



AT/CL 250 BUILDING FOR ETERNITY: CONSTRUCTION TECHNOLOGIES IN THE ANCIENT ROMAN WORLD

IES Abroad Rome

DESCRIPTION:

A common reaction when faced with the magnificence of ancient Roman architectural remains is to wonder how such structures were completed without the advantages of modern technology. The course intends to explore the engineering techniques and production systems used in the construction of the architectural masterpieces of the Roman world by carefully looking at the various types of archaeological evidence. By identifying and examining sophisticated construction processes, use of materials and building practices, it is possible not only to reconstruct the technological environment that made possible the completion of such monumental and long lasting structures but also to observe how many of today's technological solutions – cranes, concrete, water supply and more - actually originate from sophisticated systems developed in antiquity. From aqueducts to concrete domes, from roads to marble architectural elements, the course will make ample use of field studies and sites to observe directly the evidence of construction methods and to discover the economic, industrial, organizational, and technological processes that lie behind the creation of the astonishing monuments of ancient Rome.

CREDITS: 3 credits

CONTACT HOURS: 45 hours

LANGUAGE OF INSTRUCTION: English

PREREQUISITES: A basic knowledge of Roman art and architecture is recommended.

ADDITIONAL COST: None

METHOD OF PRESENTATION:

Lectures, PowerPoints, class discussions, field studies, course-related trips

REQUIRED WORK AND FORM OF ASSESSMENT:

- Course Participation -10%
- Midterm Exam -25%
- Final Exam -30%
- Final Project -35%

Course Participation Grading Rubric for Student Participation

A	Excellent participation The student's contributions reflect an active reading of the assigned bibliography. Skillfully synthesizes the main ideas of the readings and raises questions about the applications and implications of the material. Demonstrates, through questions and comments, that he or she has been capable of relating the main ideas in the readings to the other information discussed in the course, and with his or her own life experience. The student makes informed judgments about the readings and other ideas discussed in class, providing evidence and reasons. He/she respectfully states his/her reactions about other classmates' opinions, and is capable of contributing to the inquiry spiral with other questions. The student gets fully involved in the completion of the class activities.
B	Very good participation The student's contributions show that the assigned materials are usually read. Most of the time the main ideas are identified, even though sometimes it seems that applications and implications of the information read were not properly reflected upon. The student is able to construct over others' contributions, but sometimes seems to interrupt the shared construction to go over tangents. He/she is respectful of others' ideas. Regularly involved in the activities but occasionally loses concentration or energy.
C	Regular participation The participant evidences a regular reading of the bibliography, but in a superficial way. He/she tries to construct over others' ideas, but commonly provides comments that indicate lack of preparation about the material. Frequently, contributions are shallow or unarticulated with the discussion in hand.
F	Insufficient participation Consistently, the participant reads in a shallow way or does not read at all. Does not participate in an informed way, and shows lack of interest in others' ideas.

Midterm and Final Exams

Each consist of slide identifications, multiple choice, short answers, and short essays. Both midterm and final exams cover class lectures, site visits and assigned readings.

Final Project

Option 1—Design Project-Identify with the instructor a type of building and develop relevant floor plans, elevation and cross section drawings and then describe the construction process in a detailed report that will include organizational and operational procedures for the construction site taking into consideration, budget, quantity and nature of materials, workforce, tools, building sequencing etc.

Option 2—Model Project-Identify with the instructor a type of building or construction technique to develop into a scale model.

Suggested projects: Roman quarry, section of Roman concrete wall; aqueduct arcade; section of an aqueduct; dome of the Piazza d'Oro at Hadrian's Villa; section of a Roman road; carving sequence of a Doric capital; carving sequence of a column; Roman arch in construction; Roman crane; opus sectile marble floor; wooden vault centering; wooden arch centering; wooden dome centering.

Materials: construction paper, clay, balsam wood, cork, plastic, foam, effective combination of any of the above; 3d computer modelling and 3d printing is permitted if students already have skills in 3d CAD.

Further guidelines about the final project will be discussed in class and published on the course Moodle page.

The final project will be evaluated on the basis of the following:

- Option 1: thorough research; accuracy in scale; attention to detail; thoroughness of analysis and description of operational procedures.
- Option 2: thorough research; use of materials; accuracy in scale; attention to detail; level of finish; appropriate use of color and textures; creative presentation of building sequence and process.



LEARNING OUTCOMES:

By the end of the course, students will be able to:

- Recognize evidence of technical methods in construction
- Identify different typologies of building materials, their provenance and use
- Become familiar with fundamental structural principles
- Examine production and building processes in the Roman world
- Reconstruct the organization of ancient construction sites

ATTENDANCE POLICY:

Attendance is mandatory for all IES classes, including field studies. If a student misses more than two classes, two percentage points will be deducted from the final grade for every additional absence. Please note: four percentage points will be deducted from the final grade in case of an absence on a scheduled academic day trip. Any exams, tests, presentations, or other work missed due to student absences can only be rescheduled in cases of documented medical or family emergencies. IES will only consider extreme emergency cases and will strictly adhere to this policy.

CONTENT:

The CONTENT section, below, indicates the required readings for each week, which students are expected to read before class, in order to actively participate in class discussions, answer questions posed by the instructor and comment on relevant topics. This directly affects the class participation grade. Quizzes and reaction papers (also affecting the class participation grade) may take place during class time in order to assess that students are keep up with assigned readings.

The course meets twice week. Most weeks have one in-class session and a second session on site for a relevant field study. The course also includes two academic day trips, which are held out of classtime to accommodate travel to location. Details on the academic day trip will be provided in class.

Week 1	Session	Content	Assignments
	Session 1	Changing the Landscape - Roman public infrastructure and civil engineering • Aqueducts, roads, bridges. Sources and evidence for the study of construction techniques. The role of the Roman army in technological development. Building traditions in the Ancient Mediterranean world: the influence of Etruscan and Greek forms in Roman architecture.	• Adam, pp. 1-19; pp.276-290;
	Session 2	Course-related Trip: Parco degli Acquedotti	• Adam, pp.239-260

Week 2	Session 3	Building materials and structural principles From timber to marble: the combined use of diverse materials for the evolution of an architectural style. From post-and-lintel to the arch: engineering principles in ancient buildings; structural behavior of specific forms of construction; tensile stress and compressive force; use and development of the arch form.	Adam 59-76; pp.196-215; pp. 158-173;
	Session 4	Course-related Trip: Forum Boarium and Forum of Augustus	Claridge, 177-180; pp. 285-288.
Week 3	Session 5	Roman Concrete – a revolutionary construction material The development of a new material and its implications on design and form: mortar, aggregate and sand; “pozzolana”; facing. Vaulting: evolution and typology of Roman vaults; structural aspects of vaulted spaces; the importance of carpentry: formwork and centering.	Adam, 125-150; 177-195. Lancaster, pp.1-22 (concrete construction); pp. 51-67 (concrete materials).
	Session 6	Course-related Trip: Markets of Trajan	McDonald 1982, pp. 75-93.
Week 4	Session 7	Dome construction-spanning centralized spaces(I) Geometric evolution of dome forms; engineering principles in dome construction.	Lancaster, 130-165.
	Session 8	Dome construction-spanning centralized spaces(I) Methods in dome construction: formwork, coffering, lightening materials, buttressing, “relieving” arches, tie bars, ribbing.	Lancaster, pp.22-50 (centering); 86-112 (vaulting ribs)
Week 5	Session 9	Dome construction-spanning centralized spaces(II) Structural and design challenges in the Pantheon dome	Mc Donald 1982, pp. 104-118.
	Session 10	Course-related Trip: Pantheon	Wilson Jones 2000, pp.117-212
Week 6	Session 11	Review	

	Session 12	Midterm Exam	
Week 7	Session 13	Ratio marmorum – the Roman marble industry Geographic sources and distribution of white and polychrome marbles; exploitation of marble quarries; “standardized production” and the Roman marble trade.	Dodge, pp.29-50; Ward Perkins, 1980, pp.137-158; Borghini, photographic catalogue of white and polychrome marbles.
	Session 14	Ratio marmorum – the Roman marble industry Quarrying techniques (channeling, splitting, wedges, slipways, debris disposal); supply of materials: land and sea transportation	Korres, pp.10-60; Pena, pp.126-132.
Week 8	Session 15	From quarry block to masterpiece - production of marble architectural elements Sequences of the production process; marble yards; unfinished work; templates; measuring and carving tools.	Adam, 20-56; Asgari 1988, pp. 115-125; Asgari 1992, pp.73-80; Ponti 1995, pp.291-320.
	Session 16	Course-related Trip: the marble yards at Ostia Antica	Fant, pp.115-119.
Week 9	Session 17	Design and form – architects and masons The architect - designing architectural forms: the Roman Corinthian order and systems of proportions; floorplans and models	Wilson Jones 1989, pp.35-69; Wilson Jones 2000, pp.49-68; Vitruvius, Book I: the education of the architect; the fundamental principles of architecture; the departments of architecture.
	Session 18	Design and form – architects and masons The mason - creating architectural forms: templates, surveying equipment and measuring tools	Ponti 2015, pp.15-25. Rockwell, pp.53-69.

Week 10	Session 19	Anatomy of a construction site – putting it all together, from foundation to rooftop Supply of materials; phases of construction; work areas and organization of work forces. Cranes and lifting devices; scaffolding; metal clamping. Changing a project under construction: the Severan Forum at Leptis Magna.	DeLaine, part 2. The generating processes: Design; Decoration; Materials, sources; Materials, production and man-power; Construction, techniques and processes; Construction, man-power and logistics.
	Session 20	Course-related Trip: Baths of Caracalla	DeLaine, part 3. Social and economic implications; The building industry of Severan Rome; The cost of the Baths of Caracalla.
Week 11	Session 21	How was it ever possible? - Extraordinary architectural projects The Vatican Obelisk; the Roman harbors at Ostia Antica; Trajan's Column; the Pont du Gard; Reconfiguring the urban layout of Leptis Magna.	Keay, Chapter 1: The port system of Imperial Rome
	Session 22	Course-related Trip: Column of Trajan	Wilson Jones 2000, pp. 161-174.
Week 12	Session 23	After the end – dome construction in the Byzantine east Agia Sophia	Krautheimer, pp. 205-219.
		Review	
Week 13	Session 24	Final Exam	

COURSE-RELATED TRIPS:

- Parco degli Acquedotti—the site shows evidence of sections of Roman aqueducts crossing the Roman countryside and the excellent state of preservation of the aqueduct arcades allows detailed analysis of construction techniques.
- Forum Boarium and Forum of Augustus—in these locations the remains of temples, porticoes and theatres allows a survey of particular building materials, showing clearly how Roman architecture developed from using local materials to imported marbles. A number of building practices are evident on site, from post and lintel techniques to examples of arched construction.
- Markets of Trajan—one of the most massive Roman building complexes with an original design made possible by the use of Roman concrete.
- Pantheon—the best preserved of all ancient Roman buildings, covered with a monolithic concrete dome whose engineering is still one of the wonders of Roman architecture. On site analysis of the building shows solutions adopted to resolve major structural challenges such as the use of buttressing and relieving arches. The building allows students to fully experience the perfectly preserved and unaltered interior space of a Roman monumental public structure and to verify the use and effect of marble veneer.
- The marble yards at Ostia Antica—In the harbor town of ancient Rome archaeologists have recovered a number of marble architectural elements in export form that were stored in marble yards next to the Tiber and intended for shipment to construction sites in Rome. These unfinished artifacts show preliminary stages of block carving at the quarries and are evidence of how the *ratio marmorum* operated to ensure adequate marble supply to the imperial building projects in Rome.
- Baths of Caracalla—one of the largest public bath complexes in Rome where it is possible to observe building solutions adopted for the vaulting of massive interior spaces; for water distribution to the pools and fountains; for the heating of the hot rooms. J. DeLaine's detailed study on this complex constitutes a seminal work on how to analyze and evaluate the sophisticated processes that lie behind the construction of a major Roman building.
- Column of Trajan—A rare type of triumphal monument in the Forum of Trajan. It functioned as a mausoleum, a historical record, a tribute to the accomplishments of the Emperor and a symbol for his divine status. It represents one of the most original, elaborate and complex buildings constructed in marble. This monument is essential to understand how sophisticated some construction processes could be in the II c. CE, including block stereometry and carving, lifting and precise positioning of massive architectural elements.

Students are expected to take full advantage of their stay in Rome by completing the course program also through independent visits to monuments and sites not included in the course field studies program (galleries and museums, churches, monuments, urban sites; see Independent Visits on the course Moodle page).

REQUIRED READINGS:

Required reading materials are accessible either in the course textbook, on the reserve shelf at the Center Reading Room or as pdf copies on the course Moodle page.

- **Course textbook:** Adam, J.P., Roman Building, Materials and Technology, London, 1999 ed.
- Asgari 1988 = Asgari, N., The Stages of Workmanship of the Corinthian Capital in Proconnesus and its Export Form, in Classical Marble: Geochemistry, Technology and Trade, NATO Papers, 1988, pp. 115-125.
- Asgari 1992 = Asgari, N., Observations on Two Types of Quarry Items from Proconnesus: Column Shafts and Column Bases, in Ancient Stones, quarrying, trade and provenance, Waelkens, Hertz, Moens eds., Acta Archaeologica Lovaniensia, 4, 1992, pp. 73-80.
- Borghini, G., Marmi Antichi, Materiali della Cultura Artistica 1, Rome, 1997.
- Claridge, A., Rome. An Oxford Archaeological Guide, Oxford, 2010.
- DeLaine, J., The Baths of Caracalla: A Study in the Design, Construction, and Economics of Large-scale Building Projects in Imperial Rome, Journal of Roman Archaeology, Supplement 25, 1997.
- Dodge, H., Ancient marble studies, in Journal of Roman Archaeology 4, 1991, pp. 28-50.
- Fant, J.C., The Roman Imperial Marble Yard at Portus, in Ancient Stones, quarrying, trade and provenance, Waelkens, Hertz, Moens eds., Acta Archaeologica Lovaniensia, 4, 1992, pp. 115-119.
- Keay, S., Portus and the Mediterranean, [British School at Rome Archive - BSR Archive](#), 2013.
- Korres, M., From Pentelicon to the Parthenon, Athens, 1995.
- Krautheimer, R., Early Christian and Byzantine Architecture, Yale, 1986 ed.

- Lancaster, L., Concrete Vaulted Construction in Imperial Rome, New York, 2005.
- McDonald 1982 = McDonald, W., The Architecture of the Roman Empire I, Yale, 1982.
- Pena, T., P. Giss. 69: evidence for the supplying of stone transport operations in Roman Egypt and the production of fifty-foot monolithic column shafts, in Journal of Roman Archaeology 2, 1989, pp. 126-132.
- Ponti 1995 = Ponti, G., Marmor Troasense: granite quarries in the Troas, in Studia Troica 5, 1995, pp. 291-320.
- Ponti 2015 = Ponti, G., Marble Entablatures from the Severan Basilica at Leptis Magna: a working import model of materials from the Proconnesus Quarries, in Paradigm and Progeny: Roman Imperial Architecture and its Legacy, (D. Favro, F. Yegul, J. Pinto eds.), Journal of Roman Archaeology, Supplement 101, 2015, pp. 15-25.
- Rockwell, P., Carving Instructions of the Temple of Vespasian, in Rendiconti della Pontificia Accademia Romana di Archeologia, 60, 1986, pp. 53-69.
- Vitruvius, The Ten Books on Architecture.
http://academics.triton.edu/faculty/fheitzman/Vitruvius_the_Ten_Books_on_Architecture.pdf
- Ward-Perkins, J. B., Quarrying in antiquity: Technology, Tradition and Social Change, in Proceedings of the British Academy, 48, 1980, pp. 137-158.
- Ward Perkins 1994 = Ward-Perkins, J. B., Roman Imperial Architecture, Yale, 1994.
- Wilson Jones 1989 = Wilson Jones, M., Designing the Roman Corinthian Order, in Journal of Roman Archaeology 2, 1989, pp. 35-69.
- Wilson Jones 2000 = Wilson Jones, M., Principles of Roman Architecture, New Haven, 2000.

RECOMMENDED READINGS:

Besides the required readings, some further readings will help the comprehension of some of the topics discussed during the course while others provide a more in-depth analysis of the material and can be consulted for developing the final project for the course. These works are available in the IES Center reading room.

- Fant, J. C., Cavum Antrum Phrygiae: The Organization and Operations of Roman Imperial Marble Quarries in Phrygia, British Archaeological Reports, International Series, 1989.
- Giuliani, C. F., L'Edilizia nell'Antichità, Rome, 1993. (Illustrations).
- McDonald, W., The Architecture of the Roman Empire II, Yale 1986.