Fig. 1. American Delegation visits apartment construction in Moscow using pre-tensioned elements. Left to right are: Professor T. Y. Lin (head of Delegation), Professor Boris Skramtaev of Soviet Academy, Mr. Walter Price, Russian lady-architect, Professor Boris Bresler, Russian interpreter Mr. Sergeev, Mr. Ben C. Gerwick, Jr., Mr. David Billington, and Mr. James D. Piper.

prestressed concrete in russia

Prof. T. Y. Lin, University of California, who co-authored this article with Ben C. Gerwick, Jr., San Francisco, California.

1. INTRODUCTION

At the invitation of the Soviet Academy of Construction and Architecture in Moscow, an American Delegation of concrete specialists visited the U.S.S.R. in May, 1958 (Fig. 1). The purpose of the trip was to inspect recent Soviet research and development in the field of precast and prestressed concrete engineering.

The American Delegation consisted of the following members:

1. T. Y. Lin, Professor of Civil Engineering, University of California, Berkeley — as Chairman of the Delegation.
2. Boris Bresler, Professor of Civil Engineering, University of California, Berkeley — as Secretary of the Delegation.
3. David P. Billington, Engineer, Roberts and Schaefer Co., Engineers, New York City.
4. Ben C. Gerwick, Jr., President, Ben C. Gerwick, Inc., San Francisco, California, and President of Prestressed Concrete Institute.
5. Walter H. Price, Chief, Engineering Laboratories, Bureau of Reclamation, Denver, Colorado, and Past-President of American Concrete Institute.
6. James D. Piper, Vice President, Portland Cement Association, Chicago, Illinois.

A complete report is being written by the Delegation and will soon be published. It is the purpose of this paper to describe Soviet research, design, production, and construction of prestressed concrete as observed by the Delegation. Most of the material presented in this paper is taken from the manuscript for the above report.

2. GENERAL OBSERVATIONS

Our observations of prestressed concrete engineering in the U.S.S.R. were limited in time and locale: we were there only for ten days and visited only Moscow and Leningrad areas. However, because of our concentration on various phases of prestressed concrete and due to a full schedule of conferences and inspections, a surprisingly broad picture was obtained.

In prestressed concrete engineering, the development in the Soviet Union is ahead of that in the U. S. in certain respects, and behind in others. Generally speaking, they emphasize precasting, but do little in-place prestressing; they use more prestressed elements in buildings, and much less in bridges; they are well-advanced in mass production, but only beginning in unique designs; they concentrate on continuous pretensioning but have barely started on the long line process or post-tensioning as a whole.

Their emphasis on prestressed concrete was partly motivated by the desire to reduce steel consumption, although the main consideration is overall economy. Their ability to make the most of prestressing results from the state control over planning, standardization of design, and mechanization of production. The government order to build over thirty million square feet of apartments per year in Moscow alone, all of a few standard floor and wall units, makes it possible and worthwhile to highly mechanize the production techniques, thus attaining economy. Their emphasis on precasting resulted from the trend toward mechanization and also from the severe cold weather which tends to favor indoor and factory production; whereas our highway and trucking facilities together with a well-developed ready-mix concrete industry enable us to build economically either monolithic or precast structures.

The ability of the Russian engineers to design and construct unique engineering projects is not open to question. There are, however, lesser number of unique designs, when compared to Western Europe or the United States. The appearance of the structures and building products is inferior judging by our own standards. Soviet engineers often indicated that appearance was of secondary importance to them, although time will come when more attention will be paid thereto.

3. RESEARCH

There is no question that Soviet research in the field of prestressed concrete is outstanding, especially in applied research which includes the development of prestressing methods, machines, and various designs using prestressed concrete. The concentration and centralization of efforts under one or two organizations enables them to carry out costly but fruitful work not otherwise possible. This is in direct contrast with Germany, for example, where dozens of contractors are independently developing their own systems of post-tensioning.

Soviet research on prestressed concrete is essentially carried on by their Academy of Construction and Architecture. This Academy employs 8,000 engineers, scientists and technicians in 22 research institutes under its direction. The major portion of research on prestressed concrete is carried on in the Prestressed Concrete Laboratory, under the direction of Professor V. V. Mikhailov — this Laboratory being a part of the Research Institute of Concrete and Reinforced Concrete. Related work is also carried on in the Central Institute of Structures. Some 600 persons work in the six laboratories of these two institutes; and it is estimated that about 1/3 of these are working on prestressed concrete.

These laboratories are very well equipped. (Fig. 2.) For example, there are six heavy floor slabs for testing members under bending, with slot fittings permitting a maximum load per bolt of 50 tons. One big testing slab was 230 x 33 feet. We were told that a new 400 x 66 feet testing slab is to be built soon.

Many pulsators were used for testing the fatigue strength of steel reinforcement and concrete specimens. Six pulsators were in operation and new pulsators were being installed.

Research projects in the laboratories change from time to time. The following projects were witnessed by us during our visit.

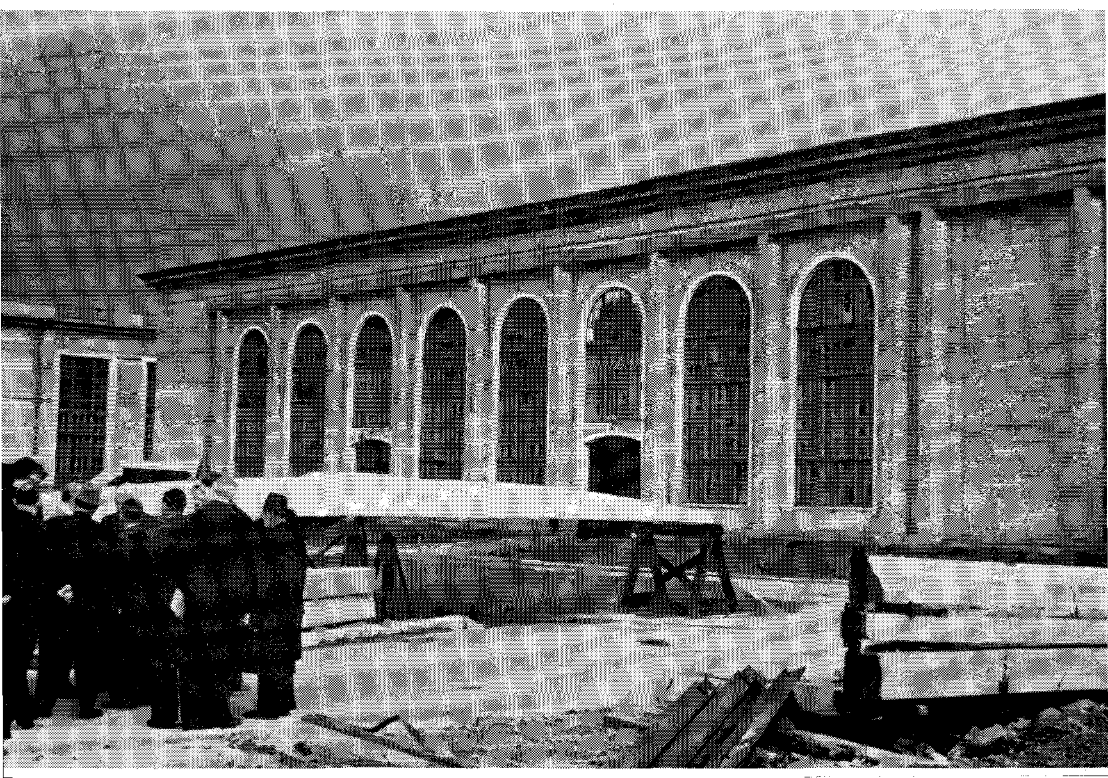
1. Monolith-Precast Prestressed Construction

Investigation was being conducted on precast pretensioned elements acting as reinforcement for poured-in-place concrete. The precast elements thus also act as forms and support during pouring. Preliminary tests showed that it was possible to utilize the ultimate tensile strength of the poured-in-place concrete, since its cracking is prevented or delayed by contact with the prestressed elements. In the tests, there was no separation between the two elements or portions, even at failure. These tests were carried out on very highly stressed beams, where the concrete strength was in the range of 10,000 to 12,000 psi. A paper on this subject was given by V. V. Mikhailov at the Third International Congress on Prestressing held in Berlin in 1958. One of the test specimens is shown in Figure 3.

2. "Self Stressing" Cement

"Self stressing" cement is a type of expansive cement, which due to its chemical composition and special hydrothermal treatment during placing and hardening expands and stresses the reinforcing bars. An investigation of the chemical composition, physical properties, and curing procedures for a self-stressing cement has been under investigation for several years. The main purpose was to control the amount and time of expansion by proper

Fig. 2. In front of Soviet Research Laboratories, prestressed thin shells are being tested.



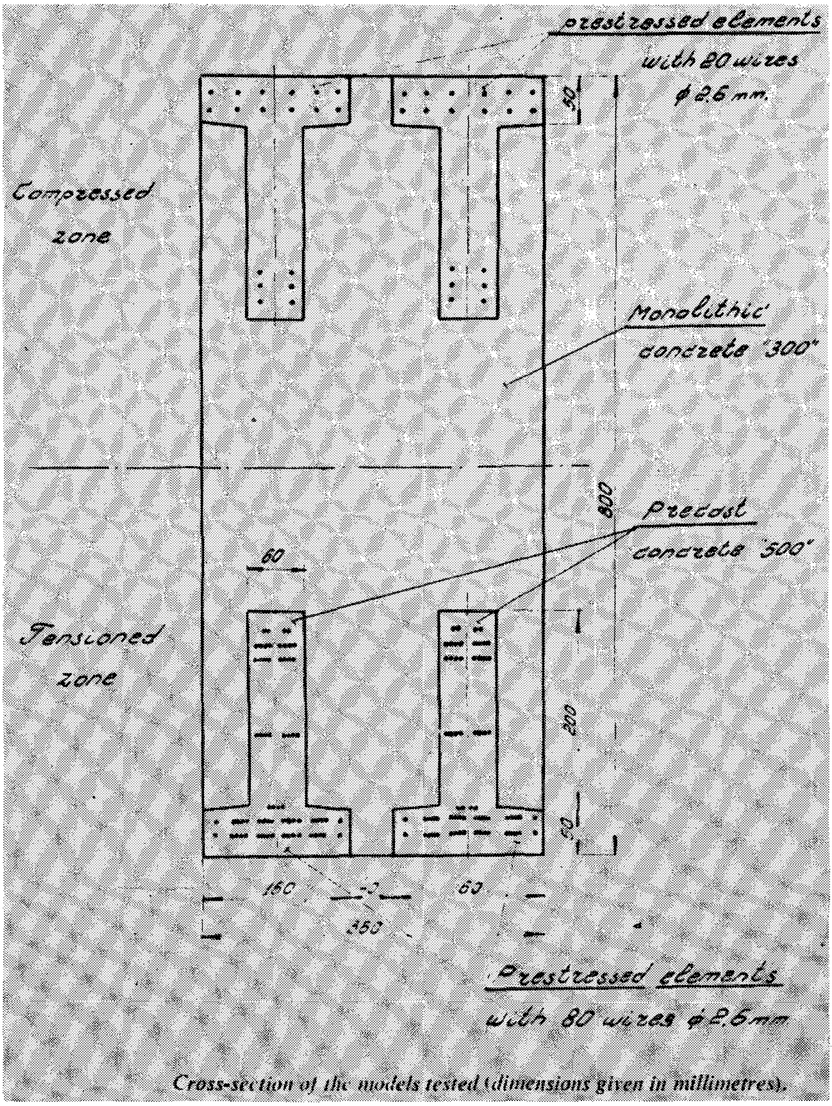


Fig. 3. Models for determining the effect of precast monolithic construction, where precast elements are used for forming and to help developing the tensile strength of in-place concrete.

proportioning and curing. Numerous small specimens were used to measure expansion and plastic flow under constant stress or constant strain. It was being put into commercial application for the self-stressing of pipes, both longitudinally and circumferentially. (Paper on this was presented by Professor V. V. Mikhailov in Proceedings, World Conference on Prestressed Concrete, San Francisco, 1957.)

3. **Prestressing Machines**

Essentially, two types of machines for continuous prestressing are developed and improved in the laboratory: one is the turntable with a stationary feeder head, and the othei is a stationary table with a movable feeder head. This method of continuous prestressing

Fig. 4. Pre-tensioned railroad ties being tested in the research laboratory. Note the rails along the long side of the rectangular frame.

is described by Professor V. V. Mikhailov in a paper published in the Proceedings of World Conference on Prestressed Concrete, San Francisco, 1957. Plans are being made for using prestressed concrete frames instead of steel for the D.N. 7 or turntable machines.

Some other research projects are listed as follows:

4. Post-tensioning methods — anchorage device up to 400 tons per cable.

5. Large bars for post-tensioning pretensioning — pullout tests on bars up to 1 and 2 inches in diameter anchored by bond alone.

6. Corrosion in sea water — Professor V. M. Moskvin recommended 3 to 5 cm of concrete cover for prestressing steel in the tidal range and immediately above high tide.

7. Railroad tie frames — thin rectangular frames continuously pretensioned to replace wooden ties (Figure 4).

8. Precast roof shells — various types of hyperbolic-paraboloid thin shells were tested.

9. Prestressed trusses — 30 meter span roof truss built of precast units was being post-tensioned together and tested.

10. Crane girders, prestressed pipe machines, prestressed concrete autoclave units, etc., were being developed and tested.

4. DESIGN

So far as we know, there are apparently no engineers in private practice in the Soviet Union. All engineering design is concentrated in Government Design Organizations. The biggest organization of its kind is probably the Moscow Design Institute which designs and supervises all building construction in Moscow. It employs 3100 structural engineers, architects, sanitary engineers, electrical and mechanical engineers. Over half of the employees are women.

All design and construction are planned and scheduled two years ahead, and designs are now ready for 1959 and 1960. The daily work of design is greatly simplified by standardization. Catalogues are prepared by the design organizations which show available precast and prestressed structural units that are to be used in all standard construction. Standard details are published in handbooks and revised annually.

The specifications for prestressed concrete have been revised several times, and the latest issue is of 1958. These specifications are approved by the State Committee for Construction of the Council of Ministers. It is interesting to note that, instead of empirical allowable stresses the following three basic criteria are used for design: (a) ultimate strength, (b) excessive deformation, and (c) local damage — such as cracks, etc. Ultimate strength design conditions include two coefficients: one is an "overload or load factor", and another is "service condition factor" which varies for various types of structure and service conditions. The resulting factor of safety appears low in some instances, but in others appears comparable to those normally recommended in the United States.

A typical framed construction has the precast reinforced concrete columns set on precast footings. The columns would have protruding corbels on which are set precast prestressed cored rectangular beams. The cored flat floor slabs rest on these beams. The connections for the precast units are made by welding and grouting. We were informed that studies were being made to use prestressed concrete even for the footings and columns. Indeed, some crane columns were already prestressed.

Special individual building designs are made only occasionally in this organization. The Chief Engineer showed us plans for the Permanent Building Exposition in Moscow with a span of 200 ft. The roof is to be made of corrugated precast thin shells, with a structural depth of 8 ft. The sections are to be precast in length of about 15 ft. and are to be prestressed together after assembly on the job-site.

As another example, the Design Institute No. 1 located in Leningrad differs from the Moscow Design Organization in that it specializes in large civil engineering and industrial projects such as shipyard construction, hydroelectric plants, docks, hangars, repair shops, industrial plants and buildings. Only about 10 percent of the work is done for Leningrad, the rest is scattered all over Russia, and even in China, Czechoslovakia, Poland, Hungary, etc. This Institute at present employs 650 people.

Many of the projects of this Institute, owing to their very nature, have to be individually designed. However, whenever possible they standardize the projects. For example, they are working on standardization of precast shells for factory and other buildings. It was also reported that they were working on standard designs for prestressed concrete transmission towers.

One daring unusual design was shown to us — a stadium cover of 500 ft. x 820 ft. supported only on columns along the perimeter with no intermediate supports. This will be made up of precast units, joined and post-tensioned both along the edges and across the corners. It will have an average thickness of concrete of no more than 6.3 inches.

Both for drydock construction and for dams, they were introducing the use of precast prestressed panels for forms and for composite action. A typical panel size would be 66 ft. long x 13 ft. wide and 4 in. thick. It was felt that the use of such forms simplifies the construction, speeds up concreting, economizes the job, and increases the longevity of the structure. Great quantities of precast forms were used in the construction of the Kuybyshev Hydroelectric Station on the Volga River which has a capacity of 2,100,000 kw.

Figure 5 shows a precast post-tensioned truss for industrial buildings. The roof truss is made of five precast pieces and post-tensioned with three cables strung through preformed holes; two running the full length of the bottom chord, and the third raised up through the last tension diagonals.

It will be interesting to describe two types of precast prestressed concrete thin shells being developed and built in Leningrad. The first shell is 131 ft. square, supported on four corners only and made up of 135 precast elements, of 16 different types, each weighing about 3½ tons. The entire shell, weighing 560 tons, was assembled on falsework at ground level by welding, grouting, and prestressing. Then it was lifted 66 ft. to slightly above final position, by use of a temporary column at each corner of the square. Then the permanent columns, made up of precast circular hollow core units, each about two ft. sq. by three ft. high were erected in place with a crane and the shell lowered onto them.

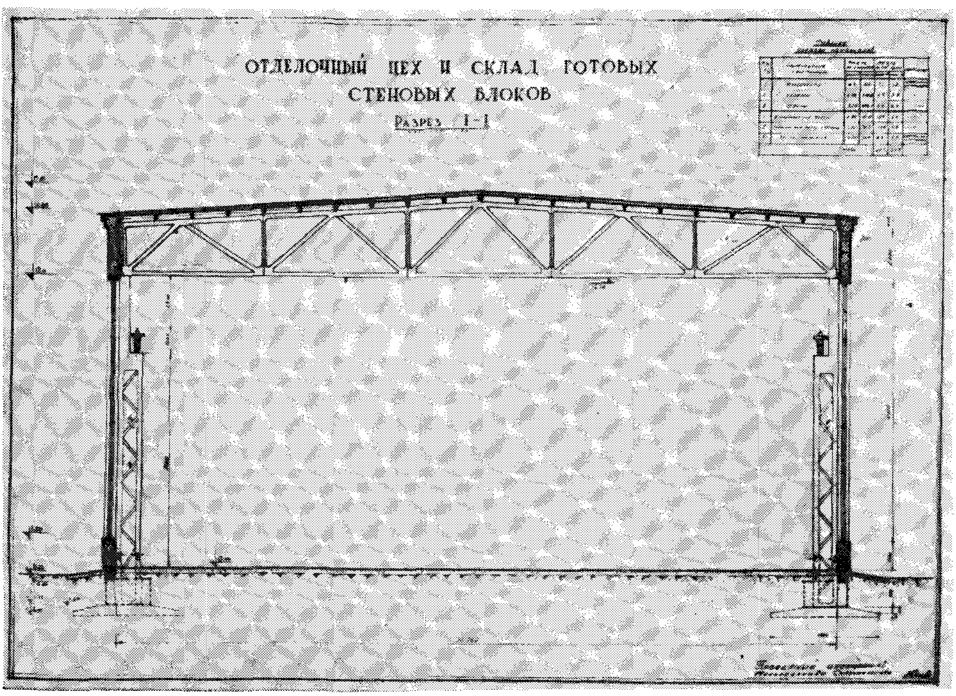
The shell itself was 4 in. thick with ribs 10 in. deep, (Figure 6). Each of the four edges of the shell was supported in a vertical plane by a shallow truss made of precast elements. Post-tensioning was applied to the trusses and to the four corners of the shell. To simplify erection, the trusses were assembled flat on the ground and then tilted up and connected to the shell on the ground-height falsework.

After tensioning the cables, initially, they waited two months to check the loss of prestress before performing the final tensioning and the grouting. No special means were taken to prevent corrosion during the two months. After the first shell was completed, but before raising, it was tested under superimposed loads. In lifting the shell, there was one jack with two rams operating at each corner. The first shell took 11 hours to lift — it was during a heavy storm. The second shell took only about half that time.

The lower chord of the trusses for the first shell was of rectangular section, with 15 tubular voids for the prestressing cables. There was difficulty in inserting the cables through the voids and in grouting them. For the second shell, a U-shaped section was adopted for the bottom chord. Cables were laid in the trough and post-tensioned; then the trough was filled with concrete. This represented a big improvement. The diagonal post-tensioning cables in the corners of the shell proper were inserted through ducts in both shells.

A second type of precast prestressed concrete shell has a 328 ft. span, see Figure 7. The entire building consists of eight arched barrel shells, each 25 ft. wide and separated from the next by a 8 ft. width of skylight. Thus an area of about 256 ft. x 328 ft. is covered without a single interior column. Each arched shell is fabricated at ground level, and lifted into final position.

Fig. 5. 100-ft. precast post-tensioned truss resting on pretensioned crane columns for a factory building.



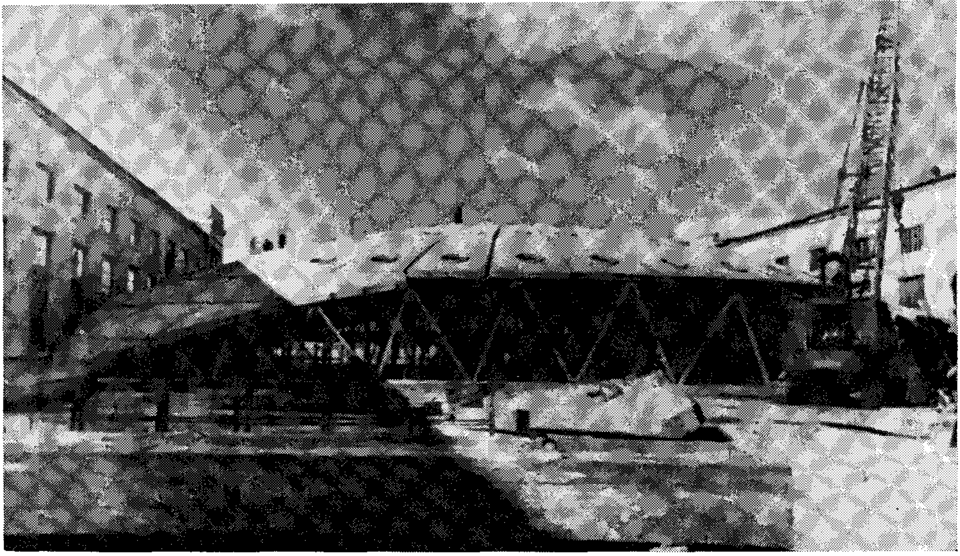


Fig. 6. Precast and post-tensioned thin shell being assembled and post-tensioned on the ground, to be lifted into position. Shell is 131 ft. square in plan and supported on four corner columns.

The arch has a rise of 35 ft. at the center and will be tied by means of a prestressed concrete lower chord which will also support 10-ton cranes. Each arch is made up of 13 precast elements about 30 ft. long and weighs 406 tons in total. It will have an average thickness of 6.3 in. with a minimum thickness of 2.4 in. The tie is a thin vertical web, with grooves on both sides, in which the prestressing cables will be placed and then concreted.

The shell units are precast in a casting yard, delivered and placed by a large gantry revolving crane, and joined by welding and grouting. The forms for these units are made of ferro-cement concrete panels, 3 cm thick, reinforced with mesh. These forms are quite flexible and are supported by light steel framing.

5. PRODUCTION

The production of precast and prestressed concrete elements in the Soviet factories possess certain important features which deserve attention. These are enumerated as follows:

1. Standardization of units
2. Specialization by each plant on a limited number of items
3. Mechanization for production of the standardized units
4. Large size of individual plants, permitting mechanization and resulting in economy
5. Long range scheduling of production, involving no problem of sales
6. Coordination of research, design, manufacture and construction

By combining these advantages, the Soviet precast and prestressed concrete industry has developed in certain areas — particularly in the production of floor slabs and walls for apartment buildings — so that its capacity, output, and perhaps economy are unequalled in other countries. On the other hand, from the point of view of efficiency and of quality, there still is much left to be desired. It is pointed out, for example, that with all the mechanization and standardization, the man-hour of labor per unit of concrete is just about the same as that in the United States plants where a variety of products are produced in relatively small quantities and mechanization is not nearly as complete. This is probably because not sufficient advantage has yet been taken of the new process of mechanization. It was partly explained by the lack of experienced workmanship.

The pretensioning process developed in the Soviet Union differs radically from that in Western countries. Whereas we prestress on a long-line process, the Russians employ the continuous process almost exclusively. In this continuous process, the wires are stretched

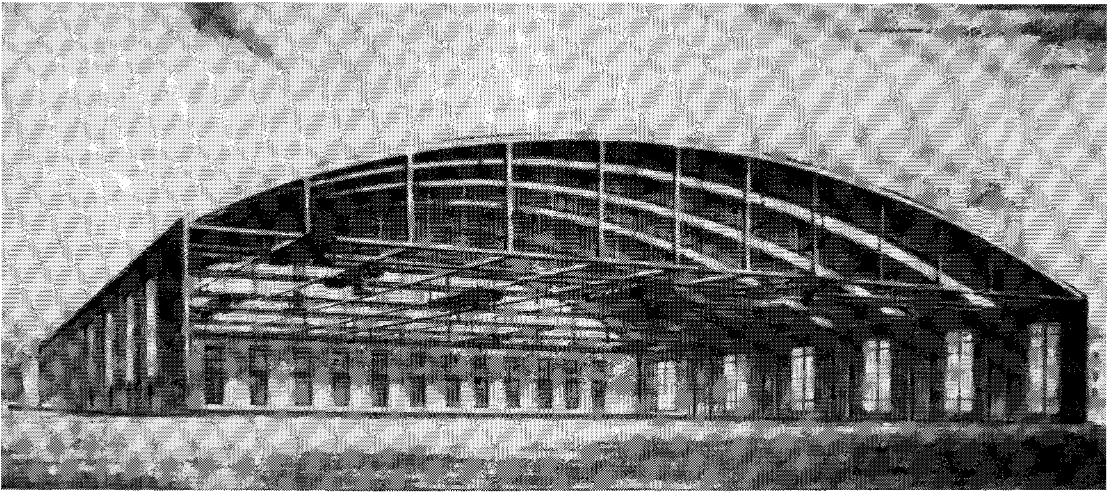


Fig. 7. Factory of 328-ft. clear span roofed by precast post-tensioned concrete thin shell, assembled on ground and lifted into position.

out, tensioned and bent around pegs held to the pretensioning frame. The process is somewhat similar to the Preload wire-winding procedure developed in the States, although much more advanced. It has the advantage that the wires can be laid out in any desired pattern.

The first experimental stressing machine in the Soviet Union was completed in 1945, and the production of these began in 1949. In 1957 about 35 machines were in operation. It is their plan that this number will increase to 120 by 1960.

There are two distinct types of stressing machines in the Soviet Union. The universal turntable was first developed. This winds and stresses the wires horizontally on itself as it turns. A later invention was the spinning machine, which spins and stresses the wires on a stationary table (Figure 8). There are several variations of this latter type, made by various government factories, apparently on a competitive basis.

The essential difference between our production of prestressed concrete and theirs could be summarized as follows: "They move their products to the process as in an automobile assembly shop, whereas we move the process to the product by our long line process."

After prestressing their wires on it, Figure 9, the frame is moved to the casting area where the concrete is poured and vibrated. Then the frame with the concrete is moved to the steam pit for curing. After about eight hours of curing up to 95 degrees Centigrade, the unit is stripped from the frame and moved to the storage yard.

A typical product is the cored floor slab, Figure 10. These slabs are 9 in. deep x 4 ft. wide x 16 to 22 ft. long. Some slabs have 6 holes of 6½ in. diameter. One production line would produce one slab every 15 minutes. Thus for a factory with four production lines, working in three eight-hour shifts, it is possible to produce 800,000 sq. meters of slabs per year.

The total production of prestressed concrete in the Soviet Union was given as 1,200,000 cu. meters in 1957; the amount of precast concrete products, with and without prestressing, was about 9,000,000 cu. meters, and the total amount of concrete work both precast and in-place, was about 25,000,000 cu. meters. It was their plan that by 1960, annual production of prestressed concrete products will amount to 7,000,000 cu. meters; precast products to 25,000,000 cu. meters, and total concrete work to 80,000,000 cu. meters. These figures indicated their emphasis on concrete in general, and precast and prestressed concrete in particular.

In the city of Moscow alone, there are a total of 25 precast factories in 1958, aggregating 2,000,000 cu. meters of products per year. We visited two of the largest ones. Factory No. 6, the biggest in Moscow, is scheduled to produce 170,000 cu. meters of concrete in 1958; and it is planned by 1965 that the capacity of this plant will go up to 300,000 cu. meters per

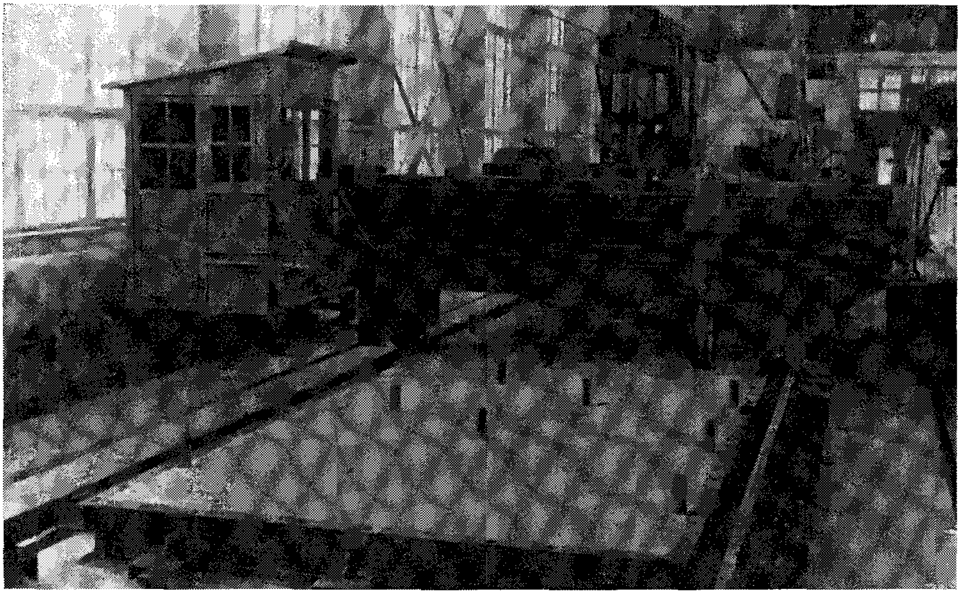
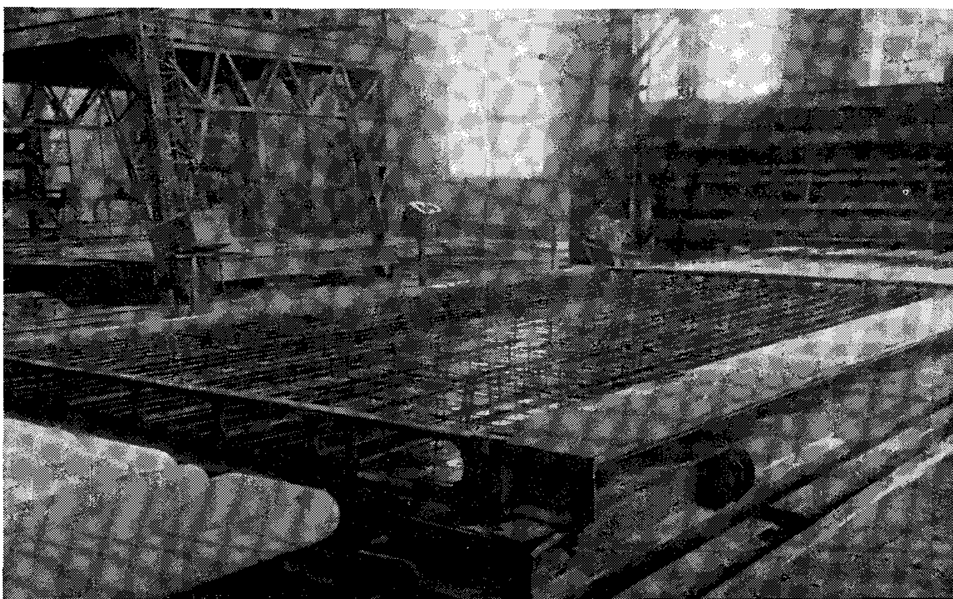


Fig. 8. Soviet stressing machine D.N.7. The swivel arm traverses in any regulated pattern. It tensions and loops the wires around the pegs set on the steel frame. This enables pretensioning in two directions.

year, essentially by improvement in production methods and efficiency, but without additional factory area. (Note that the above volumes included the voids in the cored-slabs, and the amount of solid concrete production is about 30% less than as given.)

As an example of Soviet conversion from precast into prestressed production, Factory No. 6 in Moscow had 44% of its products prestressed at the time of our visit. We were informed that by the end of 1958, prestressing will be applied to 100% of their products.

Fig. 9. Steel frame complete with pre-tensioned wire, reinforcing cage and steel side forms; note the steel cores at lower left corner are ready to be pushed into position to form the voids.



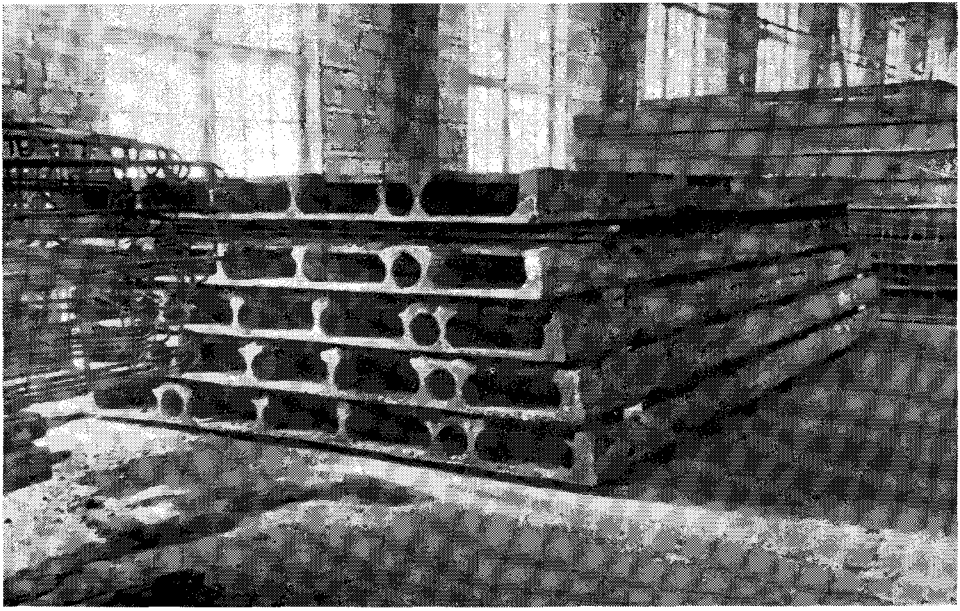


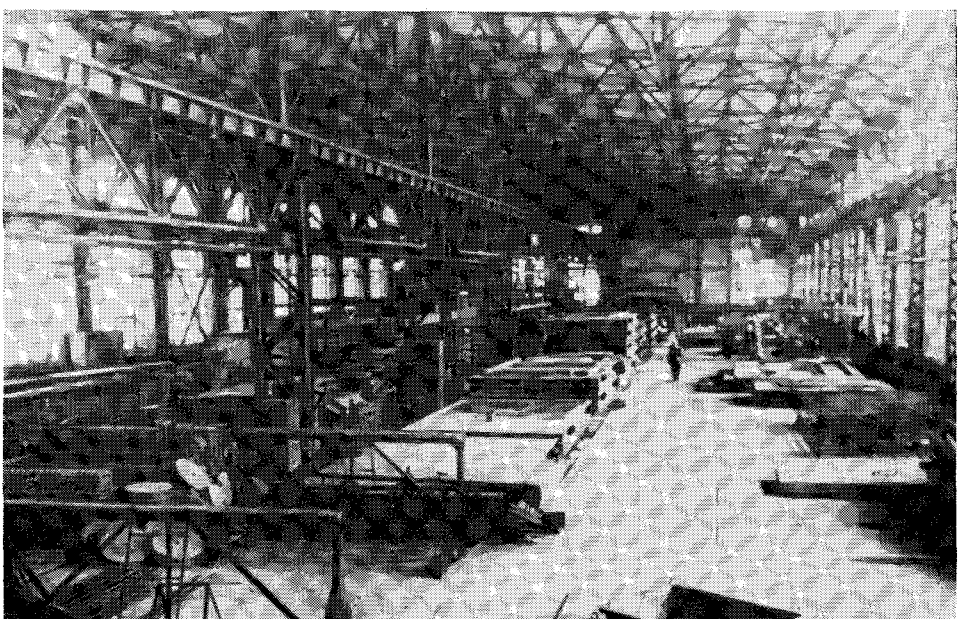
Fig. 10. Some typical prestressed cored slabs for apartment buildings.

Economy was given as the main reason for this conversion, since prestressing results in saving of material, labor, and overall cost. But it was also pointed out that lighter and better quality products were obtained as a result of prestressing. Furthermore, a saving of 30,000 tons of steel is effected per million cu. meters of products prestressed.

The amount of mechanization and the cost of the factory are justified by the big volume of production. For example, it is estimated that the initial cost of a typical Soviet factory producing 170,000 cu. meters per year would be about $5,000,000 in the United States, exclusive of land. Since the value of the products per year, translated to U. S. prices, would be approximately $12,000,000, it is evident that the high capital investment can be easily justified, if this amount of sale can be guaranteed.

Soviet production of prestressed concrete units for bridges is apparently far behind our attainments. This is partly explained by the fact that the total amount of bridges being

Fig. 11. The interior of a precasting prestressing factory.



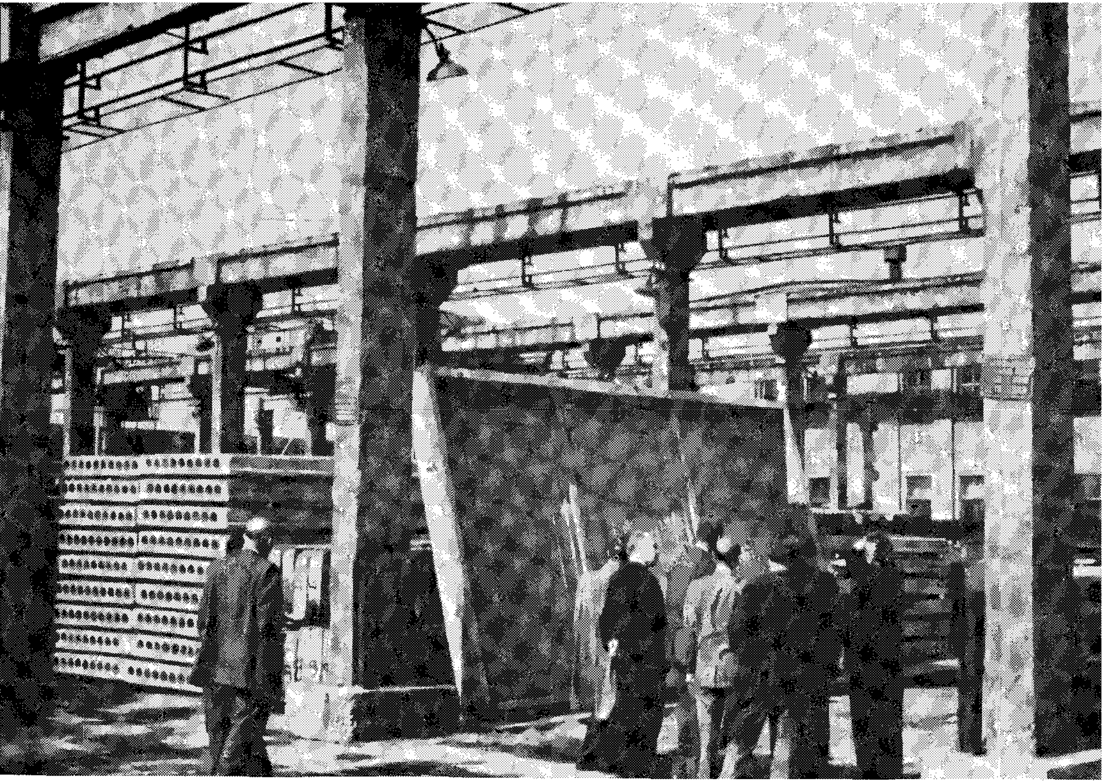
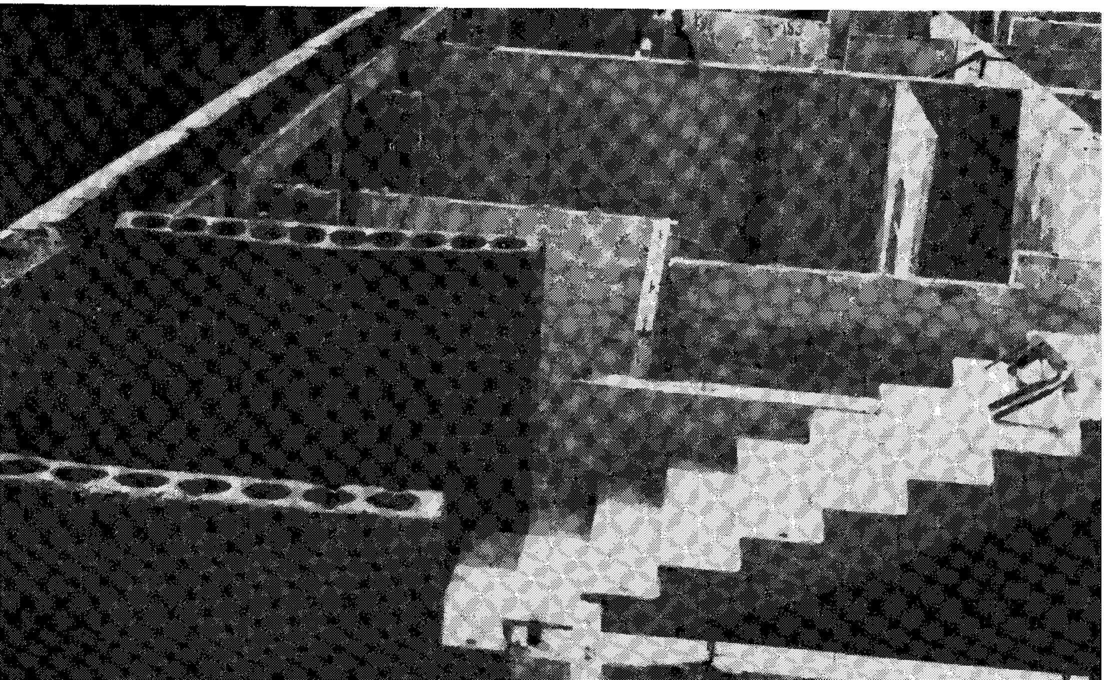


Fig. 12. Storage of cored prestressed slab at left; at center, a square slab panel pretensioned in two directions.

Fig. 13. The assembling of precast and prestressed elements for an apartment building.



built in the Soviet Union is nothing compared to what we are building under our highway construction program. Their emphasis is almost solely on apartment construction, which is their major use of precast prestressed elements at the present time.

To give an idea of the magnitude of their biggest plants, three precasting and prestressing factories visited by us are summarized and described in the following table:

	Factory Number		
	No. 6	No. 4	No. 5
1. Location	Moscow	Moscow	Leningrad
2. Principal type of product	Cored slabs	Cored slabs and channel slabs	Cored slabs
3. Other products	girders railway slabs large panels		
4. Present annual production capacity* m^3	170,000	125,000	80,000*
5. Projected annual production capacity* m^3	300,000 (1965)	—	192,000* (1959)
6. Present Prestress production %	44	40	70
7. Projected % of prestress projection	100 (1959)	100 (1959)	70 (1960)
8. Workers employed	500	400	500
9. Productivity $\frac{m^3}{m\text{-}hr}$	0.167	0.125	0.18 (projected for 1960)
10. Cost of plant	—	50,000,000 rubles	(we estimated at approx. $5,000,000 U.S. equivalent)
11. Cost of annual product	—	32,500,000 rubles	—

Plant is just being finished; operating at less than half projected capacity which is 192,000 cu. m in this plant. The figures quoted were solid volume which should be adjusted for void ratio of product.

6. CONSTRUCTION

Because of the program for decentralization of industry and for alleviation of urban congestion, there is very little industrial construction in Moscow and Leningrad areas. Such industrial construction as we saw was largely related to the housing program, particularly factories for precast prestressed concrete.

The 1958 construction program includes apartment buildings providing 2,300,000 sq. m (25,000,000 sq. ft.) of "living area" in Moscow and about 800,000 sq. m. in Leningrad. This is equivalent to 64,000 apartments in Moscow and 22,000 in Leningrad. The "living area" is calculated exclusive of kitchen, bathroom, hall, stairs and walls, so that to convert to U. S. equivalent building area about 30% must be added to "living area".

Also there are 40 schools to be built in Moscow each year, in addition to hospitals, office buildings, and dwellings. The entire Moscow program requires 2,000,000 cubic meters of precast and prestressed concrete per year. Since this value includes about 25 percent voids in the hollow concrete cores, it is equivalent to about 1,800,000 cubic yards of solid concrete. At the present, less than half of the precast concrete units are prestressed, but it is believed that more and more prestressed work will take the place of the conventional reinforced concrete. It is estimated that each square meter of living area requires about ½ cubic meter of precast concrete (including voids).

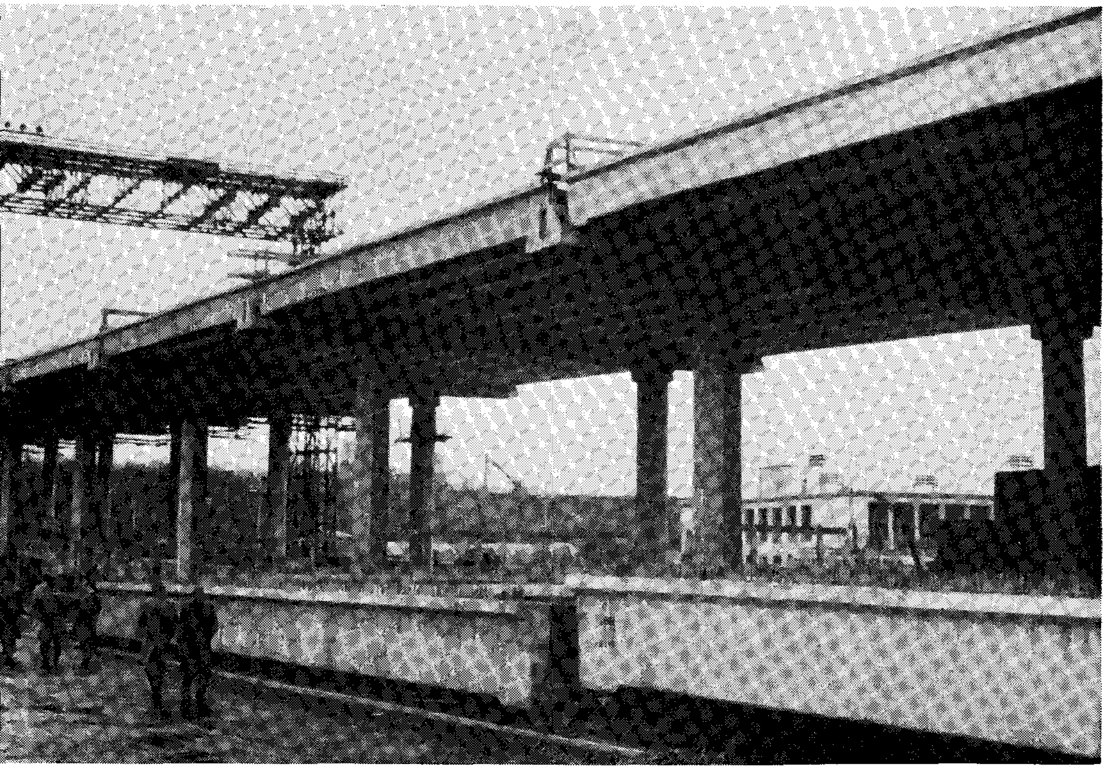


Fig. 14. Approach to the Moscow River Bridge, using precast post-tensioned girders of 72-ft. spans.

In Leningrad we visited a group of 8 apartment buildings, of 5-stories high, each building containing 60 to 80 apartments, thus providing a total of some 600 apartments in the group, with a total living space area of 20,000 sq. m. These buildings form a court, in the center of which is provided a large park area, including a kindergarten and a nursery building.

All the apartment buildings we saw were built using precast reinforced or prestressed concrete from the foundation footings to the roof, including walls, partitions and stairways. Ventilation ducts are provided by the hollow cores of slabs placed as a vertical partition. Radiators and heating wall panels are slabs with embedded steel pipes. Electrical ducts are formed with glass tubes of 1 to 1½ in. in diameter embedded in concrete, with no apparent chemical reaction between the glass and the concrete. Non-bearing partitions were made of slag concrete or gypsum, and gypsum suspended ceilings were used.

Attempts were being made to schedule erection so that the precast panels can be delivered from the factory to the site by truck, and lifted directly to the final position, thus avoiding the cost of stockpiling and rehandling the panels at the site. Tall tower cranes were usually utilized for erection, and in Leningrad we saw one tall gantry crane used for erection of an eight story apartment building.

In Leningrad a group of apartment buildings was constructed in four stages, so that one crew puts in utilities and foundations, a second erects panels and units, a third completes the structure, and a fourth does the finish work. Each crew moves on from building to building as they complete their phase. The above project took 19 months to build, with each building taking some 125 days from start to finish.

We visited the construction site of the Moscow River Bridge, a new combination automobile and subway (Metro) bridge across the Moscow River connecting the sports area of the city proper on one side of the river and Moscow University area on the other side with the main subway system. This structure will permit extension of the Metro to provide direct service to the University and the adjacent large residential area now being developed. This was the only bridge that we saw under construction in Moscow, but it was a spectacular structure, uniquely conceived, demanding first class engineering skill for its design and execution.

It is a two-level prestressed concrete bridge, with the upper deck carrying eight lanes of highway traffic, and the lower deck carrying two tracks (one in each direction) plus a Metro station directly over the Moscow River.

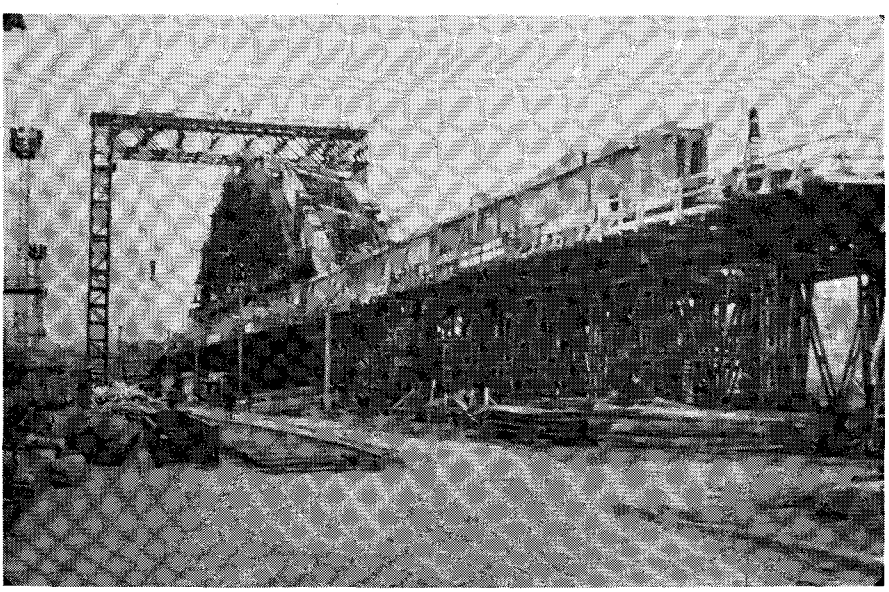
The length of the bridge proper is 4,000 ft. including the approaches. The main span is built on a 37 degree skew and consists of an arch 354 ft. long flanked by two smaller arches at 148 ft. span, thus making the main crossing 650 ft. The other spans are essentially 72 ft.

The arch spans have four ribs each and are being built along the shore in two halves — each half made up of two main carrying elements 650 ft., supported only at the intermediate piers, with a 148 ft. cantilever overhang at each end. During the floating operations temporary steel cables will tie the cantilever ends over the center span, thus making it possible to transport the assembly on two supports. The weight of each assembly is 5000 metric tons. This includes the structure of the lower deck, while the upper highway deck will be erected only after the assembly has been placed in final position.

The assembly on the bank would be moved sidewise on rollers out onto two timber piers. Four pontoon barges (two under each support) would float under the unit, pick it up and move it to position. The pontoons would be gradually lowered by flooding so that the unit would sit on its piers. At the time of our inspection, the first assembly was nearing completion on the bank — almost ready for the floating operations.

It was stated that this particular design was selected after a study of and analysis of 12 alternate designs, including designs in steel. We were later informed that this type of design was now being used to construct two other major bridges in Siberia. There is apparently an attempt to standardize or repeat novel designs once they are proved to be economical. The arch ribs, suspenders, and lower chords are all made up of precast elements joined by welding and grouting, with joints about one foot wide. The lower chords are post-tensioned.

Fig. 15. Main span of Moscow River Bridge with 354-ft. center opening and two flanking spans of 148-ft. Each assembly of 650 ft. and weighing 5000 tons is being erected on shore, to be floated into position.



The approach spans are also of precast prestressed concrete. The 72-ft. girders are of U-shape with end blocks and three diaphragms and weighed 37 tons apiece. They were approximately 4 ft. deep and 5 ft. wide. After they had been cast, they were post-tensioned with external cables in the factory and the cables were then encased in concrete. The bridge construction group has its own precasting factory, and these units were of much better quality than the building panels we saw in the previous precast factories. They appeared structurally strong, true to line and dimension, and free of honeycomb, although the surface finish was still poor.

The precast cap units were roughly "L" shaped in cross-section. Two of these with their legs facing each other formed the cap. Pouring the trough in-between full of concrete also provided the connection to the column. The columns were of precast reinforced concrete. When they got too long to be handled in one section, they were spliced, by welding embedded plates doweled with reinforcing bars into the column sections. All precast units were delivered to the bridge site by rail and truck, the larger units, of course, moving by truck.

For the erection of the precast units in the approach and in the arch ribs, giant gantry cranes were used. These have a capacity of 50 tons, and a span of perhaps 150 feet. They were of standardized steel elements, giant "erector sets," which could be assembled as required to build different towers and gantries. They belong to the bridge construction group and are used for many jobs. They spanned not only the bridge itself but about 60 ft. of delivery and storage area alongside. In the States, probably large crawler cranes would be more efficiently used.

On these girders, precast deck slabs were placed transversely and joined with deck pours that make the slabs act compositely with the girders. Sidewalk brackets are also precast prestressed, and stick out through slots in the sides of the girders. Precast sidewalk slabs were to be placed on these brackets.

7. CONCLUSION

The fast growth of prestressed concrete throughout the world is very much evidenced by the progress in the Soviet Union. Generally speaking, mass production techniques are being developed and applied most in Russia and the United States, while basic research and unique designs are pioneered in Western Europe. There is a great deal which one can learn from another. While it is not possible for any country to directly copy other's methods, many foreign ideas and approaches can help lead to fresh avenues of attack.

There is a common bond among engineers of all countries, perhaps even beyond the techniques of prestressing. Since engineers are all concerned with seeking and applying the laws of nature for the benefit of mankind, it is evident that exchange of technical information will lead to better understanding among peoples. It was with this in mind that the trip was made and this report was written.

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