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MİMARLIK EĞİTİMİNDE TAŞIYICI SİSTEM TASARIMINA GÜNCEL YAKLAŞIMLAR[1]

CURRENT APPROACHES IN STRUCTURAL DESIGN IN CASE OF ARCHITECTURAL EDUCATION

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Öz: Güncel tasarım yöntem ve stratejileri, teknolojik inovasyonlara bağlı üretim modellerinden bağımsız düşünülemez. Gerek temsil düzleminde, gerek fabrikasyon araçlarına bağlı üretim esas ve süreçlerinde güncel tasarım araçlarının, strüktürel tasarım modelleri ile etkileşimi çalışmanın kuramsal esasını oluşturmaktadır. Çalışmanın eylem pratikleri ile ilişkileri mimari eğitim ortam ve süreçleri içinde değerlendirilecektir. Kuramsal bilginin yanı sıra, oluşan güncel tasarım startejilerinin mimarlık eğitiminde karşılık isteyen yeni temsil araç ve yöntemleri bu çalışmanın esas tartışma konusunu oluşturmaktadır. Beykent Üniversitesi Mimarlık Bölümü 4. sınıfında yürütülen "Taşıyıcı Sistem Tasarımı" dersi kapsamındaki yeni yöntem arayışları ile bu yeni temsil araçları sorgulanmaktadır. Öğrencilerin kuramsal bilgi olarak edindikleri düşünsel pratiğin eğitim içinde eylemsel pratiğe dönüşmesi için tasarlanan bu araçlar ve oluşan sonuç ürünler bu çalışmanın örneklemlerini oluşturmaktadır.

Anahtar Kelimeler: Mimarlık Eğitimi, Taşıyıcı Sistem, Strüktür Tasarımı, Geometri, Grid, Topoloji

Abstract: The current design methodologies and strategies cannot be considered independent from technological innovations and production methods. The conceptual framework of this study is based on the interactions between structural design models and current design approaches due to the fabrication tolls both in presentation context and production processes. The relation between the concept and the practices will be considered in education process and context. This new design strategies in architectural education with new tools and processes is the main concern and discussion of this paper. In this research the experiences in the course titled 'Structural System Design' in Beykent University Department of Architecture will be evaluated due to current approaches in structural design. The case studies are the student's final products including new tools which are cases for transformation from intellectual practice based on theoretical knowledge to actual practices.

Key Words: Architectural Education, Structural System, Structural Design, Grid, Topology

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1. INTRODUCTION

The innovations in structural theories generate architectural schemata and solutions. Structure is not only a construction based on standing but also a conceptual reference. The current design methodologies and strategies cannot be considered independent from technological innovations and production methods. The conceptual framework of this study is based on the interactions between structural design models and current design approaches due to the fabrication tolls both in presentation context and production processes. The relation between the concept and the practices will be considered in education process and context.

The improvements in the production models are cases in both computer technologies and the basic principles of design based on structural improvements and evolutionary strategies. This evolution gives mathematical opportunities for production of interactive patterns which have complicated geometries due to the topological and parametric spatial relations. Mathematic becomes a common tool for interdisciplinary studies in complex design processes. As Pedreschi (2008) argued, the refinement of form depends on a heightened sense of structural behavior, employing both a conceptual and mathematical understanding of structural action. It is worth considering the development of structural mechanics in the two centuries preceding the 20th century. Prior to this time, structures were designed in a primarily empirical way based on experience and observation. In this sense, this study tries to explore current parametric processes and the control of design strategies which becomes possible by new mathematical knowledge. The innovations based on new solutions can be considered with new performative and interactive parameters at the same process. This process includes interactive and multilevel adjustments. This generating process has possible requirements as Lawson (2006) discussed through design objectives. Architectural design needs to incorporate complex organizational and functional requirements and therefore constitutes a recurrent negotiation of analyzing existing and requisite conditions as well as generating and evaluating possible responses. Additional knowledge gained through such iterative processes may require further analysis of the specific context or even the adjustment of previously defined design objectives (Lawson, 2006).

The new capacities in visual models crates a new media for engineers and architects to work together and helps to orient their intellectual knowledge on process more. Instead of cold objectivity of numeric methods, the warm interface of computer simulation models provoke different disciplines in order to involve in process. This interface creates a

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new media for architects and engineers to work together. In order to use this interface productive, the architectural education should be revised and reorganized. Beside the theoretical knowledge, students should be a part of this new media and should know to use it productive with all the parameters inside these new strategies. This new experience in architectural education with new tools and processes is the main concern and discussion of this paper. In this paper the experiences in the course titled 'Structural System Design' in Beykent University Department of Architecture will be evaluated due to current approaches in structural design. The case studies are the student's final products including new tools which are cases for transformation from intellectual practice based on theoretical knowledge to actual practices. For that purpose, the process includes tree aims. The process tries to explore and find solutions for tree aims for a bazaar structure. The first aim is to transform the ecology based knowledge to the information of structural system. The ecology based knowledge means all kind of performative environmental forces and affects as strong as the basics of structural forces. The second aim is the knowledge of events and actions based on foreground. These phases need a clear geometric optimization due to these parameters. The third aim is the challenge of structuring wide spans and heights. This phase needs a clear structural optimization which has reference both to geometric optimization and fabricability. This praxis through the applications of new production models and strategies give opportunities for exploring new contexts before professional practices. They are getting a closer look to current demands and their requirements.

2. PERFORMATIVE STRUCTURAL STRATEGIES

When we analyze the improvement of architectural design from past to now it's obvious that in last 20 years especially the challenges in information and technology affects to rethink the design processes again. The main reason in that is the dynamic structures in new design methologies. Designers very quickly saw the greater potential offered by formless or, more precisely, form-finding qualities of plastic-liquid concrete. Thin, double- the curved concrete surface structures with little historical precedent evolved. As designers studied new material, many incorporated a strong desire for structural expression and structural efficiency- to make virtue out of economy. Thus they drew together form, force and architecture. Designers, all of who sought expression in new materials and the opportunities to create structural forms (Pedreschi, 2008).

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Mainstone (1999) describes three forms of intuition that have guided structural innovation:

Intuitions of structural behaviour: A spatial or muscular sense of the actions of force and stability, that an arch may spread if the abutments are not sufficient to push against the thrust or that slender column is less stable than a short broad column.

Intuitions of structural action: a deeper understanding of structural behaviour, supported by care ful observation that led to more precise ideas of force, moment and equilibrium; the start of a quantitative understanding of structure.

Intuitions of structural adequacy: A perception of the adequacy of a generic structural form for a particular application, conditioned perhaps by the significance of changes in scale and proportion.

Chain curve is the basic of structural models. When you turn the free form which is stabilized from to points it becomes an independent spring (Kavurmacıoğlu, Arıdağ, 2013). Several designers and structural engineers used this method in building structures in the first half of the 20th century. Robert Maillart's ideas were in case of mathematical theories that would give possibilities for numerical analysis of structural behavior.

Figure 1. Robert Maillart, Salginatobel Bridge, near Schiers, Switzerland, 1930

Nervi had an advanced interpretation about the nature of concrete. The structures of the earlier Nervi's hangars were constructed in situ. In the later projects structures was simpler and consist of a hybrid of prefabricated elements and in situ concrete.

Figure 2. Pier Luigi Nervi, Hangar for Italian air force, Orvieto, Italy, 1935.[1]

Like Nervi, Candela improved complex theories and their applications by using concrete. He used the hyperbolic paraboloid as a generator of structural form.

1 http://pierluiginervi.org/pier-luigi-nervi-architecture-as-challenge/the-12-architectural-icons-presented-in-the-travelling-exhibition

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Figure 3. Felix Candela, Los Manatiales restaurant, Xochimilco, Mexico, 1958[2]

Eladio Dieste's structures there are no ribs or beams but just a folded surface. He developed catenary to produce more complex double-curved forms, which he called Gaussian vaults. The geometry is defined by a series of curves which have different heights where each shares the same originating point.

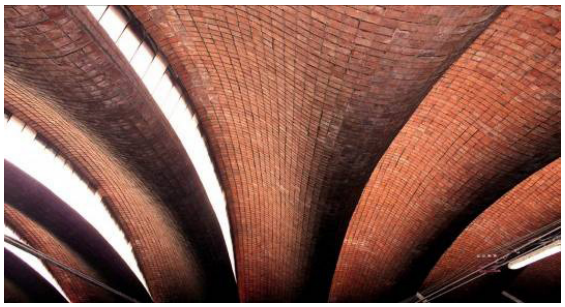

Figure 4. Eladio Dieste, Gaussian vault under construction, Uruguay, early 1960[3]

3. COMPUTABILITY in STRUCTURAL DESIGN

The transdisciplinary studies in architecture, mathematics, biology, genetic and the others need a new interface which is computable and performative. This new interface has possibilities both for the analyses through the universal flow of information and for the new fiction on a proper field with a required tool. Beside, computability has a universal structure which refers to unlimited frame of studies with the information flow between different disciplines. By the exploration of structure based new possibilities which constitutes parameters to architectural design, mathematics become more than a tool for creating proportions and forms. This new tool is basically a new agent to create new structures of different kinds of information which can easily become a parameter for design and used to generate structural relations. Thus, the environmental factors like earthquake, rain, wind or water which are considered as chaotic structures had been involved in design processes as vectorial and performative forces by compatible computer simulations. This agents provide the improvements in geometry and generate non-euclidian geometries which are named formless generations. 'The critical difference between the use of Information Technology (IT) and structure-

2 http://www.archdaily.com/496202/ad-classics-los-manantiales-felix-candela/53462042c07a80a76e0000a6-ad-classics-los-manantiales-felix-candela-image

3 http://archleague.org/2014/06/material-tour-de-force-the-work-of-eladio-dieste/

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based form-finding is the possibility to create form without predefinition, without an underlying geometric condition, translating the surfaces of an abstracted volume directly to a digital mapping of the surface' (Pedreschi, 2008). These new formless generations have a capability to create new patterns in structural design. The topological continuity of the pattern provides the strength of the structure. This continuity created by the optimization of dynamic parameters dependent on time and movement. These optimizations are the basic principle of the current approaches in structural design.

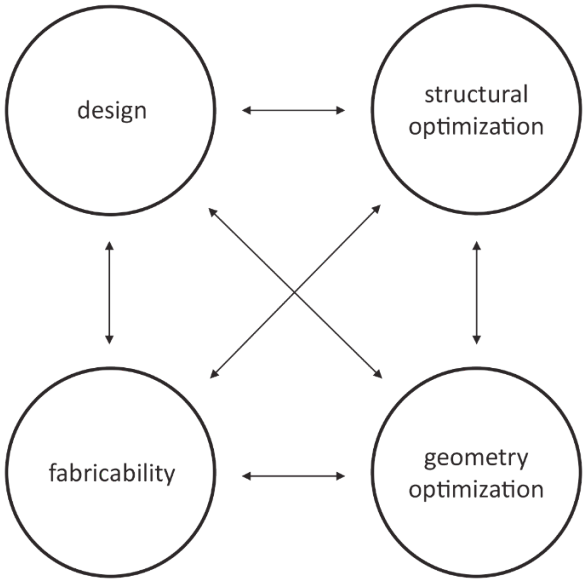

Figure 5. Designing Complex Structures (Greco, 2014)

Designing complex structures requires iterating over various aspects, such as design, structural and geometry optimization and fabricability. Each aspect is related to each other, so the project evolves in every direction (Greco, 2014) The knowledge of structural optimization is based on the production of the conceptual framework by operational grid and the generation of the information based on the actions and events. The elements of structural optimization argued with the reference to Liu and Lim (2009)'s comparison of the factors between classic and new tectonics. Where the seven classical factors are; joint, detail, material, object, structure, construction, interaction, the factors of new tectonics are; motion, information, generation, fabrication. Thus, the elements of geometric optimization are a kind of exploration for a dynamic production. The adaptive structures need a formless generation for a representative reference to the knowledge of nature and the motion. In the adaptation of structure grids are configurations that are resolved in orbit of a possible hybridization between architecture and infrastructures. Replace, in effect, the idea of outline with that network and that of reticule with that of mesh. This level of internal organization points to a meshed organization, aimed at favoring an elastic topology- a greater capacity for linkage and deformability-in the system. (Gausa, Porras, 2003).

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To represent the geometry of complex structures we need topology without certainty but with relativity of information. Thus, in space-time-information flow the algorithms take place of numeric mathematics (Arıdağ, Koş, 2015). A project's diverse design criteria can be understood as a network settles into a state of equilibrium of various influences a high level of integral performance of the building and its structure has been attained. This capacity cannot be achieved through single-parameter optimization of the building and its structure has been attained. This capacity cannot be achieved through single-parameter optimization of the overall system, as the linearity of such processes cannot account for the complexity of architectural projects. Likewise, in digital processes each individual structure needs to be fully defined and modelled in order to be evaluated. Each evolved structure is based on the generic information of a previous generation and has undergone further adaptation (Bollinger, Grohmann, Tessmann, 2008).

4. CASE STUDIES

The process tries to explore and find solutions for tree aims for a bazaar structure. The first aim is to transform the ecology based knowledge to the information of structural system. The ecology based knowledge means all kind of performative environmental forces and affects as strong as the basics of structural forces. The second aim is the knowledge of events and actions based on foreground. These phases need a clear geometric optimization due to these parameters. The third aim is the challenge of structuring wide spans and heights. This phase needs a clear structural optimization which has reference both to geometric optimization and fabricability. As Özgencil (2015) argued that the experimental studies in architectural design education propose two main arguments; one is the esthetical values system due to the regeneration in architecture and the second is the inadequacy of conventional systems and the search for new design strategies.

The selected studies give references for both structural and geometrical optimization processes in different ways. The contextual parameters like the movement in bazaar, sun light, the programme configuration and environmental forces are the dynamic inputs in these processes. Structural innovations are for wide span challenges and new structural fabrications. The explanations of the selected cases are;

[1] The shopping events have solved as modules with additive units. This additive organization creates the grid. Each module includes 6 shopping units. The folding layers of structural units create possibilities for other events when the bazaar is off. The canopies have performativity for sun light.

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[2] The structural system has improved by analyzing the stripes on Armadillo. The southern facade of the oblique axis over the system obtains solar power and shading. The structure itself also behaves as a layer for environmental protection. The gaps have produced by the repetition of the structure create layers for benches. The structure overlaying the forum allows collective working, meeting and waiting spaces.

[3] Project has designed with hyperbolic parabolic wide range structures. The connection points of the hyperbolic parabolic curves with ground have designed with four sided oblique brackets. The metallic sheet covers the oblique beams and creates a continuous canopy. The wooden boxes have replaced into modules of the metallic sheet and creates an environment for self-green agriculture. The frequency of these plants changes according to the bazaar events. They are more frequent through the brackets in order to protect the bazaar benches.

[4] The concept is based on the wide range structure possibilities of the natural pattern of lichens and geometric abstraction of this pattern. While the structure of the designed shell creates a continuous relationship with the ground and transforms the upper layer a promenade, the other sides of the shell have openings to create the entrances of the bazaar. The porous columns are the parts of the continuity of the structure. The natural water transmits through the depot from these holes. The oblique differentiations on the ground allow some backwater for animals like cats and birds. The southern surfaces of the system used for solar panels.

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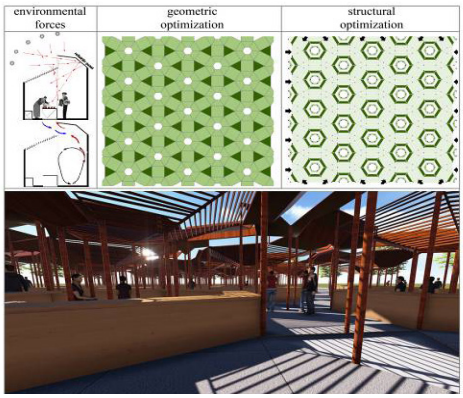
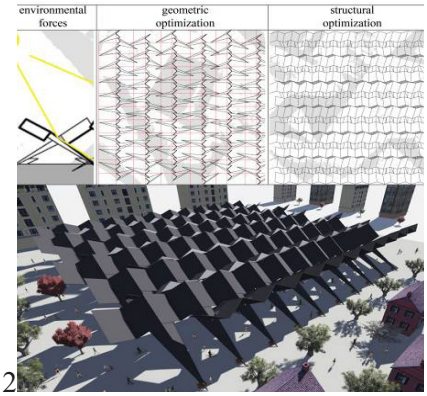
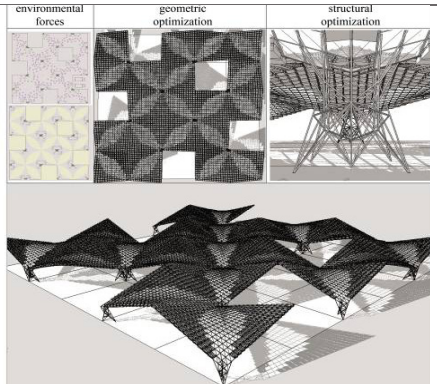
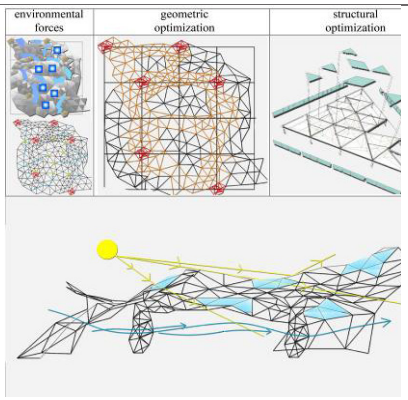
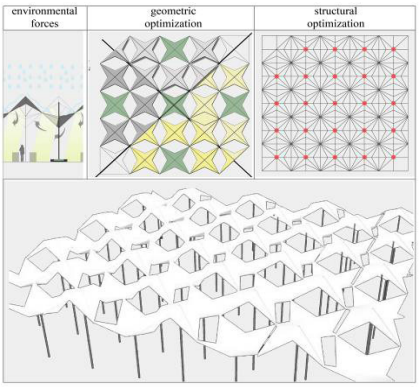
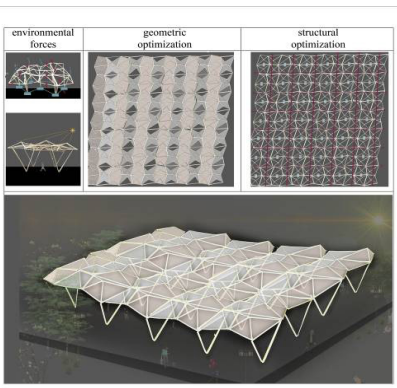
Table 1. Case Studies

1  	2  	• Contextual Geometry: Movement, Programme • Structural Module: Environmental Forces
3  	4  	• Wide Span: Structural Optimization • Structural Module: Environmental Forces
5  	6  	• Eco-Module: Sustainable Parameters

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[5] The module has designed with gathering different types of products together in the bazaar and creates a four divided cell for a unit. The other parameter for the module is ecologic water supply strategy. The surface module on the canopy transmits water to each bearing base. There are water depots under them. The surface of the canopy has light tense textiles too. Collecting water use to irrigate surrounding green and the light tense textile helps to natural ventilation with these green.

[6] The module has designed with gathering different types of products together in the bazaar and creates a four divided cell for a unit. Dairy products replace in order to less sunlight. The clothing benches replace according to duration and need for wider spaces. The openings on the canopy are in the south-north direction in order to decrease the wind load and supply natural ventilation. Transparent and opaque materials have used together for natural sunlight.

Table 1 represents both similarities and differentiations for different parameters and fabrications. Cases 1 and 2 are module based studies which search for a unique module for a bazaar and its repetitions for the context. The geometry is based on the contextual parameters as programme and movement. The structural innovation based on basic structural rules. Cases 3 and 4 are structural innovations for wide span challenges. Structural optimization based on complex geometries and rules for regular repetition in case3 and irregular repetition in case 4. Environmental forces are affective for whole structure. Cases 5 and 6 are sustainable innovations which search for an eco-module. These modules are self-efficient and regularly repetitive.

5. CONCLUSION

Stability concept as one of the basic features of dynamic systems may create far more innovative results. Dynamic conversion, heterogeneity and stability, becomes a combination of economic and ecological sustainability. Wherein the objective is a method based relational or intellectual design. By this method topology allows the coverage of various vectors and thus can accommodate different parameters in a single uninterrupted surface. Thus the structure, as an active information will be formed in the context of the stored information is moved into structural.

Structure based new possibilities in architectural design creates a new area where architects and engineers work together with

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computer simulations. These simulations have possibilites to interact any kind of design parameters and structures with this interactions which are more than proportion and form. To design structure with esthetics value transform the occupations like the architect becomes almost engineer the engineer become almost an architect which is called transdiciplineer. Nervi, Candela, Maillart and Dieste are the references from history with the inspiration they bought through. The inovations and experiencew through history help to discover the invisible parameters in design. Chaotic structural vector parameters like earthquakes, wind or water become more relevant and easy to simulate. Thus the geometry improves through non-Euclidian forms. These forms have topological characters and a pattern. The continuity of this topology helps the stability of the structure. This continuity is also an optimization which the time and movement based parameters are active. Also, sustainability, minimum consumption, flexibility, polymers and membranes create opportunities to improve new structures. The ability of computer to work together for different disciplines helps to include with intellectual knowledge into design. The warm real like images of computer simulations beside the cold numeric methods create a common interface for all disciplines. This new interface is a new language which everybody can understand. Before these innovations numbers are just for engineers and hard to understand for others. In order to work efficiently with this interface the structural design topic has gain importance in architectural design education. To discover a structure with optimizations of information is the basic experience in education. The architects need a structural experience with the knowledge of mathematics, physics and computer based modeling to work with other disciplines. In architectural schools engineering students and architects should work together. The basic knowledge on computer simulations should be thought and help students to adapt contemporary solutions.

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