Digital modelling and representations: Design and works by Riccardo Morandi and Sergio Musmeci

Curti G. (a), Polimeni B. (a), Raschi S. (a)

(a) Università degli Studi Mediterranea Reggio Calabria Facoltà di Architettura

Abstract

Purpose:
The purpose of this abstract is as a contribution to research on the representation of flat or variously shaped curves. The study is focused on the ability to model surfaces with traditional CAD systems.

Method:
The analysis is focused on the possibility of determining the morphological configurations of architectural coverings and other structures by means of the traditional, CAD, instruments.

Result:
The characteristics of the architecture are highlighted by a process which starts from the "pure form" and arrives at the completed, built structure.

Discussion & Conclusion:
Our approach requires that a special focus be given to the works of R. Morandi and S. Musmeci who used shaped surfaces for particular architectural structures in various ways.

1 Introduction

In the field of Digital modeling, there are many programmers who are working on the relationships between geometrical and mathematical spaces, from analog to digital representation. It is useful to observe the great variety of experiments taking place. The subject of this proposal is a contribution to research on the representation of flat or variously shaped curved shapes. In particular we want to try to study the possibilities of modelling surfaces by using traditional, CAD systems. Leaving aside the obvious considerations about the relationship between architecture and computer interpretation of the digital revolution, and without intending to abandon the instruments and techniques of conventional representation, we refer to certain works by Riccardo Morandi and Sergio Musmeci so as to investigate the possibility of modelling the shapes produced by structural tensions. Without using the nurbs or the loft surfaces, the origin of the built form can be found by investigating the primary idea. The CAD redrawing of the examples built, could be used therefore, in order to find ways of excluding the need of modeling programs and to give priority to traditional drawing programs. In this case the use of drawing programs is not a simple replacement of traditional methods, but is an instrument which allows us to design hyperbolic geometry, quadrics and ruled surfaces in order to search out the original idea. Our reflection is not oriented on the use of digital modeling programs to create forms whose genesis is organic, known as "hybrid", but on is on the contrary focused on the use of drawing software to propose a "reversed analysis". A graphic analysis which starting from original sketches and drawings becomes a powerful instrument for understanding, evaluating and communicating the original ideas. Digital modelling facilitates the awareness of forms and spaces otherwise not easily accessible for "non-experts". This use of the 3D Graphic representation methods can increase the knowledge of architectural spaces, and can be entered into by a conscious observer, accompany him on a targeted observation of the most important factors that the photographic documentation alone would not be able to communicate. The next renderings allows us to understand the added value of light which, in most favorable conditions could flood the illuminated space entirely. The possibility of being able to observe renderings, compared to the real situations, could be an incentive for further research developments in the field, establishing a strategy of coordinating the work that is potentially very important.

2 Design and works by Riccardo Morandi and Sergio Musmeci

2.1 Riccardo Morandi: The Alitalia hangars

If the representation can assist in the construction of space, not only for those geometries, but for those structurally complex, implementation operation may have unusual economic benefits. With rendered image you want to bring out the formal and technical aspects of single coverage, show that the hangar is, according to Morandi: a "stress-shaped structure in accordance with the overhead determined by the permanent loads imposed on it, with no ammann".

1 Riccardo Morandi in "Nuove aviorimesse Alitalia per i Boeing 747 all’aeroporto di Roma-Fiumicino", p. 458.
Digital representations can assist in the construction of space by highlighting the geometrical characteristics and the structural complexity. By rendering an image we bring out the formal and technical aspects of single coverage and show that the hangar is, according to Morandi: a “stress-shaped structure in accordance with the overhead area, determined by the permanent loads imposed on it and without using "ammari". More effectively than drawings and photos of repertory, the digital model shows some of the essential elements: the innovation of the structural solution and the light that filters into the building through rectangular openings each covered by a dome of translucent synthetic resin. This reading offers a reflection on two topics, identified according to Morandi, as the “solution to the problem of the minimum mass for maximum lift” and “the pursuit of reducing the density of materials”, which are two of the most challenging and extensive research topics in the field of technical installations with important implications for function and form.

The possibility of covering large areas, in a way which becomes more and more efficient, highlights the challenge of the designer versus gravity. Already, during in the nineteen fifties, innovative features for creating three-dimensional structures with the ribs particularly in evidence were recognized in Nervi’s work. His work revealed an architectural sensitivity similar to that of Morandi as seen in the pre-stressed concrete structures used to cover the new, international airport hangars.

With the invention of ‘ferro-cement’, Nervi produced many, original ideas concerning the classic theme of structural engineering, the covering of a broad structure. A perfectly level roof, was of course often used as programmatic architecture by the Modern Movement, although in sharp contrast to this idea, vaulted surfaces were also used, giving a more solemn aspect to the areas concerned and to the entire building. In defining the spaces, the essential form of a vaulted surface over a large area, demonstrates the complexity of creating it and of keeping it in equilibrium because of the reciprocal contrast between vertical and horizontal, capable of accommodating the thrust as it is those same elements which have to bear the strain and ensure the stability. It is known that the vault is an architectural element which is generally designed for the most important creations of human talent.

Vaulted structures reveal the designer’s skills in many examples, from ancient times up to the present time. Modern architects have used the vault structures, especially for covering large areas, trying to create new solutions each time. From this point of view Riccardo Morandi revolutionized this structural field by discovering new possibilities offered by both traditional and modern materials.

“The breaking down into linear elements such as struts, beams and tie rods, emphasized by leaving the joints exposed, becomes similar to a mechanical device but without renouncing its plastic form. In this twofold aspect the structures of Morandi recall older craftsmanship”. The most significant innovation is probably the possibility of being able to walk freely and to be able to observe this coverage without any apparent sustaining structures. To do so, Morandi decided to “hang” the large surfaces onto external reinforcements.

2 Riccardo Morandi in “Nuove aisorimesse Alitalia per i Boeing 747 all’aeroporto di Roma-Fiumicino, cit.
In the first project for the Alitalia hangar in Rome’s Fiumicino Airport, the external stays support a surface sixty meters long. In the second case, ten years later, the covering, similar to a tent, is hooked to several tie rods positioned around three big pillars. The construction of these structures in reinforced concrete represents for Morandi the reintroduction of suspended ancient forms such as the tent. We read in the technical description for the Alitalia Boeing 747 maintenance center (Rome, Fiumicino) written by Riccardo Morandi: “The distinctive feature is the roof construction; it consists of a tent structure attached to an overhead rail. The tent consists of a series of parallel strips of concrete. The curtain coverage, free of restrictions, corresponds to the longitudinal walls of the hangar, suspended at both ends, with the terminal edge beams of pre-stressed concrete 3. These experiments related to surfaces modeled in different forms for covering hangars, which are often definable mathematically by ruled surfaces, prefigured a new interest towards a research field in evolution. Scientific and professional communities aspired to great developments in the study of thin shell-vaults, of pre-stressed structures, of self-supporting structures and double-curved surfaces. Subsequently many architects and engineers studied this kind of structure experimenting with both steel and steel and reinforced concrete combined. The large use of sketches and accurate construction drawings, with the aim of reducing the total costs, is what now seems most important. Architecture owes much to engineering particularly in this phase of structural research. Nowadays however there seems to be is a subsequent lack of interest for this kind of research. Many scholars explain that: “at the end of the sixties, attempting to catch up on technological tardiness and trying out the idea of general industrialization, the golden age of Italian engineering drew to an end 3”.

In 1969 the Italian engineer, Sergio Musmeci’s project of the Bridge over the Basento river, introduced another theme of our paper: the theme of ‘Minimal Surfaces’. 2.2 Sergio Musmeci’s bridge over the Basento

The reconstruction of thousands of bridges which were bombed during the second world war was characterized by a large use of pre-stressed concrete arched structures. Bridges and viaducts were built especially for highways and motorways. The new structures were mostly built using liner beams or mixed structural systems in order to minimize the price of scaffolding. Contrary to the ideas of Pier Luigi Nervi, the engineer, who realized only a small number of bridges, Morandi was a great experimenter, who paid great attention to new structural solutions, studied parallel to the building phase in order to optimize method, technical aspects, and execution times. He was also coherent with the recurring, different planning ideas. Musmeci instead carried out a research which departs from previous ones. In the Bridge over the Basento river he based the structure on the application of the physical models of Minimal Surfaces.


4 The subsequent construction of bridges and viaducts on Highway led to an increase in the number.
The paradoxical and attractive result is, according to Sergio Poretti: "The theme of the bridge offers many exciting design possibilities when inspired by a personality as genial as Musmeci, using his original procedure based on minimal surfaces\(^5\). The bridge shows Musmeci's intention of "preferring shells which have forms related to equistressed membranes". The shape of this bridge was determined by using the mathematical calculus method of Rudolf Trostel, the geometrical shape of every semi-arch was based on a unit of 173 cm, shown in a total of twenty-one drawings. Musmeci focused his attention on the stability problem, postponing the construction problems to a later moment. "The determination of the mathematical forms it's easy to study if you ignore the weight; Instead, the geometric aspects are clear using a soap solution and forming soap film bubbles"\(^6\). Probably that the transformation of a mathematical model into a form based on the equistressed shell generated problems for its realization. However, this attempt was victorious in the continuous challenge to the engineers of that time. The great deficiency of this project is the lack of a pedestrian pathway below the vehicular road. This can be studied using 3d graphic instruments. The potentiality of 3d modelling in this case is fundamental for evaluating an aspect which would be difficult to understand without this instrument.

2.3 Sergio Musmeci's: Covering of the general markets

Another case study in which the graphic 3d modelling instrument can be used to analyze an idea, (but which was never realized), is the covering of the general markets in Rome. This coverage is characterized by a series of vaults intersected by slanted holes symmetric with respect to a longitudinal axis. The shape suggests a structural efficiency research, and draws the same conclusions as those of the Bridge over the Basento.

3 Conclusion

With this contribution we intend to show the applications of the traditional 3d modelling software way of drawing the geometrical shapes which generated the original ideas. Our process starts from the geometrical essential elements and arrives at the complex shape. The interaction among geometrical forms, physical actions, mathematical models, are elements that, combined, allow the creation of those surfaces and shapes which characterized the history of architecture and engineering in the last fifty years. Awareness of these new forms passes only through a conscious digital interpretation. Geometrical structural control, which was Musmeci's basic tool in the planning phase of the bridge over the River Niger (1976), indicated that a final form can be implemented, starting, for instance, from numerical aspects. Following this line of research we can re-think about using digital instruments for avoiding all the arbitrary processes that often characterize modern digital representations.

So, just as Musmeci checked the form of his realizations by dipping a wire frame into a soap solution and forming a soap film bubble, we can study the forms scientifically in a way that excludes subjective interpretations.

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**References**