Contents

Preface by Pier Luigi Nervi vi
Introduction by Ernesto N. Rogers ix

Illustrations

Cinema "Augusteo", Naples 2
The Municipal Stadium of Florence 4
Design for the grand stand of a stadium in Rome, seating 100,000 18
Design for a bridge across the Bredano Valley near Rome 19
Design for a circular hangar in reinforced concrete 20
Design for a circular hangar in steel 21
Design for a revolving house 22
Prefabricated house 24
Storage tanks for crude oil 26
A hangar 28
Hangar of pre-cast concrete components 34
Hangar of prefabricated concrete components 36
Sketch designs of Exhibition Pavilions for the World Fair at Rome 44
Sketch design of a large hall in prefabricated reinforced concrete units, clear span 990 feet 45
Design for a Station Hall of prefabricated components 46
Reinforced Concrete Ship of 400 tons 48
Storehouse in Rome 50
Covered Swimming Pool of the Naval Academy of Leghorn 52
Wharf Conte Trossi, San Michele di Pagana (Genoa) 54
Sketch design of a hall with special shed construction for thermal insulation 56
Design for a Station Hall in Palermo of prefabricated units of "ferro-cemento" 58
Exhibition Hall (Salone Principale), Turin 59
Exhibition Hall «C», Turin 65
Design for a hangar at Buenos Aires, span 592 feet 70
Beach Casino at Ostia 77
Multi-purpose hall, Terme di Chianciano 79
Storehouse for salt in Tortona 80
Pressure pipelines of "System Nervi" 82
Tobacco factory at Bologna 84
Gatti Wool Factory in Rome 88
Spinning mill of Gatti Wool Factory in Rome 92
Municipal Tramway Depot in Turin 93
Municipal Tramway Depot in Turin 94
Storehouse of Tobacco Factory in Bologna 95
Naples Central Station 96
Competition design for a Sports Centre in Vienna 99
UNESCO Building in Paris 110
Factory buildings for the Fiat Works at Turin 124
Office building for Messrs. Pirelli in Milan 128
Design for a bridge over the River Tenza 133
Design for the "Centre National des Industries et Techniques" in Paris 136
Design for a large Exhibition Centre in Caracas 140
Naturally it is not easy to comment objectively on my own work, yet I think it is possible to describe simply and honestly the intentions and fundamental conceptions which guided and influenced me. If I ask myself what were the principles by which I approached my problems I see clearly that a single aim and a single method have always governed my work as a creative engineer.

The first step in any design was the search for the most suitable structural solution technically and economically; then followed patient and passionate work: the detailing and calculation of the various structural elements so as to refine the form and thus meet the static and structural requirements.

In examining and deciding upon the most suitable structural scheme, the most varied solutions gradually emerged. In so doing, I was always anxious to arrive at an independent decision free from existing aesthetic theories as well as from solutions I or others had already discovered.

I must admit I was once in danger of losing this clarity of judgment. Because of flattering comments on the Florence Stadium, I tried to bring aesthetic theories to bear upon structural problems. I tried to do so with the help of purely theoretical preconceptions, but soon convinced myself that to find an architectonic expression becomes more difficult the more one works with such an idea in mind. That is why I dropped aesthetic prejudices, to return to the simple approach of my earlier years: the approach of a designer who works without bias but with enthusiasm. My belief in the inherent aesthetic force of a good structural solution was never shaken. Never did I find a good building, old or new, which departed from this principle. Therefore I maintain that a good structural organism worked out passionately in detail and in general appearance is essential to good architecture.

It is more difficult to define a good structural organism. Let us look at the great architectural creations of the past such as the Gothic cathedrals or the great domes of the Renaissance. We are filled with unbounded admiration for their designers, whose intelligence, sensitivity, intuition and genius made them such immensely complex and magnificent buildings.

It could be argued that the main characteristic of these works, which makes them still speak to us across the centuries, lay in the fact that their builders realised their design in a form which shows an intuitive understanding of the laws of equilibrium and gravity normally alien to human understanding. Seen thus all great buildings of the past were successful just so far as they were the result of the complex mental process inherent in grasping their statical basis—something accessible only to a powerful and exceptional brain.

As a direct result of the revolution in building which started in the middle of the last century, architecture to-day not only has immense potentialities but is also endangered by structural theories, steel and reinforced concrete. Complex theories and mathematical formulae were discovered which enabled forces to be evaluated even in highly complicated structures. The importance of this advance can hardly be over-estimated.
Nowadays, an architectural student can check the calculation for a section of the Dome at Florence as a practical exercise in graphic statics. He can indulge in the illusion of having an understanding of this great structural organism such as Brunelleschi achieved only after long and agonising work. But today even complicated statical problems can be solved easily, abolishing that endless struggle for knowledge concerning the behaviour of solid masses, once the only basis for a design. As always, however, a less intense mental effort and the absence of that struggle which alone guarantees intuitive vision of structural systems, result in a loss of expression and in the technical coldness seen in many buildings to-day.

The indirect results of theoretical formulae and of the greater mechanical properties of modern materials seem to me even more harmful. I am thinking of buildings conceived purely sculpturally. Their equilibrium has not been achieved by the spontaneous ”give and take” of action and counter-action, but through complex and artificial structural solutions. In other words, such buildings were designed in an abstract and formal manner and built by means of a technique with a similar basis. That is why I believe that the mark of a good structural organism is the degree to which the qualities and potentialities of steel and reinforced concrete have been fully exploited while following natural static forms. Such forms would have been achieved by the great builders of the past if our materials and structural methods had been at their command.

A further very important factor in achieving good architecture is the need to solve the problems of execution simultaneously with those of the structural organism. For instance, two of my most interesting projects, the hangars built of pre-cast elements and the roof for the Turin Exhibition Halls, would have been impossible without a simultaneous invention of the structural method. They would have looked completely different if they had been built on the same principle but in a conventional technique.

If a structural project is approached without a close study of possible methods of execution, and based only on conventional technique, it is in danger either of being a dead letter or of having to be much modified during execution.

Structural architecture leads to that synthesis of static-aesthetic sensitivity, technical knowledge and mastery of execution which produced the masterpieces of the past. I may say that the need for this synthesis – be it achieved through combining the ability and specialised knowledge in a single individual, or through a genuine co-operation between different specialists – is the only certainty which I have reached in a long life spent in various fields of construction.
Sometimes people’s names are an omen or augury of their character; they are, so to speak, a prophecy. Such is the case with Pier Luigi Nervi, whose buildings are like a delicately woven fabric, a system of nerves made from structural elements purged of all frills so as to seem always in vibration. Their harmony is based on an equilibrium of tensions and of restrained, disciplined movement. This is also true of his personality. Nervi’s eye sees in objects more than their shape: it penetrates to the essence of things, where true vitality can be found. If Nervi had been a doctor, he would assuredly make use of psychology and intuition to deduce from the sub-conscious the essential qualities of the patient. Similarly, when Nervi shakes hands with you, he weighs your hand in his, and from your reactions deduces your condition and health.

For many years I have known him as a man, and could tell of the fascination which he radiates. But since I know him to be a modest, retiring person, I shall do him greater service if I pass immediately to his work, which reflects his real personality.

No engineer since Maillart has faced with greater realism the problem of *teknę* in its proper and original meaning.

The distinction between science and art, between use and means, was an unbridgeable gulf in the realm of structural phenomena. In the work of these two great engineers, Maillart and Nervi, this new synthesis is seen – a synthesis which dominated all creative architecture of earlier times. For the mediaeval craftsmen this synthesis was unconscious, but with the Renaissance architect deliberate, by reason of his Classical approach.

Looked at in this way, the words of Leon Battista Alberti renew their meaning: «Him I call an Architect, who, by a sure and wonderful Art and Method, is able, both with thought and invention, to devise, and, with execution, to complete all those Works, which, by means of the movement of great Weights, and amassment of Bodies, can, with the greatest Beauty, be adapted to the uses of Mankind.» (trans. Leoni).

In that synthesis the artistic understanding of form and of its material content must not be a dual conception leading to diverging roads, but rather a dramatic process where both are interchangeable. When this process depends upon two opposing forces, the architect has to resolve them into a synthesis.

The word *teknę* here reverts to its original meaning. It does not only, as in modern usage, refer to a concerted interplay of technique and execution in the service of science and art but, as with the Greeks, it refers to a synthesis of art, science, knowledge, craft, skill and profession.

Obviously this fresh view of the problem has great importance and influence in Nervi’s projects and teachings. The gate is now open to unexplored realms accessible not only to him, but to many others. If one has had contact with Nervi’s work and writings one knows that he was sometimes a victim of his own slogans, that he was under the illusion that some of his most brilliant solutions have been reached solely by the disciplined and precise mind of an engineer, that the beauty of his work was due to a neutral or passive
process of thought having nothing whatever to do with aesthetics. This illusion, however, hardly dimmed the clarity of his thought. Nervi is an artist against his will, sometimes even against his own theoretical conviction; he is an artist because in spite of his astounding knowledge he does not confuse the ends with the means, because he is not satisfied with the means alone but makes them subservient to his aim through proper use.

It is characteristic of Nervi’s approach to design that he starts with a basis of scientific certainty, but transcends it through his intuition. Nevertheless, he submits his intuitive powers to rational laws. Cocteau’s saying “Find first, then look for it,” could well apply to the methods of this poet among engineers.

When one considers Nervi’s work in all its manifestations, it is clear that his solution of technical problems tends to define and crystallize their sculptural quality. The stylistic character of Nervi’s three-dimensional language is based on a yearning for original expression, whereby form and content are identified so that they become a single spatial diagram, a harmonious balance between opposing realms of thought. His special gift is an expression, through mathematical severity, of a perfect structure which, although the result of complicated formulae, appears so simple that it could have been observed from the laws of nature rather than arrived at through human thought.

Nervi’s secret lies in his ability to discover the truth in the kernel of things and to extract and express it. He does not try to create afresh, but he invents his structures with the help of all our available scientific and cultural progress. He acts like a medium who invokes the ghost of statics and materialises it; a ghost which others too frequently symbolise in incomprehensible mathematics.

Nervi appears to say: “Try it yourself, it is simple and you will succeed,” so intimately connected in his mind is the interplay between thought and creative activity. And yet nothing is more difficult than to express complex things in a simple way.

Nervi, too, sometimes succumbs to the temptation of striving for an ideal beauty, which threatens to overshadow the simplicity of his structures. That only happens when he is tired of simplicity and treads the dangerous ground of aesthetic theory. Nervi himself confesses this in his Preface which, in my opinion, is the best interpretation of his work: “My belief in the inherent aesthetic force of a good structural solution was never shaken.”

The identification of truth and beauty is the leit-motif of many contemporary engineers – even for such a sensitive mind as that of Mies van der Rohe, who likes to quote St. Augustine that “beauty is the glory of truth.” It is remarkable that both Nervi and Mies van der Rohe go back to the same source, even though the difference in their creative approach is obvious. Nervi, in spite of his great intuitive ability, is always conscious of the danger threatening him from the exponents of dogmatic science. He submits himself to constant self-criticism, and again and again in his work he chooses to employ those methods which best
allow of that discipline. He is always reminding others of the limitations and dangers of the present-day training of engineers, of the theoretically correct test papers that take insufficient account of empirical knowledge and of the «feel of the material», which means they are not controlled either by a physical or psychological experience of practical work such as only daily contact with building on the site can bring about. This type of training leads to that formalism which Nervi hates.

Perret as well as Nervi is often accused of having mixed up the rôle of the engineer with that of the contractor, a point of view which regards the contractor as a purely functional tool. But just because of this constant mixing of the two rôles both Perret and Nervi achieved that free mastery and complete control of the structure which was the foundation of their success. Both are exceptional exponents in the history of modern architecture. Through them the art and wisdom of architecture, which were the strength of the old master-builders, are carried on.

Today, this knowledge is generally split up between different individuals, who may work together but are in constant danger of becoming isolated specialists. The exceptional example of Nervi and Perret remains as the broad foundation of our present culture in which the ordinary individual can normally understand only a limited aspect of the whole.

I do not think it is a fault that normally divergent realms of knowledge and experience should be found in one mind. After all, Nervi in spite of his gifts never imagines that he can cope with all problems facing him in our complex society. He is the last man to refuse to co-operate in a team.

I had the good fortune to follow at close range the conception and projects for the UNESCO Building in Paris, and I was able to watch Nervi working in a team with Marcel Breuer and Bernard Zehrfuss. It did not prevent him from giving his utmost, from giving all his energy to the common task. In that building his innermost being is expressed just as much as that of the other two architects; the three men were so perfectly complementary to each other that the danger of a lifeless compromise was overcome. The same applies to the building of the Pirelli skyscraper in Milan now being built in co-operation with Ponti and other engineers; also to the project for the Sports Centre in Vienna which Nervi has designed with his son Antonio. One can differ from Nervi as to the «structural architecture» which seems to reduce design to a technical and material level. I, for one, think the matter goes beyond this; yet one must admit that Nervi is in no way a technocrat barricaded behind his own preconceived ideas. The rôle he has chosen in the particular kind of world in which he believes suffices to make him tower serenely above the mass of the uncreative, the sceptics and the conventional.

Those who look at the evidence of his work collected in this volume will surely be convinced by his uncompromising methods of thought. Like all creative people, Nervi has the capacity to create his own truth, a truth which we cannot escape when in some way or other we try to express or control our own truth.
Publisher's Note

A number of projects and buildings are marked with patent numbers, under which the relevant elements or methods are registered.
Professor Nervi has asked the editor to make it clear that these references have not been given for commercial reasons. As some of the detailed problems connected with the various works were too complex to be treated exhaustively in this book, Professor Nervi has given the patent numbers for the benefit of readers wishing to make further enquiries and he has also stated that he is prepared to answer all requests for information.
The buildings illustrated in this volume, except the UNESCO Building in Paris and the Pirelli Office Block in Milan, were erected by the following contractors: until the year 1932 by the Impresa Costruttrice Ing. Nervi & Nobbioi, Rome; from 1932 onwards by the Impresa Costruttrice Ing. Nervi & Bartoli, Anonima per Costruzioni, Rome, which is under the immediate direction of Professor Nervi, a joint owner of the firm.
Frequently in the captions to the various works a distinction is made between reinforced concrete and «ferro-cemento». By «ferro-cemento» is meant a smooth concrete mix of cement mortar reinforced by several layers of fine steel mesh and bars of small diameter.
Sketch of roof construction.
The auditorium of this cinema has a diameter of 99 feet with a floor above containing offices. These are arranged around a circular opening 65 feet in diameter covered by a glass roof which can be opened. The stability of the structure is achieved by a system of diagonal roof trusses (which form part of the dividing walls between the offices) and two circular slabs, the lower of which is in tension and forms the ceiling of the auditorium whereas the upper one is in compression and forms the ceiling to the offices. The gallery spans without intermediate supports by using four parallel trussed reinforced concrete beams with nine radial cantilevered beams projecting into the auditorium.

2 The gallery from below.
3 Interior during construction.
The Municipal Stadium of Florence - 1930/32

This design was selected as the result of a competition and was executed in two sections during 1930-32. It has a seating capacity of 35,000. The straight running track 657 feet long in front of the covered grand stand is unusual and necessitated a non-symmetrical lay-out and variations in the design of the grand stand on the opposite side.

1. Plan,
2. The stadium with the «Marathon» tower, seen from the south. The stairs lead to the uncovered grand stand.
3 Side view of the covered grand stand.

4 Structural diagram. The roof of the grand stand is supported by cantilevered reinforced concrete beams at 15 ft. 6 in. centres. The characteristic shape of the trusses and the varying depth of their cross-section clearly express the concentration of forces in the structure. The fusion of structural considerations with the formal solution is complete.
5 The covered grand stand after completion.

6 Below the terraced seating. The terraces have expansion joints at intervals of 100 feet.
Section showing the reinforcement of a cantilevered roof beam of the covered grand stand. This cantilevered beam is supported by a fork construction; tension being taken by the upper member and compression by the lower one. After the completion trialloading was applied. The result was that under a load of 24 lbs./sq. ft, an average deflection of only $\frac{3}{4}$ inch at the free edge of the cantilever was recorded whilst according to calculation the deflection should have been $\frac{1}{2}$ inch.

Underside of the roof. The cross beam between the forked supports serves as a longitudinal stiffener.
Access staircase to the grand stands before completion. The steps follow the line of a semi-helix. They are 10 feet wide and cantilever out from an inner spiral beam. To reduce the considerable torsion moments the inner beam is supported by a counter spiral beam. This system cannot be structurally analysed exactly and so assumptions were made to simplify calculations. Today this staircase is still in perfect condition. It proves that even simplified assumptions for calculations, if they are based on a correct recognition of the structural possibilities, give sufficiently accurate values for the dimensioning.
The staircase after completion.
11 View of the curved grand stand at the end of the 660 feet running track.

12 Plan of the curved grand stand.
13 Supports with cantilevers on one side carry the seating.
14 The «Marathon» tower with loudspeakers at the south side of the stadium.

15 Lower part of the «Marathon» tower with one of the external access stairs.
The stadium, looking south. In the foreground are the stairs leading to the upper tiers of the grand stands.
Design for an upper extension to the existing grand stands – 1950.
The upper stand terraces are carried by inclined cantilevered beams balanced about V-shaped supports.
Design for the grand stand of a stadium in Rome, seating 100,000 - 1935

Design in collaboration with Professor Cesare Valle

The same structural idea is the basis for the design of a stadium in Rio de Janeiro in 1945, seating 150,000. Structurally and aesthetically interesting is the freely cantilevered middle tier of the grand stand.
Design for a bridge across the Biedano Valley near Rome - 1934

The construction is of reinforced concrete A-frames braced at three intermediate levels.
Design for a circular hangar in reinforced concrete – 1930

The structure is umbrella-like and is supported by an inner ring of V-shaped supports. The external wall consists of fixed and movable elements. When opening the hangar the movable parts of the wall slide in front of the fixed ones.

1. View of the inside through the open doors.
2. Plan and section.
Design for a circular hangar in steel – 1932

In contrast to the previous solution the external wall consists of movable parts only which run in two planes behind each other. The aeroplanes can be taxied from the outside to any place inside the hangar. The principle of construction is similar to that of the hangar illustrated on the previous page but instead of reinforced concrete structural steel is used. The rigidity of the hangar is achieved by the robust core.

1 Possible arrangements for placing aeroplanes.
2 Plan and section.
1 Section.
a Stationary motor
b Rollers
c Spur-gear at the edge beam
d Water connections
e Gas connections
f Electrical intake
g Main electric conduit
h Gas mains
i Rising water mains
j Soil pipe
m Drainage connection to sewers
n Movable hydraulic stopper
The house is a reinforced concrete frame structure with brick panellings. In the basement is a circular edge beam which rests on rollers. Through this circular beam all loads are transmitted via the rollers to the foundations. A stationary motor sets the house turning. Energy is transmitted with the help of a cogged wheel to a spur-gear at the circular edge beam. All services enter the house in the centre which is the only solution to this problem in the case of a revolving house.

2 Plan of ground floor.
3 Plan of first floor.
1-4 Possibilities for extensions according to growing need of space,
1 Bedroom
2 Dining room
3 Kitchen
4 Bathroom and WC
5 Living room
6 Shower and WC

5-10 The individual prefabricated elements and their dimensions.
Prefabricated house – 1946

The plan is arranged in such a way that the house can be extended according to the occupants’ growing need of space, or the finished house can be divided into two apartments. (See Illustrations 1-4). The construction consists of three prefabricated elements of varying sizes for the external wall. (See Illustration 5 – Element I: 3 feet 8 inches × 2 feet 6½ inches; Element II: 2 feet 7½ inches × 2 feet 6½ inches; Element III: 10 feet 4 inches × 2 feet 6½ inches). There is only one unit for internal partitions. (See Illustration 10). The roof consists of trapezoidal prefabricated elements (see illustration 6) above which two further trapezoidal elements are placed (see illustration 7). The size of these is 7 feet 6½ inches × 2 feet 11 inches and 9 feet × 1 foot 11 inches respectively. The circular core is roofed over by vault-like prefabricated units. (See Illustrations 8 and 9).

11 Section C-D.
12 Perspective section.
13 Plan.
Storage tanks for crude oil
Pat. No. 348,774 - 6. 2. 1937

During the years 1936-1942 several storage tanks with a capacity of 355,000, 530,000 and 1,060,000 cubic feet were built for the Italian Navy. The tanks were built below ground level and covered with a reinforced concrete slab strong enough to resist explosions. The main characteristic of the tanks is the inner lining of the stone wall (see illustration 3) consisting of concrete hollow blocks, the cavities of which form continuous vertical ducts opening into an inspection gallery at the bottom. The smallest leakage of oil can thereby be detected and located. The inner wall surface is formed by a 2 3/4 in. thick layer of sprayed-on concrete reinforced by double layers of mild steel bars and wire mesh. The layer of concrete was sprayed on after the cover of the tank was completed. Thereby a nearly constant temperature and humidity were achieved, thus avoiding any formation of hair cracks and other possible damage. The tanks were built into rock whereby the hydrostatic pressure and the shear force were taken up by the rock. A special solution was evolved for the erection of such tanks on sandy or clay conditions, whereby the subsoil was precompressed to enable it to withstand the pressure and resist the shear (Pat. No. 375,055 - 19. 5. 1939).

1 Storage tank of 355,000 cubic feet capacity during construction.
2 Inspection gallery with openings.
3 Section through external wall.
1 Tufa stone laid in hydraulic lime mortar
2 Concrete hollow blocks
3 «Torkret» concrete
4 Model of one of the oil storage tanks.
5 Internal view of a finished tank.
A hangar - 1935

Size 132 ft x 330 ft, height of doors 30 ft. The project was selected as the result of a competition. The construction is of reinforced concrete. Two hangars of this particular type were erected at Orvieto in 1936. The vaulted roof is supported by diagonally intersecting beams which are supported at the back and the ends. At the front there are two end supports and one central support. The lower portion of the roof forms a truss which spans across the three supports. Wind pressure at the front and horizontal forces from the structure are taken up by this truss.

1+2 Model made of celluloid for static tests in the laboratory at Milan Technical High School. The exact dimensions and calculation of this construction could not be worked out with the known methods of structural theory. For that reason a test model, scale 1:30, was built to obtain information of the internal forces. The dimensions of the model were arrived at by experience and approximate calculations. Probably this is one of the first instances where the dimensioning of a major building project was based on experimental tests.
3 Section.

4 Plan.
5 Erection of shuttering. The beams are 5\(\frac{3}{4}\) inches \(\times\) 3 feet 7\(\frac{1}{2}\) inches. Their length between intersections is 17 feet.

6 + 7 Details of reinforcement.

8 View of interior. Between the concrete ribs a reinforced hollow block slab, 2 inches thick, spans below an asbestos cement roof covering.
Reinforcement of the centre support. The curved form allows the transmission of forces without having to take bending into consideration.

9 The horizontal truss forms a wind-bracing to the front part of the hangar which is only resting on three supports. The truss is hung from the roof structure. The upper tracks of the sliding folding doors are fixed to this truss.

10 Reinforcement of the centre support. The curved form allows the transmission of forces without having to take bending into consideration.

11 View of hangar with closed doors.
Details of corner support. The diagonal thrust from the roof is taken up by two corner supports, one of which serves also as a stabiliser to the opened doors.
Hangar of pre-cast concrete components – 1939-41
Pat. No. 377969 – 9.11.1939

The hangar covers an area of 148 feet x 197 feet. The pre-cast components are formed in a truss-like pattern for reasons of economy in weight. The load-bearing construction consists of trusses which are stiffened longitudinally by alternate purlins.

2. View of hangar.
3. The hangar during construction.
4. Load-bearing construction of hangar during assembly.
Hangar of prefabricated concrete components – 1939/41
Pat. No. 377909 – 9.11.1939

Each hangar covers an area of 330 feet x 132 feet. Of this second type six hangars were built during 1939-41 at Orbetello, Orvieto and Torre del Lago. The design was based on the same requirements as were put forward for the type developed in 1936. This new design, however, brought a few important modifications. The construction is now symmetrical as it rests on six supports which made simplified approximate calculations possible. The results of these were checked by tests on models. The upper part of the construction is of prefabricated reinforced concrete components. The roof was covered with asbestos cement trays, which are supported by a prefabricated diaphragm.
1 Plan.

2 The hangar during construction. In comparison with the hangar of 1936, the solution here shows boldness but also simplicity. The roof is carried by six supports only. The striving for lightness and transparency has been met successfully in this conception.
3 Manufacturing process of the prefabricated components. They are cast into simple wooden moulds placed on the ground next to the hangar. Starter bars project from the upper and lower chords.

4 Full size test model for the examination of the assembly of individual components and their connections.

5 Overlap of prefabricated components. The protruding bars are tied together by binding wire and are electro-welded before in situ work is started.
6 The build-up of construction.
7 The hangar before fixing of roof decking, in the foreground are prefabricated components.
9 Detail of corner solution. In contrast to the earlier type, as shown at the 1935 hangar near Orbostello, here Nervi discontinued the use of two linked supports at right angles to each other and placed only one support diagonally, i.e., in the direction of the resultant force. The opened door has to be stabilised through a separate construction. The wind-bracing in this construction is achieved through the fork-like shape of the supports.

9 Interior of the finished hangar. The hangar is lit at the back and front by continuous windows. This emphasises the lightness of the construction.
10 View of a corner support.
11 Underside of structure after completion of the hangar.
12 The hangar during construction. The horizontal truss at the springing of the roof construction (see illustration 10) takes up the thrust and serves as a distributor of wind forces to the six supports.
Sketch designs of Exhibition Pavilions for the World Fair at Rome - 1939

**Pavilion A**

The plan is circular. The roof slopes from the perimeter to the centre. The construction was visualised in «ferro-cemento» (Pat. No. 406296 - 15.4.1943).

1. Interior.
2. Exterior.
3. Section.

**Pavilion B**

In contrast to Pavilion A, B was designed for a steel frame construction. The plan is rectangular. The steel ribs which support the roof decking intersect at the centre and thereby provide the necessary cross bracing for the hall.

4. Elevation.
5. Perspective.
6. Perspective of the interior.
Sketch design of a large hall in prefabricated reinforced concrete units, clear span 990 feet – 1943
Pat. No. 429331 – 29.9.1944

The roof structure consists of corrugated pre-cast elements of «ferro-cemento». The prefabricated reinforcement, consisting of mild steel bars and several layers of wire mesh, has sufficient stiffness, after being placed into position, to carry the load of the cement grouting.

1. Details of the construction.
   1.1 Diagonal plate
   1.2 Longitudinal plate welded to the diagonal
   1.3 Several layers of wire mesh
   1.4 Stiffening ribs at 16 feet 5 inches centres
   1.5 Valley gutter of asbestos cement
   1.6 Corrugated asbestos roofing
   1.7 Small opening for ventilation between the sheets of asbestos and the load-bearing structure
   1.8 Tie beams at 132 feet centres
2. + 3 Views of the interior.
   2.1 Mounting of prefabricated units
   3.1 Longitudinal section through ridge of hall. On the right is the elevation of part of the roof.
1 Section through the roof construction.
2 Thermal insulation
3 Galvanised sheet metal
4 Fixed glazing
5 Frame of prefabricated reinforced concrete elements
6 Galvanised sheet metal
7 Fixed glazing

2 + 3 Cross section and longitudinal section through the hall.
Design of a Station Hall of prefabricated components - 1943

This hall with a span of 660 feet was roofed by prefabricated reinforced concrete units. The truss-like pre-cast parts are connected by in situ concrete. The thrust of the arches is distributed by a longitudinal beam to the supports.
Reinforced Concrete Ship of 400 tons - 1942-43
Pat. No. 395090 - 28.1.1942

The construction consists of four prefabricated truss-like elements, which are stiffened by longitudinal beams of in-situ concrete. The external cladding is of timber as usual.

Because of the war, the ship could not be completed.

1. Details showing the four prefabricated reinforced concrete elements.
2. Manufacturing of prefabricated units in simple wooden shuttering.
3. Test trial under load.
4. Longitudinal section. Overall length, 132 feet. Length at water level, 112 feet.
5. Plan (above: at level of deck, below: at water level).
6. The vessel during construction.
7. Erection of a full size test model. The external wall consists of wooden planks and is connected to the reinforced concrete parts by bolts.
8. Details of keel and deck showing the fixing of the wooden planks.
Storehouse in Rome - 1945
Pat. No. 406290 - 15. 4. 1943

The external wall consists of «ferro-cement» and has a thickness of 1\(\frac{1}{4}\) inches only.
To give this wall sufficient stiffness it was formed in large corrugations.

1 Plan (above: section at window level; below: section below the windows).
2 Interior.
3 Section A-B.
1 Tension bar, \( \frac{3}{16} \) inch diameter
2 Anchor bar, \( \frac{3}{16} \) inch diameter; the anchor bars are 17 feet 3 inches long
3 Reinforced concrete slab
4 Concrete foundations

Exterior of storehouse (unfinished).
Covered Swimming Pool of the Naval Academy of Leghorn - 1947

Large corrugated prefabricated units of «ferro-cemento» form the roof construction of this swimming pool. In the cavities warmed air is circulated to prevent condensation. (Pat. No. 445781 - 26.8.1948).

1. Longitudinal section.
2. Cross section.
3. Process of manufacturing the prefabricated units. The shuttering is of concrete.
4. Lifting of a unit from the shuttering.
5. Planning of individual units.
6. Interior of finished hall. In the centre are the ceiling outlets for the warmed air.
Wharf Conte Trossi, San Michele di Pagana (Genoa) – 1947

Architectural design: Arch. Ing. Carlo Daneri, Genoa

Shallow arches of reinforced concrete support the roof of the hall which has a width of approximately 102 feet. The arches are at 33 feet centres. Corrugated pre-cast 'ferrocemento' units span from arch to arch. The corrugation guarantees a high stability with maximum economy of materials.

1 Details of reinforcement.
2 Perspective.
3 Interior of the unfinished building.
1 Section.
2 Fixed glass
3 Surface painted white for light reflection
4 Vent pipe
5 Roof deck
6 Roof skin of asbestos cement
7 Rain water down pipe
8 Stiffening ribs.

2 View of the interior.
Sketch design of a hall with special shed construction for thermal insulation - 1948

The prefabricated components of "ferro-cemento" have a length of 13 feet 2 inches. The shallow northlight sitting on the corrugated prefabricated units forms a thermal insulation and provides good natural lighting.

3 View of the interior.
4 Longitudinal section.
This design already shows all those elements which were later used for the Exhibition Hall in Turin.
The hall is rectangular and covers an area of 240 feet × 309 feet. On one of the two shorter sides is a semi-circular apse. Windows are arranged in the corrugation of the prefabricated roof elements. (Pat. No. 445781 – 26.8.1948).

1 View of the interior during the Turin Automobile Show.
Longitudinal section through the Exhibition Hall (Salone Principale) in Turin. A semi-circular apse 132 feet in diameter adjoins the main hall which is 240 feet long. Its roof consists of corrugated pre-cast units. The half-dome roof of the apse is also constructed with prefabricated elements.

1. Corrugated roof of prefabricated elements
2. Windows
3. Suspended floor of prefabricated elements
4. Half-dome of prefabricated elements
Section through the Exhibition Hall (Salone Principale) at Turin. The vaulted construction of the hall consists of prefabricated elements which spring from in situ concrete abutments.

1. Corrugated roof of prefabricated elements
2. Windows
3. Suspended floor of prefabricated elements
Section through a prefabricated unit. The units are of *ferro-cemento* and have a length of approximately 15 feet and a width of 8 feet 3 inches. The thickness of the curved pre-cast parts is less than 2 inches. This small thickness is achieved only by the increased rigidity through the corrugation and the transverse webs at either end. The individual units are joined by in situ concrete. (See illustrations 14 and 15).

---

Prefabricated parts.

Concrete cast in situ.

Interior of hall. The transverse webs for stiffening are clearly visible at the ends of the prefabricated units.
6 Reinforcements of a prefabricated unit without windows.
7 Storing of prefabricated units, ready to be built in.
8 Placing of a prefabricated unit. The protruding bars serve as a better bond to the in-situ concrete.
9 Placing of prefabricated units on tubular scaffolding which can be moved on after completion of a section.
10 Detail drawing showing the reinforcement of a main support.
11 View of side gallery.
12 In situ abutment construction. Each in situ abutment supports three arches.
13 The hall during construction.

14 Fixing of reinforcements for the in situ concrete at the junction of the supporting branches.
15 Making of shuttering for the in situ construction.

16 Construction of the hall. The tubular scaffolding has been moved on for the next bay.
17 View towards the apse (proposal by Nervi). Originally the design envisaged a curved sheet of glass as a division between the hall and the adjoining apse. The lower edge of the curved glass was to continue the line of the dome down to the floor. The V-frames were to carry the half-dome of the apse taking the thrust in the inclined supports.

19 The final proposal which was carried out. The elegance of the curved sheet of glass as a demarcation line to the enclosed space is disrupted by openings and the placing of supports. The half-dome of the apse rests abruptly on the inner supports of the gallery. (See illustration 19.)
19 View of interior of the apse of the Exhibition Hall (Salone Principale), Turin (Pat. No. 405206 - 15.4.1943). The load-bearing construction of the half-dome consists of prefabricated units, which had been cast in concrete moulds. In situ concrete is cast between these prefabricated units, the underside of which forms part of the ceiling.

20 The dome during construction. The view shows the prefabricated units ready to receive the concrete which will form the in situ ribs and topping.

21 Section through roof construction.
1 Prefabricated element
2 Reinforced in situ rib
3 Concrete topping

22 A prefabricated element.
The hall consists of a low rectangular building with a shallow central dome resting on four supports. The dome and the roof of the surrounding arcade are of prefabricated units. The units employed for the dome are of the same type as those of the half-dome (see illustrations 21-22). For the roofing of the arcade corrugated units of «ferro-cemento» were used. The arches spanning between the four supports of the dome are inclined so as to correspond approximately to the direction of forces from the dome.

23 View of the interior. The prefabricated units of the dome are supported by four reinforced concrete arches.
24 Section.
25 The roof structure from below.
26 Erection of shuttering for the dome. In the foreground is the roof of the surrounding arcade.

27 The prefabricated units are covered by a reinforced screed 1\(\frac{1}{2}\) inches thick.

28 Sections through the roof construction of the surrounding arcade. The prefabricated units of ferro-cement are corrugated and are slightly shallower at one end. Their thickness varies from \(\frac{3}{4}\) inch to \(1\frac{1}{2}\) inches. The units are stiffened by four transverse webs.
29 The manufacture of prefabricated units for the roofing of the surrounding building. The concrete shuttering in which the units are cast was made in plaster moulds.

30 Process of manufacturing prefabricated units for the four-sided dome. The protruding bars are for the bonding with the in situ concrete.
31 The dome during construction. The prefabricated units are in position. The reinforcing rods are inserted in the ribs.

32 Detail of a corner support where two arches meet.
View of interior.
Design for a hangar for Buenos Aires, span 592 feet – 1948

Prefabricated units of reinforced concrete are supported by frame-like abutments of in situ concrete. The back wall is of folded pre-cast units for the sake of increased rigidity. A horizontal shelf-like slab supports the upper track of the sliding doors.

1 Sketch at design stage.
2 Section.
3 Perspective.
Beach Casino at Ostia - 1950

Architectural design: Attilio La Padula, architect

The roof consists of prefabricated units and in situ ribs similar to the half-dome construction of the Exhibition Hall at Turin. The smooth underside of the prefabricated parts forms part of the ceiling, while the upper side is roughened to improve the bond to the in situ concrete topping.

1. Interior.
2. The prefabricated units in position.
3. Section and ceiling.
Multi-purpose hall, Terme di Chianciano - 1952
Architectural Design: Mario Loreti and Mario Marchi

Here again the roof construction is of prefabricated «ferro-cemento» units exposed on the underside (Pat. No. 465636 - 19.5.1950).

1 Underside of ceiling,
2 The units in position.
Storehouse for Salt in Tortona – 1950/51

1 View of the exterior during construction. In the foreground are prefabricated units ready to be built in.
2 View of the interior. The tubular scaffolding is used for placing the prefabricated units in position and is on wheels.
3 Interior after completion.
Pressure pipelines of «System Nervi»
Pat. No. 465359 – 7.11.1952 and American Pat. No. 2771655

During 1952/53 the firm of building contractors Nervi & Bartoli produced a pressure pipeline of pre-stressed reinforced concrete pipes. These pipes were made by a special process evolved by Nervi. In principle the pipe consists of a pre-stressed ring of in situ concrete. The compression is obtained by a thin pre-cast outer skin which is put in a state of tension during construction. The method of construction and pre-stressing is as follows:

a. The pre-cast ring of fine aggregate reinforced concrete (6) is dropped over the prestressing drum, called by Nervi «torre di forzamento». This drum consists of vertical hollow steel sections (4) between which and the main body of the drum (1) are arranged horizontal rings of rubber tubes (2). The gap between the steel sections and the outer pre-cast skin is 3'/4 inches.

b. This gap is now filled with cement grout (5) and the top surface sealed by the lock (7).

c. The outer skin is then tensioned by forcing water under pressure into the rubber tubes. This tension is maintained until the in situ concrete has set. The setting is accelerated by pumping warm water through the hollow steel sections (4).

d. Transfer of stress is now brought about by reducing the water pressure in the tubes. The inner in situ skin of the pipe is compressed by the outer tensioned skin.

e. After removal from the apparatus the pipe is ready for laying.

With each «torre di forzamento» one pipe 16 feet 5 inches long can be manufactured within 24 hours.
1 Elevation and section of pre-stressing apparatus.
2 Shuttering drum of concrete
3 Horizontal rubber tubes for building up pressure
4 Connection between warm water pipes
5 Vertical hollow sections for the transmission of pressure
6 Pre-stressed core of the concrete pipe
7 Outer skin 1 1/4 inches of fine aggregate concrete with spiral reinforcement
8 Lock
9 Sending of spiral reinforcement over a wooden drum.
10 Detail of the pre-stressing apparatus. The horizontal rubber tubes for the building up of pressure are visible. In the vertical hollow plates warm water is circulated to accelerate the setting of the cement.
11 Manufacture of pipes in the workshop.

5 Cross section through pipe, showing method of supporting.
6 Transportation of finished pipes.
7 Laying of pipes. These pipes have a projection on either side on which they are supported. In this way bending moments caused by unequal loading are reduced to a minimum.
8 Connection of two pipes.
1 Outer skin
2 Pre-stressed core
3 Mastic
4 Sheet metal
5 Cement mortar
In 1949 a competition was held by the State Monopoly Administration for the most economical design solution of a 5-storey factory measuring 700 × 80 × 90 feet. Determined by technical as well as economical considerations is the construction of the two identical floor slabs with an area of 250,000 sq. ft. Nervi developed a special technique for this job using shuttering boxes of «ferro-cemento». These rest on a tubular scaffolding, which can be raised and lowered by means of hydraulic jacks and can be moved horizontally along tracks. First, all columns are cast. Then the shuttering is built up for one bay, and after concreting, the shuttering is lowered and moved on. As is usual with shuttering the surface of the concrete boxes is treated to facilitate easy removal. (Pat. No. 455 750 – 23. 7. 1949).

1 The reinforcement in position.
2 The shuttering boxes, which had been cast in plaster moulds, are built up for several bays. The darker coloured units have already been treated for easier subsequent removal.
3 The shuttering which has been lowered is about to be moved on for the next bay.
4 Underside of finished roof construction.

View of the interior of the factory with the finished roof construction. For the exterior view of the tobacco factory see page 95.
The particular construction used here is patented by the engineers Nervi, Bartoli and A. Arcangeli (Pat. No. 455,678 - 23.7.1949).

It is based on a further development of the system employed at the tobacco factory at Bologna. The ribs follow the line of the main forces and give the ideal direction of reinforcements. The ceiling is calculated as a mushroom construction. Shapes like these could not be made with normal shuttering; that is why Nervi again used shuttering boxes of «ferro-cemento», which were made in plaster moulds. By this means he was able to achieve the free shapes of the blocks.

1 Plan and section of ceiling.
2 The finished ceiling (corner solution).
3 Underside of construction after completion.

Gatti Wool Factory in Rome - 1953
4 Shuttering boxes of «ferro-cemento».
Concreting of floor slab. The shuttering boxes rest on a movable scaffolding. The bay on the left is ready for concreting. On the right are two bays where the shuttering boxes have just been placed.
Trusses of pre-stressed concrete spanning transversely support the north lights.
The construction consists of triangular, curved precast units of "ferro-cemento," which are exposed on the underside. These units are supported by longitudinal beams. After placing the units, the whole structure is stiffened by a thin top layer of reinforced in situ concrete. The construction is similar in principle to the one employed at the half-dome of the Turin Exhibition Hall (see page 69).
Municipal Tramway Depot in Turin – 1954

Tied arches form the roof construction of this depot. The maximum span is 82 feet. The north lights are constructed above the arches.
The vaults consist of a block construction strengthened by reinforced concrete ribs. At 20 feet centres arched stiffening beams protrude above the roof. At both sides are strip windows. The load of the vaults is taken up by double supports on the outer sides. The long building in the background is the factory, the construction of which is described on pages 84 to 87.
The authors of the three winning designs of this competition for the new Central Station of Naples formed a group and worked out the final design together. Architecturally the handling of the entrance hall is of special interest. It is framed by diagonal portals with the beams intersecting.
1 The station from the outside.
2 Plan of the offices on the sixth floor.
3 Plan of ground floor at the level of the entrance hall.
1 Terminal platforms
2 Circulating area
3 Entrance hall
4 Waiting rooms
5 Left luggage
6 Snack bar and restaurant
7 Luggage
4 Interior perspective.
5 Elevation of the whole group.
1 Site plan.
1 Main hall
2 Gymnasium for various activities
3 Tennis courts
4 Covered tennis court
5 Covered swimming pool
6 Ice rink
7 Restaurant
8 Administration
9 Main entrance
10 Entrance for athletes
Competition Design for a Sports Centre in Vienna – 1953
Ing. Pier Luigi Nervi and Arch. Antonio Nervi

In 1953, Pier Luigi Nervi together with his son Antonio Nervi took part in a competition for a Sports Centre in Vienna. Their design envisaged a circular main hall with seating accommodation for 8,400 and standing room for 3,600. The smaller gymnasium were planned as simple cubes. For the construction of the main hall the same system of corrugated pre-cast concrete units was planned as for the Exhibition Hall in Turin. This construction is very light and at the same time extremely strong because of the stiffening effect of the units. Acoustically the underside of the dome provides an excellent diffusing surface. Access to the main halls via ramps, which lead to the accessible roof of the gymnasium in front and to the access galleries of the hall. On the south side is a separate entrance for athletes. Four external staircases placed radially facilitate speedy evacuation of the hall.
3 South elevation. In the centre is the entrance for athletes and above is the entrance for official guests.

4 East elevation. In the foreground are the administration buildings and the restaurant.
North elevation. In the foreground are the covered swimming pool and tennis court.

West elevation. Access to the main hall is via two ramps between the gymnasium and the main hall.
Section showing the different levels.

Plan at level 50.95 m. (166 feet)
1 Entrance for spectators
2 Entrance for athletes
3 Ascent to the main hall
4 Showers and WCs
5 Cloakrooms (for 50 and for 2-6 people)
6 Training quarters
7-9 Rooms for massage, steam bath and sauna
10 Changing room for the choir
11 Technical management and umpires
12 Doctor and First Aid
13 Central management
14 Resting room
15 Practice room for boxing, judo etc.
16 Training quarters
17 Practice room for table tennis
18 Practice room for rowing
19 Practice room for gymnastics
20 Day room for 50 people
21 Practice room for fencing
22 Multi-purpose room
23 Running track
24 Kitchen with stores and servery
25 Restaurant
26 Gymnasium
27 External escape stairs
28 Stores
29 Practice field for hockey etc.
30 Hall for gymnastics
31 Box offices
32 Ice rink
33 Roller skating rink
34 Parking space (at various levels)
9 Plan at level 63.20 m. (207 feet 6 inches)

10 Plan at level 68.70 m. (225 feet 6 inches)
1. External escape stairs
2. Raised platform of practice hall
3. Access to the ramps
4. Gallery
5. Cloakrooms
6. Access to lavatories
7. Seating accommodation for 8,400
8. Standing room for 3,600
9. Cycling track
10. Running track
11. Access to seating
12. Entrance for athletes
13. Administration
11. Section through east-west axis.

12. Gallery below the seating.
13. View of the interior of the main hall.
14 Sections BB and CC through pre-cast units.
1 Pre-cast reinforced concrete element
2 Duct openings for the air-conditioning
3 Window area
4 Prefabricated beam of the independent flat roof
5 In situ concrete connection of the pre-cast units
6 Window area
7 In situ concrete
8 Acoustic treatment
9 Pre-cast roof units
10 Sheet aluminium for waterproofing and thermal insulation

15 Section through dome with section AA through concrete supports.
1 Main ducts of air-conditioning plant
2 Roof lights
3 Covering of sheet aluminium
The construction of the main hall consists of corrugated pre-cast units of «ferro-concrete» which rest on inclined supports of reinforced concrete. At the junction of the in situ construction and pre-cast construction are the air-conditioning ducts through which warmed air is circulated to the duct openings in the units. The prefabricated units were planned to be similar to those of the great Exhibition Hall in Turin. The units are joined together by continuous bars embedded in concrete. In contrast to the Turin solution Nervi here had planned for a second roofing skin over the pre-cast units. In this way better thermal insulation would have been obtained.

16. Placing of pre-cast units.
1 Tubular scaffolding
2 Centring for the support of the units
3 Metal rail for placing the units
4 A unit being placed in position
(maximum weight 2,650 lbs.)
17-19 Perspectives and plan of an external escape stair.
The practice hall for various activities adjoins the north side of the large domed hall. Similar to the construction of the Congress Hall of the UNESCO Building in Paris, Nervi curves the roof to the line of compression in the beam. This gives a spacious effect and results in steel economy for the beams. It necessitates, however, an independent flat roof of pre-cast units to allow access to the roof.

20 View of the practice hall from the outside.
21 Plan and section of structure.
22 Perspective of the practice hall.
UNESCO Building in Paris – 1953/56
Architects: Marcel Breuer, Pier Luigi Nervi and Bernard H. Zehreruss

The curved north side of the Y-shaped secretariat forms part of the group of buildings around the Place Fontenoy. The south side opens towards a new square which is bordered by the projecting Conference Building. The outline of the main building forms an extremely clear-cut shape. Lifts, staircases and vertical services are in the core of this Y-shaped block. The vestibule space diverges into corridors which lead to offices on both sides. Further lifts and secondary stairs are at the ends of each wing.

The conference block is linked by a «clip» to the office building. This block contains the architecturally interesting Conference Room and several session rooms.
4 Photo of model.

3 Plan of a typical floor.
1 Offices
2 Director General
3 Vestibule space
4 WCs
5 Stores
6 Gallery at the foyer
7 Committee rooms
8 Cubicles for simultaneous interpretation
9 Room for Commissions' sessions
10 Press and public
11 Projection chamber
12 Access gallery for the lighting
13 Conference hall
The Secretariat is a reinforced concrete frame structure in which the main supports are inset from the face of the building. The floors are carried by a series of main and secondary beams. All services are in ducts above the central corridors. The beams taper off towards the outside where they carry the brise-soleil of reinforced concrete.

5 Section through structure.
6 Plan of structure and ceiling.
Structure of ground floor. The upper structure is supported on a rigid portal frame at ground level in which the columns are raked to give greater stability. The shape of the supports is dictated by the geometric problem of transforming the elliptic section at the base to the rectangular junction with the ceiling. The plastic form thus evolved is the characteristic element of a purely architectural treatment of reinforced concrete.

7 The supports at ground floor level.
8 Sectional elevations (above) and plans (below) of one ground floor support: at right angles to the main facade (left) and parallel to it (right).
9 The ground floor during construction. View of the junction of the three wings. In the centre is the multiple lift shaft.
10 Staircase during construction.

11 Plan and section of stairs. In an unconventional manner the treads are cantilevered from a spine wall.
The canopies at the entrances to the Secretariat are of unusual design. The canopy of the north side shown above still adheres to the conventional solution of a horizontal roof on supports; but it has an interesting pattern on the underside. The whole is designed for rough concrete work leaving shuttering marks visible. The down pipes are cast into the columns.

I Plan
II Underside section EE
III Section BB
IV Section CC

12
13 The canopy of the south-west side shows an unprecedented solution. An asymmetrically placed arch forms the support for a three-dimensionally curved slab cantilevering on both sides. The thickness of the slab is $3\frac{3}{4}$ inches.

I Plan and section DD
II Elevation
III Section AA
IV Vertical section
The roof of the Conference Building is a folded slab construction in reinforced concrete, which is stiffened by a central up-stand beam carried by six supports. In the Conference Room an extremely spacious solution is achieved by raising the slab between the folds. The roofing slab is being utilised to full advantage by following the direction of the compression forces. The continuation of the folded slab structure around the gable walls provides the necessary lateral stiffeners for wind moments. There are few examples of modern architecture where such a convincing form has been achieved integrating architectural and structural design.
16 Interior of Conference Room.
The bending moment diagrams show the forces and the direction of the stresses in the structure. Above the Conference Room, as can be seen from the diagrams, considerable compressive stresses occur in the upper parts of the folded slabs. The slab here is raised to follow the line of compression, forces thus being in compression throughout.

17 Bending moment diagram.
18 Cross sections through the structure at AA and BB (see moment diagram).
   1 Zero line
   2 Stressing zone
   3 Tension zone
19 Deflection diagram of the structure under vertical loading, indicating compression and tension zones.
   1 Upper stressing zone
   2 Central stressing zone
   3 Lower stressing zone
20 Longitudinal section
21 + 22 The Conference Block during erection.
23 A centre support of the Conference Block in the course of erection.

24 Placing of folded slabs and laying of reinforcements.
25 The cladding of the folded slab construction.

26 The folded slab construction of the Conference Block during the finishing stages.
The advantages of a construction based on prefabricated reinforced concrete units are especially apparent when the building is very large, and when one can limit the number of different elements. These two conditions were present with this project to a high degree. The three-story building has the unusual length of 2103 feet and a width of 66 feet. The building had to be erected within five months. After allowing for time to install the site equipment, only four months were left. This time-limit was even improved on, as the building was erected within 100 days.

The construction is clearly explained through the diagram above. The shuttering for the ground floor slab consists of "ferro-cemento" (illustration 4). The shuttering rests on a travelling scaffold and can be lowered after striking and moved into the adjacent bay. There are two intermediate columns at basement level (Illustrations 3 and 6) but the other two floors span across the complete width of the building. The ground floor construction consists of in situ concrete while the upper floors are constructed of pre-cast girders at 6 ft. 2 in. centres with in situ slabs (Illustrations 7-10). The pre-cast girders are constructed in similar shuttering to the ground floor slab.
3 The shuttering for the ground floor slab mounted on movable scaffolding.
4 Section through ground floor slab showing the removable shuttering of «ferro-
cemento».
5 Section through the upper floor slab, showing the removable shuttering for the
construction of the in-situ slab.
6 Diagram showing the placing of the girders.
7 A girder ready for casting. All shuttering is specially treated before each casting, for easy removal.

8 Finished girder ready to be placed in position. The protruding bars are for the in situ connection with the framing beam. The surface of the girder is so smooth as a result of the fine aggregate concrete shuttering that any further treatment or rendering is unnecessary.
9 Hoisting a girder into

10 Underside of first floor girders. The loads differ from floor to floor. The ground floor slab can carry a superimposed load of 200 lbs./sq. ft. while the other floors carry 100 lbs./sq. ft. and 50 lbs./sq. ft. respectively.
The main problem which the erection of a tall slender structure poses is the provision of wind bracings. Two rectangular supports which branch out in the upper floors serve as cross bracings (see illustration 7 on page 131). The width of a support in the basement is 6 feet 7 inches tapering to 12 inches at the top of the building. The triangular end walls form lateral wind bracings to some extent but they are mainly for longitudinal stiffening. A curtain wall of 108,000 sq. ft. is attached to the structure. The floors span right across without intermediate supports, i.e. 79 feet. This unusual span is achieved by rows of pre-stressed reinforced concrete beams at 5 feet centres, which have a depth of 2 feet 6 inches.
2 Plans of structure at 1st, 15th, and 30th floors. It is clearly visible how the area of the load-bearing structure is reduced in relation to height (see illustration 7 on page 131).

3 The plan is rational and functionally well thought out. The triangular end walls hold the fire escape stairs, lifts, and the air-conditioning ducts. The internal corridors taper off towards the ends according to the diminishing amount of use; they are widest in the centre of the building where there is a group of six lifts on the north side. The subdivision of the rooms is extremely flexible. Movable partitions can be placed in all directions on a 3 ft. 1 in. × 3 ft. 1 in. grid. The plan shows one of the many possibilities for subdivision within the grid.

1 Lift hall
2 Small reception room
3 Large office
4 Small offices
5 Grid of 3 feet 1 inch × 3 feet 1 inch on which the partitions are based
6 Ladies' cloakroom
7 Gentlemen's cloakroom
8 Internal staircase
9 Vertical service ducts, air-conditioning ducts, escape stairs and lift
10 Balcony giving access to escape stairs and lift
11 Lifts for the delivery of post
4 Plan of shuttering.
5 Diagram of typical reinforcement (section and plan) of a post-tensioned beam. In addition to the post-tensioned reinforcements the beam has also ordinary mild steel bars which are dimensioned to take the weight of the beam only. The post-tensioned reinforcements are put under stress after the removal of the shuttering. The post-tensioning serves in addition to increase the moments at the support of the beam which has a clear span of 79 feet. Of special interest is the variation of the width of the beam from 6\(\frac{1}{2}\) inches to 2 feet to cater for the variation in bending moment and shear force. The openings in the beam are for service ducts and pipes.

1 Axis of symmetry
2 Pre-stressed bars
3 Openings for service ducts and pipes
Section between the centre supports. Access to the lifts is from three different levels. The visitors enter from the Piazza Duca d'Aosta, the square in front of the station, at level +3.60 (12 feet) above the car park (below are workshops and an auditorium seating 600 people). The staff enters at the rear of the building at level +0.10 (4 inches) crossing the ramp of the access road by a bridge. The access road passes parallel to the building down to level —4.90 (—16 feet) where there is a delivery entrance. With the help of a goods lift delivery vans or even lorries can be taken down to level —7.55 (—24 feet 9 inches) to the service rooms.

Section through two of the centre supports which branch out and taper off in the upper floors.
Nervi’s main consideration in this project was to reduce to a minimum the necessary scaffolding as the height of the road crossing the bridge is 164 feet above the valley.
The bridge is supported by a series of reinforced concrete trestles at intervals of 164 feet. These can be erected consecutively with the same scaffolding. The road structure consists of main beams, with cantilevered ends, supported by the trestles. The internal spans are simply supported with special connections to the cantilevered beams. They are hoisted into position with the help of winches attached to the trestles. The stiffness of the bridge is achieved through the stability of each individual trestle. The pre-cast beams are carried on rollers and thereby allow for any movement due to settlement.

1 Elevation of bridge.
Horizontal section AA, cross section BB and longitudinal section CC of a reinforced concrete trestle.
Diagram showing typical reinforcement.

1 Prefabricated girder
2 In situ concrete
3 No-fines concrete
4 Hard core
Design for the «Centre National des Industries et Techniques» in Paris – 1955
Architects: Camuset, de Mailly, Zehrfuss
Engineer: Pier Luigi Nervi
Consulting engineer for the structural steelwork: Jean Prouvé

The great Exhibition Hall of the projected Centre at the «Place de la Défense» is to be for permanent as well as periodical exhibitions. The whole project consists of a large hall covering an equilateral triangular area and smaller adjoining buildings. The triangular plan form has been partly dictated by the shape of the available site. The picture of the model shows the extraordinary boldness of the construction of the hall. The sides are 736 feet in length. The height at the top of the side walls is 158 feet. The beams hold the springing points of the three arches together. The structural calculation is not based on the theory of shell construction, but on the principle of the cross-vaulting. The principal structure consists of three intersecting arches with dia-grid vaulting between the main ribs. The use of prefabricated units for the vaults was favoured by economic considerations.

1 Model seen from the south-east.
2 Section through the east-west axis.
   See A-B of plan below.
3 The south-west elevation.
4 Plan of ground floor at level + 55.50
   (182.00 ft.)
   1 Vertical ducts
   2 Information kiosks
   3 Stairs
   4 Escalators
   5 Goods lifts
   6 Lobbies
   7 Goods lifts and stairs to the kitchen
   8 Goods lifts and stairs for the fire brigade
   9 Goods lifts and stairs for the post
   10 Goods lifts and stairs for the Red Cross
   11 Customs office

Of special interest is the aesthetic and structural solution of the enormous curtain walls. The glass is fixed to vertical tubular supports which are at 30 feet centres. In order to provide the necessary stiffness to counteract horizontal wind forces a vertical truss is formed of tubular supports and tension bars which are positioned by horizontal struts. By this means a very light and elegant form is achieved. The curtain walls are non-load-bearing. Between the horizontal members of the vertical trusses there is room for cat-walks and brise-soleils.

5 Vertical section through the curtain wall. The height of the tubular truss is 158 feet.
6 Horizontal section through the curtain wall between two tubular trusses. Below the cat-walk and above the adjustable brise-soleils
7 Detail of roof construction at the intersection of the arches.
8 A node point of the vaulting.
1 Pre-stressed concrete
2 Prefabricated elements of "ferro-cement" 
9 Section through a prefabricated element.
10 Plan, section and various cross-sections through the structure.
   a. Thickness of slab approximately 3½ inches
   b. Approximate outline of foundations
   c. Tie beam
11 View of structural model from above.
Design for a large Exhibition Centre in Caracas – 1956

The building consists of a central domed hall of 590 feet in diameter, around which a low circular walk of 246 feet width is placed. The covered area is 972,000 sq. ft. Below the circular walk are stores and garage space for 3,000 cars. The lighting of the hall is through a central roof light. The roof structure of the circular walk is corrugated and will be constructed with the help of movable shuttering. The dome will have structural rigidity through its prefabricated units above which is a roof membrane of further prefabricated units in «ferro-cemento» for thermal insulation and weather proofing.
2 Interior perspective of the circular walk.

3 Plan and section.
Acknowledgement to Photographers

F. Barsotti, Via Scala 4, Firenze 5, 6, 7, 9, 10, 11, 12, 13, 14, 15
Besso - Pressphoto, Piazza Barberini 2, Roma VIII
Foto A. Cartoni, Via Michele di Lando 48-54, Roma 19, 20
Foto Casali, Milano 126
Foto Cresta, Piazza Principe 4-6, Genova 55
Foto-Studio Davio-Bazzan, Via E. De Amicis, Tortona 80 (1)
Lucien Hervé, 11 Rue Soyer, Neuilly s. Seine 111, 113, 114, 115, 118, 121, 122, 123
B. Miniat, Livorno 52
Foto Mosio, Gall. S. Federico, 18, Torino 62, 65 (12), 68 (18), 69 (19), 70, 73 (30), 93, 94
Foto Riccardo Moncalvo, Via Ponza, 2, Torino 59, 63 (7, 8, 9), 66, 67, 69 (20), 72, 73 (29), 74, 75, 81
Pier Luigi Nervi, Lungotevere Arnaldo da Brescia, 9, Roma 48, 49 (6), 79 (2)
Foto Panizzon, Socchieve (Udine) 82 (2, 4), 83 (7)
Foto P. Pollini, Pordenone 82 (3), 83 (6)
Foto Oscar Savio, Via di Piazza, 82a, Roma 89, 92
Foto Vasari, Via Condotti 39, Roma 3, 26, 27, 28, 30, 31, 32, 33, 34 (1), 37, 38, 39, 40, 41, 42, 43, 49 (7), 50, 51, 53 (6), 65 (11), 78, 80 (2), 85, 90, 91, 92, 105, 124, 125, 126, 127, 139
Foto Villani, Bologna 79 (1), 84, 85, 86, 96
<table>
<thead>
<tr>
<th>Due</th>
<th>Returned</th>
<th>Due</th>
<th>Returned</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEC 02 1996</td>
<td>APR 01 2006</td>
<td>DEC 17 2003</td>
<td></td>
</tr>
<tr>
<td>JAN 02 1997</td>
<td>DEC 13 1996</td>
<td>JUL 02 2003</td>
<td></td>
</tr>
<tr>
<td>SEP 02 1998</td>
<td></td>
<td>SEP 09 2000</td>
<td></td>
</tr>
<tr>
<td>NOV 08 2000</td>
<td></td>
<td>OCT 14 2000</td>
<td></td>
</tr>
<tr>
<td>JAN 08 2001</td>
<td></td>
<td>DEC 14 2000</td>
<td></td>
</tr>
<tr>
<td>MAY 25 2001</td>
<td></td>
<td>APR 06 2001</td>
<td></td>
</tr>
</tbody>
</table>

Architecture & Fine Arts Library
University of Florida
Gainesville, FL 32611