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Artikel: Application of precast reinforced concrete and steel for long span highway bridges: economical considerations

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Application of Precast Reinforced Concrete and Steel for Long Span Highway Bridges. Economical Considerations.

Application du béton précontraint et de l'acier aux ponts routiers de grande portée. Considérations économiques.

Spannbeton- und Stahlanwendung für die Autobahnbrücken grösseren Spannweite. Wirtschaftliche Aspekte.

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Generally two materials - steel and prestressed precast reinforced concrete are used for long span highway bridges. Experience obtained in the USSR and other countries during construction and design of these bridges allows to determine an effective area of application for superstrustures of different forms using as the main index - the cost per sq.meter of deck area. This envisages that the index takes into account:

- unit cost of bridge construction work accounting requirements in temporary auxiliary assembly facilities;
- unit cost of main constructions of superstructures of different systems;
- unit cost of main construction of piers corresponding to the chosen system of superstructures.

Thus, the index takes into account all factors such as: cost of material and the fabrication of superstructure and piers and cost of bridge erection.

It is interesting to note that technological factors have considerable impact on final cost of the bridge.

This research indicates that depending on the chosen erection method the cost of auxiliary assembly structures and facilities (piers, falsework, trestles, pontoons, etc.) approximates from 70 to 20 per cent of the cost of superstructures. Consequently

the wrong choice of assembly method can lead to the cost of superstructures erection being equal to the cost of main construction.

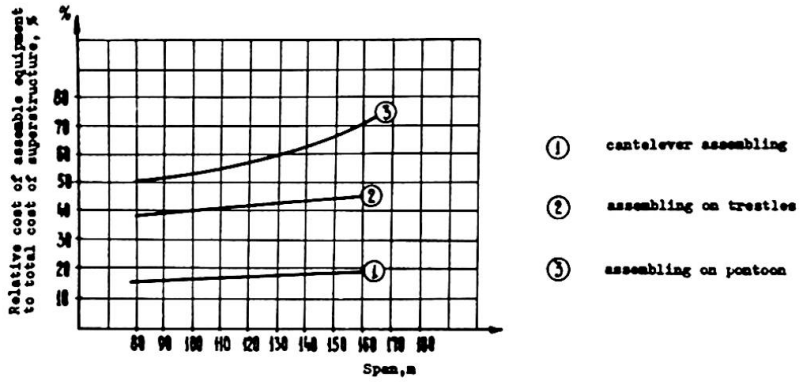


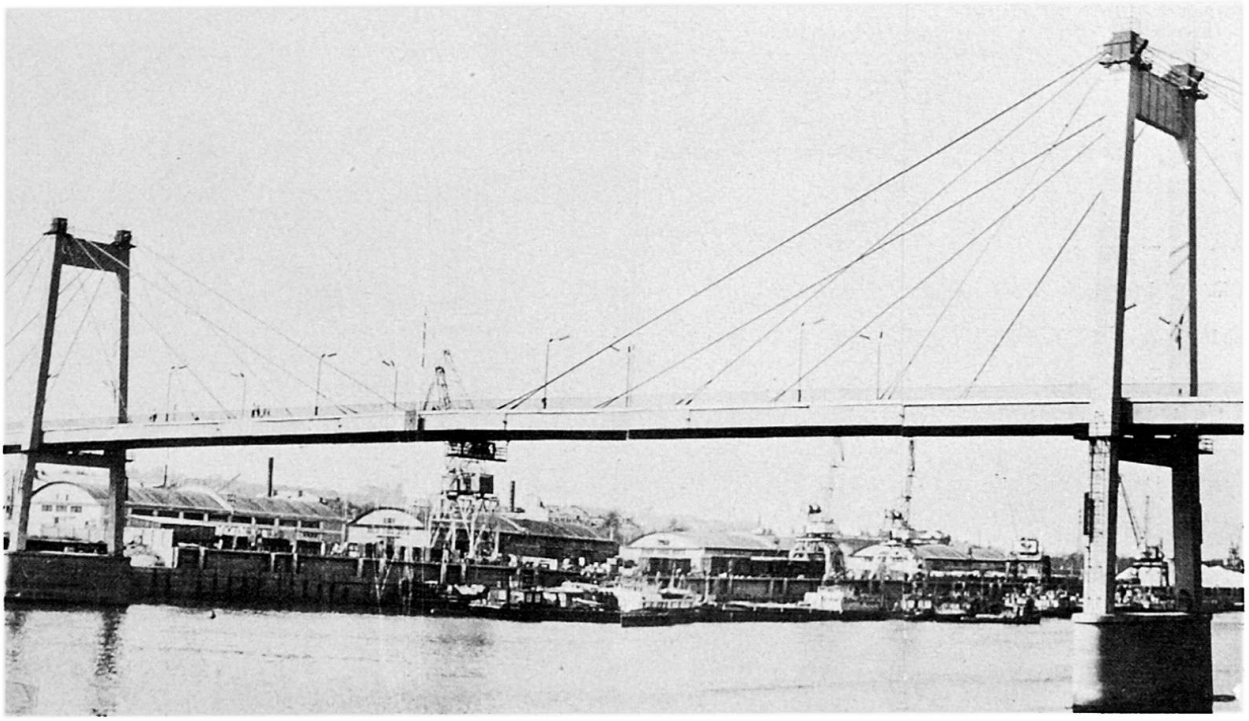
Fig. 1 Relation of assembly equipment and total cost to span of the bridge

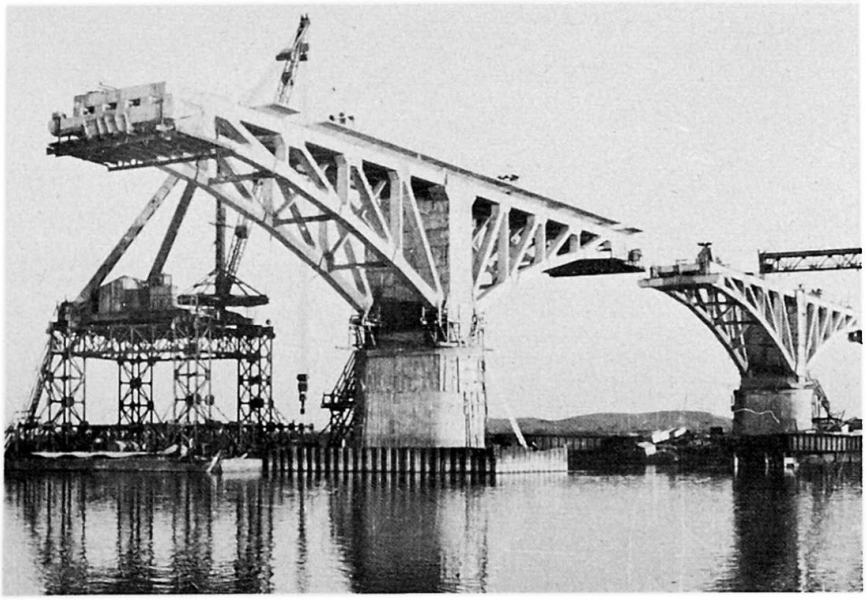
Figure 1 shows graphs of dependence of assembling facilities relative cost upon the cost of main constructions of superstructures of bridges with different spans. Most of the large bridges in the USSR are being erected this way due to the evident technological and economic advantages of cantilever assembly method.

The analysis of the main constructions cost included a review of the most promising superstructures:

I. Reinforced concrete bridges: continuous, rigid-frame cantilever, arch cantilever (Fig.2), arch, cable stayed (Fig.3), rigid-frame suspension (Fig.4).

II. Steel bridges: continuous girder, arch, cable stayed, suspension.





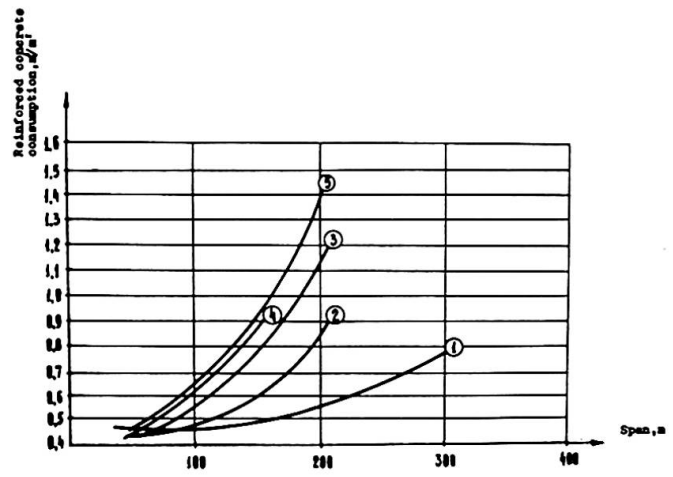


Fig. 5 Relation between reinforced concrete consumption and span of the bridge

The consumption of steel and reinforced concrete per 1 sq.m of superstructures of various systems is shown in Fig.5 and Fig.6. The curves are drawn in accordance with the minimal consumption reached in practice of designing and construction. Then the specific material consumption for the bridge piers of various systems (Fig.7) was analysed, because the account of material consumption only for superstructures without respect for the consumption of material on piers can lead to serious errors while evaluating the chosen structure. The proposed approach to the evaluation of the economic effectiveness of various bridge systems made of steel and reinforced concrete is not expressed by the comparison of the steel and reinforced concrete consumption as a whole,

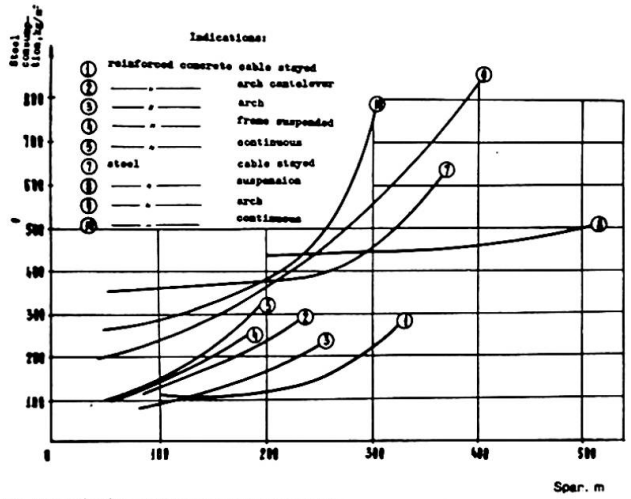


Fig. 6 Relation between steel consumption and span

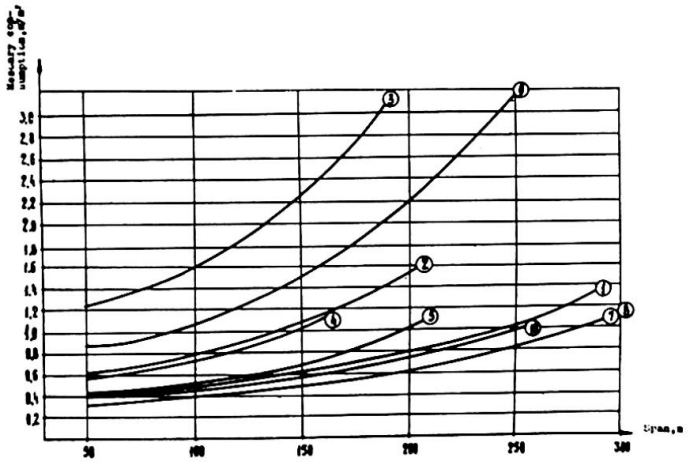


Fig. 7 Relation between masonry consumption and span

but is revealing the area of rational application of each system based on the comparison of certain specific consumption of materials for structural elements depending on spans and the real unit cost of these elements which takes into account the expenses both for manufacturing and erection of structures.

As a result of this analysis a graph was made for the unit cost per sq.m of various steel and reinforced concrete bridges. It includes the costs of construction of superstructures and piers and auxiliary assembly structures and facilities (Fig.8).

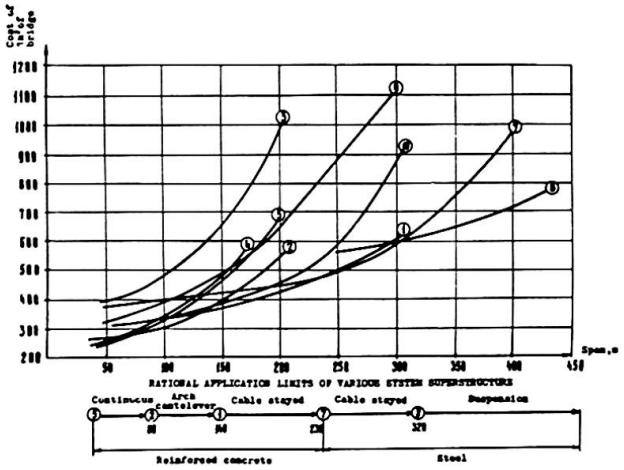


Fig. 8 Relation between cost of 1 m² the bridge and span

It's seen from the graph that at present, under the existing real prices one can speak about the rational application of reinforced concrete bridges of certain most effective systems with spans up to 230 m. These are the following:

- continuous superstructures with box girders erected by the cantilever method with spans from 50 to 100 m made of prestressed concrete;
- arch cantilever structures erected by the cantilever method with spans from 80 to 150 m made of prestressed concrete;
- cable stayed superstructures with the reinforced concrete rigid girder erected by the cantilever method with spans up to 140-150 m.

Then comes the area of the application of various steel bridges-cable stayed and suspension ones.

Naturally the local conditions of construction can considerably influence the definition of the rational application of the above systems. Thus, the availability of works located close to the surface or the construction of single-span bridges over deep canyons will require an additional study of the possibility to use thrust systems, since the volume of materials to be used for piers under these specific conditions is sharply reduced.

For example, when bridges are erected under conditions of city development where the construction of high access is not expedient, the structures of continuous girder or cable stayed bridges of small structural height are preferable.

The proposed method for the evaluation of the economic effectiveness of systems does not exclude real local conditions which are quite different from those mentioned in the present article, but on the contrary, it takes them into due consideration. For the overwhelming majority of bridge superstructure erected under the conditions of plain rivers with soft soils it is reasonable to continue persistent work at the modification and development of the most perspective reinforced concrete systems using them for spans up to 250 m.

SUMMARY The article presents method of choosing the area of rational application of bridges with reinforced concrete and steel span structures of various systems. It considers both the cost of main bridge structures (superstructures, piers, etc.) and the cost of assembly works, accounting necessary temporal structures (falseworks, pontoons, etc.). Cost index per sq.meter of deck area is used as effectiveness criterion.

RESUME L'article présente la méthode de la détermination d'application rationnelle des ponts en béton armé et en acier des systèmes différents. On y tient compte du coût des constructions principales du pont telles que la superstructure et les piles aussi bien que du coût des travaux de montage y compris les ouvrages proviscires (piles provisoires, coffrage, pontons, etc.) Comme le critère d'efficacité on utilise l'index du coût d'un mètre carré du tablier du pont.

ZUSAMMENFASSUNG Im Beitrag wird die Methode der Bestimmung der rationellen Anwendung der Brücken mit Stahlbeton-und Stahl-Spannweitenbauten der verschiedenen Systemen beschrieben. Dabei wurden sowohl die Kosten der führenden Brückenkonstruktionen (Brückenspannungen, Stützen) als auch die Kosten der Montagearbeiten unter Beachtung der notwendigen Behelfsbauten (Baugerüst, Brückenschiff u.a.) berücksichtigt. Als Kriterium der Effektivität wird hier die Wertkennziffer eines Quadratmeters der Brückenfläche benützt.