Abstract:

Architecture involves multiple disciplines that must coherently exist within a design. The structural aspects of buildings have significant impacts on the design process, and students must be able to incorporate structures in their design to be successful. It is crucial to a student's education that structures be introduced early in the curriculum to expose the students to their effects on the design process.

The study of Architecture at Oklahoma State University is a combination of aesthetic and technical design involving multiple disciplines that must coherently exist within its context. The structural aspects of buildings have significant impact on the design process, and students must be able to incorporate structures in their design to be successful. It is crucial to a student's education that structures be introduced early in the curriculum to expose the students to their effects on the design process. Our belief is that the incorporation of structures into the first design studio is crucial in developing student's awareness of structural limits and effects on the design process of architecture. Once introduced, the student is expected to employ the structural concepts to their future design projects, as well as build on their knowledge of structures.

Architecture : Shading indicates level of Architectural Engineering Faculty contact/emphasis

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Oklahoma State University’s School of Architecture offers five-year professional degrees in Architecture and Architectural Engineering. The first two years of the five-year curriculum consist of the pre-professional program, in which architecture and architectural engineering students take primarily the same courses and major courses are taught mainly by faculty who are licensed architects. As the flow chart below illustrates, the curriculum is organized such that structural design courses do not begin until the third year of the program, after acceptance into the professional school.

Application is required for entrance into professional school, and only those students who meet the requirements are accepted. The student would be at a disadvantage if structures was not introduced until the third year of school, thus the incorporation of structures in the early design studios help give the students an understanding of structural issues and resultant effects of structural requirements on the design process.

The first semester freshmen course is titled “Introduction to Architecture”, and is a two credit hour class that gives the student a rudimentary understanding of the study of architecture and design studio process. In this course, architecture and architectural engineering students are exposed to several design problems to give them a better understanding of the qualities and complexities of architecture. There are three exercises that involve the architectural engineering faculty and structural design issues. The first is an interview session with practicing professional architects and architectural engineers, and the second is a design problem focusing on architectural engineering design issues. The third is a curricular meeting discussing the requirements of both degree programs.

During the interview sessions, the studio professors arrange for practicing architects and engineers to meet with and be interviewed by the students. This is often the student’s first experience with a practicing professional, and the first meeting with the architectural engineers or faculty, who participate in the interviews. The process of architectural engineering is
explained to the students, as well as insights into the demands, expectations, and rewards of the profession. Often, example projects are shown to the students to give them a better understanding of the type of work performed by the professional. Questions and discussions arise over topics varying from curriculum expectations, to types of firms available to work for upon graduation, to expected salaries and benefits. The outcome from these interviews is a written exercise performed by the students in which they document the interview and discuss what they have learned from the interview and how it has affected their thought on becoming a professional architect or architectural engineer.

The architectural engineering project for the introductory architecture course is a two hour sketch problem titled “Construct A Tower”. This is a team project that promotes the concepts and ideas of teamwork in the profession while exploring the structural aspects of design. Students are separated into teams of 4 or 5 students, and are given the project requirements. A tower is constructed at the scale of 1/2” = 1'-0” utilizing a limited number of materials given to the student teams, and adhering to constraints set by the program. Constraints for the construction of the tower include tower attachment to a base within a set 5” diameter, the height of the tower being between 15” and 20”, and the tower having a cantilever that extends a minimum of 4” outward beyond the base of the tower. Additionally, pedestrians must be able to pass through the base of the tower, and stick figures of pedestrians are given to the teams to test this requirement. The towers are to be built in such a way that a testing weight hung from the end of the cantilever will not cause the tower to collapse, or deflect excessively. The limited amount of building materials given to the students include a cardboard base to which the tower is to be attached, 2 sheets of cardstock, 25 straws, 2 small diameter wood dowels, and a small amount of string from which to hang the testing weights. Connections in the tower are allowed to be made with hot glue and masking tape.
teams. Some teams appear to start building their towers without much thought, while other
teams are meticulous and plan all details before constructing their tower. Some teams are vocal
with no discernible team leader, while others are dominated by one or two students. The time
frame for the building of the towers is limited to approximately 60 minutes, so decisions are
forced upon the teams and they adapt quickly to this situation. The approaches and results of the

teams vary widely, leading to much discussion during the testing phase of the project.
At the end of the construction time, the teams bring their towers to the front of the class to be
tested. The students explain their tower, the structural concepts that were used during the
planning and construction of the tower, and make a hypothesis on how the tower will react to the
testing weights. The testing weights are broken into a lesser and a greater weight, and each are
hung from the towers. Once the weights are applied to the tower, the effects of the weights can
be discussed. For many, the result is not what they thought it would be, and some indeed fail or
deflect excessively.
The architectural engineering professors discuss the structural concepts with the class during the testing phase of the project. Shearwalls, lateral bracing and rigid frames are discussed as well as torsion and diaphragms within a building system. Suggestions are offered that would make the towers more stable, and insight is given into the types of construction to avoid, such as hinge points along the height of the tower. By organizing the design problem in this way, the students participate well and are eager to learn what did and did not work with their design. This first exposure to structures in design is carried on into the second semester of the curriculum and is incorporated further into the design process.

The first architectural design studio is conducted in the second semester of the first year of study. This course, like all pre-professional design studio courses at Oklahoma State University, is a six credit hour course that meets for sixteen hours a week. Students work on a variety of design problems aimed at increasing their intuitive sense of order and design logic, including structural considerations. The course begins with a series of simple abstract design problems and increases in complexity throughout the semester. The design problems build on each other and are used to demonstrate ordering principles, patterns, and focal points within the designs. These initial problems give the students a background that is used in the design of the final two projects of the semester.

The first of these projects deals with the construction of a tower. The project, titled “A Vertical Construct”\textsuperscript{3}, is a two week project consisting of the design and construction of a tower utilizing basic design principles with a focus on the structural components of the tower. Architectural engineering faculty act as critics for the students, and offer advice on structural concepts and systems that can be utilized in the design and construction of the student’s tower. Structural concepts such as shearwalls, vertical bracing, rigid frames, and cable supports are discussed and examples are shown. A document titled “Rules of Thumb for Preliminary Structural Design”\textsuperscript{4} is provided to the students for use in properly representing the structural components of their tower in model form. This information consists of span to depth ratios for many of the structural systems available. The rules of thumb are set up primarily for gravity loads. Effects of combined forces are covered once the student has been admitted to the professional school.

Additionally, the architectural engineering professors discuss the concepts of floor and roof diaphragms, as well as continuity of structures required to ensure the structural stability of the
Example pages from “Rules of Thumb for Preliminary Structural Design”

towers. Through the interaction of the architectural engineering faculty with the beginning design studio, the student is exposed to structural concepts that can be used throughout their career.

Rough Study Model and Final Project of a “Twisted Ladder” structural concept.

At the annual Pig Roast celebration held at the end of Architecture Week in the spring semester at Oklahoma State University, the first year studio often has a one week sketch problem that culminates at the Pig Roast. In past years, this project has been titled “Can Buildings Fly?” The project is to build a kite that will fly, with the kite being modeled after one of a series of well known architectural buildings. This project involves working in teams to solve the problem, building and testing models and structural concepts to arrive at the solution.
The kites are given the final test flight at the Pig Roast celebration. Some of the more successful kite designs have been based on Falling Water by Frank Lloyd Wright, and the Sydney Opera house by Jorn Utzon. The test flights result in spectacular successes, and spectacular structural failures. In both instances, the students are adding to their intuitive knowledge and experience of incorporating structural aspects into the design process.

The final design project of the first year studio is focused on the creation of a small building, such as a museum or artist studio. In this four-week project, students must apply all that they have learned about fundamental design principles including structural systems. Additionally, students often consult the architectural engineering faculty for advice and critiques of their design. Upon completion of the project, the students present their designs to a jury consisting of faculty members, including architectural engineering faculty. The student explains their structural system and receives feedback from the jury. This jury process is utilized through the five year curriculum, and benefits the student through open dialog with practicing professionals.

In the second year of the pre-professional student experience, students enroll in two consecutive architectural design studios. These studios stress that basic ordering principles be further applied to increasingly complex architectural problems designed to accommodate human activity. Structural system development is further incorporated into the design process, giving the students a better experience of incorporating structures into their designs. The project types include programmatic planning issues, vertical and horizontal circulation, simple structural systems layout, and site design. A listing of typical design problems given would include a golf clubhouse, a library, and a branch bank. Formal teaching is the responsibility of the architectural faculty, and on some projects architectural engineering faculty are available to the students for any questions they may have pertaining to the structural systems they are utilizing in their design.

The architectural engineering components of the curriculum are presented during the first semester of third year for the architectural engineering students and during the first semester of fourth year for architecture students. A six credit hour architectural engineering design studio covering the topics of timber, steel and concrete design is taken during this semester, as well as
introduction into environmental controls design. The comprehensive structural course is positioned in the curriculum such that it is considered the studio course for the semester, and students can concentrate on the design of structures during this semester. Upon completion of these courses, the students continue their education while interacting with the architectural engineering faculty both informally and formally. Informally through seminars and critiques given to the fourth year studio design course, and formally through co-teaching the nine credit hour capstone design studio during the fifth year of the curriculum.

The architecture and architectural engineering student at Oklahoma State University are not formally taught structural design until the third year of the curriculum. It is important that the student be exposed to structural concepts and their effects on design from the beginning of their education at Oklahoma State University. With this exposure to structures at the beginning of the student’s education, they may become aware of structural issues and maintain a realistic approach to incorporating the effects of structures into their design. As noted by Mario Salvadori, “Even though the functional and structural components of architecture are most often distinct, structure has always had a decisive influence on architecture.”6. It is our belief that by incorporating structural concepts into the curriculum at the earliest stages, the students benefit from this exposure and adapt to the concepts of structures they can anticipate and celebrate the structure within their design.


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