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Adding the Third Dimension to Building Construction Technology in Architecture Education

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Abstract: This paper looks into conventional teaching practices and intends to generate a new approach towards the teaching of Building Construction in architecture schools. With the fast pace of the current world and changing technology, conventional teaching practices that are largely based on information assimilation have ceased to serve us adequately. The rate of change in trends and technologies in the current times do not match the content of our existing syllabus. This paper tries to identify the role and application of Building Construction Technology for training the young minds for handling future challenges and coping up with upcoming developments. It talks about various experimentation and exploration techniques aimed at enhancing the student's analytical ability as well as his/her understanding of materials, techniques, systems, etc. The Building Construction Technology team at IDEAS has tried to bridge the gap between conventional teaching methods and the changing technology by adding a third dimension to teaching-learning methodology. The paper presents methods devised and tested in the Second Year Building Construction Studio for enabling the students for creative handling of materials and technology.

Keywords: Information; Facts and Acquaintances; Experimentation and Exploration.

1. INTRODUCTION

Courses in architectural education aim at identifying a variety of possibilities in each situation and developing rational thinking in students. These, in turn, develop the potential for achieving an aesthetic, functional and meaningful design outcome. With fragmentation of the total content of architectural teaching into different subjects, the critical link between them weakens, causing gaps in the continuity of the teaching process. One of the issues

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identified here concerns the manifestation of design ideas through developing an understanding of construction materials, systems and details.

The UNESCO / UIA Charter for Architecture Education (2004) also insists that architectural education should be aimed at acquiring an understanding of technicalities of structure, material and construction in the Design courses (Uzunoghu & Uzunoghu, 2011). Construction practices are necessary and an integral part of design process, and this integration should be reflected in the academic curriculum (Bologna Declaration, 1999). The two streams should be interconnected in a holistic manner in order to enable students to comprehend their interconnection as well as to apply technical knowledge to the architecture design course (Voyatzai, 2006).

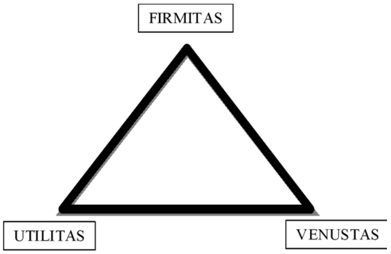
2. PEDAGOGY FOR CONSTRUCTION TECHNOLOGY

The aim of the course on Construction Technology and Materials, in architecture education, is to understand the details of the process of construction. It includes an understanding of materials, their properties, possibilities and limitations of use, along with their potential with regard to technology. At IDEAS, the objective of teaching this subject is mainly to integrate the process of execution of design ideas into the final built form. The teaching methodology focuses on detailing by the designer, i.e., by the student, under guidance of the Faculty. For the designer, it is necessary to provide appropriate and functional details for execution of design ideas which, in turn, are the outcome of understanding the project in terms of aesthetics and function. Prior to preparing construction details, the designer needs to have a clear understanding of various materials, their structural properties and their behaviour.

It can, thus, be said that this subject, i.e., Construction Technology & Materials, has a definite relationship with aesthetics, function as well as structural stability. As Vitruvius stated in his Vitruvian Triad (Fig.1), Firmitas (Structural Stability), Utilitas (Practical Function) and Venustas (Aesthetics) are equal attributes of design. The same concept was later supported by Alberti and Le Corbusier. Architecture schools always attempt to teach these attributes of design through various approaches. The Bauhaus philosophy and stress on exploration, experiment and problem-solving, along with practical application, has also proved enormously influential. As already stated, this paper will discuss a new approach to construction teaching to the Second Year students at IDEAS.

3. APPROACH TO BUILDING CONSTRUCTION PEDAGOGY

The conventional method of teaching generally relies on Information, Facts and Acquaintances**.** In this process of teaching, information available in books



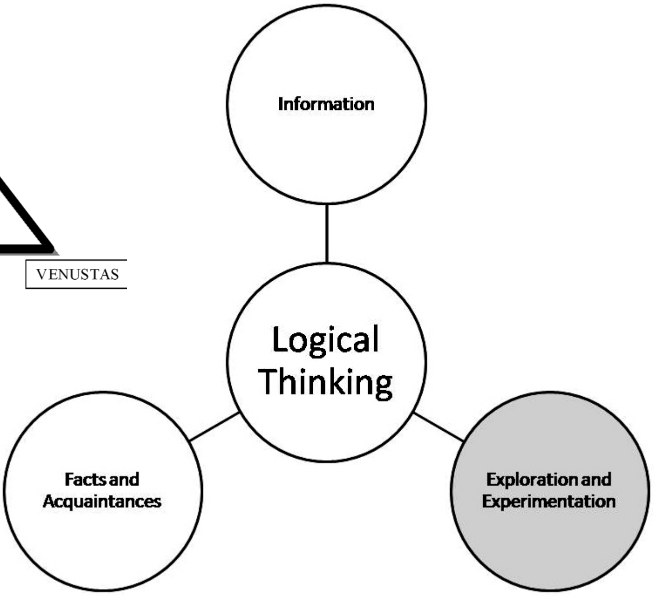
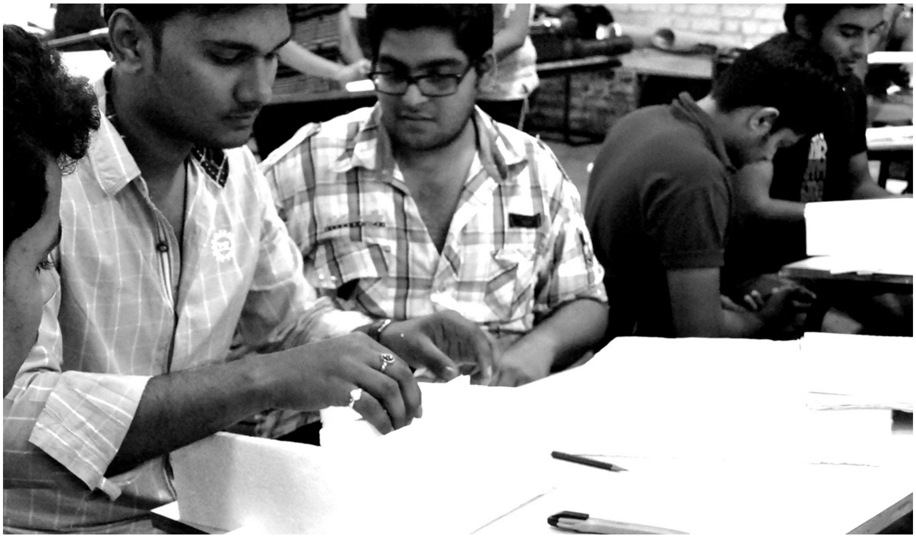


Figure 1(Top Left): The Vitruvian Triad

Figure 2 (Top Right): Addition of a new dimension to conventional teaching.

is conveyed to students through various mediums like blackboard teaching, PPT presentations, etc. Students are then acquainted with facts through site visits and general observations. Site visits help to bring about clarity regarding the detailed working procedure and sequences within the construction process, along with precautions and preparations made for site execution. Interaction with professionals in the field helps students to understand the changing needs, development and adaptations of building materials and systems. The site visit is followed by sketching and drafting construction details given in books and studied at sites, on drawing sheets.

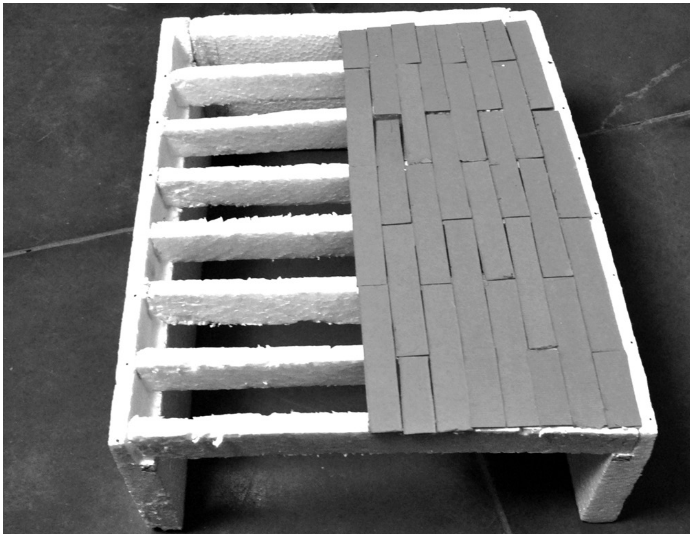
As construction technology has always had a strong correlation with materials and their properties, students need to develop an understanding of characteristics and limitations of materials, elements and system involved, along with operational needs of using a particular technique. In order to stimulate thoughts for design detailing through logical thinking and, to select appropriate techniques for achieving the desired form, yet another dimension needs to be added to the conventional design process. Further, for bringing about innovation in design, the process needs to involve exploration of various systems as well as experimentation with different materials (Fig. 2).



Secondly, the subject should be seen as working on details of design and not merely a mechanical drafting exercise with very little potential to engage students' interest. It is necessary that students should be led to the process of exploring and experimentation and, thereby, making a habit of transforming and materialising his or her individual design ideas into feasible construction details. Thus, the Faculty at IDEAS decided to add one more parameter to the usual teaching of Construction, i.e., Experimentation and Exploration.

'Experimentation and Exploration' is inculcated through well-planned group exercises which provide sufficient opportunity for exploring various working or operational details. The students achieve this objective through trial and error as well as discussions amongst themselves. The exercise also prepares them to become responsive to given situations and more aware of the fast-changing architectural trends and building technology in the current scenario. The method is used to stimulate logical thinking through exploration. This particular method helps every individual student, provides an opportunity to explore at deeper level, to clear his/her doubts, and to develop reasoning and analytical power. The practice of reasoning develops a habit of logical thinking in students and, in turn, contributes to the overall design process.

The findings of Experimentation lead students towards developing facts and a set of rules for a particular building element or system. Further, it also allows them to make a judicious selection of specifications required for design and execution, ultimately contributing to a holistic application of the facts and rules to their design projects (Figs. 3a, 3b, 3c).



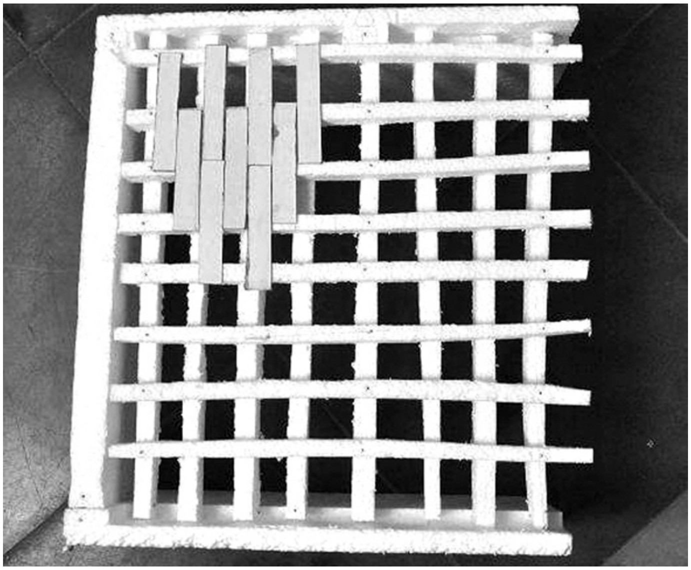


Figure 3a (Top Left): Students experimenting with models to derive logic of the timber floor (Image Source: Authors).

Figure 3b (Top Right): A model of a 'Timber Single Floor' made after understanding the system (Image Source: Authors).

Figure 3c (Bottom Right): A model of a 'Timber Double Floor' made after understanding limitations of the material and the concepts of spanning (Image Source: Authors).

4. THE TEACHING PROCESS

The subject of Construction Technology and Materials contains several topics covering basic construction and details of various systems and materials. The process of teaching starts with identification of various objectives of a project. This helps the teacher to figure out the correct sequence and the right time for introduction of the parameters (Information, Facts and Acquaintances, Exploration and Experimentation) listed above.

Given here is the demonstration of some representative cases that were followed in our Construction Studio, along with an account of the methodology adopted to meet the identified objective. Of the three cases that have been documented and presented in this paper, the first deals with designs using a natural material such as timber. The second case deals with available systems for designing openings and, the third discusses the process for teaching the attributes of a composite material such as Reinforced Cement Concrete (RCC).

4.1 Case 1- Timber Partitions

4.1.1 Objective

While designing a Timber Partition, a designer generally needs to assess the requirement of size, communication needs (visual or physical) and acoustics, in addition to the Partition's aesthetics. While doing this, learning the relevant construction principles -- in terms of joinery, stability of partitions, creation of openings and, incorporation of different materials -- comes as a challenge. In order to address these issues or, to make the student aware about the process and complexities involved, the following method is adopted.

4.1.2 Methodology

The assignment is framed with due consideration to factors of Exploration and Experimentation. These two factors are kept in view when designing the partition in a given context (like an office) to suit the requirement of the concerned space, the degree of communication expected, as well as the aesthetics. This assignment is conducted in the following manner:

a. Students are asked to prepare a sketch design of a partition under a given situation and for a given span with due consideration to aesthetics and function.
b. At the second stage, students are expected to prepare a model of the partition designed by them, considering timber as the material for construction. They are instructed to use vertical, horizontal and inclined members to make their partitions stand. At this point, as they start executing their own design in a small-scale model, their thought processes get stimulated

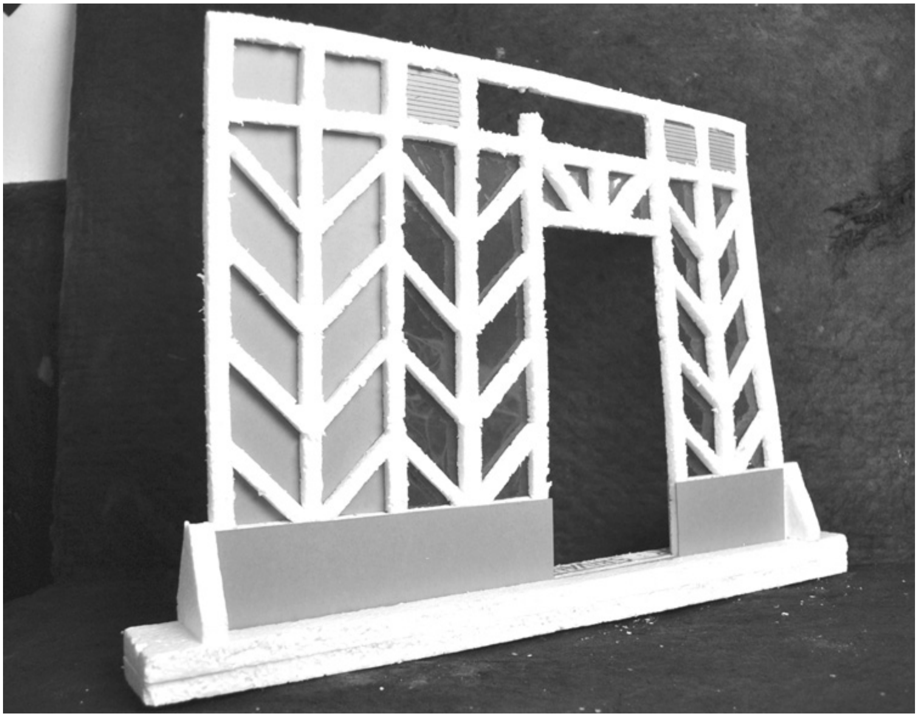


Figure 4: Experimental Model of a 'Timber Partition' designed and executed by students (Image Source: Authors).

and, they learn to judge the feasibility of design for size, shape, pattern of openings and arrangement of members with a trial-and-error method. Teachers intervene only to help them in understanding what goes into the making of a structurally stable partition.

c. Once the model of the partition is ready, inputs are given by teachers about structural stability as well as various joinery details Standard terminologies used for various components of timber partitions are also introduced to orient the students towards further detailing of partition.

d. Finally, the students are required to express their designs in a graphical format which can be read in terms of various drawings and sketches. Since each design is different, the sketches or graphical representation produced are also unique (Fig. 4).

A similar process is applied for teaching-learning of construction of timber roofs, louvered windows, pivoted windows and timber floors.

4.1.3 Summary

This method has proved to be a very effective teaching tool, where feasibility of design and issues of structural stability play an important role in developing understanding of construction details. Working with models helps students to explore the viability of various jointing methods in a given system. The operation in cases like louvered or pivoted windows can be effectively explored.

4.2 Case 2 – Timber Sliding-folding Door

4.2.1 Objective

The objective of this exercise was to understand the design, construction, and operation systems of sliding-folding doors in timber. The primary concern was to create awareness of the area of application, arriving at appropriate shutter sizes and choosing the door's operational system.

4.2.2 Methodology

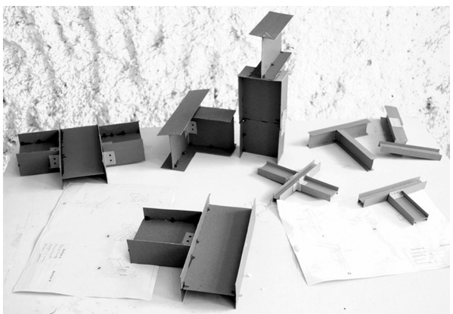
a. Students survey the market for available systems -- such as top-hung gear, bottom track and bottom sliding gear, top track, etc. -- used for operating sliding-folding doors. The purpose is to understand the limitations and potential of each system with respect to application in timber. The survey also exposes them to assembled units like sliding or sliding-folding doors and windows in aluminum. The observed details are sketched by students, while technicalities of each system are explained by the teacher.

b. The sliding-folding door is to be designed for a specific size. The task includes evolving sizes of shutters and specifying materials for panels, exploring various possibilities for designing it as a model (Fig. 5). The model lays emphasis only upon the mechanism, not detailing shutters / panels. Graphical expression in the form of sketches is expected.

c. A similar process is followed for other ready-to-install systems such as aluminum sliding doors and windows, revolving timber doors, steel windows, steel stanchions (Fig. 6a and 6b) and steel trusses (Fig. 7).

4.2.3 Summary

In case of systems where operation and mechanism is governed by manufactured sections and assemblies, it is important to know about various products available in the market. Once the student has investigated the characteristics and working of the mechanism, it becomes easy for him/her to understand the details of other similar mechanical systems that he/she may come across in future.



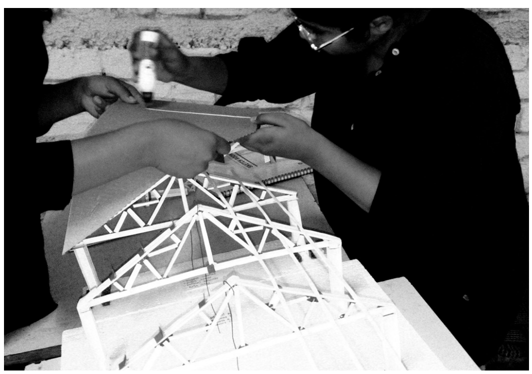


Figure 5 (Top): Model of a 'Timber Sliding-folding Door,' made to understand the mechanism involved

Figure 6a, 6b (Centre): Models of various joints of steel structures prepared by students

Figure 7 (Bottom): Scale models of steel trusses being assembled in the Construction Studio

(Image Source: Authors).

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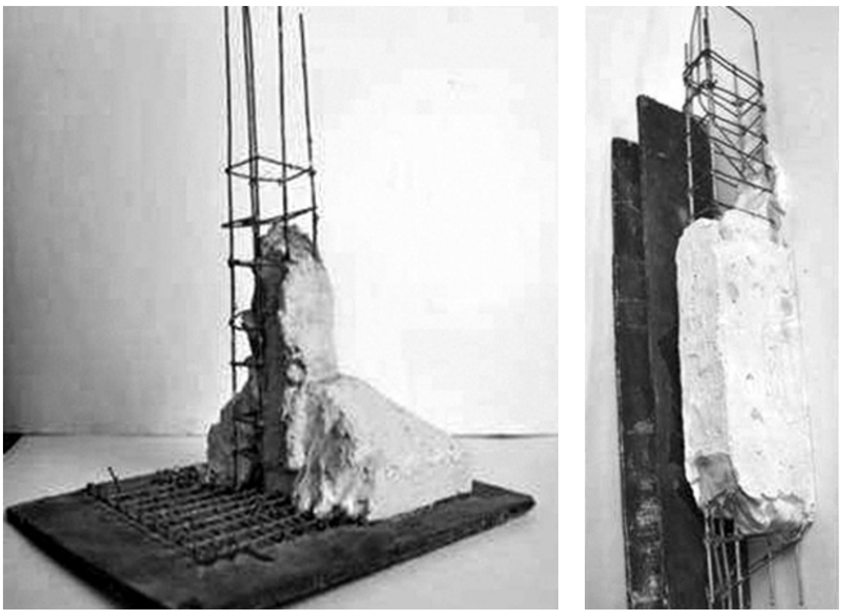
4.3 Case 3 - R.C.C. Structures

4.3.1 Objectives

The study of systems of composite materials such as reinforced cement concrete (R.C.C.) revolves around a holistic understanding of the behaviour of material, theory of load transmission, behaviour of individual elements, and the total structure system. It is necessary to understand the above concept in order to use it effectively as a directive from which to derive the physical form and the aesthetics of an allotted function for a building design.

4.3.2 Methodology

a. In order to understand the role of concrete and reinforcement in R.C.C., small scale models were prepared and tested under various loading conditions. These were of three types (i) Plaster of Paris, (ii) Plaster of Paris and Steel Wires as reinforcement and, (iii) Small-scale Concrete models. When these blocks are tested under loads, the behaviour of concrete as a single material and R.C.C. as a composite material is grasped by the student. It is to be noted that experiments on strength of concrete had already been conducted by these students in their first year of school.



Figures 8a, 8b: Small scale models were cast to understand the nature and behaviour of reinforced cement concrete (RCC).

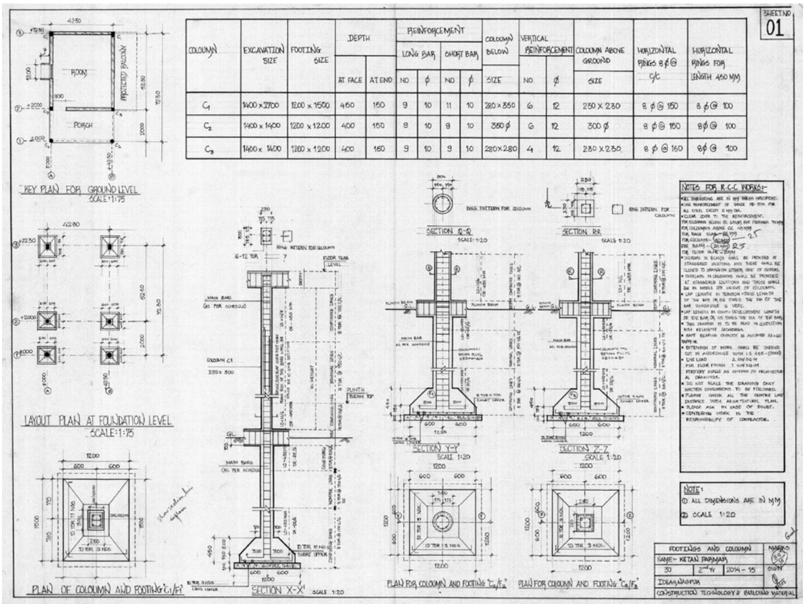


Figure 9a: Graphical Expression of the design and construction of R.C.C columns (Image Source: Authors).

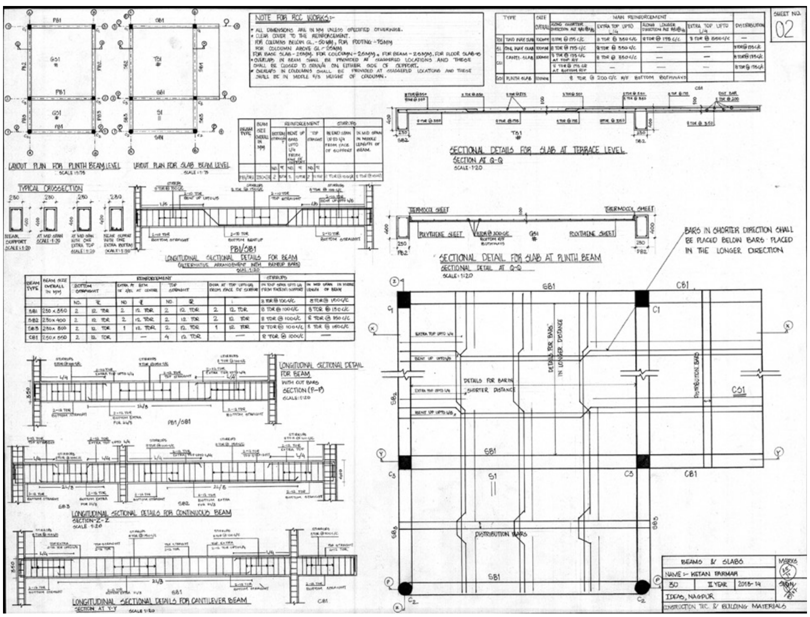


Figure 9b: Graphical Expression of design and construction R.C.C slab and beams (Image Source: Authors).

b. The exercise on load-testing is followed by lectures to understand the role and the structural behaviour of various structural elements like columns, beams, footings, etc. This helps students in the preparation of small-scale models out of steel wires, while casting the mesh in Plaster of Paris helps them to understand the details and geometry of R.C.C. elements, formwork and casting (Figs. 8a, 8b).

c. During the next stage, the students are provided with drawings of a small built form having various elements in different conditions -- like square, rectangular, or circular columns; simply supported, cantilevered and continuous, beams -- all composed into a single structure. This exercise is further consolidated with lectures, site visits and, lastly, expression in a graphical form (Figs. 9a, 9b).

4.3.3 Summary

This approach of teaching-learning through scale models allows the coming together of inter-disciplinary fields, making students aware of the systems which work together for structural stability, the material behaviour and transfer of loads. It helps to convey the characteristics of components of R.C.C. elements -- an education necessary for making their designs structurally feasible.

CONCLUSION

Exploration and experimentation is a key factor for conducting Building Construction Technology Studios. The activity aims at

a. Building the foundation of students' thinking and understanding, thus preparing them to deal creatively and confidently with future architectural developments;

b. Developing students' ability to adapt to changing social, economic and technological needs, acquaintance with new inventions, as well as understanding materials and elements;

c. Developing logical thinking for economic use, exploring new methodologies for bringing out sculptural or aesthetic qualities, adapting to a given situation, and moulding designs to respond to time, place the fast-changing technology.

A student should not rely only on the information provided by others but should also be trained to investigate on his/her own and, derive knowledge from various applications and changing trends. Thus, the approaches devised for teaching Building Construction Technology are extended beyond imparting information and, raised to the third dimension of Experimentation and Exploration.

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