

Preservation of a Valuable Historical Adobe Building by Designing a Lightweight Structure in Yazd University



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ABSTRACT

This article is a report of the design and construction process of a lightweight roof structure over the remains of a historical building called the "Naji house" in the Historical City of Yazd. the Naji courtyard includes the remains of a historical house belonging to the Faculty of Art and Architecture of Yazd University and is part of the Historical City of Yazd. Archaeological sondage shows that the house is more than 600 years old. Therefore, it was necessary to design a structure that could preserve and protect the remains of this house against the wind, rain and sunlight. It was also necessary that the structure be very lightweight and have a minimum number of foundations to make the least intervention in this historical site. This project was defined as the final exercise of the building technical design course for senior B.Arch students. The result of this exercise was the construction of an early prototype of a structure designed by students. During this exercise, students understood their previous teachings about materials and structures as well as the climate in more depth and used them to design a highly efficient and environmentally sustainable structure.

Keywords: Naji house, adobe architecture, student project, design, construction

1 INTRODUCTION

Naji's house dates back to the Ale-Muzaffar historical period and is more than 600 years old [1]. This house is located in the block complex of the Faculty of Art and Architecture of Yazd, next to Movadat house and Lari Darband, which is now recovering its historical layers through restoration. This house has two parts, basement and ground floor. As shown in Figure 1, all the roofs are destroyed over time and the rest of the walls are exposed to sunlight, wind and rain. The dimensions of this building are approximately 17 x 16 meters.



Figure 1. Naji house. ground floor plan (right), current situation(left)

Therefore, it was necessary to design a protective roof for this building, which lies in the category of sustainable and earthen architecture. Of course, the designed structure should be environmentally sustainable and implementable in the historical context. Therefore, designing and constructing part of this structure was chosen as an exercise for the building technical design course. This exercise was performed in 2018-2019 in the art and architecture faculty of Yazd university. The aim was that students use their acquired knowledge of structures to design an efficient and lightweight roof structure and construct an early prototype. This exercise became an excuse for students to think about designing optimum and efficient structures and learn their previous teachings in structure, environmental control and materials in a more conceptual way.

2 technical design of buildings course

Course of technical design of buildings is one of the courses that has been planned with the aim of integrating the taught technical material and the architectural design practice. This course provides educational conditions for the theoretical courses to be memorized, understood and applied. Therefore, due to the existence of suitable contexts for the integration and application of structural knowledge in architectural design, this course was selected.

B.Arch. Students in the 7th semester take the technical design of buildings course, which is a 3-credit course consisting of 1 theory unit and 2 workshop units. according to the curriculum, these students have already taken theoretical courses related to structure and technical subjects in the previous semesters. technical design of buildings course is held seven hours a week as a workshop class.

before the outbreak of covid-19 in 2018, This course was held in person and allowed the students to experience field study, team work and finally design and construct an architectural structure according to the needs of a real project. This course was held with the full-time presence of two professors of architecture and a part-time professor from the field of structural engineering who in the past taught statics and structural courses in the faculty.

2.1 Structural Design for environmentally sustainable architecture

Macdonald has defined the role of structure in environmentally sustainable architecture. It depends on the relationship between the form and performance of structure. An efficient structure is one in which a high load-carrying capacity results from the use of a small amount of material. The principal reason why the shape of a structure affects its efficiency is that it determines the types of the internal forces which occur when a given load is applied. The important distinction is between bending-type internal force and axial internal force. the type of internal force which occurs is

dependent on the form of the structure. for any load pattern, there will be a form, the form-active shape, which will allow the load to be resisted by purely axial internal force. [2]

For designing an efficient structure, it was necessary to convert the prior knowledge on basics of structure to conceptual knowledge. [3]. Conceptual knowledge is very important in applying the teachings in the design process and achieving innovation. Professionals are the people with more conceptual knowledge [5], [6].

al of designing a protective structure , an attempt was made to make students better understand the basics of structure in some exercises with theoretical explanations in between.

2.2 structural design process

Theoretical and prerequisite knowledge of structures have already been presented in related courses in previous semesters. Therefore, what is important in technical design of buildings course is understanding the taught materials and implementing them in the design process.[4]

In the first sessions of the semester, first theoretical explanations were given about the forces, axial, moment and shear stresses, as well as the effect of the form and geometry of the structure on the distribution of internal forces in structural members. The purpose of providing these explanations was to create a conceptual understanding of the axial force in the efficiency of the structure as well as the role of the structural form in determining the internal forces of the structure and understanding form-active structures. These short seminars were completed with practical exercises and design with the help of physical models of structures, model making, hand drawings and case analysis. One of the exercises related to this section was designing a compressive structure similar to Gaudi suspended models and then designing a tensile structure using a maquette.

Students were asked to study and design compressive and then tensile structures in groups of three to four. they were asked to design a compression structure similar to Gaudi's work, and then a tensile structure, both in a plan in the form of a cross, and present them with maquette and drawings. Then, these designed models were analyzed in the classroom with the help of professors of architecture and structure, and their structural defects were corrected to create a proper understanding of the behavior of these structures with high efficiency.



Figure 2. Exercise 1, design and construction of a maquette of a compression structure By students who used paper and origami techniques to show how compressive forces are transferred. More than a thousand paper pieces are used in this maquette as compressive elements.



Figure 3. Exercise 2, design and construction of a maquette of a tention structure

3 Final Project: Designing a Lightweight Structure for Naji House

The final exercise was to Design a Structure to protect the remains of the Naji House. A structure like a roof which con covered the house and be resistant against the wind, rain and sunlight radiation and Also be lightweight. In addition, according to the basement, the foundation should Have been a minimum number and be placed on top of the rafters.

The final exercise began based on students' previous knowledge using sketches and structural drawings. during the initial design, students studied cases similar to their structures in groups. next, the concept diagrams created by students were analyzed and evaluated in terms of sustainability, optimization and response to various problem factors in the presence of teachers of architecture and structure, and new options were created again.

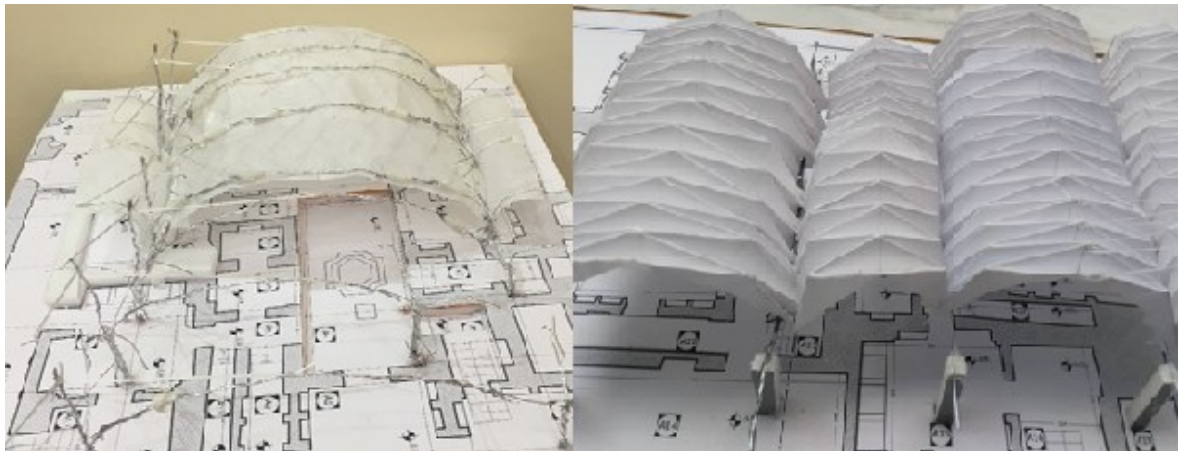


Figure 4. Final Exercise, Examples of Lifeguard Roof Design.

3.1 Design and construction of final project

one proposed design was selected from among the 11 finalized designs by students to be constructed in a real scale, pictures of which are presented here. The selected design included a modular and single-base structure based on spatial lattice structures and satisfied the design criteria including the lightness and efficiency of the structure, the small number of foundations and the minimum intervention in the historical site, the applicability of the structure without damaging the historical building.

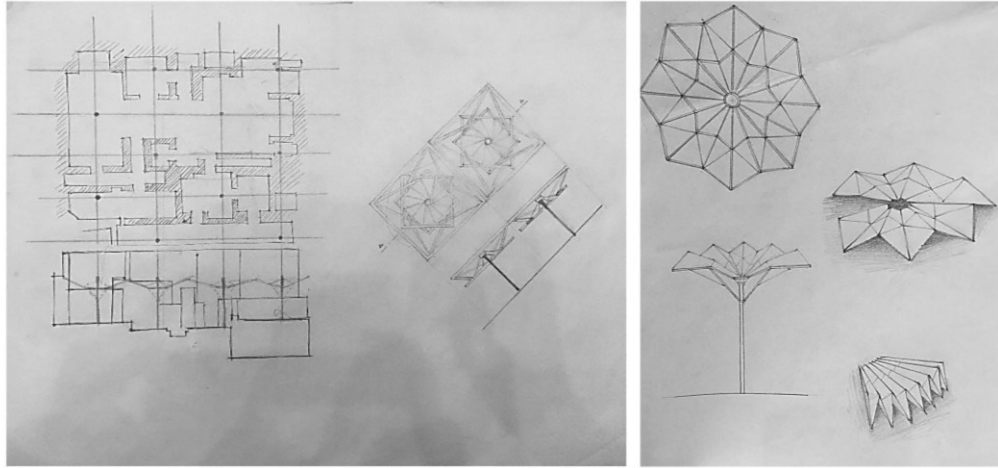


Figure 5. some of the initial sketches that led to the construction of the final structure



Figure 6. selected proposed structure

Then, students in new groupings, began designing and drawing the executive details of the structure, Numerical calculation and Structural form analysis, financial and executive estimates of the construction. The selected structure was analyzed with the cooperation of the structural instructor, and numerical calculations were performed based on wind, snow, cover and live loads. The selected structure was then constructed in 1:5 scale in the construction workshop of the art& architecture faculty in a one-month period from late December to January 2019. It's 1:1 construction required funds provision, which was delayed because of covid-19 outbreak; it will be finished in the new semester when in-person attendance is allowed again. The design process of one of the groups which led to the final structure is presented below.



Figure 7. constructed structure with 1:5 scale

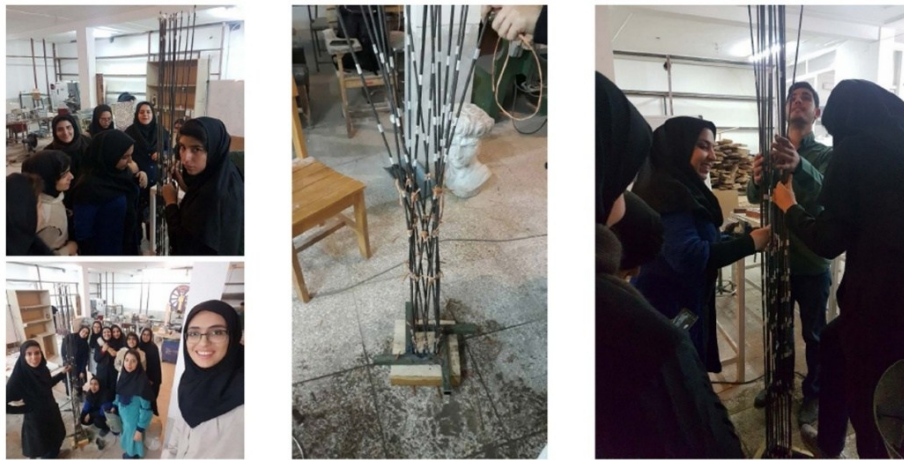


Figure 8. construction process of the selected structure, in the workshop of Rasoolian's house (art & architecture faculty of yazd).

conclusion

The construction of a structure to preserve the valuable historical building of Naji House on the site of Art and Architecture faculty of Yazd university was considered as the final project of the technical design of buildings course for B.Arch students. During this project, students became familiar with this valuable house and collected information, took measurements and also designed and constructed a roof structure to protect it. The project design criteria Included the lightness and efficiency of the structure, minimum number of foundations to have the least intervention in the historical site and being able to construct the structure without damaging the historical building. During this process, in addition to constructing a structure by students, the teachings on the basics of structures were understood and implemented in a design-based method.

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