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Pedagogy of Structural Design for Students of Architecture: An Appropriate Approach

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Abstract - Structural design is a very important domain to learn for the architectural students without which their unique and original thinking cannot be carried through to completion. While the students' emphasis is more on creative aspects in design studios and they fail to realize the relevance of various aspects of structures to their creativity. The academic curriculum and pedagogy here plays a major part in establishing the correlation between both architectural and structural aspect of building design in the minds of the students. This research is done to assess the teaching pedagogy used to solve the problems faced by students while studying structural design in their curriculum. This paper has identified the pedagogical helping tools to bridge the gap between the issues and solutions to understand the structural design subjects by the architectural students. Additionally this paper has also tried to recommend innovative pedagogical techniques which can change the outlook of architectural students while studying structural design from the beginning.

Keywords - Structural design, teaching pedagogy, pedagogical techniques.

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INTRODUCTION

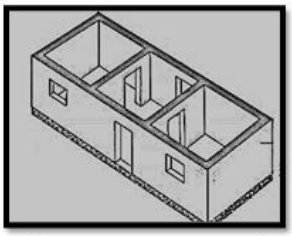
Structural design pedagogy is one of the most important support subjects for architects and as such for the students of architecture. Students who have clarity of understanding of structures are in an advantageous position to come up with architectural designs which are innovative and different. There have been many cases when structural design specialist have subsequently trained and become architects and have produced exceptional prize winning architectural designs. Some names are Gustave Eiffel, the designer of Eiffel tower in Paris and the statue of liberty, Andrew Charleson, Structural Engineer turned Architect working in School of Architecture Victoria University of Wellington New Zealand, famous for Earthquake Engineering advisor, Ar. Prabir Mitra of Kolkata best known for his creation Ffort Radisson at Raichak,West Bengal and many others. This deductively shows that architects who have strong sense of structures shall be well equipped to produce architectural designs of exceptional qualities.

THE BEGINNING

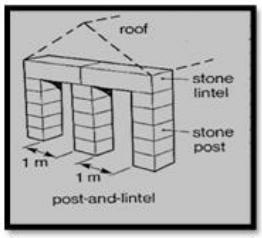
When we start teaching structures to the students it has to be kept in mind that the student from his time of birth has been developing his/her sense of understanding of the strength of materials. For example if I will ask a fresh student of architecture to cross a bridge made of material having strength insufficient to carry his load then he recognize and will not cross because he knows that it will not take his load. But when he is provided with adequate thickness and strength of the material, he will recognize and cross the same bridge. Therefore the teaching has to start from a point where the student has a conscious understanding of material strengths.

UNDERSTANDING STRUCTURAL ARRRANGEMENT SYSTEMS

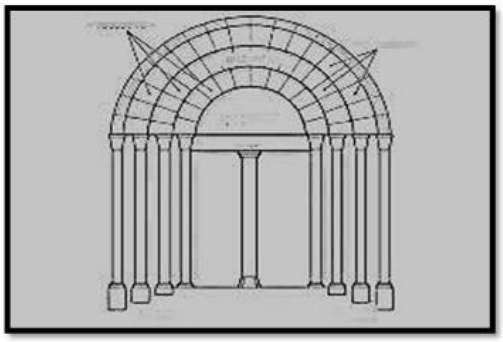
Starting with the simplest arrangements the student will be exposed to the most complex systems. The simplest is load bearing wall system followed by different systems such as the trabeated construction, the arch construction, the vault system, trussed structures, framed structures, tensile structures, shell structures, bracing system, etc.



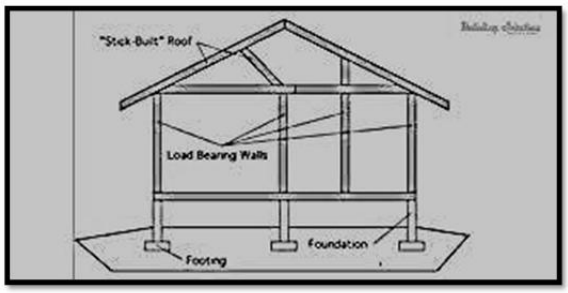
WALL BEARING SYSTEM



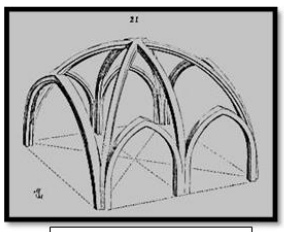
TRABEATED SYSTEM



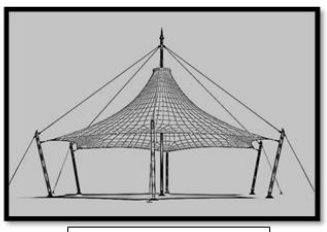
ARCHED SYSTEM



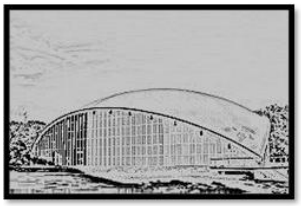
TRUSSED STRUCTURE



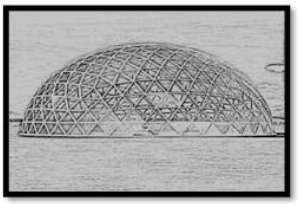
VAULT SYSTEM



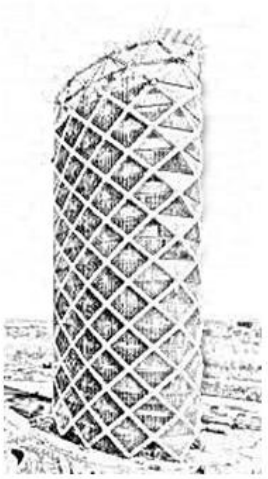
TENSILE STRUCTURES



SHELL STRUCTURE



SHELL STRUCTURE



BRACING SYSTEM

In table-1 the span range of various structural systems made of different materials has been given along with the number of storey possible in case of such structural systems in table-2.The values given in these tables may vary in some situations where the load pattern is complex or the structures are subjected to combination stresses.

Table-1 Maximum Span For Various Structural Systems

SL. NO.	TYPE	MATERIAL	SPAN RANGE	UTILITY
1	WALL BEARING	CONCRETE	UPTO 15M	SHORT SPAN STRUCTURES
2	ARCHES	R.C.C	UPTO 150M	VERY LONG SPAN STRUCTURES
3	ARCHES	STEEL	UPTO 200M	VERY LONG SPAN STRUCTURES
4	FRAMED STRUCTURES	R.C.C	UPTO 30M	MEDIUM SPAN STRUCTURES
5	FRAMED STRUCTURES	PRESTRESSED CONCRETE	UPTO 150M	VERY LONG SPAN STRUCTURES
6	SPACE FRAMES	STEEL	UP TO 150M	VERY LONG SPAN STRUCTURES
7	VAULTS	STEEL	UPTO 100M	LONG SPAN STRUCTURES
8	TENSILE STRUCTURES	R.C.C	UP TO 90M	LONG SPAN STRUCTURES
9	TENSILE STRUCTURES	STEEL	UP TO 250M	VERY LONG SPAN STRUCTURES
10	SHELL STRUCTURES	R.C.C OR PRECAST CONCRETE	UP TO 60M	LONG SPAN STRUCTURES
11	SHELL STRUCTURES	STEEL	UP TO 100M	LONG SPAN STRUCTURES

***M=METRES**

Table-2: Various structural systems with maximum no. Of storeys

SL. NO.	NO. OF STOREYS	TYPE OF STEEL STRUCTURAL SYSTEM
1	UPTO 15	SEMI RIGID FRAMES
2	UPTO 30	RIGID FRAMES
3	UPTO 40	FRAMES WITH SHEAR TRUSSES
4	UPTO 50	FRAMES WITH OUTRIGGER TRUSSES
5	UPTO 60	FRAMED TUBES WITH SHEAR TRUSSES
6	UPTO 100	BUNDLED FRAMED TUBES

ARCHITECTURAL DESIGN ….. THE INCEPTION

One of the essential quality that future architects need in piloting responsible design, is to have an appreciation of the basic concepts relating to building functionality and performance. Thus, the present architectural students must have a good understanding of the applications and unification of existing and future technologies to create innovation in response to the demands of a changing infrastructure development around the world.

An architectural student should understand how the execution is done for buildings without the need of doing actual structural calculations.. The important aspect here for the students is to realize the proper execution of their creative ideas into real structures with adequate safety .

The design studio which in the college is dealt with on a separate module has to be worked out based on the architectural design requirements such as topography,climate,services, functional requirements, flow aspects, family size, case studies, questionnaires, literature reviews,etc.

BREAKING INTO DESIGN

Breaking into design is an important point for the students/architects. The architect at this point has understood the requirements of the client, the conditions of the site and the structural arrangement types available to him for proceeding with the design work.

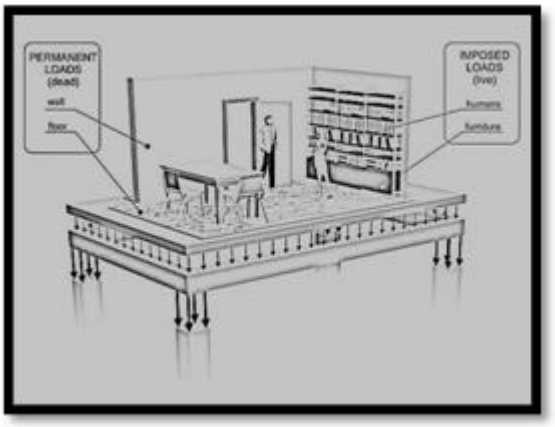
DETAIL STRUCTURAL DESIGN PEDAGOGY

The architectural students have to know the detail design works for two reasons.

1. To design simple and small structures, and
2. To be able to interact and understand with structural engineers in case of large and complex structures. Architects need to have a more integrated approach towards structural design keeping in view the complex load pattern along with diverse functional requirements for different type of structures. Also they need to be emphatic in having better building controls in their region for reducing the sudden failure of structures. For this it is necessary that architectural students have also to be taught the analysis and design of structures.

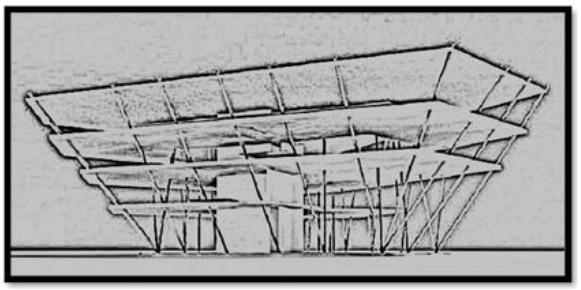
Structural Analysis

The study of structural analysis provides a foundation for structural design and also it estimates whether a specific structural design will be able to withstand external and internal stresses and loads or not. The structural analysis helps to determine the source of a structural failure.



Design of R.C.C Structures

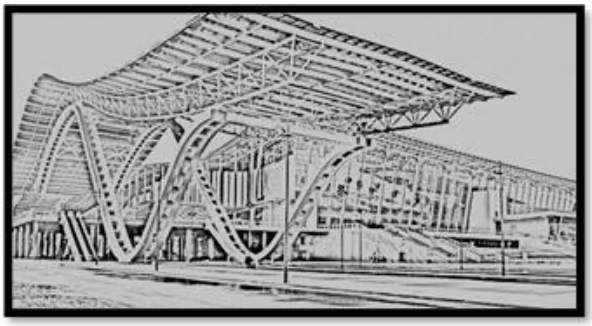
Reinforced cement concrete is a type of structural system, which leads the way in shaping the built environment. This structural system's characteristics, benefits and limitations must be learnt by architectural students who are going to design the artificial environment and become a part of the rapid urbanization process which the entire world is undergoing.



Design of Steel Structures

Steel as a material is very vital in the development of any country as it can be understood as the backbone of infrastructure revolution. As a construction material steel is very versatile with respect to shapes and properties. Use of steel in building facades, interiors, roofing systems, etc. along with the use as a structural element makes it the best choice for modern architecture developments. The life of architects has become easier by the use of steel in

construction as there is no restriction to their madness in designs and ideas. Steel being a strong material in taking structural loads as well as flexible in being easily moldable solves many issues like in providing long cantilevers and curving the walls and slabs.



Design of Special Structures

Special structures are those where art and science merge together and produce a structure that's far from ordinary, that pushes the limits of the possible, and that's truly special. Here we need the creative inspiration of an architect with critical analytical capabilities that of an engineer. Because of this, some insightful ambitions transform into credible accomplishments.

In this study, it was further noted that there are some pedagogical tools to effective teaching in structural design for the architectural students which helps the students to examine their presumptions, and inspires them to learn, execute the knowledge and understand the fact that they are responsible for change in the architectural developments around the world. Some important observations were noted below:

1. Carrying out workshops on disaster resistant architecture or low cost housing relating to the contentstaught in structural design subjects.

2. Rather than going by traditional text book numerical solving, doing the calculations based on the studio projects done in architectural design.

3. Rules of thumb for calculating the size and proportion of some structural systems such as catenary cables and arches, trusses, and framed structures.

PEDAGOGICAL APPROACH SUGGESTIONS

Effective pedagogies always give adequate space to the slow and average learners to keep their views about classroom teaching methodology and subsequently results in developing better education for all. For students of architecture the structural subjects have always been a matter of serious concern especially for those who are weak in mathematical subjects. So special strategies to be made by the teaching faculty to the need for evidence-based, effective, and innovative teaching and learning approaches that can result in not only better learning outcomes but also better student prosperity. Overall, an increasing focus on memorization and testing has been observed in education, including early years, that leaves no space for active exploration and playful learning, which needs to be modified. Some of the pedagogical modifications may be as follows :

1. The teaching methodology should focus more on application based approach for example, understanding the concepts of deflection of beams under loads by making clay models and studying the failure of such models under loads by the students individually or in group assignments. This will give rise to clear thinking towards both long term learning outcomes and short term goals as well.

2. The Structural subjects should be taught in adequate horizontal linkage with other subjects like building construction, architectural design etc. to make students understand the reason behind they need to study structures and their behavior properly. Some examples are- application of structural load calculations using actual data available in architectural design taught in the same semester or previous semester with proper involvement of B.I.S code guidelines.

CONCLUSION

In this paper we presented some innovative approaches to teaching and learning exercise for structural design subjects for the architectural students and stressed the importance of transforming the existing pedagogical practices in this field. The success of these innovative pedagogical practices depends on faculties making functional relationship between the ideas from research and the students. The best way of teaching architectural students about structural design can only be achieved if the subject faculty understands the mentioned pedagogical techniques and at the same time being passionate about bringing a change in this field for the best learning experience for the learners. Having being taught the subject of structures and the influent knowledge of structures into the architectural design programmes, the student is now ready to create projects which are aesthetically beautiful, socially relevant and structurally viable.

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