COMPUTATION:
THE NEW REALM OF ARCHITECTURAL DESIGN

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The "Formalization" of the In-Formal

Design and Materialization Evolution of 'Paramana' Square as a Case Study

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Abstract: *Informal has to do with shifting certainties and the insertion of unexpected, chance and improvisation. The 'formalization' of the informal is the subject of this paper; seeking to explore the possibility to have atypical and not rigorous formalizations. But if that is possible until what point informality can be described and designed? By presenting an experimental and realized architectural project we bring forward the necessity of rethinking the concepts of design and construction evolution. There is a strong relation between techniques and the generation, control and construction of complex forms. It is clear that the animation techniques and the dynamic vectorial systems that they are used during the design process played a vital role in the liberation from a pre-conceived typology, as well as in morphing, in controlling, and in materialization of the new that didn't exist before.*

Keywords: *Informality; animation techniques; dynamic design systems; optimization; rationalization.*

Introduction

Informal has to do with shifting certainties and the insertion of unexpected, chance and improvisation. As Cecil Balmond writes 'uniformity is broken and balance is interrupted. The demand for Order! In the regimental sense is ignored: the big picture is something else' (Balmond, 2002). In the informal there are no distinct rules, no fixed pattern to be copied blindly. If there is a rhythm it is in the hidden connections that are inferred and implied, and not necessarily made obvious. Order, in a hierarchical and fixed sense, is taken as furthest removed from the natural state of things. Strange juxtapositions take place. The composition is holistic and multidimensional from the start.

The technologies of our time offer new design techniques and processes. Instead of designing by hand we construct vector systems as tools of control, freedom and action, introducing a new world of possible expressions and architectural experimentation. From initial stages the design unfolds in digital 3D environment by the application of animation techniques and software that utilize time and changeability as vital ingredients of design. In the design process of the central «Paramana» square is clear that the animation techniques (The branch

Figure 1
'Paramana' central square of Thermi Municipality

of mechanics that treats of motion in itself and of the motion of bodies or matter under the influence of forces in opposition to kinematics which is the branch of mechanics that deals with pure motion, considered without reference to the objects in motion, or to the forces acting on them) that they are used have played a vital role in morphing the square, in the liberation of the Euclidean geometry and in realization not of a pre-conceived image, something similar, but the other, the new, the virtual that has never existed before.

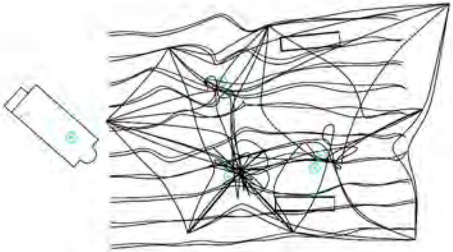
Time as design «substance»

In classical physics time is perceived as linear and is related to the three-dimensional space. This linear perception of time and its isolation from the natural phenomena made possible their observation and their study. So time is transformed into a tool for measuring the phenomena that occur in the «container» of space. In the field of physics, in most thermodynamic systems time is not linear, and as a result the processes of the phenomena are not symmetrical between past and future. Time from a measurement instrument is transformed into «substance», which takes part in the morphogenesis processes. Time operates as information enabling the differentiation and change of matter in it.

Atypical shapes and the technology of design

The emergence of complex and curved shapes can be seen far in the historical past and of course in many contemporary examples. We could argue that in different periods of history there is a strong 'legitimization' between the developments of technology for the representation of design information and the types of the architectural drawings and the invention of complex components and shapes. The projective geometry was followed by differential geometry and calculus and the associated general theory of curved space, as it was further developed by Karl Friedrich Gauss and G.F.D. Reimann, providing thus the required theoretical basis for understanding the complex surfaces. However, these formulations remained for a long time separate from the practices of design (An interesting and innovative example is the Philips Pavilion, by Le Corbusier and Iannis Xenakis design for Brussels World's Fair in 1958). If we assume that design is the preservation and medium of the established knowledge of the past then its

Figure 2
Animation techniques applied on the initial networks



continuity in time embeds a controlled and ensured result by the previous experience. Acting as a preconception, it is a kind of standardization and classification of the pre-existed information, behaviour, and cultural and social practices. This knowledge is realized and presented through a specific design process and a final design result.

Vectorial systems and the realization of the new

By the development of advanced digital design systems many of the historical barriers were overcome like the representation of complex geometrical shapes. Rather than drawing a line with our hands or an organizational grid we are using the computer to represent a vector which has nothing to do with the Euclidean line which is defined by two points. The vector has a density, direction; it is a force that we cannot draw.

In the design process we construct digital vectorial systems by introducing diagrams, vectors, force fields and parameters through the application of animation techniques. The representation that systematically reflects some features of reality, may serve as a representation - tool of control and action. That can open a new world of possible expressions and architectural experimentation. Computing design provides new possibilities for the genesis of free forms but these new shapes are just a facet if their formation and rationale is based on the typical structural organizations. An internal logic and method is important. Cecil Balmond an innovative engineer inscribes in his book under the title 'informal': "the ingredients are all there to evolve form in fascinating ways…the challenge is to make structure the new discipline in a re-examination of space'.

A materialized case study

Architects: Kontaxakis Dimitrios, Kosmidou Maria – Eleni, Papadimitriou I. Spiros, Associated Architects: Ioakimopoulou Aggeliki, Hatzimichali Meropi, Lighting design: Klonizakis M. Aristidis.

Design and form evolution

The specific experimental design process of the central square produces an informal architecture in contrast to preconceived and predictable results based on the implementation of conventional square typologies and standards. The proposal is based on dynamic 'formation' of two overlapping and interactive network-fields: a 'path network' of the possible pedestrian movements and a 'programmatic network' of the potential activities on the surface of the square. Further on, additional processing optimized their correlation and synergy and generated the final form.

At the first stage, in a three dimensional environment of an animation software, the two-dimensional networks are designed on the topographic plan of the square. The first network represents the possible pedestrian paths. This diagram consists of nine points and all the possible lines of mutual connections. The points represent origins and destinations from and to the perimeter of the square and three other points of special interest inside the square. Then these straight segments are converted to 'soft curves'. three attraction fields of different magnitude, which are located at the points of interest, are applied on the 'soft' network for a specific time period. The 'soft' segments shift, curve and gradually converge to form bunches and patterns of routes of different size on the two-dimensional surface of the square. The second network refers to the 'stationary'

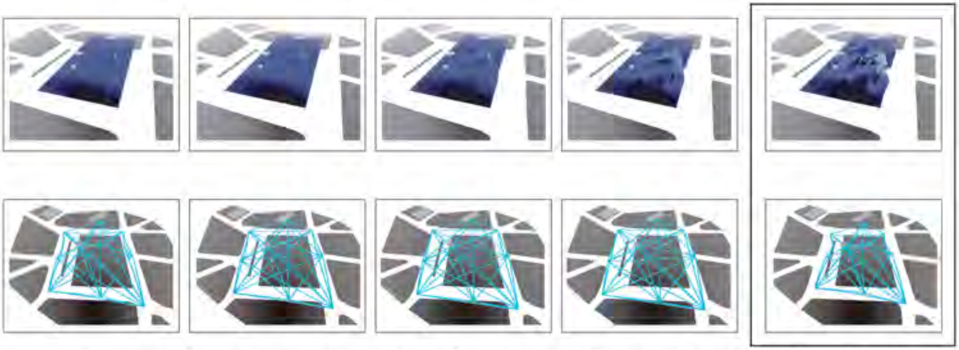


Figure 3
Gradual deformation of the networks by dynamic fields

programmatic areas of the square. it consists of seven parallel double lines at the longitudinal axis of the square. These lines are extensions of the support beams of the roof of the underground parking station. The lines, inscribed by twelve serial points each, create an invisible two-dimensional orthogonal grid.

Located at the same points of interest and for equal period of time as the first network, three turbulence forces of different intensity and magnitude are applied to this grid of double lines. The orthogonal grid becomes an elastic network of points and it gets 'exfoliated'. (Sanford Kwinter uses the concept of the mathematician Rene Thom, awarded for his research for topology and fields. Exfoliation refers to a violent expression (or a geometrical unfold) of applied forces that they haven't been visible yet.) The pairs of lines are progressively shifted, curved and twisted under the influence of the forces, and produce a different effect. The lifted lines escape from the two-dimensional surface of the square level and generate three-dimensional stripes of varied width, height and wave intensity.

By converting the lines to soft curves the network of interrelated point locators, is defined in 3d space. This 3d wireframe could be varied continuously by testing different combinations of magnitude and attenuation values of the forces that applied on the nurbs splines. The transformation of the network (by the use of animation) is 'frozen' when the forces produce the desired effect on the curved lines and generate the desired spatial relations. Finally by 'lofting' the curved lines with nurbs surfaces the wire-frame model is converted to a surface model and a closed shape is produced. the level square from a 2d surface is transformed to a 3d surface with 'depth', behaving as an intelligent interface able to host and generate the new program by proposing new activities and provoking others, unpredictable, as an outcome by the users' personal experience.

Optimization

The gradual decisions of materiality, load resistance and surface performance for the desired activities to occur informed the digital model with required data. The final form of the square is the effect

Figure 4

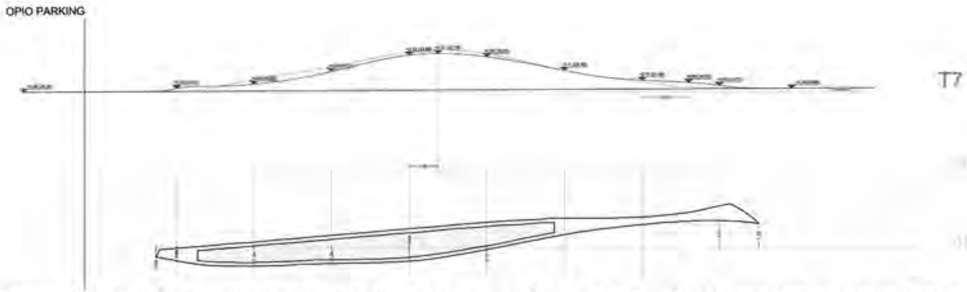


Figure 5
Projection of the outlines of the free form shape to the reference levels

of two processes of morphing and controlling. It is the amalgam of the two dynamically transformed networks and the outcome of the intensive inspection of the surface altitudes and inclinations by serial cross-sections along the whole length of the square. In this way the generative curves are reformed and improved to shape the final surfaces of the square. In both cases the original networks constructed as representations and design tool - diagrams are continuously re-informed. They are re-formed by the external information that is inserted in the system and also by the internal information that is produced by the system itself. These systems by behaving dynamically throughout the design process are able to respond and to manage the potential movements and activities of the future users of the square.

Rationalization

As the technical development of cad techniques proposes new ways of thinking, representation, and simulation, respectively, the evolution of cam techniques facilitates the production of non-standard forms and further encourages the systematic exploration of novel approaches of rationalization, which is required for their manufacture.

A systematic method is needed to describe and define geometric free form shapes, as in many examples constructed internationally. One of the methods most widely used is the inscription of the shape in a Cartesian coordinates system in order to project vertically the outlines of the shape in the three reference levels of the system. Another complementary method is to project an orthogonal grid on the free form shape in order to produce the sections resulting from the intersection of this form and the grid (Like the skeleton of a wooden boat). A third method beyond the orthogonal projections, similar to axial tomography, involves serial transverse sections along the irregular – curved axis (skeleton) of form growth.

The evolution of design – which is the subject of this paper, has focused on a systematic attempt to structure the project through standardization as more as possible, to deal with the construction challenges while reducing costs. The atypical - non standard shapes of multiple curvatures, arising from form finding design process, need occasionally a different method of rationalization to implement due to different local conditions and material performances. The main challenge to be confronted during design and construction is the limited load bearing resistance of the underground parking, located

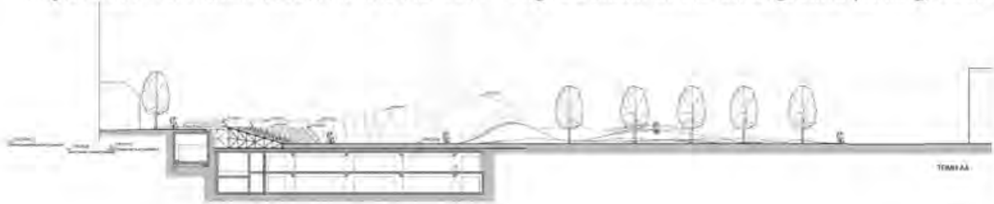


Figure 6
The section of the square reveals the relation between the parking and the metal structure

under the half of the square surface. Due to this fact a more complex but significantly lighter structure is required for the part of the project located in this area.

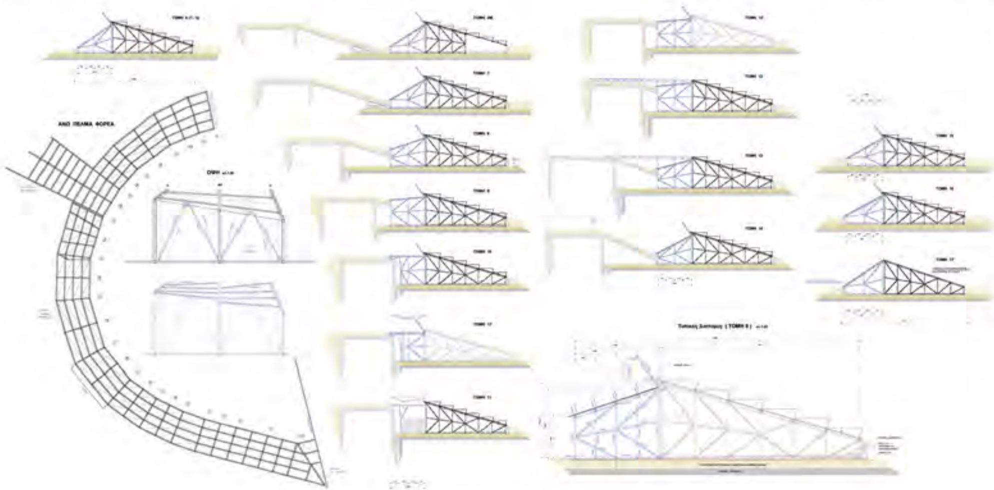
Diverse approaches of manufacturing processes are applied to the different parts of the square. a metal structure is developed above the underground parking because of its limited load bearing resistance, while at the remaining area of the square reinforced concrete is used to materialize the varied curvilinear surfaces.

Space frame as components

For the metal structure cost reduction requires maximum standardization. The structure consists of a metal skeleton covered by two kinds of cladding. The atypical shape gets rationalized and described by the same space frame derived from cross-sections perpendicular to the curved axis of the form, which ends to be the load-bearing structure also. Standard elements are combined into repetitive triangular-shaped space frames – component (derived from sections) repeated serially by changing in-between angle and distance as they follow the curved axis of the form. However many space frames vary gradually following the shape transformation. Despite geometric variations they are easily produced as typical parts. They are cut, assembled and painted in an industrial plant using cam technology. Then transported to site, placed in exact location and connected using varied linear elements regulated at site.

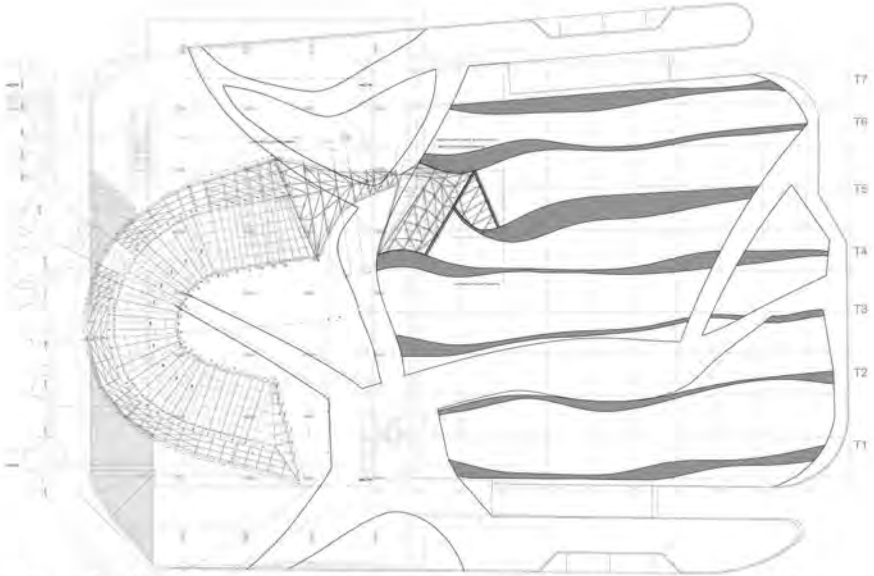
Cladding

Cladding is attached to a specially designed light



Figures 7,8
The metallic space frames as components derived from the cross-sections of the shape

Figure 9
The rationalization of the metal structure (by space frames) embedded in the reinforced concrete stripes



metal frame fixed to the bearing structure. The two materials of cladding are planks of tropical wood and perforated galvanized metal panels as prescribed by the design, one for each surface of the atypical form. For further cost reduction incurvation of materials is avoided. Thus, necessarily, the curved contours are translated into polylines and the topological surfaces are analyzed to polyhedrical and then triangular faces. The triangular panels of perforated metal sheet and their metal frames are welded together, transported and placed in predetermined positions on the metal structure. Some stages of the construction, such as the connection of the frames on site and the attachment of cladding, are not completely automated and therefore driven by creative treatment and the use of available tools.

This manufacturing process is not applied to the entire project. The part of the square lying out of the

Figure 10

parking area is carried out by more conventional methods. The curved forms are constructed of reinforced concrete "in situ". The moldings are shaped on site according to alignments made with the use of topographical instruments. Due to the rationalization the whole procedure is facilitated and accelerated. The shapes are regulated, defined and controlled by the cross-sections obtained by the intersection of forms with the orthogonal grid and by the outlines obtained by their projections on the vertical planes of the Cartesian system.

Conclusion

Responsive design systems offer to the designer the ability to construct ad hock digital models. The design in specific project was evolved in computational environment by using animation software and morphing techniques. Throughout the design process the initial Euclidean grid, a usual tool of control and order it is transformed to an elastic grid, to a network of flexible curves that balance between two and tree dimensions. Time from a measuring tool becomes a vital design 'substance'. The initial rigorous rigid and standardized organizational grid is transformed to a flexible, dynamic and responsive network. This design paradigm indicates the ability of the designer to construct a variety of dynamic and digital parametric systems according to the specific occasion, and his/her objectives and desires. Also the design stages and the hierarchic relations of the system can be preserved in its memory as 'the history of the design processes'. That ability of the system to be 'open' offers the capacity to recall the necessary information and be re-formed to the new demands at every stage of dynamic design process by 'formalizing' it.

Diverse approaches of manufacturing processes are applied to the different parts of the square. The technical development of cad and cam facilitates the production of non-standard forms and encourages further more the systematic exploration of novel approaches of rationalization, which is required for their manufacture. What is obvious is the need for dynamic systematic methods that escape the common ways of describing and defining the a-typical shapes. The atypical - non standard shapes of multiple curvatures need a different method of rationalization adapted to various conditions and material performances.

Thoughts

The process of morphogenesis and materialization must not be comprehended independently. a new theory of interrelation is important. The computer based processes support the distribution of the information between the disciplines and also produces interesting overlapping between them by blurring the strict frames of each discipline. What remains constant in time is the need for continuous dialogue and interchange between architecture and engineering in a broader sense. New forms of architecture will not emerge only as a result of the flexible, fluid, complicated architectural shapes. By shaping idiomorphic architectural singularities it is more important to start shaping the form of the design process and practice by including new techniques and theories.

We should develop approaches which will interconnect the structure, materiality and programme. Material and structure are traditionally discussed as independent issues. It would be very interesting, if the outer shell of the structure was involved in the overall strength and stiffness of the shape. However this should be treated and resolved at the design stage and special dynamic software should be developed. A theory of correlation is necessary and a deeper association with the process of construction and industrial productions. The new design processes based on computer bring architecture closer to the construction concepts resulting to a fusion of disciplines. What we need is a constant dialogue between architecture and engineering.

Reference

Balmond, C. (ed.): 2002, informal, Prestel, Germany, p 14.