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Design education of industrialised building systems

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Abstract

Design, production and installation processes are distinguished between designers and manufacturers by common conventions in "open building" concept as an industrialised building system approach. Since being rapid construction and increasing the quality of building production, industrialised building systems are preferred in construction industry. Qualified engineers and architects are required during design and installation phase of these systems. Design education of four industrialised building systems for low rise residential at undergraduate level is discussed in this study. Student studies carried out according to structural installation principles of these systems are presented. The system design education will help to widespread of mentioned industrialised building systems in construction industry.

*Keywords:*Industrialised systems, open building, system design education,structural member

1. Introduction

The notion of "building system design" finds an application field in the intersection of the professions of architectural and civil engineering. Industrialised building systems are required to be widespread in construction industry through meeting of rapid construction requirement and increasing the quality of building production. In order to enable this, awareness of industrialised building systems have to be increased at the level of technical staff and public authorities. Design education of industrialised building systems at undergraduate architectural and civil engineering education will meet this requirement.

2. Industrialisation of Building and Open Building Concept

Transferring of experiences of automobile, furniture and toy industries to building industry takes an important role in industrialisation of building. Meccano is a model construction system comprising re-usable components and it enables the building of working models and mechanical devices in toy industry [Url-8]. It was invented in 1901 in England and the principles and the name was used in industrialisation of building in 1960' s. Industrialisation in construction is required due to technical and economical reasons as being in automobile and furniture industry (Figure 1).

The word of "system" is; a set of interacting or interdependent components forming an integrated whole or; a set of elements and relationships which are different from relationships of the set or its elements to other elements or sets. Systems have structure defined by components/elements and their composition [Url-9].

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Re-distribution of design control is part and parcel of industrial systematization. Design, production and installation processes are distinguished between designers and manufacturers by common conventions in "open building" concept as an industrialised building system approach. Building system is separated as support (base building) and infill (fit-out) level and "support" refers to structural system of a building and also "support" is designed separately (Figure 2) [Habraken, N. J., 2005]. The role of designer in open building concept is; designing by using common conventions with defined and limited number of components independently from the manufacturer [Atasoy, A., 1995].Particularly, dimensions of the components is determinative while consisting of geometrical shape of the building during design phase [Şener, H., 1990].

Figure 1.Industrialisationof building [Url-1] [Url-2] [Url-3] [Url-4].

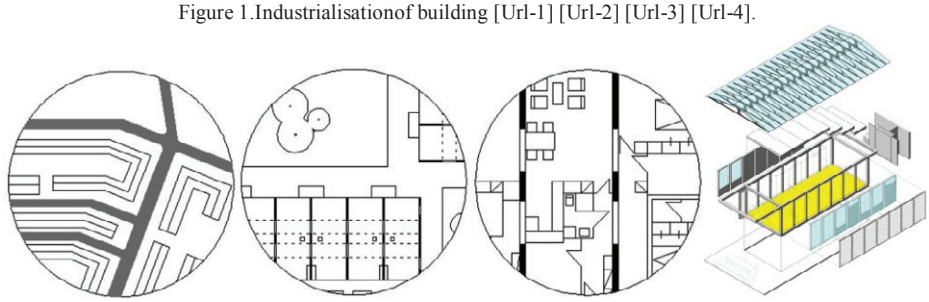

Figure 2.Distinguishing of levels in open building concept[Kendall S.H., Teicher J.][Url-4].

"Prosteel" and "Ytong" student project competitions can be samplised in education field as designing of building system with the defined and limited number of structural members.

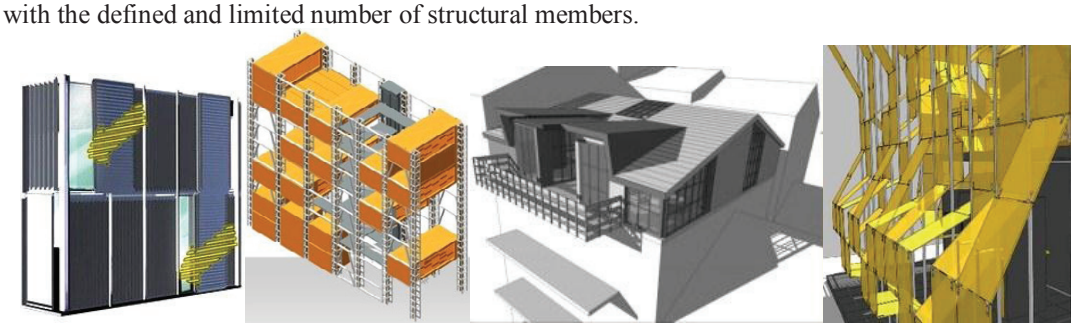

Figure 3.Structural system design with limited number of structural members in Prosteel and Ytongstudent project competitions [Prosteel, 2008] [Prosteel, 2009] [Ytong, 2011] [Ytong, 2008].

3. Design Education of Industrialised Building Systems

Concern to alternative building technologies was increased in Turkish construction industry after 1999 Izmit earthquake and different building technologies were introduced in construction industry to meet this concern, but could not be widespread in Turkey. The reason of this is; engineers and architects, whom work on these systems, do not have sufficient knowledge about installation principles and building components of these industrialised building

systems. Due to fact that education of industrialised building system design in architectural and civil engineering departments are required. Existing housing stock with 85 % is consisting of low rise residentials (1-3 storey) in Turkey [Die, 2000] [Tüik, 2006].Therefore, low rise residentials are chosen for this study.

Cold formed steel frame system, timber frame system, prefabricated reinforced concrete system, and aerated concrete panel system are chosen at design education of industrialised building systems, because of preferences at low rise residential. Cold formed and timber frame system are installed as platform frame system in terms of load distribution and load bearing wall thickness is accepted as 15 cm in both system [Götz, K. H., 1989] [NASFA, 2000] [Yıldırım, S. G., 2010].

Main difference of cold formed steel frame and timber frame systems is; using hollow section conductive constructional steel material instead of solid section wood with high insulation value [Işık, B., 2001]. Prefabricated R.C. system is accepted as stick system in terms of sub category. Columns and beams are prefabricated as reinforced concrete elements in conformity with the designed sections and floor and wall elements are consisted of aerated concrete panels. On the other hand, stock ready panels are used at aerated concrete panel system [Ayaydın Y.,2004].

Figure 4. Cold formed steel frame, timber frame, reinforced concrete prefabricated and aerated concrete panel systems[Aksan, 2008] [Url-6] [Url-7] [Ytong, 2007].

Industrialised building system design is studied with the second year students of architectural department in Istanbul Arel University. 13 type of modular layout is designed with anticipating not to be effected architectural layout by the difference of structural system and used in design education. The class with 52 students is divided 4 group and 4 building systems are applied over 13 layout type seperately.60 cm basic module is accepted for modular grid for system design. Dimensions of OSB and gypsum board panels used as covering in cold formed and timber frame systems are effective in acceptance of this module. Beside, modular dimension of aerated concrete panels are available widely in the construction market and used in prefabricated R.C systems, conforms with this basic module.

Students were responsible with preparing of building system drawings (layouts, sections and elevations) showing structural members as the level of "support system". Moreover, scaled model and computer aided three dimensional perspectives were prepared in order to make the systems more comprehensive in student' s perception. All these studies finalized in 12 weeks as an education term.

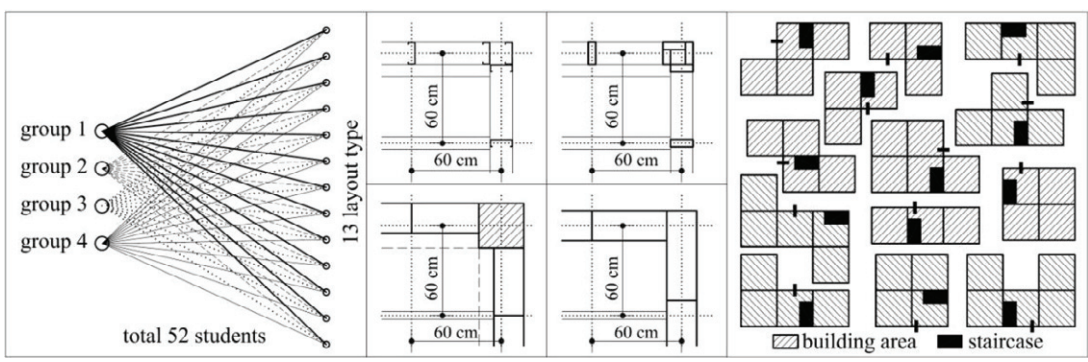

Figure 5.Oriented groups, applied modular grid and layout types

The results of cold formed steel framing system design education are presented in Figure 6. Group 1 students faced with a difficulty during erection of scaled model since unavailable of scaled proper members as C and U profiles.

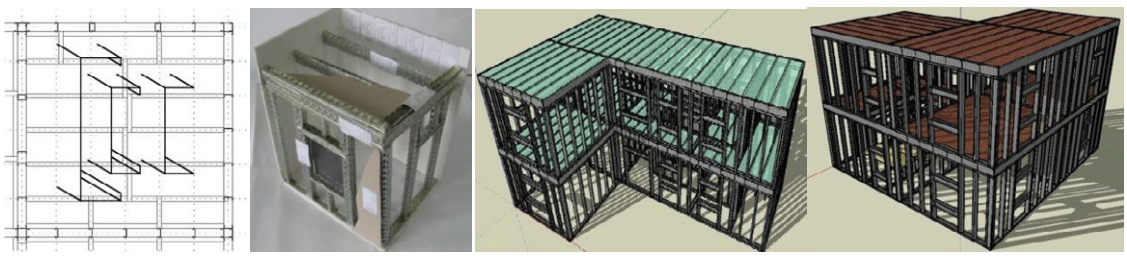

Figure 6. Results of cold formed steel framing system design education

Timber frame system is more comprehensive than cold formed steel framing system since the familiarness of the students to the system and ease of connection of the scaled structural members (Figure 7).

Two different constructional members are used in reinforced concrete prefabricated stick systemas reinforced concrete column / beam and aerated concrete panels for walls / slabs. The results of this system is presented in Figure 8.

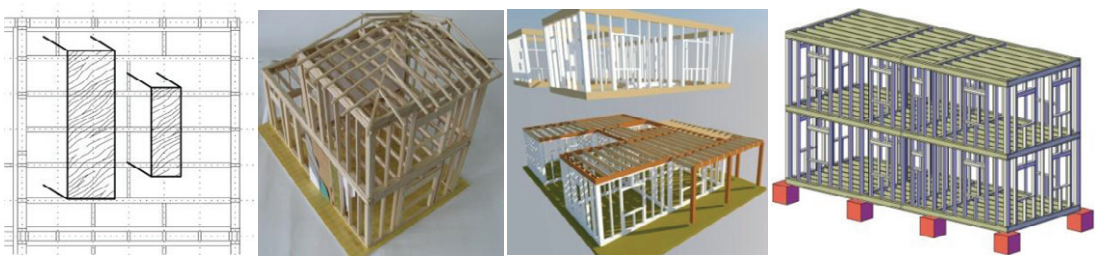

Figure 7.Results of timber frame system design education

Figure 8.Results of reinforced concrete prefabricated system design education

Figure 9.Results of aerated concrete panel system design education

Aerated concrete panel system is more comprehensive than reinforced concrete prefabricated stick system for the studentssince using of single type of structural members (Figure 9).

Consequently, four building systems are tested over a typical layout by students in order to compare the architectural layout and façade order differences. Hence, a comparative analyze made by students regarding mentioned systems.

4. Conclusion

Separation of building systems as “support” and “infill” level in building industrialisation and how building system design is implemented with limited number of components are studied and applied by students in industrialised building system design education. How architectural layout and facade order effected by applying of four industrialised building systems over a layout are tested by implementing this education in order to make more comprehensive the systems for students.

The study of structural members and connection of structural members of scaled model is being handled as an industrial design. Difficulties were faced by students during erection of scaled model since unavailability of proper scaled structural member and so, education kit for these building systems is required. It would be useful for students to find a stock ready education kit of industrialized building systems in order to time saving during education. Thus, graduate architects and civil engineers whom are interested in industrialised building system design can use these education kits to learn the installation principles and used components in limited time. Finally, the system design education will help to widespread of mentioned industrialised building systems.

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