STRUCTURAL APPRAISAL: A CLASSICAL WAY FOR LEARNING

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ABSTRACT

Structural Analysis is an important subject in the Architecture curriculum at Temple University. **Structural appraisal projects help a student understand architectural and structural integration, construction and technology, and address practitioners concerns for preparing students for practice.** Projects incorporated in the Structural Analysis course typically focus on the documentation of historic structures. Students survey neglected and/or abandoned historic buildings that are in danger of collapse or demolition. The students are encouraged to appreciate the beauty in abandoned structures rather than view them as eyesores. They are required to integrate sustainable design and building conservation approaches in their solutions. On specific projects, they are required to 1) visually inspect the building and note damage, deficiencies and overall condition; 2) perform analysis of the existing structural system; 3) identify necessary repairs; 4) perform analysis of the building for varying stages of conservation, including associated cost estimates; and 5) determine a new use for the building. The students are encouraged to follow both the intuitive and mathematical paths in their analysis. Example projects include the historic Baptist Temple (from which Temple University is named), farmhouses, greenhouses, warehouses, barns and bridges. The goal of the projects is to illustrate the significant impact of the integration of structure and architecture and educating students about the significant contribution they can make to protect historic structures.

1. PURPOSE OF THE WORK

Teaching structural analysis to architecture students is simply not easy. The concepts are often hard for the student to understand and there is often no simple solution. To help the students learn these concepts, they are assigned a research project to provide a structural appraisal report on a historical structure at the beginning of the semester. Structural appraisal is the procedure of evaluating the capability of the structure for sustained use.[1] The students in the class learn to efficiently organize, coordinate and communicate information in order to convey data necessary for structural analysis. In the field of architecture it is difficult to teach structural analysis where the groundwork consists exclusively of a system of theoretical concepts. Structural analysis is a problem solving activity. Authentic problems are abundant in historic buildings to provide examples. Teaching structural analysis to architecture students requires that the students must develop the aptitude to deal effectively with problems, which occur in real circumstances. A historic building with an exposed structure system provides an excellent case study to directly involve the student in this learning experience. The course emphasis is based on the concept of "how to learn how to learn" from abandoned historic buildings in the built environment of Philadelphia. Temple University architecture students are exposure to of the subject of structural analysis through the class lectures, assignments and structural appraisal project. The purpose of a building's structure is to offer a safe and strong method of sustaining the loads imposed by the

[1] P.F.G. Banfill. Structural Engineering for Building Conservation; Heriot-Watt University, Edinburgh, 2003

building's composition, the building's occupants and their property, and the forces of nature, through a series of load paths down to a sturdy foundation.[I] The subject content addressed in the course include loading determination and evaluation; resolution and equilibrium of force systems; truss analysis, etc. The students learn how to calculate centroids, moment of inertia, and shear and bending moment diagrams. In addition, the students are taught basic beam, column and system design. The course builds on the awareness of the theory of force equilibrium. Force equilibrium stands for one of the most influential concepts in the field of structures for architects, and is the starting point for the learning of structural behavior.[II] For equilibrium in a beam, the externally applied bending moment has to be resisted by the internally produced moment between the tension force and the compression force.[I] The students gain first hand experience about force equilibrium while examining a historic building. At the completion of this course, the students generally have a sound understanding of this concept and are able to utilize it in analyzing statically determinate force systems.

The course is divided into two parts consisting of statics and strength of materials. A principal intention of strength of materials is to acquire an effective connection between applied loads on a non-rigid body and the resulting internal forces and deformations induced in the body. The properties of a variety of structural materials in resisting the applied forces are addressed. Upon completion of the strength of materials section, students gain an understanding of the correct relationship of material strength, stresses, section properties, and deformation derived from the analysis of the load and different support conditions of the structural member.[III] The field observations conducted by students deal with the likely causes of structural failure in the building under investigation and ways of strengthen and repairing walls, piers, arches, roofs, etc.

2. STRUCTURAL DOCUMENTATION

A structure being appraised is by description able to maintain the loads at the moment of assessment.[I] At the beginning of the semester the students do not have the knowledge or ability to undertake the structural investigation work. However, as the semester progressives and the students learn the basics of structural analysis, they gain confidence in their abilities to carry out the appraisal. Particularly important is the introduction of load tracing and how tributary loads act on structural members. The field report is required and is to be supported by many annotated sketches and calculations. The final documentation is approximately 2000 words in length, excluding appendices. The students are taught in the weekly lectures that as future architects they should be taking a leading role in sustainable design, green architecture and building conservation. Through the lectures they start to see the potential beauty in abandon structures that others see as eyesores.

In summary, the scope of the students' research investigation includes 1) visually inspecting the building documenting any damage, deficiencies and overall condition; 2) analyzing the existing structural system to determine code compliance; 3) recognize vital repairs to the existing building; 4) examine the building for varying stages of conservation including associated cost estimates; and 5) determining a new use for the building. The report is to clearly explain the structural system of the building and the way loads, and forces are distributed through the building to the ground. Using the extent and probable weights of the building materials being supported, the students are required to estimate the stress level in one element in each of the following categories: 1) a load bearing wall; 2) a floor system, including joists, boards, any secondary materials; 3) a structural component in the roof, such as a connection, rafter, ridge beam or

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[II] P. Beckmann. Structural Aspects of Building Conservation; McGraw-Hill, London, 1995

[III] B. Onouye and K. Kane. Statics and Strength of Materials for Architecture and Building Construction; Prentice Hall, New Jersey, 2002 purlin; or 4) the foundations at one point where loads reach the ground. Foundation performance is important to all buildings and the students gain knowledge about the basic principles of soil and foundation behavior, outline possible causes of problems including differential settlement. They summarize alternative strengthening procedures in the report. The students are asked to compare the stress level with the likely loadbearing ability of the member concerned and comment on the occurrence of any visible deflection, deformation, cracking or settlement, which might confirm the successful operation of the existing structural system.

3. WORK ACCOMPLISHED

The structural appraisal project is primarily about recognizing how the structural system of the building works.[IV] The project includes field sketches representing elevations, sections, important architectural/structural details, connections, roof framing, ceiling framing, floor framing and foundation layout. Both transverse and longitudinal sections through the structure are sketched, etc. All sketches are to be clearly documented to show all necessary load paths and how loads transfer from point to point. An understanding of the types of loads and forces and the behavior of materials and components is a necessary prerequisite for assessment of a building's present condition and for consideration of engineering alternatives.[V] Therefore, the students report on all structural items and conditions that concerns them and makes suggestions for repair. This process allowed the 2002 class to save two historic buildings scheduled for demolition after presenting their report to administrative officials. The 2003 class analyzed and built two replica trusses of the transept trusses in the historical Baptist Temple. As the contractor was making the field repairs, students gained first hand experience by site visits. The students are encouraged to follow both the intuitive and mathematical paths in their analysis. Each student normally has to make several trips to the site to document and study the structure. They are required to visit the library, city or county building permitting office to obtain the history of the structure and other related information. They are encouraged to obtain advice from consultants when required (i.e., from students in landscape architecture, construction engineering technology, engineering, architecture, etc.). In the fieldwork they utilize digital cameras, levels, lasers, etc. as required. They are required to use structural terminology learned in class when discussing the project and to explain that terminology in their report or when called upon in class. Students take the assignment seriously and gain a general understanding of the integration of architecture and engineering in the process.

4. CONCLUSION

Structural appraisal projects can be used to motivate students to learn about building structures. By researching and investigating a historic building the students have a means to assess what they have learned in the classroom and apply their knowledge to a real project. They learn more through this case study teaching and learning approach than in the traditional lecture course. It is evident that significant progress was made through the course of the semester. This observation prompts the question: how does a student learn to bridge the gap between academics and practice?

5. VISUAL MATERIAL

5.1 Photographs

[IV] P. Robinson. Structural Repair of Traditional Buildings; Donhead Publishing Company, Dorset, 1999

[V] F. Moore. Understanding Structure; McGraw Hill, New York, 1999

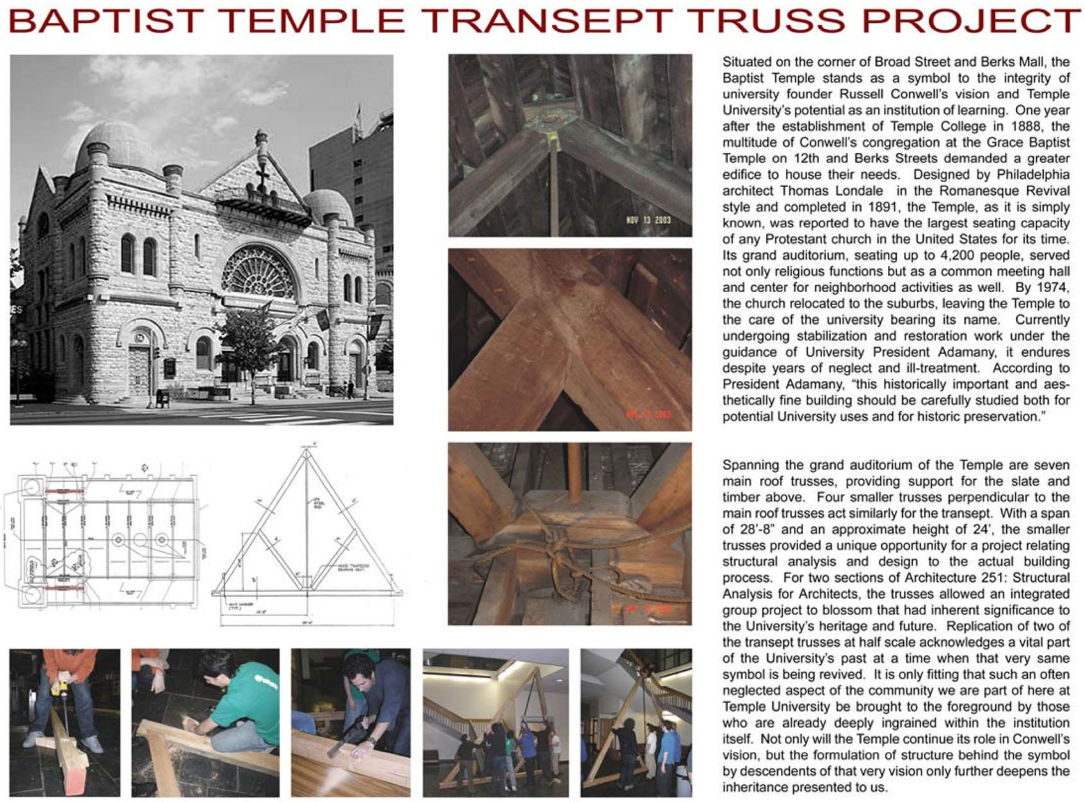

Fig. 1 Baptist Temple Transept Truss Project

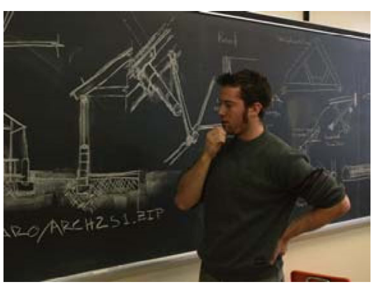

Fig. 2 Ambler Greenhouse Project

Fig. 3 Ambler Greenhouse Project

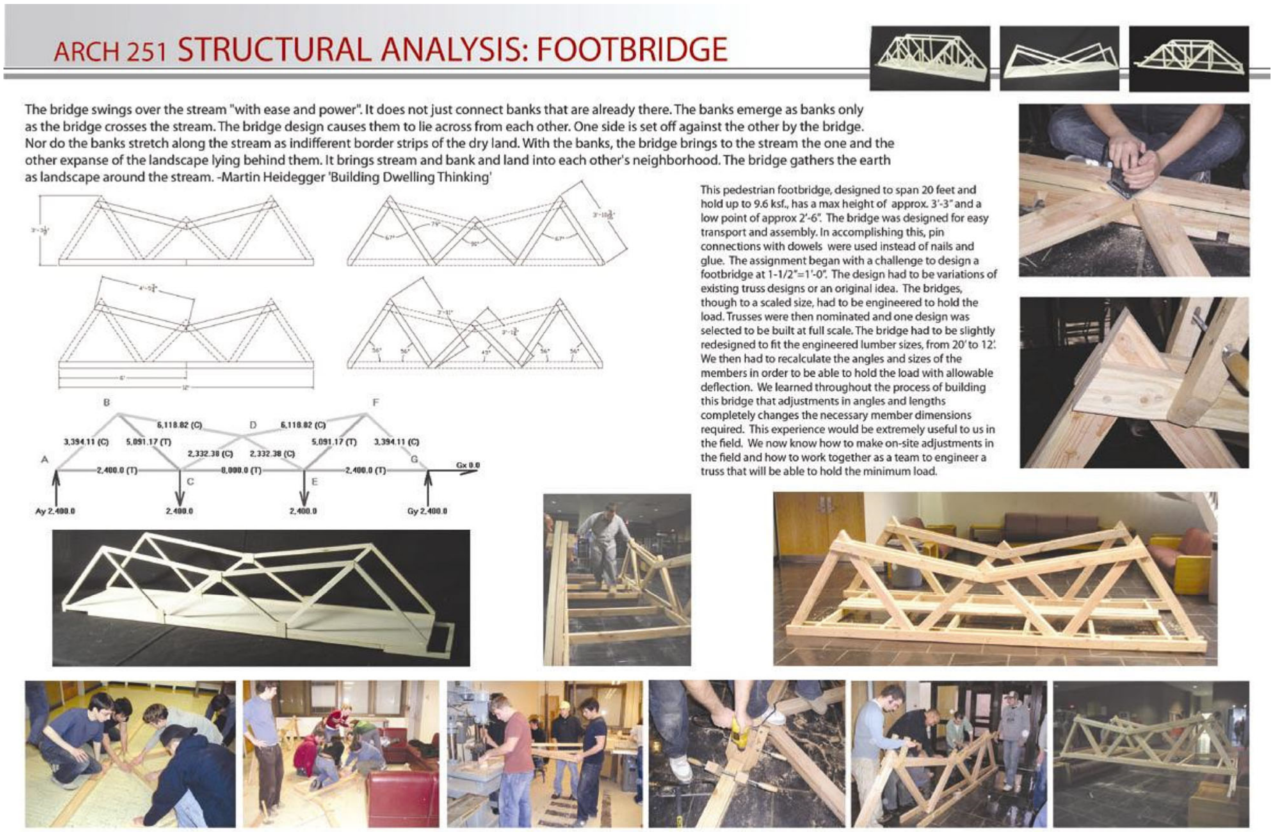

Fig. 4 Footbridge Project

Fig. 5 Spring House Project

Fig. 6 Spring House Project

6. REFERENCES