STEEL LATTICE SPACE STRUCTURES ON DESIGN ARCHITECTURAL PROJECTS

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Technological development in structural design has resulted in an increasing wealth of information with consequently growing interest amongst architects in the application of this knowledge in search of new architectural spaces. This paper takes part of the general interest in the use of steel lattice space structures to create architectural spaces; analyses relations between form and structural behaviour, -Structural Morphology- and includes considerations such as, structural behaviour, shaping structures, structural efficiency and innovative structures. Design methods, generation processes, definition procedures, geometrical characteristics and a depth analysis of the structural behaviour of spatial structures, especially lattice are the focus of this work. The paper presents generic structural models, where essential dimensions have been studied in connection with formal configuration, structure, natural light, texture and the outer skin. Later, more specific dimensions, such as the surrounding environment, the climate, the temperature and the functional program are introduced onto models. All of these abstract references assumed by the project are responsible for its formal configuration as pieces that adopt a specific shape and become balanced architectural projects. In designing a lattice configuration, the tendency is to search for an ideal model by means of the definition of some general principle or guideline to classify different models. However, different grid patterns do indeed have their own characteristics, and their suitability should be considered in terms of geometrical configuration, the shape and size of the boundary, support positions, loading characteristics, materials and construction technology. Even so, it may be difficult to generate complex spatial structures unless we are equipped with suitable tools. The present study describes generation procedures to define space structures, presents essential dimensions used in design and defines how they become specific design projects.

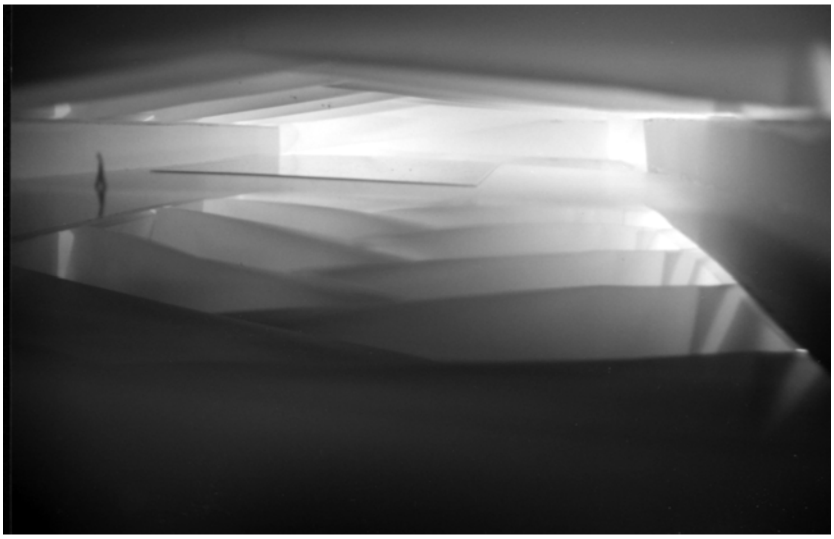

Figure 1. View across the interior of the main swimming pool area.

"Images reflected in the water lack the stability and solidity provided by the earth. As emigrants and fleeting, they only leave an ephemeral impression….
Where is reality, on the earth or in the bottom of the water?
Gastón Bachelard.

The design method described here is based on the use of lattice structural models that evolve into architectural work after they have been inserted into specific locations to resolve a functional program. In this way, the original proposal never loses consistency but rather grows to become a complex design involving the surrounding environment to make up an architectural whole. These pieces integrate both structure and outer skin to make up a single unit, in search of an invisible architecture not conditioned by technological requirements. All of this makes prior analysis of the program and the site through the study of its morphology, geography and history. The project presents an unbuilt architectural design project for a swimming pool at the University of Navarra The program for the building invited me to play with the strange situation produced when a dynamic and universal medium - water (movement, flow, infinite, abstract landscape without references), faces a local medium - the earth (solidity, memory, coded figurative landscape). So the pool aims to take advantage of this trapped water by using the big eyes of water opened in the ground to reflect the light and contours thus dissolving the piece and generating an illusion space

In this project, the piece is dissolved in an attempt to emphasize the presence of natural light in interior spaces that becomes material. As a consequence, the space acquires greater presence than the peripheral cortex. It becomes invisible losing its gravitational load to float in the space. Both container and content balance their demands focusing attention mainly on the space where, not only the light but the graveness, the landscape and the organic features of those who imagined the space become present. In this homogeneous space, the structure should not attempt to avoid its absolute continuity and so it should not extend along the plane. It moves to the contour, concentrating the structural support on the enclosing skin and revealing the construction system. Thus it becomes texture losing autonomy and establishing a relationship with the other elements of the composition. This work tries to solve the problems of an exposed structure and to establish relationships with the skin to conform a unitary space. The skin loses its solid appearance, which defines different areas, becoming a contour that limits the whole space. This continuous skin is only interrupted by the light that modifies the air under the covering, identifying different areas within the unitary space. So, this project is not concerned with defining physically concatenated spaces but with describing a unitary piece where light is responsible for fragmenting the whole space. To achieve this, a columnar structure has been suppressed and a fold becomes the principal element of structural support. In this way, structural efficiency is solved using an innovative shaping structure where folds act both as support and as a closing skin. The space created is the opposite of a Cartesian space where areas are separated from each other by means of support elements. Here, bodies float independently within a neutral space. The idea of structure is not based on the formal quality of the space but on the development of architecture as a spatial proposal where different areas are linked through soft connexions. The steel lattice space structure covers the main space to suppressing traditional support systems and reducing emphasis on structural elements to emphasise the outer skin.

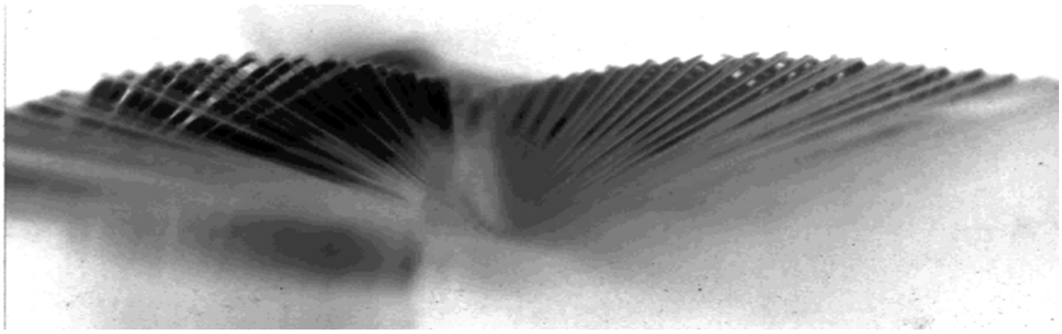

Figure 2. Steel lattice space structure. Model.

The building is configured as a clear volume where a concrete contention piece resolves the service areas while a steel lattice space structure protects and organizes the whole space in the main area. It is located on a soft sloping hillside that rises toward the north and falls toward the river to the south. The project must respect the geographical conditions at the site, as well as the Sports Buildings and University Schools that already exist. The site is on the brow of a gentle hill, offering broad views over the surrounding countryside under immense skies. This, in itself, suggested horizontality, a profile that would mark the skyline without dominating it. The surrounding landscape, whether in summer or winter, creates a rich visual backdrop to the different existing buildings; even the new building is far enough from the rest to develop its own formal configuration. The new piece is oriented toward the surrounding landscape but at the same time, it makes the interior contents visible. Service and Administrative Areas run along the front side of the building to protect the main space from the south, and provide access to the public areas in front, facing them onto the road. Access is thus ordered logically. The first floor contains the Hall and Service Areas such as Bathrooms and Locker Rooms and separates male and female Changing Areas. The Cafeteria is located on the second floor and is designed to completely open onto the central unit, a large open space which houses the pools. From the Bar and Cafeteria immediately under the roof, there is a complete panorama of the views defined by the line of the projecting roof. It becomes a viewpoint from which the landscape, the University and their surroundings can be admired. Under the unifying structure of the roof, the different areas of the building each have their own identity. The service area presents a concrete façade, which provides a neutral aspect to the adjoining buildings. On the eastern and western facades, glass walls rise from the ground to the steel covering. Glass set to the plane of the façade provides a literal and metaphorical reflection of the landscape and the sky, aiming to dissolve the building into the surroundings. At the same time, glassed walls allow the inclusion of the exterior views flowing into the interior to allow views to pools users. The north façade is practically nonexistent because, on this side, the terrain rises to the roof. The piece tries to represent a synthesis responding to the needs of a visual site yet creating a whole building, clearly readable through its bold subtleties. The building is open to the west and east, obtaining the best protection from sunlight and glare. Protection on the main façade is assured and on east and west sides, screens of trees frame both sides. Large areas of side glazing should be treated carefully because they create reflection areas on the surface of the pools. The most effective way of solving this problem is to raise the windows to eyelevel so as to avoid areas of high level glazing responsible for the greatest glare problems. The location of trees and shrubbery outside acts as a screen and the use of a cantilever on the south side reduces glare in the pool area. Although some areas of the building should enjoy artificial light, it is generally agreed that wherever possible, main pool spaces should have some degree of natural light or window areas.

Figure 3. The plan in the surrounding countryside

There is still a preference for pools with large areas of glazed sidewalls, presumably to give the feeling of outdoors to the interior of the pool hall. In this case, the exterior walls are largely glazed to allow continuous interaction between the formality of the constructed interior and the natural variety of landscape and sky on the exterior space. The gaps between the internal units of the building and the surrounding, largely public space bring daylight into the interior as well as open perspectives onto the park and river. So there is a deliberate use of natural light in the main area, which is illuminated through both east and west facades, while service areas are closed and protected from the outside.

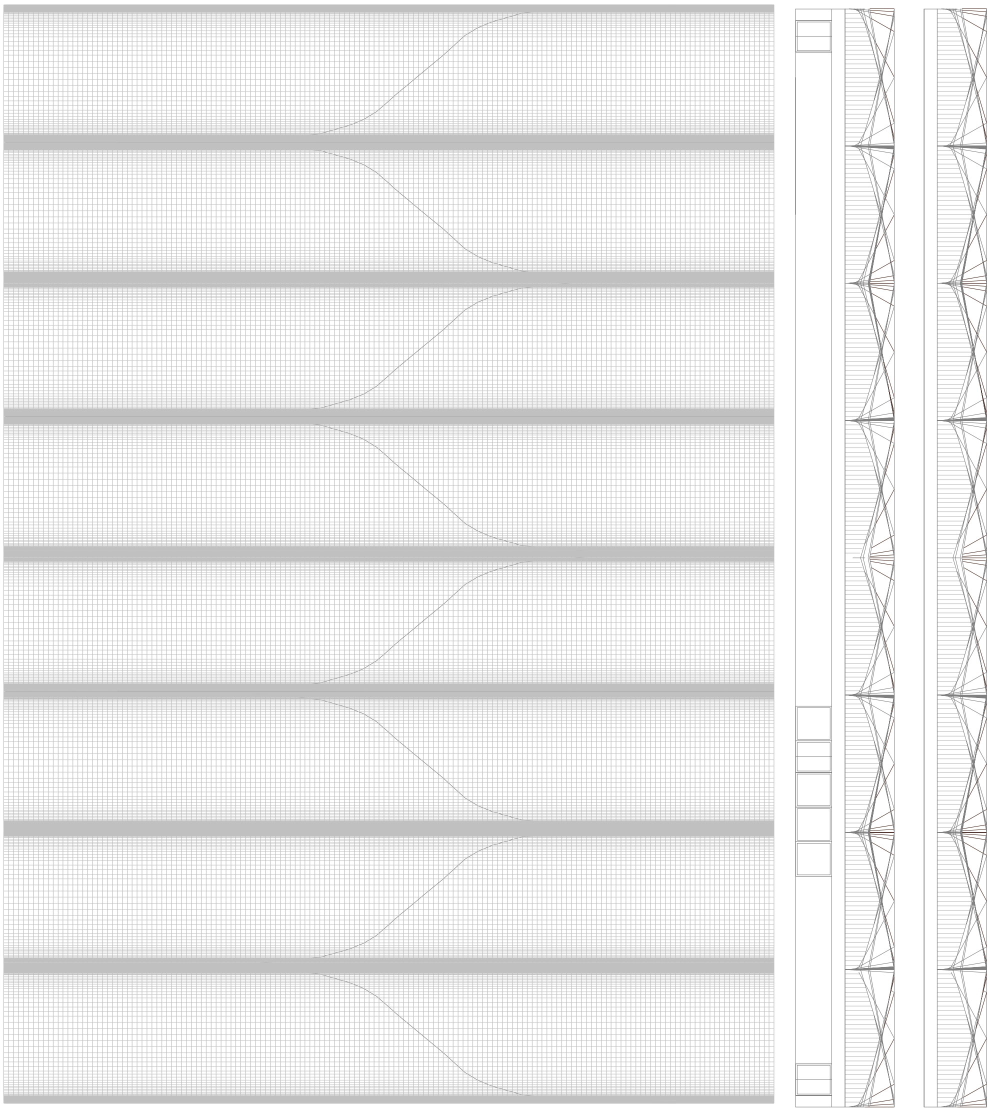

Figure 4. Steel lattice space structure. Plan and facades

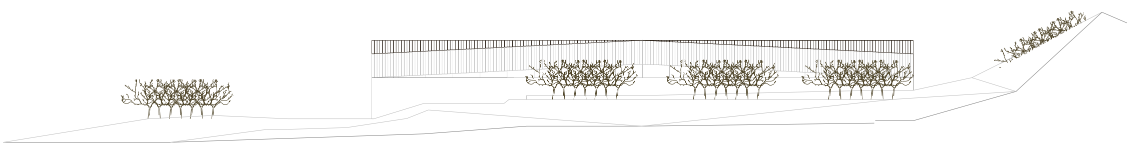

Figure 5. Steel lattice space structure. East facade

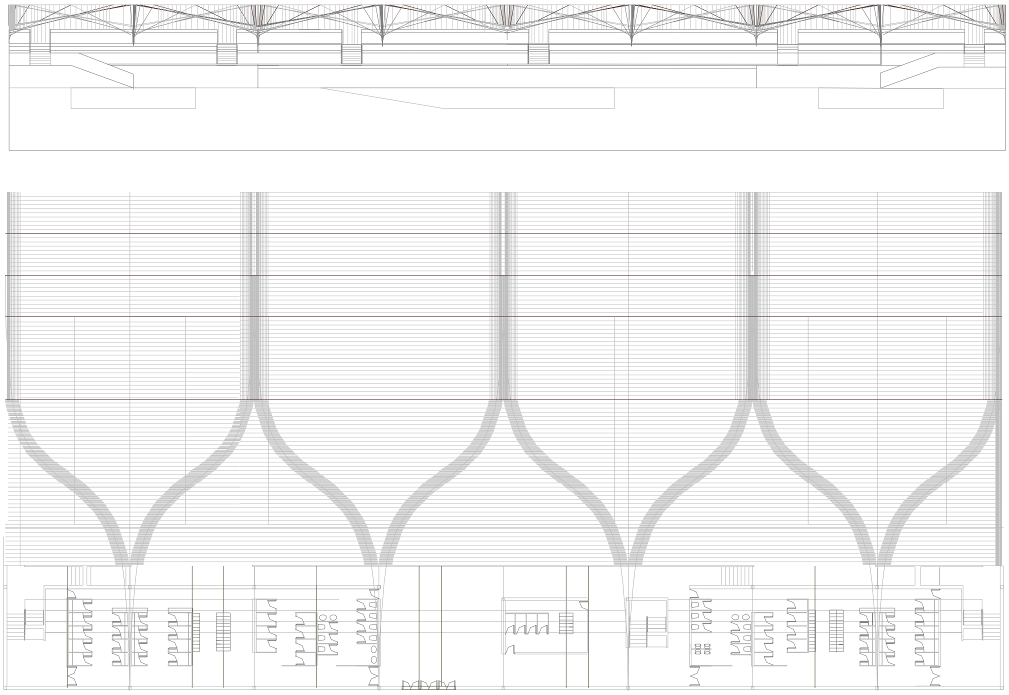

Figure 6. Plan showing the first floor

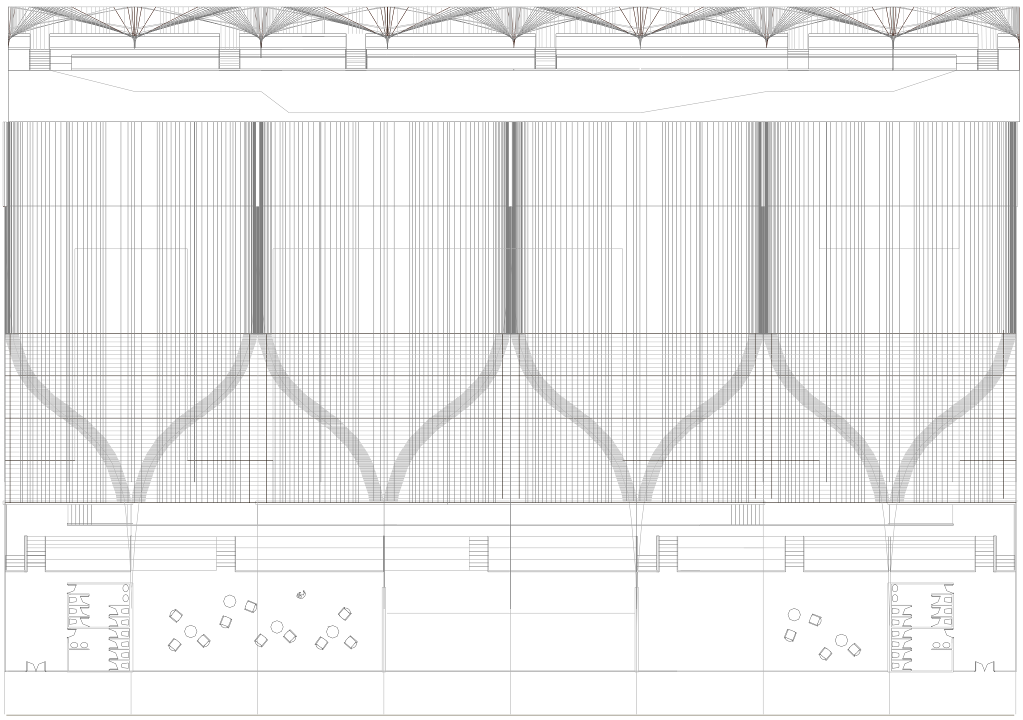

Figure 7. Plan showing the second floor

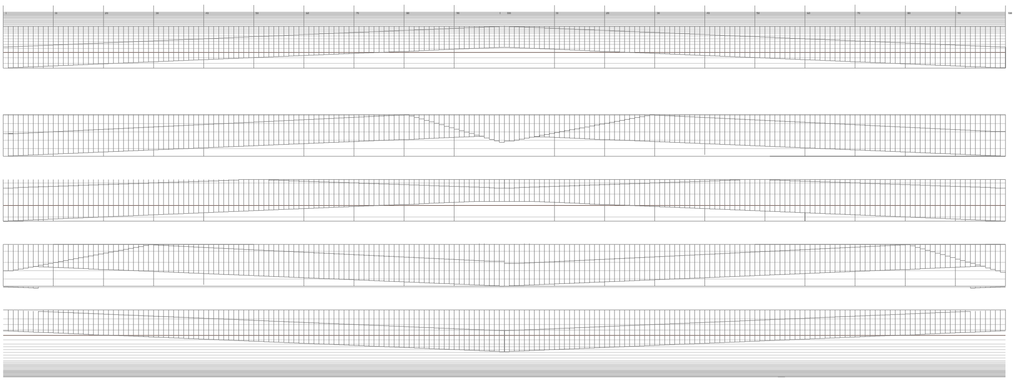

Figure 8. Steel lattice space structure. Section drawing

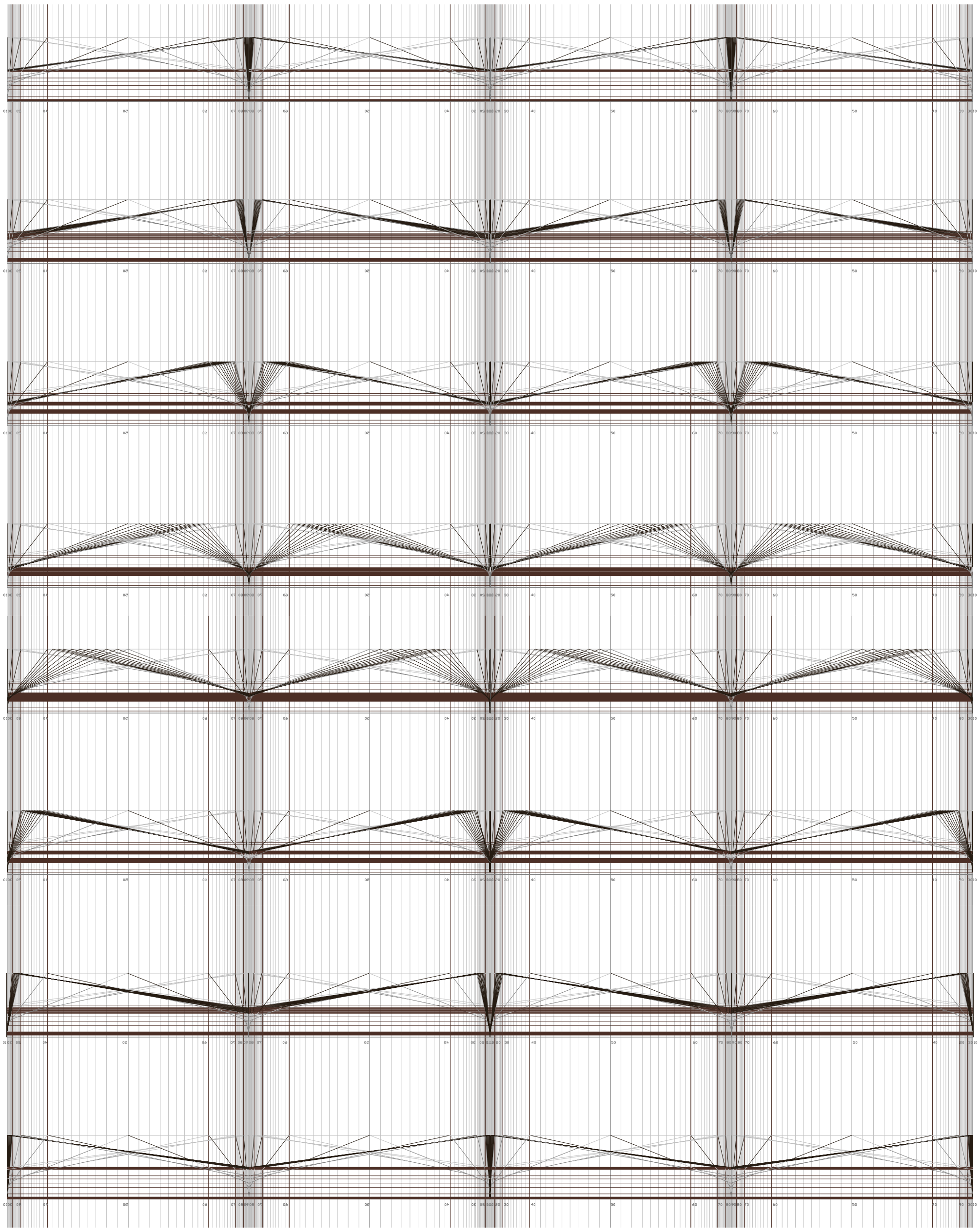

Figure 9. Steel lattice space structure. Section drawing

Steel is the ideal material to construct the self-supporting lattice space structure because of various characteristic properties, such as regular behaviour under different environmental conditions, high resistance to volume ratio or great ability to withstand mechanical and atmospheric demands. All of these properties combined with new technologies make it possible to formalise constructions where no differences between skin, structure and formal configuration are appreciated. Geometrically defined by surfaces - and therefore suitable to conform closed frames -, steel lattice structures are assembled on site. The easy application of plates is aided by the dimensions in which they are handled: widths of between 400 and 1600 millimetres, lengths from 12 meters long to the infinite, where rolls are used, and 9 millimetres thick, which bring high relative lightness due to the sheet section. The characteristic of higher mechanical resistance than that offered by other metals allows thinner sections. The properties of stainless steel are different enough to those of other materials used in construction to allow greater traction rigidity and torsion with a considerable reduction in plate section. Thus the increased resistance of structural elements allows economy in terms of material and weight.

Plates offer considerable resistance to high temperatures without oxidization or discolouring up to 675 C. Long term inalterability is combined with ductility and easy rolling properties, both cold and hot, curving by means of rollers or press folding. The creation of double structural faces and the use of sprayed-on insulation ensure a high degree of fire and a flame resistance. In order to achieve maximum durability and minimum maintenance in this aggressive atmosphere, stainless steel brings decisive qualities. Steels contain mainly iron, nickel and chromium. They remain passive to oxidation processes if the latter metal proportion is at least 12%. In these cases, they adopt spontaneous self-repair properties. Steels suffer corrosion over a long period in time, although this period may shorten due to the average level of atmospheric pollution, and the relative humidity of the ambient conditions. Corrosion on stainless steel plates caused by urban pollution produces pinprick forms on the surface. In order to avoid these pricks, it is advisable to use ferrite steels on interior spaces and austenitic steels on exterior ones. Protection procedures are aided by regular, careful cleaning of surfaces to remove possible aggression nuclei, always using soapy or nitric acid-based products.

The linear panel support will be resolved by means of metal joints at the base and adhesives in joints between panels. Conditioned by the thickness and the cost of the operation, soldering will be done by fusion. The most effective solution for joints depends on the smallest diameter possible in welding points to reduce the inner tensions to the minimum. So, I have tried to minimize separation, designing a minimum amount of contacts per flap. The interest in the aeronautics industry has generalized the use of adhesives with metals and, thanks to continuous joints that uniformly distribute loads, good structural properties are obtained. Some of the most highly developed adhesives are polyurethane, polystyrene and epoxy resins, which are applied as any other synthetic resin. These joints also contribute to reducing the weight of the building, without weakening its structural behaviour, improving resistance to vibrations and blows. At the same time, a continuous insulating barrier will be created between two adjacent plates thus reducing costs and reducing the need for qualified personnel. The only inconvenience comes from the low resistance to high temperatures. The degradation of joints depends on the adhesives' softening temperature, and consequent difficulty withstanding dilations. Joints between steel and other metals should always allow electrolytic separation between the materials. In these processes the elastomeric supports (neoprene, PTFE or sheet Teflon) solve the problem, as they are fixing elements that allow movements in two directions and withstand rotation on three different axes simultaneously and absorb short duration vertical and horizontal loads.

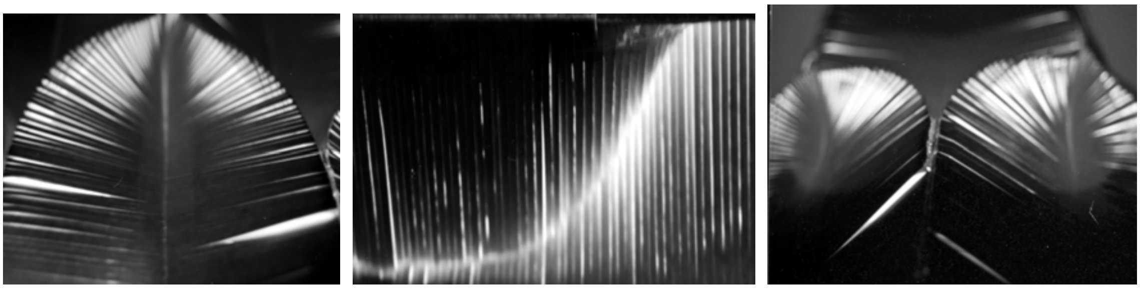

Figure 10-11-12. Steel lattice space structure. Details.

Lamination procedures will be used to finish surfaces and hot acid solutions applied as a film will complete the electronic treatment. As the extensive plane surfaces produce optical distortion phenomena, it is necessary to divide big surfaces into fragments. It will thus be possible to carefully choose degrees of surface finishing with a specular sheen, as well as to place continuous reinforcement for panels, in order to avoid deformation caused by heat expansion. The use of sound-absorbing materials is absolutely necessary in this kind of space and all materials must be resistant to moisture and chemical attack. The materials that may be used successfully include purpose-designed acoustic plasters and boards, and bagged mineral wool or glass fibre faces with specially treated materials. Adequate ventilation of the construction is essential to avoid condensation and to protect the elements.

To create in this environment, it has been necessary to take into account a great amount of varied elements that make up the surrounding reality. Architectural pieces have to display equivalent variety to what lies around them in order to cover all the requirements of the site, although they have to adopt specific formal configurations. This work involves a piece in coexistence with each other and with other spaces. The validity of this proposal is based on the incisive analysis of the reality surrounding to emphasise numerous parameters invisible at first sight. Once defined all the heterogeneous elements are connected in a coherent spatial entity. These relationships build the space, balancing the composition and establishing syntactic bonds, to configure a unitary space that extends its influence beyond the surrounding environment. This space organizes the piece and establishes temporary visual reviews of perception

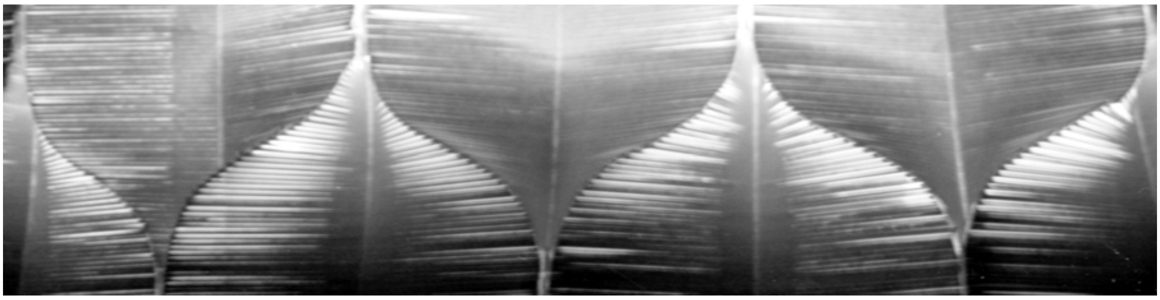

Figure 13. The original model for the project showing the V shaped structure

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