MATHEMATICS AS MEANS OF DESIGN PROCESS: COMPOSITIONAL PRINCIPLES IN THE ORGANIZATION OF THE "TURKISH HOUSE" AND THE WORKS OF SEDAD HAKKI ELDEN

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Abstract

Many people would be perplexed to see two concepts - "mathematics" and "architecture"- side by side in the same paper. However, since the early times, architecture has always retained a strong interaction with mathematical issues. From the ancient Greek and Egyptian temples to the works of Andrea Palladio and Le Corbusier, in the design of almost all architectural products mathematical principles have been applied. This paper aims to analyze the relationship between mathematics and design through the structural organization of the "Turkish House" and the principles of composition in the architecture of Sedad Hakki Eldem -the Aga Khan Award winner Turkish architect- with particular reference to the "Turkish House". Analyzing the "Turkish House" in depth, Sedad Hakki Eldem has captured the essence of its compositional principles and succeeded in interpreting these mathematical principles in his designs efficiently. If architecture is defined as giving form to empty space, then it is through mathematical sensitivity that architecture is created. Mathematics, as means of architectural composition, is not only about measuring dimensions but also about geometrical shapes, a sense of order, achieving balance and creating a feeling of rhythm and pattern.

Keywords: the "Turkish House", mathematics, architecture, mathematical compositional principles, Sedad Hakki Eldem.

Mathematics as means of Architectural Composition

Sedad Hakki Eldem is one of the architects (or the architect) in Turkey on whose works and architectural ideas dozens of papers and books have been written. Yet, most of these researches have bypassed the endeavors of Eldem until recent times. The essential ideology lying in Eldem’s architectural discourse is his intentions in extracting out a design methodology from his studies on the "Turkish House" -a generic term applied to the timber-frame Turkish house that is spread from the Central Aegean to the northern side of the Taurus Mountains, from the coasts of Anatolia to the mid plateaus and reaching out to the Balkans and Rumelia. The “Turkish House” illustrates the relationship between mathematics and design in the most credible and beautiful way. Depicting the mathematical principles hidden in the organization of the “Turkish House” through a critical approach, Eldem’s architectural oeuvres exemplify the strong ties between mathematics and design.
Principles of Composition in the Design of the "Turkish House"

Structure

In this section, the structure of the "Turkish House"—in terms of both a general rule determining the constructional technique of the building and its syntactic qualities lying behind the arrangement of the architectural elements within a whole—is aimed to be analyzed.

Serial Structure

The composition of the "Turkish House" displays structures formed by the serial use of an element or a group of elements. In his article The Notion of Enclosure in the Formation of Special Building Types, Giuseppe Strappo defines the serial structure as "...an ensemble in which one element can be replaced without causing substantial changes to it" (Strappo, 1995:93). It should be emphasized that the character of the structure is strictly related to the character of its elements. There exist two types of components in the structural organization of the "Turkish House", the combinations of which determine its typological process: the repeatable series of elements (rooms, eyvuns, regular spans) and an interior space (bayan, sofo, courtyard) dominating the spatial hierarchy.

Nodal and Polar Types

Two plan types that Eldem stresses the most—the house type with an inner sofo and the house type with a central sofo—seem to correspond to the two types defined by Strappo as the "nodal type" and "the polar type" respectively. Strappo explains the notion of nodality as expressing the connection between the components of a building, which is not necessarily identified by a point but by axes and their intersections: the intersection of two continua (Strappo, 1995:94). Polarization, on the other hand, as Strappo mentions, indicates "...a sublimation of the term node, determined by the presence of various continua, not so much intersecting but rather terminating or starting from one point" (Strappo, 1995:95).

Even if one of the serially organized elements is eliminated, the nature of the nodal composition is not disturbed. On the other hand, the elimination of any element from the polar organization (and from the central sofo type) would destroy the unity of the composition. In any case—be it the nodal or polar type—the major compositional principle of the "Turkish House" is the assemblage of geometrical and clearly defined interior elements.

Axiality

The spatial structure of traditional houses is strongly developed along axes organized by the grid system and modular logic. Each room specializes itself by establishing its own central axis and is treated as a special unit in itself. The building’s spatial structure is legible from outside as the location of rectangular masses (referring to the rooms) around a central volume—the sofo—is drawn in or projected out. The side façades maintain their original aspect indicating the serial layout of rooms and the recurrence of the modular units along the axes through the windows’ modular arrangements.

The house type with two circulatory axes:

Fig. 1a: The circulatory axes of the type with a central sofa.

The house types with a single circulatory axis:

Fig. 1b: The circulatory axis of the type with an outer sofa.

Fig. 1c: The circulatory axis of the type with an inner sofa.

In the planimetric schemes of the "Turkish House" there exist either a single or two circulatory axes intersecting with each other at right angles. Along the predominant direction of these axes the modular cells are serially organized, however, in a free layout rather than in a rigid order. The main circulatory axis can be defined as a linear route consisting of an open space between other spaces, serving for various functions.

Modulation

Modular Structural Elements

The timber-frame serves as the basic measurement unit for the spatial composition. The building elements are arranged within a modular system derived from this measurement. The modules dimensioned in certain scales are applied on the wooden house’s façades, serving as a tool to arrange their proportional relations and their composition as well as their structural system. Yet, the modular logic of the anonymous "Turkish House" is not limited to the façade arrangements only; a strong modulation is also evident in the plans.
Grid

The grid functions as an instrument to be used in design process and to insert order as well. The grid system drawn as a two-dimensional plane in the planimetric schemes can also determine the relations and hierarchical sequences of volumes through its orders—that of pure relationship. The organization of the grid represents an overall regularity. The application of modular units is derived from this grid system, which is evident in the planimetric compositions of the "Turkish House". The representation of the "Turkish House" on a grid system makes it a modular, repetitive and regularized composition.

Proportion

The proportional system of the traditional Turkish dwelling architecture is based on a modular logic and simple arithmetical relations—evident in the overall composition of the house. The proportional system of the "Turkish House" determines the rhythmic and distinctive façade arrangement; the vertical 1:2 proportion of windows and their lateral arrangement are emphasized.

Geometry

Geometry is one of the basic a priori compositional principles of the Turkish dwelling architecture: both the planimetric and volumetric compositions of the house can be simplified to schematic, regular geometric forms. The use of modulation naturally contributes to the formation of strong geometry. The "Turkish House" may be read as the assemblage of rectangular units in a free order.

Formal Expression

Repetition

The formal expression of the "Turkish House" is based on the repetition of elements, its proportion system and its strong geometry. In the composition of the "Turkish House" the basic principle is the repetition of the elements rather than their plasticity. The traditional house is formed of geometrically defined, repetitive elements. These elements of the house can be categorized under very simple archetypes: rooms, sofa, cumbar, façade modules, windows, eaves, etc., and these elements can be assembled in an infinite number of variations. The lateral arrangement of the architectural elements creates a horizontal geometry.

Symmetry

Symmetry, distinguished in the composition of the whole house or its single parts, does not only serve as a tool to arrange the façades but also acts as a rule to establish the compositional logic and clarity of the interior spaces or the structures spreading out in the forms of pavilions. The embryo of the symmetry principle resides in the ensemble of two rows of serial rooms and a distribution space in-between (as in the case of the inner sofa type) or rooms located on four sides of the core (as in the case of the central sofa type). This central space—when folded up on itself on the vertical axes passing through the sofa in the first case, and on two perpendicular axes in the latter—determines the center of the plan. Symmetrical arrangement in the "Turkish House" is widely established in the planimetric compositions of both the inner sofa type and the central sofa type.

Fig.3 The modular structure of the "Turkish House". Source: Eldem (1987).

Fig.4 The modulation and proportions of a timber-frame structured house in Koprovitza—redrawn by Cerasi. Source: Cerasi (1999).

Fig.5a Symmetry axis of the type with an inner sofa.

Fig.5b Symmetry axis of the type with a central sofa.
Principles of Composition in Eldem’s Architecture
(with particular reference to the “Turkish House”)

Repetition

In both the monumental and traditional Turkish architecture, repetition of certain architectural elements is very common and widely praised. Eldem, in his designs, inherits this compositional principle as a basic invariable and applies it in his organizations of both the windows and other elements. In his designs, in order to achieve the repetitive pattern of the windows, Eldem either refers to the serial use of certain vertical façade elements or he depicts this repetition through the consecutively used use of windows. He sets the arrangement of windows on the norm of 1:2 proportion - a fundamental compositional principle in the Islamic architecture and the “Turkish House”.

Common to most of Eldem’s designs is his consistent emphasis of certain elements through their repetition - both horizontally and vertically. The lateral arrangement of windows of 1:2 proportion on the façades of the State Monopolies General Directorate in Ankara-Turkey (1934-1937) (Bozdoğan, 1987:58) and the recurrent vertical present façade elements of the Indian Embassy Building are two examples from a wide range of buildings, in which the architect applies the repetition principle. The masses gain a vertical volumetric effect via the attachment of long, slender elements on the façades while at the same time their lateral arrangement lends the buildings horizontality. Eldem’s elevations reflect a successful rendition of this dialectical quality.

Modulation

For Eldem, the module serves as the basis of both planimetric composition and of volumetric organization. Strong modulation is a fundamental architectural constant which the architect uses with much attention and consciousness in his designs – powerful modulation expressed in the planimetric organizations, on the structural formations, elevations, interior ceiling finish, underneath the wide projecting eaves and even on the garden pavements.

On the façades of the Indian Embassy Residence (1965) (Bozdoğan, 1987:128), the modular logic is expressed via the repetitive arrangement of prefabricated casings placed in-between the windows. Eldem explains the function of these elements as emphasizing the planimetric module of the building on the elevations (Eldem, 1982:56).
Eldem recognized that the plans and elevations of the simple geometric shapes of the traditional dwelling architecture could easily be represented on a grid of regularly spaced lines intersecting at right angles. The reason underlying Eldem’s choice of composing on a grid may be delineated in two ways: the success of the grid due to its simplicity and its potentiality to serve as an ingenious tool in the composition of masses and spaces in plan. The grid allows for the abstraction and standardization critical for Eldem’s compositional method.

In the planimetric schemes of the Upalghilli House, the plan is laid out on a grid system reflecting both the strong axiality and the modular logic of the composition. In this drawing, it is evident that Eldem used the compositional method of Durand and of the Beaux-Arts architect: the relation of masses with each other, their proportions and scale are all organized with regard to the grid system. On the grid, Eldem locates the main point-supporters—namely columns—and then considers the enclosing walls, which leave the columns as freestanding as possible.

Fig. 11 Upalghilli House—the grid system of the house. Source: Eldem (1982).

Eldem’s compositional logic adhered closely to a grid stated by not only the columns of the circumferential peristyle but also the pattern of squares covering the floor spaces. In his Suna Kırcaş Yali (1965), the significance of the grid is re-emphasized both on the elevations and on the garden pavement via the square pattern of marble floor tiles.

Fig. 12 Suna Kırcaş Yali, Istanbul. Source: Bozdoğan (1987).

It is the clarity of expression and potential of variation that Eldem pursues in the modular logic of the tradition. Eldem expresses the reason lying behind his preoccupation with the modulation as:

“Typical modular features of the Turkish House have the capacity to be regenerated in contemporary design principles...as a system of structure, the Turkish House presents a tradition for contemporary architecture” (Eldem, 1981-50).

Axiality

The structure of Eldem’s buildings is strongly developed along axes organized by the grid system and the modular logic in conformity with the structural organization of the “Turkish House”. The strong axiality in his designs is legible both from the planimetric compositions and from the exterior. The Ilicak Yali is designed along an axis of symmetry passing through its central sofa. The köşk type projections of the living room located on two sides of the sofa emphasize the main axis—or the nodal axis. The varied spaces preserve mirror symmetry to left and right of the central axis. The resulting sea frontage is symmetrical, reflecting the planimetric composition.

Fig. 13 The nodal axis passing through the sofa. Source: Strappas (1995).

In Şark Insurance Company Headquarters, the strong axiality achieved through the grid system of the planimetric schemes and the perfect symmetry of the plan-volumetric composition is reflected on the elevations through the repetition of aluminum cumbar and the symmetrical arrangements of the façades. The center of axes is emphasized by the high, spacious central void within the building and the octagonal gallery at the center on the ground floor. The planimetric composition of the building can be classified into the polar type structure—in other words, the structure of the house type with a central sofa—in which the various parts of the building are united into a whole via a unifying central element. In this project, the offices are organized around a central void pressing over the overall composition.

Fig. 14a Ilicak Yali—view from the Bosporus. Source: Tanyeli (2001).

Fig. 14b Ilicak Yali—first floor plan. Source: Tanyeli (2001).
As a result, it can be suggested that in his compositional method, Eldem proceeds from the general to the particular, moving from the main axes to secondary axes, and then planning to grids. His composition on grid system is directed and organized by axes. In other words, Eldem recasts the traditional archetypes, which he obtains from the decomposition of the traditional architecture, according to a modular grid and an elemental vocabulary of columns, walls, galleries, etc., and then synthesizes them along the axes of composition to generate ensembles. Apparently Eldem’s ideological position is clearly stated in his designs: he is interested not in their detailing or ornamentation but rather in the pure forms—the essence of their geometry—and the generative principles. The compositional principles of the Turkish dwelling architecture are manifest, presiding over the overall design.

Concluding Remarks

Since the ancient times, mathematics and architecture have retained close relations. When explored, it would be evident that extending from the Great Pyramids to contemporary design most architectural products are organized within mathematical principles. However, it was in the 19th century that a rupture has taken place, which caused a distinction between the terms “science” and “art”. Beginning from this period, the change of attitude, which considered the roles of mathematicians and architects separately, led to the evaluation of scientific and artistic aspects as complementary skills not be possessed by the same person (O’Connor & Robertson, 2002). This separation in concepts forms the basis of today’s misconception that architecture is merely a form of art and not related to scientific issues. However, if architecture is by definition the process of giving form to empty space, and if forms embody a logical system of order and an internal physical structure, then it can be deduced that the field of architecture also possesses scientific aspects. In fact, architecture can be classified with sculpture and painting as a type of art and with mathematics as a form of science as well. Therefore, it is clear that architecture is explicitly concerned with formal regularities and disciplines in compositions that are shaped by certain mathematical principles.

The strong relation between mathematics and architecture is displayed genuinely within the spatial organization of the "Turkish House". Its structure is based on certain patterns; its planimetric organization is organized along certain axes, building elements are derived from the basic module by use of a system of ratios; the plans are laid on a grid system; its formal expression is formed through the repetition of elements, geometric forms, well-proportioned masses and symmetrically organized elements around an axis. Considering the "Turkish House" as a tool to extract out an operational design methodology, Sedad Hakki Eldem adopts its compositional criteria through an interpretative approach. The works of Eldem are structured along certain mathematical principles, which the architect has abstracted from the "Turkish House". In summary, it can be put forward that extending from the anonymous craftsmen of the Turkish dwelling architecture to Sedad Hakki Eldem, mathematical fundamentals have been praised highly. It is through the pure structure of mathematics that beauty may be achieved.

Glossary

avlu: courtyard.
cuma: a bay-window.
çeyvon: a vaulted recess for sitting within the sofa.
sofa: a seat, constituting the distributive space and the focal point of the traditional "Turkish House"; also a pavilion continuing in front of the rooms as a passage to the garden/courtyard.
bah: a term used for projecting bays in the Turkish House; also a pavilion built separately for shelter.
revak: a domed or vaulted colonnade flanking a courtyard or garden.
yol: a mansion built along the shores of the Bosphorus.

References

Özbil, N. A.; 2001. Drawings (plans, elevations, sections and details) obtained from Şark Insurance Company Headquarters; photographs of the building taken by the author.