliest known examples, which date to the 15th century, are from the town of Brandenburg on the Havel. New archaeological evidence is, therefore, of great importance to further research on medieval timber structures and building techniques. Eberswalde is built on waterlogged ground and well-preserved timber structures, dating from 13th century up until the 19th century, have been uncovered during excavations in the town. The analysis of over 1200 tree-ring dates has established an exact chronological sequence, and provided information about the lifetime of individual buildings and the reuse of timbers. The tool marks visible on many of the timbers, and the survival of various joints and fixings, provide details of woodworking and construction methods. The sequence of dates shows that the development of the town was accelerated by margrave Albrecht III at the end of the 13th century.
Friday 6 July, 11:00-13:00    MALAQUAIS SITE, Room 312

438. Interior Environment, Heating
Chair: Emmanuelle Gallo, HTTP-CNAM / ENSA Paris-Belleville, France

Lynne C. Lancaster
Ohio University, Athens, OH, USA.
Heated Vaulting in Roman Britain and the Invention of Hollow Terracotta Voussoirs

During the last quarter of the first century A.D. in Roman Britain, a new type of bath heating system was invented that included hollow terracotta voussoirs creating hot air channels within the vault. The invention of the new vaulting method can be traced to a particular group of tile makers around Chichester (on the south coast) due to the application of roller-stamped patterns on the tiles. Only a few whole voussoirs have been preserved, but a study of these along with the excavated bath plans show that the vaults were generally small [three to five m.]. Later examples of the voussoirs were made with thinner walls, and their use in large-spanned [nine to 13 m.] unheated rooms demonstrates that the hollow voussoirs were subsequently adapted into a structural device to reduce the lateral thrust of very large vaults, such as those at the Sanctuary of Sulis Minerva at Bath.

Rainer Atzbach
Aarhus University, Denmark
The Stube: Constructive Evidence for the Concept of a Smoke-Free Heated Living Room between the Alps and Southern Scandinavia

Based on archaeological evidence as well as written and pictorial sources, the project explores the spread of the tile stove and of a specific floor plan connected to it. In the North Alpine area, the tile stove was invented in the eighth century. Apart from convection air heating, this system provided the only possibility of a smoke free heated living room. The use of the tile stove spread towards the north and reached the southern Scandinavian region by the 12th century. In the Upper German speaking area, the tile stove was used from the 13th century in a characteristic floor plan, which consisted of the stove, adjacent kitchen, a central corridor and unheated chambers in three bays and two or three aisles, the so-called nine-fold floor plan. In contrast to the spread of the heating system, this floor plan only gradually was adapted in the Lower Mountain Range, northern Germany and southern Scandinavia by the 16th century.

Spyridon Papavasileiou, Magdalini Makrodimitri, James Campbell
University of Cambridge, UK
The Construction and Integration of Historic Heating Systems in Churches in the United Kingdom from the 17th to the Early 20th Century

The study of historic environmental systems in the UK prior to the introduction of air-conditioning in the 20th c. reveals outstanding innovations in the development of heating-systems and their adaptation to architecture. This paper attempts to clarify the range and history of construction, appendage and assembly of heating systems, from the 17th-early 20th century in the UK, using the church building type. The heating of churches remains largely unexamined in construction history, although it is rife with examples of profound ingenuity and innovation. A literature review has been undertaken, examining both primary and secondary sources but also historic systems still found intact. A revised classification re-assesses the localised and central heating categories by examining each system’s components, assembly and function. Conclusions highlight the importance for further research on the origins, effects and history of these developments.

Carlo Manfredi
Politecnico di Milano, Italy
Comfort versus Industry: Maintenance of the Royal Palaces of Milan during the 1860s

Despite the fast and widespread distribution of technical literature, technical knowledge is assimilated very slowly and in varying ways. This study is based principally on documents found in the State Archives of Milan and shows exact dates and phases of the building work developed and carried out on the Building Sites of Court Buildings and the royal palaces of Milan. In the mid-19th century, technology for buildings, heating, dwellings, factories and conservatories were well understood throughout Europe. Experimentation was focused on official buildings such as seats of political power, churches, hospitals, theatres, Lariboisière Hospital and the Palace of Westminster. An enormous number of buildings, e.g. those belonging to the Habsburgs, the Papal States and the southern Kingdom of Two Sicilies, founded by the House of Savoy after the unification of Italy, needed maintenance and renovation. A widespread program of maintenance work began and local supervisors were put in charge of the building sites.

Sessions
Friday 6 July, 15:00-16:30    VERSAILLES SITE

302. Construction History, Sources & Methods 1
305. Rules & Standards, Architectural and Urban Norms
308. Training & Education 1, Engineers
309. Technical Literature, Manuscripts
311. Craftsmanşhip & Technical Tasks
315. Metal
320. Prefabrication 2
The results of research conducted by the CNRS European research group "Ceramic Building Materials and New Dating Methods" are presented. We focused our studies on series of monuments constructed before 1000 A.D. in France and south-east England. They include ceramic elements such as bricks or tiles. These constructions are well known by archaeologists of the medieval periods, historians and art historians, but they were dated, in most cases, either by textual sources or by typology. Luminescence techniques [thermoluminescence and optically stimulated luminescence] and archaeomagnetism were employed to date brick production, in conjunction, with radiocarbon dating of charcoal found in mortars. Different practices were identified: reuse of materials, production of bricks ad novo, and association of reused and new ceramic elements in the same masonry. Dating bricks produced ad novo allowed us to refine or revise the building chronology. Dating mortar by OSL, as a direct access to information about construction is possible. Certain conclusions can be drawn about the construction systems used in that time, together with the complexity of the cases and how each approach contributes to the final result. Some case studies, taken from the research done in 2006 on the Sacre Monte di Ossuccio, a complex included in the UNESCO World Heritage List, will be presented to illustrate the application of methods such as topographic survey, Infrared Thermography, stratigraphy, field measurements, archival research and use of past construction manuals. The first case study will illustrate the analysis of an early 18th century stone and earth promenade. The second case study will show how active Infrared Thermography combined with the consultation of 19th century construction manuals revealed construction techniques used for the erection of the dome of one of the chapels in the complex.

The purpose of the paper is to present how high technological methods and more traditional research tools can be successfully integrated in the study of construction techniques and how each approach contributes to the final result. Some case studies, taken from the research done in 2006 on the Sacre Monte di Ossuccio, a complex included in the UNESCO World Heritage List, will be presented to illustrate the application of methods such as topographic survey, Infrared Thermography, stratigraphy, field measurements, archival research and use of past construction manuals. The first case study will illustrate the analysis of an early 18th century stone and earth promenade. The second case study will show how active Infrared Thermography combined with the consultation of 19th century construction manuals revealed construction techniques used for the erection of the dome of one of the chapels in the complex.
Structural engineering and economic growth among the civil

Between 1830 and 1865, engineers who were initially identified as state officials increasingly conquered the industrial private sector. Considering the case of Belgium in this period of transition, we will look at three specific tracks of knowledge transfer. In chronological order these are: educational institutes, professional associations and publishing journals. The first associations were indeed societies of alumni closely connected with particular engineering schools organised by the State and by other actors. Alumni journals constitute an important information source for the study of nineteenth-century engineers and engineering. For context, these journals will be compared to the Bulletin du Musée de l’Industrie, which developed a broader scope.

Mike Chrimers
Institution of Civil Engineers, London, UK
Short of Education or Short of Engineers: British Civil Engineering 1890-1910

Since the development of civil engineering as a profession in the late 18th century, the British practice-based approach to the formation of civil engineers has been regularly contrasted with the continental European, more academic approach. Many have alleged that the British approach contributed to slower economic growth in that country and less innovation. At the end of the 19th century, the Institution of Civil Engineers seemed to accept some of this criticism.

This paper aims to analyze the role and the importance accorded to architecture in the training of Italian engineers between the 19th and 20th century. Careful examination of teaching programs that professors – like Calderini, Muggia etc. – offered to young students, will emphasize the interest in the discipline of architecture and its history. The chair of Technical Architecture in the Application Schools for Engineers and in the Faculties of Engineering, testified to this attitude. It was, in effect, a teaching that was both technical and artistic. The teaching of the engineer Guerra in Naples [1920-1960] confirms this interest in architecture and in particular in the examples of the past. Constructive elements and technical aspects are often related to the history of architecture and to the practice of drawing. The paper aims to focus on the Italian teaching and pedagogy with particular emphasis on the period from the late 19th to mid 20th centuries.

Simona Tanti
University of Salerno, Italy
The Italian Engineers’ Architecture and Technique Training

De Fenestris: An Unpublished Treatise from the Mid 15th Century on the Construction of Windows and Stained Glass

The ms. Canonici Misc. 128 of the Oxford Bodleian Library preserves an unpublished treatise concerning the creation of windows and stained glass, entitled De fenestris, as part of a larger work called Thesaurus pauperum, an opera composed during the first half of the 15th century in the Veneto region, comprised of 15 brief texts regarding various artistic and artisan activities. Arranged in 21 recipes, the De fenestris addresses the production of various types of glass, describing the procedures of coloration in enamel and cold painting, production of pot-metal glass, the refring of painted glass, construction of windows utilising animal hides and paper, glass cutting and the production and soldering of metallic bands used to connect the panes. This contribution, in its presentation of the original treatise, is intended to offer an integral transcription, including philological-literary analyses and technical commentary and to present a synthetic comparison with other Medieval texts dedicated to the production of stained glass.

Francesco Menchetti, Laura S. Pelissetti
Faculty of Science and Architecture, Politecnico of Milan, Italy
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Friday 6 July, 15:00-16:30  VERSAILLES SITE, Room E251

311. Craftsmanship & Technical Tasks
Chair: Valérie Ngéré, ENSA-Paris-La Villette / HTTP-CNAM, France

Silke Kapp, Ana Paula Baltazar
Universidade Federal de Minas Gerais, Belo Horizonte, Brazil
Metropolitan Vernacular: On the History of Informal Construction in a Brazilian City

The expression ‘metropolitan vernacular’ stands for the contradictory synthesis of formal construction technologies and informal popular building practices, which characterises self-produced urban areas in developing-countries. Just like any vernacular, the ‘metropolitan’ is based on learning-by-doing, imitation and resources at hand, but its models and resources are found in an urban context, dominated by a highly profitable construction industry, which was always conceived against vernacular and even against traditional craftsmanship. The result is a bricolage from fragments of industrialised materials and techno-scientific knowledge. This paper describes a possible construction of the social and material history of this self-production of everyday spaces, based on documentary sources, broader interpretations of sociospatial processes, participant observation, and an ongoing collective project with residents of the favela Vila das Antenas. The aim of this history is to make its protagonists aware of the value of their own production of space.

Gülşah Çelik
Faculty of Architecture, Middle East Technical University, Ankara, Turkey

Chair: Karl-Eugen Kurrer, Ernst & Sohn, Germany

Friday 6 July, 15:00-16:30  VERSAILLES SITE, Room E217

315. Metal

Maxime L'Héritier
Institut de Recherche sur les Archéomatériaux-CNRS UMR 5060 Centre Ernest Babelon, Orléans, France

The restoration of the roof of the Salon carré in the Louvre, undertaken in April 2010 was an opportunity for a detailed examination of the 1789 metal frame. Designed by the architects Charles Axel Guillaumot and Jean-Augustin Renard, it is one of the oldest wide span metal structures still extant on site in France, and is made of wrought iron members filled with hollow terracotta dwarf stubs held together with plaster. Thus, under the traditional shape of a curb roof the structure is highly innovative and allows the creation of a wide skylight at the top of the roof. The choice of iron was also justified by economic considerations and by the desire for a “non combustible” structure. The frame of the Salon carré was presented as the adequate answer to the various problems of a museum, a place to exhibit in good conditions and to preserve works of art.
The fruit of an exceptional collaboration between an enlightened client [Eric Boisssonas] and an internationally renowned architect [Marcel Breuer], Flaine [1959-1988] is a unique example of the winter sports resort genre. At 1600 m., on a mountainside facing Mont-Blanc, it is emblematic of the triumph of modernity in the France of the 1960s. Known for the excellence of its ski slopes, Flaine has been disparaged for the béton brut of its architecture, which echoes the major housing projects built around the country during the same period. The connection is entirely pertinent, since the ski station was built using the same heavy prefabrication systems used in the building of mass housing. An atypical choice in the history of the winter sports facility, the technique simplified site and project organisation on a scheme of such varied technical achievement and enabled huge façade panels in relief to be developed, which quickly became a Breuer trademark.

Yvan Delemony
Ecole Polytechnique Fédérale de Lausanne, ENAC - LA-TSAM, Switzerland
Flaine: Mountain City: The Building of a High Altitude Citadel

The large formwork pieces, shaped with three-dimensional curved boards and the positioning of the reinforcement for the enclosing pillars were made entirely in a workshop and were then erected on site.

Sonja Hnilica, Markus Jager
TU Dortmund, Germany
Competing Building Systems: Post-War University Architecture in the Ruhr Area

Today, three universities exist in the Ruhr area with about 90,000 enrolled students and all were founded and built between 1960 and 1985. Designed as universities having undergone reformation, manifesting equal opportunities for study for all young people, extraordinary efforts were necessary to implement an ambitious building program. An enormous construction volume, planned in a very short span of time, was built at considerably low costs. The university buildings in Bochum, Dortmund, Duisburg and Essen are perfect examples for retracing the rise and fall of building systems types. Whereas in Bochum an international competition resulted in building a monumental prefabricated megastructure, other universities had to be content with a much more modest architecture. Different building systems were tested, culminating in the development of the building system titled “NRW 75.” This system was used for planning and building the TU Dortmund and The University of Essen. In the End, the newly developed system was discontinued in Duisburg before it was completed.

Maite Palomares Figueres, Jésica Moreno Puchalt, Veronica López Pulido
Polytechnic University of Valencia, Spain
Architectural Expression in the 60s and the Prefabrication of Formwork

In the 1960s, the technology of reinforced concrete provided highly expressive architectural solutions linked mainly to laminated structures. However, although less common, we can also cite several particular cases of framework structures where the expressiveness stems from both the material chosen and the ingenious design of the structural solution. This is so in the case of Santa María del Mar church in Jávea (Spain), built in 1963 and undertaken by the GO.DB. Arquitectos, with the roofing being reminiscent of Le Corbusier’s Notre Dame du Haut chapel.

Formworks moulded the shape and lent expressiveness to the new material, a detailed study of their geometries and individual pieces being required, which involved a painstakingly precise constructional system. In Jávea, moreover, the formwork system required a particular
The Louvre Museum possesses an interesting set of foundation deposits of various types and spanning a number of periods, most of which are housed within two departments of the Museum, especially in the Department of Oriental Antiquities (Oriental Antiquités). These foundation deposits from the Department of Oriental Antiquities relate principally to Mesopotamia and Persia, upon which this paper is also focused. Specimens currently on display in these rooms are analysed, by means of a tour of the following five circuits: 1) The first foundation documents: the archaic and early Dynastic period [Room 1]; 2) The art of the foundation documents at the time of Gudea of Lagash, Second Dynasty [Room 2]; 3) The continuity of the second millennium B.C. [Room 3]; 4) Assyrian contributions to Mesopotamian tradition [Room 4], and 5) The Mesopotamian influence on the Iranian area [Rooms 8, 9 and 10].

Dirk Bühlér
Deutsches Museum, Munich, Germany

Museums and their collections can represent an inestimable source for research on construction history. One of the most comprehensive collections of objects and documents dealing with construction techniques and their history is registered with the Deutsches Museum [Munich, Germany]. Ever since it was founded in 1903, the museum has been collecting related to construction technology in general and their applications in civil engineering and architecture [currently 2,613]. The main construction materials, their production and use are illustrated by the necessary testing devices, production methods, possible applications, surface treatment and final implementation in buildings. This paper focuses on the objects, models, dioramas and paintings in the collection of the Deutsches Museum that relate the development of the cement and concrete industry and technology and interprets it in the context of the history of construction.

Friday 6 July, 16:50-18:20
VERSAILLES SITE, Room E226

Guy Lambert
ENS Architectures Paris-Belleville / HTTP-CNAM, Paris, France
“Purpose” and “Means” of Architectural Design: Construction in Julien Guadet’s Teachings in Architectural Theory

This paper aims at examining the importance taken by construction’s principles in Éléments et théorie de l’architecture [1901-1904] a textbook based on Julien Guadet’s teaching at the École des Beaux-Arts of Paris. It is closely related to the way in which Guadet considers a course in theory for pupils/architects, which had to stick to “the uncontested.” In the filiation of the course taught by Léonce Reynaud, while teaching the elements of architecture, he gave special attention to construction. The biased system of the École, where architectural competitions generated a “worship of hugeness” among the students, engaged Guadet to focus on what was “constructible.” In addition to his will to transmit the rules of ordinary construction, he wanted to show that the logics of construction, legitimized by practical considerations such as economy and durability, should rule over architectural design.

Valérie Nègre
ENSA Paris-La Villette / CNAM- HTTP, Paris, France
Oral Transmission and the Use of Models in the Teaching of Architecture and Construction at the Turn of the 19th Century

The use of models in lectures on architecture isn’t very well known. But like drawings and images, models were used to mediate between verbal description and reality. As these disappeared, so too did a representation of materials that complemented oral communication, which photographs or slides did not replace. Subsequently, with the growing importance of lectures and due to their very nature, the teaching of architecture in French schools inexorably turned towards abstraction. This paper will address the question by examining what types of objects were used in teaching architecture and construction at the turn of the 19th century, how these were handled and the reasons that led to using them.

Amparo Graciani
University of Seville, Spain
Mesopotamian Foundation Deposits in the Louvre Museum

The object of study of this paper is the construction work of Ilha Solteira Hydroelectric Plant, built in Brazil between 1965-1974. This paper seeks to analyse the construction site as a historical document. The goal is to examine the process of production and work in construction as a field of reflection of ways to rationalise work in the “construction site form of production” of a large-scale construction. To this end, the rationalisation of work at Ilha Solteira was analysed examining each work site and the general production flow. It was found that in Ilha Solteira the form of production combines different stages of division of labour, which indicates how the contradiction between “backward” and “modern” aspects, present in the modernisation of the construction process. For example, he studied materials and devoted himself to the different parts of structures such as bridges or an atypical and specific theme of construction: the way to rebuild underwork. In fact, while he had a really practical conception of architecture he attempted, at the same time, to follow an old theoretical approach [Vitruvius, Palladio] and he is the first French theoretician to pay so much attention to those subjects. Outside the academy, La Hire’s lessons on construction had a real posterity: La Hire’s plan and sometimes words were picked up in Architecture moderne ou l’art de bien bâtir..., Patte also, in Blondel’s Cours d’architecture [1771-1777], retook La Hire’s ideas and added innovations at the same time. But La Hire is the only one who explained hydraulics, bridges and the way to rebuild underwork for example. So, La Hire’s lessons are a very important landmark to understand the most important and famous lessons on construction of the 19th century.

Carolina Heldt D’Almeida
Instituto de Arquitetura e Urbanismo da Universidade de São Paulo (IAU-USP), São Carlos, Brasil
Analysis of the Construction Site as a Historical Document of Its Production Process

Friday 6 July, 16:50-18:20
VERSAILLES SITE, Amphitheater 217

301. Construction History, Sources & Methods
Chair: João Mascarenhas-Mateus, CES-University of Coimbra, Portugal

307. Training & Education 2, Architects
Chair: Robin Middleton, Columbia University, USA

João Mascarenhas-Mateus
The Teaching in the Académie Royale d’Architecture

In 1698-1699, 1705-1706 and 1714-1715, Philippe de La Hire gave lessons on architecture [Traité d’architecture] in which he discussed and analyzed all the elements and steps of the construction process. For example, he studied materials and devoted himself to the different parts of structures such as bridges or an atypical and specific theme of construction: the way to rebuild underwork. In fact, while he had a really practical conception of architecture he attempted, at the same time, to follow an old theoretical approach [Vitruvius, Palladio] and he is the first French theoretician to pay so much attention to those subjects. Outside the academy, La Hire’s lessons on construction had a real posterity: La Hire’s plan and sometimes words were picked up in Architecture moderne ou l’art de bien bâtir..., Patte also, in Blondel’s Cours d’architecture [1771-1777], retook La Hire’s ideas and added innovations at the same time. But La Hire is the only one who explained hydraulics, bridges and the way to rebuild underwork for example. So, La Hire’s lessons are a very important landmark to understand the most important and famous lessons on construction of the 19th century.

Hélène Rousteau-Chambon
Université de Nantes, France
Teaching Construction in the Académie Royale d’Architecture

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The paper identifies key characteristics of the development of building labour in Britain at different historical stages, pointing also to the sharp disparities between a socially regulated and unregulated wage, collective versus individualised employment relations, and comprehensive versus trade-based training. It focuses on the post Second World War period, showing how within each stage different labour processes co-exist. This is evident in the final product, as shown in the building of key construction projects – including the Barbican, Stevenage New Town and Sizewell.

What stands out is the continued trade-based character of the construction labour process in Britain, conceptualised in relation to a range of tasks in the workplace and to work entailed in this work was unrecognized. That many were already trained in existing building categories of analysis. In the industrialised countries of the 20th century, labour relations were divided between the socialist and capitalist systems, the present economic crisis and political uprisings have alerted us to rethink our categories of analysis. In the industrialised countries of the 20th century, labour relations were divided between Capitalism and Socialism. After World War II, this division took the form of the iron curtain between these camps of the Cold War. For the span of 40 years, this curtain split Germany and its capital into two separate states. Nowhere can the two modes of production under socialist and capitalist regimes be better compared than in this country, and construction provides visual testimony of this crucial period of history. In hindsight, we observe not only the contrast between these contradictory modes but also what they contributed to the common global development.
Laura Balboni, Paolo Corradini, Angelo Landi  
Politecnico di Milano, Italy  
Artificial Light in the Aristocratic Palaces in the Po Valley between the 17th and 18th Centuries

The research is focused on a careful analysis of several aristocratic palaces in northern Italy between the 16th century and the first half of the 17th century; in this period a great increase in the use of artificial light in the state apartments was found. The architectural projects began to involve the effects of the artificial light in the inner halls; in this respect, the comparison between the analysis of the documents and the examination of the material traces allow the orchestra. The comparison between the analysis of the structures supporting the chandeliers and the systems of ventilation are reinterpreted. Sometimes, in order to fix more lighting devices in the halls, the architectonic structures were adapted with projecting balconies or platforms for the orchestra. The comparison between the analysis of the lighting devices in the halls, the architectonic structures was found. The architectural projects began to involve the increase in the use of artificial light in the state apartments.

Giulio Sampaoli  
Accademia di Architectura, Mendrisio, Switzerland  
Artificial Light in Architecture in France and Italy during the First Years of the 20th Century: From Gas Light to Electric Light

Architects have always been attentive to the use of natural light in design, but rarely to the qualities that artificial light can confer on a work of architecture. Only in the late 19th century, slowly but progressively, did artificial lighting, first provided by gas and then electricity, pass from being a luxury for the few to a utility available to everyone and necessarily altering architectural development. While gaslight in the 19th century influenced the perception of interior design and released society from dependence on sunlight, after 1870 the development of electricity and the steady spread of electricity for civil uses in Europe led to a true evolution of lighting and then of architecture itself. With electricity providing "clean" illumination, it was possible to vary the distribution of light, so that it gradually became the new 20th century “building material” which, though the intangible, enhances the functionality and appeal of architecture.
Carla Maria Amici
Università del Salento, Lecce, Italy
A Cloaca Maxima in the Roman Town of Privernum, Lazio, Italy: The Project, the Plan, the Construction

The recent excavation of a Roman republican town, Privernum, 90 km south of Rome, has allowed the discovery and the investigation of a channel more than four m. wide, with vaulted roofing, preserved for about 200 m. This waterway, surely the result of straightening a former stream, represents the main sewer of the Roman settlement, dating back to the middle republican period; the intention is to excavate and restore it so that it can be used to drain the archaeological area. The intervention, still in progress, has made possible an accurate examination of the building technique and construction process of the channel. It reveals a design integrated directly into the central part of the town; the need to fix exactly the relation between the channel and the urban planning, which was clearly affected by the layout and the orientation of the conduit, suggests the existence of a master plan.

Rosana Muñoz
Federal University of Bahia, Salvador, Brazil
The Most Important Construction in Bahia’s 19th Century History: Salvador’s Mountain Retaining Wall

The City of Salvador was founded in the 16th century on the high cliff escarpment of a geographic fault. Although this topography provided an ideal position to defend its urban perimeter against occasional enemies arriving via the Todos os Santos Bay, it also served to create a disaster zone, due to its subsequent landslides. In the 19th century, this cliff escarpment was called the Mountain and it divides the city into two parts: the Upper City and the Lower City. It was not until the mid-19th century that the government began to deal with this potential threat through the construction of a gravity retaining wall, known as the Mountain Retaining Wall. Today this remains the most important structure ever designed to stabilize the city slopes. The aim of this study is to describe the history of this construction, addressing its plans, materials, techniques and related difficulties.

Davide Del Curto, Francesco Carlo Toso
Politecnico di Milano, Italy
Technical Systems and Networks for a Modern High Altitude Settlement: The Construction of the Sanatorium Village in Sondalo [1932-1946]

The Sanatorium Village in Sondalo in the Valtellina valley, Lombardy region, was built by the national institution for social security [I.N.F.P.S.] between 1932 and 1946 on completion of the national scheme for the building of sanatoriums. The autonomous urban and functional program establishes a problematic technical relationship with the alpine and inhabited context in which the complex was built. The paper focuses on the design of distribution networks and technical systems [road system, underground facilities, water supply, sewerage systems] that make the Village a unique achievement among European sanatoriums during the interwar period. Cable cars connected the single pavilions to the main services building, which accommodated the shared facilities and whose parts had to operate simultaneously. The unity of the architectural and technical devices design is nowadays the main reason for the technical difficulties and uncertainty in the redevelopement of the complex, which during the postwar period progressively fell into disuse for anti-tuberculosis care.

Keynote Lecture
Saturday 7 July, 9:00-10:00
MALAQUAIS SITE [AMPHI BINET]

Susana Verdi Webster
Jane Williams Mahoney Professor of Art History and American Studies, College of William and Mary, Williamsburg, VA, USA
The Secret Lives of Buildings in Colonial Quito: People, Processes and Cultural Optics

This talk is about vision, visibility and cultural optics; it posits that, in many cases, how buildings are perceived within a historical context depends upon who is doing the looking. As a case study, this talk focuses on the people and processes—both Andean and European—involved in architectural production in colonial Quito (Ecuador). In order to chart the largely unseen construction history of monumental buildings in the colonial city, my approach combines historiographical analyses and expanded perspectives with extensive documentary evidence from archives and colonial chronicles. Systematic analyses and close readings of these sources substantially revise modern accounts of the authorship, chronology, interpretation, reception, and diffusion of Quito’s monumental colonial buildings, and suggest new avenues of approach for understanding architectural production within colonial contexts.

Closing Discussion
Saturday 7 July, 12:30-13:30
MALAQUAIS SITE [AMPHI 2]
Paula Fuentes
Universidad Politécnica de Madrid, Spain

The Islamic Crossed-Arch Domes in Cordoba: Geometry and Structural Analysis of the “Capilla de Villaviciosa”

Crossed-arch domes are a singular type of ribbed vault. Their characteristic feature is that the ribs that form the vault are intertwined, forming polygons or stars, leaving an empty space in the centre. The earliest known vaults of this type are found in the Great Mosque of Córdoba, built ca. 960 A.C. The type spread through Spain, and the north of Africa in the tenth to the 16th centuries, and was used by Guarini and Vittone in the 17th and 18th centuries in Italy. However, it was only used in a few buildings. Though the literature about the structural behaviour of ribbed Gothic vaults is extensive, so far no structural analysis of crossed arch domes has been made. The purpose of this work is first to show the way to attack such an analysis within the frame of the Modern Limit Analysis of Masonry Structures and then to apply the approach to study the stability of the dome of the Capilla de Villaviciosa. The work may give rise to a new branch of research in the field of architecture in a period of transition from medieval to modern times.

Foud Ghmori
Abooubekei Belkaid University, Tiemcen, Algeria

The Minaret of the Mosque of Mansourah: A Half-Ruin Elucidated

This study concerns an emblematic monument of the city of Tlemcen [Algeria]. This is the half-ruined minaret of the mosque of Mansourah, built in the medieval era [early 14th century] in the city of Tlemcen and classified as National Heritage in 1900. This great architectural Merinid minaret, erected over the transept of the cathedral, is a two-bodied octagonal masonry prism on conical pendentives topped with an octopartite brick vault on stone ribs. Its verticality and slenderness, together with an apparent lack of buttresses and an elaborated open tracey, confers on it an airy character that greatly contrasts with the heaviness of the cathedral fabric. After presenting a historical outline of the cathedral works, the article analyzes the lantern’s geometrical configuration comparing it with the description provided by early 18th century author Vicente Tosca and with other modern sources. Considerations are made regarding the materials, construction methods and elements that configure the fabric to finish with an analysis of its stability. To this aim, an equilibrium approach within the theoretical framework of the lower bound limit analysis is adopted.

While falling, the latter will break out the southern and lateral sides halfway. The collapse occurred in a way as to have as an epilogue the same rupture line as the minaret. This allowed not only to confirm our baseline scenario but also to understand the collapse process in the emblematic half-ruined minaret.

Maria Teresa Como
Università degli studi San Oronzo Benincasa, Naples, Italy

Structural Devices Concerning the Progressive Outer Shell Construction in Brunelleschi’s Dome

This study, through the interaction of analysis of sources and investigation of aspects of construction, statics and form, examines the initial construction phases of the S. Maria del Fiore dome which led to the building variations of the new program of January 1426 which resolved the realisation of semi-arches to be set among corner and middle ribs. The analysis highlights the essential static role of the mentioned constructional device, which together with the herringbone and the corda blanda, allowed the construction of the dome structure without the centering engendering the structural system of the rotational dome during the raising of the dome construction.

José Antonio García Ares, Ignacio Javier Gil Crespo
Polytechnical University of Madrid, Spain

The Ciborium or Lantern Tower of Valencia Cathedral: Geometry, Construction and Stability

Dating from the first half of the 15th century, this unique gothic lantern, erected over the transept of Valencia Cathedral, is a two-bodied octagonal masonry prism on conical pendentives topped with an octopartite brick vault on stone ribs. Its verticality and slenderness, together with an apparent lack of buttresses and an elaborated open tracey, confers on it an airy character that greatly contrasts with the heaviness of the cathedral fabric. After presenting a historical outline of the cathedral works, the article analyzes the lantern’s geometrical configuration comparing it with the description provided by early 18th century author Vicente Tosca and with other modern sources. Considerations are made regarding the materials, construction methods and elements that configure the fabric to finish with an analysis of its stability. To this aim, an equilibrium approach within the theoretical framework of the lower bound limit analysis is adopted.

Arturo Zaragozá Catalán
Academia de Bellas Artes de San Carlos de Valencia, Spain

José Calvo-López, Pau Natividad-Vivó
Universitat Politècnica de Catalunya, Spain

Stereometric Exchanges between Iberia and France in the 16th Century: Benoît Augier, Valencian Staircases and the Escalier de Toulouse

One of the main archetypes of French stereotomy is l’escalier de Toulouse, a lost staircase in the Capitole, or town hall, built between 1531 and 1542 by Sébastien Bougereau from drawings by Benoît Augier. Jean-Marie Proust de Montclos and Bruno Tolton remarked that Bougereau had previously worked in Spain; recent research has shown that a Benet Augier was also active in Reus and Ontinyent, in Eastern Iberia. After a brief account of the Spanish work of Bougereau and Augier, this paper analyses a number of Spanish staircases, focusing on an example in Ontinyent. Next, it examines the Toulouse staircase, using as source material a number of drawings and photographs taken just before the demolition of the piece in 1885. The paper ends by discussing the implications of these examples in the broader picture of stereometric exchanges between France and Iberia.

Hentie Louw
SAPI, Newmark University, UK

‘Machine pour ouvrir une fenêtre par contre-poids’: A Case Study Revealing the Nature of Invention and Innovation in Late-17th Century Northern European Architecture

The paper concerns an anonymous design for a counterbalanced vertically sliding wooden window, now known as the ‘sash window,’ found in the drawings collection of the French Huguenot architect/engineer, Jean de Bodt [1670-1745], in S.L.U.B Dresden. The drawing is attributed to Bodt and assumed to be for one of his Berlin projects of the fi rst decade of the 18th century. With reference to previous response to historical fenestration, the author argues that this is in fact a French drawing of the mid-Louis XIV period – probably a lost ‘invention’ of the architect/scientist, Claude Perrault [1613-1688] – which may have served as a model for the ‘sash window’ depicted in a novel window type in Prussia where Bodt settled in 1699. The paper explores issues related to innovation and technology transfer in the fi eld of architecture in a period of transition from medieval to modern industrial practices.

Fabio Tellia, Jose Carlos Palacios Gonzalez
Escola Técnica Superior de Arquitectura, Universidad Politécnica de Madrid, Spain

The Spanish Vaults in Joseph Ribes’ Llibre De Trassas De Viacs Y Muntea

The determination of the surface cladding of architecture often resulted from the availability of constructive techniques and materials as well as the cultural and social perspectives that architects sought to express, while the latter element is sometimes potentially more crucial. In this paper, the skenomorph link between structural brick and ornamental tile for the surface cladding of constructive elements and buildings in the westernised Far East is the focus. The social and cultural perspectives will be considered in significant examples, since these perspectives have strongly affected this structural morphology. This practice contained the diffusion and transfer of knowledge and of political power. Several architectural projects are examined in order to illustrate how these influences have played significant roles in the cladding of constructive elements, that is, walls, in the construction history of the westernised Far East.

Linnea Rollenhagen Tilly
HYP-CNAM, Paris, France

Knowledge of Architecture and Building Technologies in 18th Century Sweden

Two unpublished manuscripts of Carl Johan Cronstedt [1709-1777], superintendent of the Royal buildings in Sweden [1753-1767], record his use of his collection and library. These illustrated texts give new insights into the culture and the view upon building technologies and architecture in 18th century Sweden, and are considered as models by a Swedish architect, and their adaptation to the Scandinavian climate and building traditions. Through a selective bibliography and a modern footnote system, it is possible to follow not only Cronstedt’s readings, but also his personal observations and experiments – first as a young student travelling through Europe [1732-1737], then as an active architect at the Swedish Superintendency [1737-1767]. Classified according to subject areas, these manuscripts reveal the main concerns for a Modern architect-engineer which range from the aesthetical aspects of architecture, through technical issues, to a broader interest for urban infrastructures.
Roberto Eustaáquio dos Santos
Universidade Federal de Minas Gerais, Brazil

The Plot of Concrete in Brazil: A History of the Technology Diffusion of Reinforced Concrete

Drawing upon a socio-historical view, this paper analyses the spreading of the building system of reinforced concrete and the development of its hegemony, in order to disclose the related network of influences [technical, economical and political]. It describes the main agents of such hegemony from the middle of the 20th century until the end of the 30s: campaigns for professional affirmation and organisation of architects and engineers; academic reform; proliferation of consultancy and projects of architecture and engineering; creation of the Brazilian Standard Association and its first technical standards [which in fact concerned concrete]; reforms of urban regulation allowing high-rise buildings; industrialisation of civil construction; and, finally, an intense advertising campaign of the cement companies. Thus, this paper questions the belief that the intense use of concrete happens due to its structural performance, plastic qualities, and logistic and economic advantages.

Ricardo Tolosa, Jorge Galindo Díaz
Universidad Nacional de Colombia, Manizales branch, Colombia

Construction of Railway Workshops in Colombia during the First Half of the 20th Century: A National Engineering Triumph

This paper illustrates a technical debate regarding the construction project of the Chipichape Workshop of the Pacific Railway in Cali [Colombia] during the late 1920s and early 1930s. The Colombian government, of conservative ideology, projected the construction of the said shop with technical support from British mechanical engineer Paul C. Dewhurst and the German company Gutte Heffnings Hütte, which generated strong opposition from Colombian engineers, backed by liberal politicians. Finally, it was decided that Colombian engineers would execute the construction stemming from some prior experiences obtained in the construction of similar scale workshops from masonry walls and metallic and wooden roof structures. The paper show the technical debate that emerged during the phase prior to the construction process and covers the construction work [systems, materials] carried out, without leaving aside the biographical and professional training data of the Colombian engineers who actively participated in directing the construction work.

Christel Frapier
Architectural Historian, Paris, France

Conceiving the Industrialization of Construction in France in the 1950s

After World War Two, France, like many European countries, faced an unprecedented housing shortage. Experiments carried out by the Ministry of Reconstruction and Urbanism failed to nip the housing crisis in the bud. France’s commitment to the Marshall Plan in 1947 required an overhaul of its production methods, involving radical shifts in social attitudes and mentalities. The field of housing construction underwent great transformations, affecting architectural planning and on-site practices. To understand this evolution, we shall review the ways in which various French construction agencies imagined the industrialization of their trades. We shall demonstrate that the choices made were the result of international deliberation. We shall also examine the role played by leading engineers and architects in taking these decisions. Lastly, we shall observe how the pioneers of industrialization coped with the confrontation between their ideals and the reality of the construction sites.

Felipe Contier, Renato L.S. Anelli
Instituto de Arquitetura e Urbanismo da Universidade de São Paulo, São Carlos, Brazil


This paper presents a study about the construction history of the building of Faculdade de Arquitetura e Urbanismo of the University of São Paulo [FAU USP] that took place between 1961 and 1969, a troubled period in the political and cultural life of Brazil. It is a relevant building to modern Brazilian architecture, designed by the architect Vilanova Artigas [1915-1985]. We seek to analyze in what way his conception of architecture is related to the construction processes of the period and guides a production, which is congruent with a national political project. The research is affiliated with new historical studies of Brazilian architecture, to which the understanding of the constructive process is part of the research method. The analysis of the architectural decisions, both in the project and in the work in progress, demanded a wide documentary research [projects, documents, contracts, testimonies, photographic records] covering multiple agents [designers, contractors, builders].
the buildings is characterized by just this connection between specialized companies in Italy to participate in the private solution compared to the local building culture, so much so load-bearing walls with reinforced-concrete subfloors precise indications concerning the construction method: The preliminary plan drawn up in 1903 already contained reinforced concrete in civil building in the city of L’Aquila. L’Aquila according to original plans is the first case of use of The construction of the “New Provincial Insane Asylum” of Technological Innovation and Traditional Building Alessandra Bellicoso Building, Architecture and Town Planning Department, Ecole Polytechnique de Bruxelles, Université Libre de Bruxelles, Belgium Concrete Piling: Major Developments in the Historical Practice of Pile Foundations Since the dawn of civilisation, piles have either been widely used to increase the bearing capacity of weak soil conditions, or to reduce settlements under heavy constructions. For centuries, there was little change and timber was mostly used for deep foundations. At the end of the 19th century, concrete created a fundamental change in piling practice as demonstrated by the high number of patents taken out for various new kinds of piles. The reason for this lies in the properties of concrete: its high resistance to decay; its adaptability to various shapes, sizes and soil conditions; its limited responsiveness to vibration; and its high connectedness in structural systems. The present paper will analyse the first concrete piles mainly found in Belgium at the beginning of the 20th century according to type, method of execution, design and testing. This will be followed by addressing issues related to the reuse of ancient concrete piles, in order to assess their bearing capacity and safety level according to current standards. Alessandra Bellicoso Department of Architecture and Urban Planning, University of L’Aquila, Italy Technological Innovation and Traditional Building Methods in the First Application of Reinforced Concrete in L’Aquila: The “New Provincial Insane Asylum” [1903-1916] The construction of the “New Provincial Insane Asylum” of L’Aquila according to original plans is the first case of use of reinforced concrete in civil building in the city of L’Aquila. The preliminary plan drawn up in 1903 already contained precise indications concerning the construction method: load-bearing walls with reinforced-concrete subfloors and Holz-cement rooting. This was a highly innovative solution compared to the local building culture, so much so that the Provincial Administration invited some of the best specialized companies in Italy to participate in the private bidding for the reinforced-concrete work. The construction of the buildings is characterized by just this connection between masonry and reinforced concrete that is much tighter than the separation of the bids for the two categories of work could lead one to think, and it involves, at the same time, both the organizational and the technical aspects. John McGuinness Maidhead, UK Air Raid Shelters in the United Kingdom 1939-1945: An Initial Investigation This paper seeks to assess the state of technical knowledge available to the designers of shelters in the United Kingdom in 1938-1940 in anticipation of aerial attack and to describe the methods adopted for providing such shelter thereafter. Pierre Jaroux Association Engin Freyssinet, Paris, France Eugene Freyssinet’s Life and Works [1879 -1962] Freyssinet’s engineering career began in the early 20th century, at a time when Portland cement was invented but not really used to make concrete for building. Even if the mechanical properties of this new material were barely known, Freyssinet was attracted to the material because of its malleability, simplicity of fabrication and low cost. In 1903, while visiting the cantilevers of the Rue de Rome in Paris built by Rabut, he became aware of one of concrete’s major problems: cracking in the structure’s strained parts. He drew two conclusions that subsequently underpinned his long career. The first one was that the concrete should be used in structural forms undergo only compressive stresses. The second was the desire to control and eliminate cracking, which became possible with the invention of prestressed concrete, a new material that would “revolutionize the art of building”. This paper will follow key inventions in order to situate in context Freyssinet’s use of prestressed concrete in his numerous bridge and building projects. Maud De Voght, Krista De Jonge University of Antwerp, Belgium Foundation Techniques in the Early Modern Low Countries [1600-1750]: A Problematic Case - St. Walpurgis in Antwerp Archival sources exceptionally document the continuous degradation of St Walpurgis church at Antwerp [now lost] from the early 17th century onwards. Circa 1735, a thorough consolidation campaign became inevitable. Contemporary design drawings show ingenious techniques to increase the load-bearing capacity of the foundations to cope with differential settlements, such as a reversed arch system combined with foundation pits and wooden piles, and various systems for renewing and underpinning foundations. Comparison with earlier sources such as Charles De Beste, Simon Stevin and Cornille Le Coelre confirms the novelty of these solutions. Moreover, a system of iron tie rods suspended from the roof trusses was devised in order to rectify skewed walls and leaning columns, mirroring designs for new, large-span roof trusses known from the Jesuit context. Several well-known Antwerp architects, such as Guillaume Ignatius Kerriexx and Jan Pieter van Bauschert [the Younger] seem to have been involved in the restoration works. Antonia Brauchle Technische Universität Berlin and Stiftung LEUCOREA, Wittenberg, Germany Cellars: Construction and Insulation through the Beginning of the 20th Century Cellars as storage and utility areas are an indispensable constituent of domestic or economical units. Cellars prove to have a high degree of continuity compared to the rising construction, which is subject to great changes due to growing needs of comfort and representation. But even cellar constructions have different forms. Changes in domestic and economic work processes demand a new usage of cellars, thus demanding new structural engineering features. The different construction types of floors, walls, ceilings and vaults shed light upon particular construction stages on the one hand, but also express changing demands on storage space on the other. Various materials, methods and engineering skills were developed to meet and optimize these needs. Besides presenting a few typical construction forms, the emphasis of this paper lies on the specific demands on waterproofing cellars and insulating them against thermal radiation and moisture.
Bernhard Heres
Brandenburg University of Technology, Cottbus, Germany

The Iron Structures in the Buildings of the State Hermitage St. Petersburg Erected 1838 – 1850: Forming Structures and Details in Early Structural Steelwork

Starting in 1838, after a devastating fire, iron structures were supplied for the rebuilding of almost all roofs and floors of the buildings in the palace complex of the Russian tsars (today the State Hermitage Museum St. Petersburg). Successively erected by four manufacturers within a period of 13 years, these iron structures comprise a wide range of structures and details. They show the involved engineers’ continued search for appropriate solutions for structures and details, and their step-by-step improvement – including failings and obscurities from today’s point of view. As a result of recent surveys and documentation, several directions of development are perceptible. The paper presents concise examples concerning the design of trusses, the design of details, and the joining technology as well as the origin of the manufacturing technology of the iron profiles used.

Sergej Fedorov
Karlweile Institute of Technology, Germany

Rebuilding St. Petersburg’s Winter Palace in the Context of Early European Steel Structures 1838-1850s: Contemporary Sources and Documents

Within a brief period after the disastrous fire of 1837, fireproof metal structures, very modern for the time, were erected in all the reconstructed edifices of the Imperial Winter Palace Complex in St. Petersburg [the current State Hermitage Museum]. Since 2009, the German Research Foundation [DFG] has been financing a first systematic survey and investigation of the Hermitage “structural ensemble.” The proposed paper presents its results with regard to an analysis of Russian and French contemporary publications of the Winter Palace iron structures. A comparison of the unveiled drawings with the results of current measurements and observations makes it easy to understand the “structural strategy” underlying the use of the new material, steel, in the construction practice followed at the beginning of the industrial revolution.

Donald Friedman, Old Structures Eng., New York City, NY, USA
Brian Bowen, Georgia Institute of Technology, Atlanta, GA, USA

Two Crystal Palaces: Constructive Technology and Practice; Great Britain 1851 – United States 1853

On 1 May 1851, an estimated 30,000 people witnessed the opening of the Exhibition of 1851 by Queen Victoria and Prince Albert in the Crystal Palace in Hyde Park, London. The success of the Exhibition and of the building that housed it led to ambitious proposals for expositions in New York, Dublin, Munich, Copenhagen and several British towns between 1851 and 1854. Most of the proposals were based on the glass and iron model: the most significant proposal was an 1854 exhibition in New York in its own Crystal Palace. This paper explores similarities and differences in the design of the two buildings and the construction processes used to build them, with particular reference to the technological environment at that time in the two countries. The objective is to examine the conditions required for the introduction and adaptation of new technologies in construction.

Ines Prokop
Berlin University of the Arts, Germany

Wrought Iron and Steel Structures in Berlin in Their Prime from 1875 to 1925, with a Focus on Buildings for the Arts

The 19th century is generally considered to be the prime century of iron and steel construction. The continuous development of scientifically based calculation methods and iron and steel construction methods went hand in hand in ensuring the success of this materially efficient building method. The evolution of iron and steel construction in Berlin between 1875 and 1925 is illustrated in the following article by examples of the load-bearing structures of cultural buildings – such as museums, theaters and opera houses. These relatively unknown steel structures provide a framework within which the development of certain load-bearing structures can be illustrated. These include everything from the formation of statically determinate truss systems to statically indeterminate frame systems and varied structural systems for covered courtyards. The structural engineers Richard Kramer [1847-1906] and Otto Leitlhofer [1860-1939] had a significant influence on these developments in Berlin. Additionally, the resources available to the engineers at the time for planning their structures will be presented.

Maaike Van Der Tempel, Ine Wouters, Filip Descamps, Dorien Aerts
Department of Architectural Engineering [ae-lab], Vrije Universiteit Brussel, Belgium

Innovations in Ventilation: Wind Cowls in the 19th Century

In the 19th century, innovative heat-induced low-pressure systems were introduced in public buildings and dwellings. These ventilation systems were enhanced by the addition of an air extraction element on the roof – a wind cowl – to inhibit counter flow and to amplify the air flow by wind effect. Different types of cowls were developed: fixed, mobile, revolving, symmetric, asymmetric, etc. Although the importance of wind cowls is often mentioned and discussed in 19th century manuals on ventilation and heating, only few designs are included in ventilation manuals and little has been written on the different hypotheses supporting the design, design parameters and problems encountered by engineers. Patents offer additional information when combined with knowledge of ventilation and designs mentioned in 19th century manuals and contemporary insights. A survey of patent applications in Belgium is carried out to analyze wind cowls between 1830 and 1914.

Francesca Turri, Emanuele Zamperini
Building and Territorial Engineering Department, University of Pavia, Italy

The Military Engineers and Hygiene in Barracks in the Second Half of the 19th Century

Around the middle of the 19th century, doctors understood the role of living and working conditions, and of air and water quality in the health of population. Therefore medicine extended the focus from the patient to the hygiene of the built environment, leading to the birth of a new discipline: sanitary engineering. This subject had a strong influence on the design of barracks at different scales: urban location of settlements, morphology of the buildings, ventilation and dimensional standards of the dormitories, constructive details, and choice of materials. Since the early years after national unification, military engineers carried out studies and experimentation on this topic elaborating specific technical and hygienic criteria for the design of collective buildings. The paper finally focuses on the experimentation and application of new systems and devices for latrines to be used in barracks.

Emmanuelle Gallo
HTTP-CNAM / ENSA Paris-Belleville, France

Scientific Developments of Heating and Ventilation

During the 19th century, hygiene became a driving force for numerous conceptual and technical innovations in building [heating, ventilation, codes], building typologies [hospitals] and urbanism. In this paper, hygiene aspects of Horta’s oeuvre are systematically addressed and situated in its specific Belgian context, in which research and innovation and the High Hygiene Council – crucial in the codification of hygiene principles in building construction – were as well as in the construction of hospitals and housing programs – played an important part. The author addresses Horta as an architect [residences and the new Brussels Brugmann hospital] and as a technocrat. As a member of the High Hygiene Council, the Council on Monuments and Sites and the Belgian Academy, Horta reflected on general policies and regulations. This research is based on his built oeuvre and exploits both published papers and unpublished writings [Horta Museum].

Maaike Van Der Tempel, Ine Wouters, Filip Descamps, Dorien Aerts
Department of Architectural Engineering [ae-lab], Vrije Universiteit Brussel, Belgium

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Dirk Van De Vijver
University of Utrecht, Netherlands

Hygiene in Belgian Architecture: The Case of Victor Horta [1861-1947]

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