Evolution from Greek Architecture

Figure 1: Temple of Apollo at Didyma, Turkey

Greek architects created massive and impressive architectural forms. However, until the Hellenistic period the forms were mainly post and lintel, using columns and stones as the main structural components. The Greeks were able to eventually create an arch as seen in Figure 1, but it does not have the qualities of the Roman arch. It is heavy, dark and confines the space rather than opening it.

The Romans were able to use materials to engineer forms to a high quality that was previously not possible., spanning and opening up constricted spaces.

Materials

Stone

Roman builders possessed a good understanding of the geological characteristics of the area, and put the seven different volcanic tuffs to use in cut stone masonry structures. The use of travertine as a reinforcement to the soft tuff created the strong structural force needed for the masonry. However, the use of cut stone masonry was limited by inconsistency and a lack of durability due to the softness of the tuff.

Vitruvius discusses mortar in Book II of *The Ten Books on Architecture*. Both lime and sand are materials that are used in mortar to bind the stones and bricks. There are different types of sands that are suitable for mortar, with defects and positives for each type. Lime is particularly useful once heated

The types of forms and structures created from cut stone could not compare to the innovativeness allowed by the use of concrete.

Opus Caementicium (Concrete)

Roman concrete is similar to the modern substance and is composed of an aggregate, a binding agent and water. Typically the local materials, such as lime or gypsum, were used as the binding agent. In central Italy, it is significant that a volcanic dust, pozzolona, was used.

Roman engineering benefitted both technically and practically from the use of concrete. It is a material stronger and more flexible than previously available materials, allowing for new forms to be built. Additionally, it could be used to build cheaper structures faster. Finally, concrete created safer structures because it is fireproof and did not require wooden roofing systems.

Forms

Arch

The arch is a compressive form that spans across a space. It is supported by the compressive forces of the arch which counteract the tensile forces in the structure. The keystone makes the arch self-supporting.

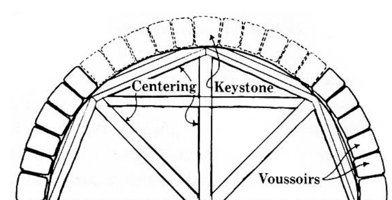
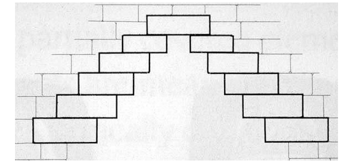


Diagram of a simple arch



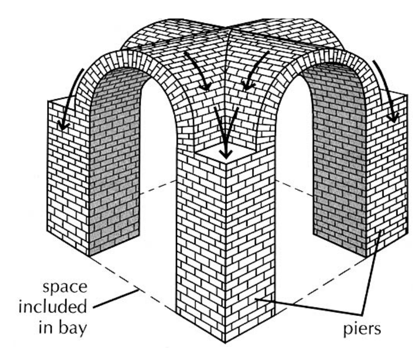
Corbeled arch structure

The corbeled arch was a form in existence before Roman engineering, but the Romans truly perfected the form. They used it to construct bridges, gates, aqueducts, and even triumphal arches.

Vault

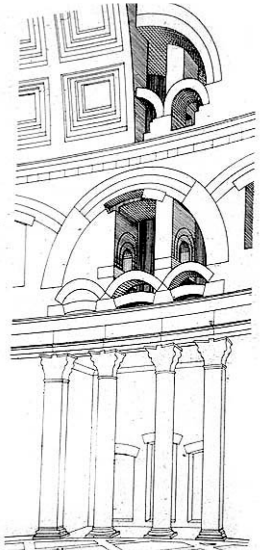
Vaults are forms spanning the roof and are made of multiple arches. Vaults, like arches, are a compressive form that is not self-supporting until the keystone is in place. Then the form is complete. However, the vault creates a large lateral force that sometimes requires extra support.

The vault rose in to popularity with the Roman builders. Two of the most common forms are the barrel vault and the groin vault. The barrel vault was initially popular but it requires thick walls to counteract the lateral forces. The groin vault, which is the right angle intersection of barrel vaults, overcame the barrel vault as the preferred vault due to its decrease in lateral forces. This allowed a better and more creative span of the ceiling space, a function mainly seen in the Roman baths.



Load distribution and diagram of a groin vault

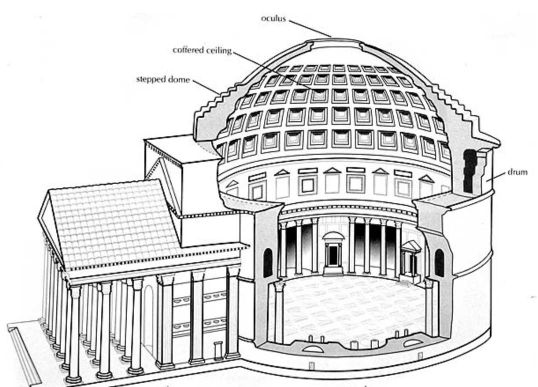
Dome



Section view of the structural support for Hadrian's Pantheon

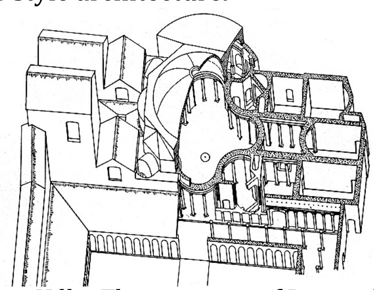
Domes are an architectural form similar to the upper half of a sphere and is a rounded vault. The difference of a dome from the arch and vault is that the dome is self-supporting during construction. Each level is a complete and self-supporting ring. The supporting walls below counteract the forces created by the dome and support it.

The true dome came about from Roman engineering. Roman domes tended to be hemispherical and were sometimes concealed from the outside. Romans were able to make them from layering concrete. One of the most famous examples of the Roman dome is the Pantheon seen below, which is made of unreinforced concrete. One of the features of the concrete is the aggregate of the concrete is heavier at the bottom of the structure than at the top, lightening the upper load.



HADRIAN'S VILLA

Hadrian's Villa is the site of Emperor Hadrian's retreat in Tivoli. The building's structures are unique in their individual forms, geometries, and symmetry. Hadrian attempted to play with the shapes of traditional archways and columned structures to create more dynamic buildings. The villa's structural flow allows viewers to proceed from one section to the other in non-traditional classical and axial settings. It goes against previous Roman works that were uniform in design with specific vanishing points, to a multitude of unique designs of structures that encompass one great area. This was a revolutionary design; one that broke ground for future design forms in later works as seen in modern landscaping as well as Asian-style architecture.



Hadrians Villa: The geometry of Piazzo d'Oro

REFERENCES

Yegul, Fikret. "Roman Concrete." *Roman Building Technology and Architecture*. University of California, Santa Barbara, n.d. Web. 29 Apr. 2014.

Jackson, Marie, and Fabrizio Marra. "Roman Stone Masonry: Volcanic Foundations of the Ancient City." *American Journal of Archaeology* 110.3 (2006): 403-36. *JSTOR*. Web. 29 Apr. 2014.

Mark, Robert, and Paul Hutchinson. "On the Structure of the Roman Pantheon." *Art Bulletin* 68.1 (1986): 24-34. *JSTOR*. Web. 29 Apr. 2014.

Wayman, Erin. "The Secrets of Ancient Rome's Buildings." *Smithsonian*. N.p., n.d. Web. 29 Apr. 2014.

Vitruvius. *Ten Books on Architecture*. Trans. Morris Hicky Morgan. Cambridge: Harvard University, 1914. *Project Gutenberg*. Web.

ROMAN ENGINEERING

Hadrian's Villa: its engineering techniques and achievements

Study 2: COA 3015
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