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Construction of Structures Set into Site by Displacement

Construction d'ouvrages d'art et mise en place par déplacement

Die Errichtung von Kunstbauten, die an ihren Standort versetzt werden

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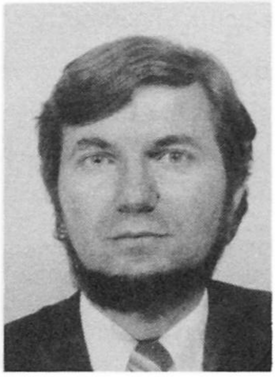

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SUMMARY

This article recalls the general principles of the four existing construction methods for structures that consist in prefabricating the structures next to their definitive site, and setting them into place by displacement. From recent examples of structures set in place by sideways shifting, by lift, launching and rotation, this article points out the advantages and limits of these various methods, exposing the last technical and technological innovations from which they have benefited.

RÉSUMÉ

Cet article rappelle les principes généraux des quatre procédés de construction d'ouvrages d'art consistant à préfabriquer la structure à côté de son emplacement définitif et à la mettre en place par déplacement. A partir d'exemples récents d'ouvrages mis en place par ripage transversal, par levage, par poussage et par rotation, l'article dégage les avantages et les limites de ces différents procédés en montrant les dernières innovations techniques et technologiques dont ils ont bénéficié.

ZUSAMMENFASSUNG

Der Beitrag behandelt die allgemeinen Grundlagen der vier Konstruktionsverfahren für Kunstbauwerke, die in der Nähe ihres endgültigen Standortes vorgefertigt und anschliessend versetzt werden. Anhand neuerer Beispiele von Bauwerken, die durch Querverschieben, Heben, Längseinschieben und Drehen versetzt werden, werden die Vorteile und die Grenzen der verschiedenen Einbaumethoden ebenso wie die letzten technologischen Entwicklungen aufgezeigt.

Among the various possible classifications of structures, we can observe two categories :

— on one hand, the structures constructed on their definitive site, among which we can find in particular, the bridges, cast on site, on scaffoldings or on launching girders, or on cantilevered bridges.

— on another hand, the structures prefabricated next to their definitive site, either entirely, or in big monolithic segments, then set in place by displacement.

In this second category, we can consider four main methods for the setting in place by displacement, that correspond to the four main movements of geometry :

— following the axis of the X : longitudinal translation movement : launching,
— following the axis of the Y : transversal translation movement : shifting,
— following the axis of the Z : vertical translation movement : lifting,
— following 0 : circular movement : rotation.

Generally the purposes are of three different kinds :

— impossibility or simply discomfort to get placed on site, or to work above the breach that is to be crossed over (river, railways, roads or highways with traffic on),

— simplifying of formwork or of the supports, the structure being on the ground,

— limitation in time of the disturbance due to the works.

Until now, these construction methods with prefabrication and setting into place by displacement, were almost exclusively used for small structures, and this for two reasons :

— the loads to be displaced being heavy ones, demand big pulling efforts,

— for important structures, the amortization of expensive specific materials can be more easily integrated in the building site budget.

Today, on one hand the looking for cheaper solutions, in order to satisfy the competition conditions, and on another hand the most recent technological perfected methods (in particular certain equipment and materials), as well as new ideas, have allowed us to extend these construction methods to much more important structures, in particular :

— the setting in place by launching of more than 1.100 m long bridges,
— the lifting up of more than 1.200 tons girders,
— the setting in place of a rigged beam with a bracket of more than 100 m which is the equivalent of a 200 m range span.

TRANSVERSAL SHIFTING

Its principle is very simple : it consists in prefabricating the structure next to its future site, and in shifting it crosswise, in order to place it in its definitive position.

The main characteristic of the shifting is that during the whole operation, the position of bearings in relation to the structure remains the same : there is no modification of the static scheme of the girder. On the opposite, during the shifting, the temporary bearings support the load corresponding to the total weight of the structure.

Four structures, constructed according to this technology are presented here :

— the first two, the Armançon bridge, for the T.G.V. railway line (SNCF) and the roofing of the Koweit National Assembly Palace, where the aim was the possibility of using again the arch supporting the formwork, in one same position.

— the two following ones, the reconstruction of the Azergues bridges for the A6 highway, and the bridge crossing over the S.N.C.F. railway lines for the deviation of the R.N. 504 in Rossillon (Ain), where the aim was the limitation of the occupation time for the definitive structure.

– The Armançon bridge on the Bourgogne canal for the Paris-Lyon T.G.V. railway line (S.C.N.F.) situated at 4 km of Saint Florentin (Yonne). Two parallel decks, 165 m long, with four spans of a varying height. The deck on the 2nd lane side is the first one to be achieved on an arch on the very place of the deck, on its 1st lane side ; then, after prestressing and centring, is shifted crosswise in its definitive position.

The second deck, corresponding to the lane N° 1 is then achieved in its site on the free arch.

– The roofings of the Koweit National Assembly are constituted of various hulls out of prestressed concrete, forming isostatic 35,00 m span girders, at a 20 m height. All these hulls are made in a same position, at the far end of the structure on a general fixed arch, then shifted transversely to their definitive position.

– the Azergues bridge for the A6 highway, north of Lyon. Each new deck has been constructed next to its definitive site, then shifted transversely in this position, after pulling down of the old one, which has permitted to reduce quite sensibly the interruption time of traffic on the structure.

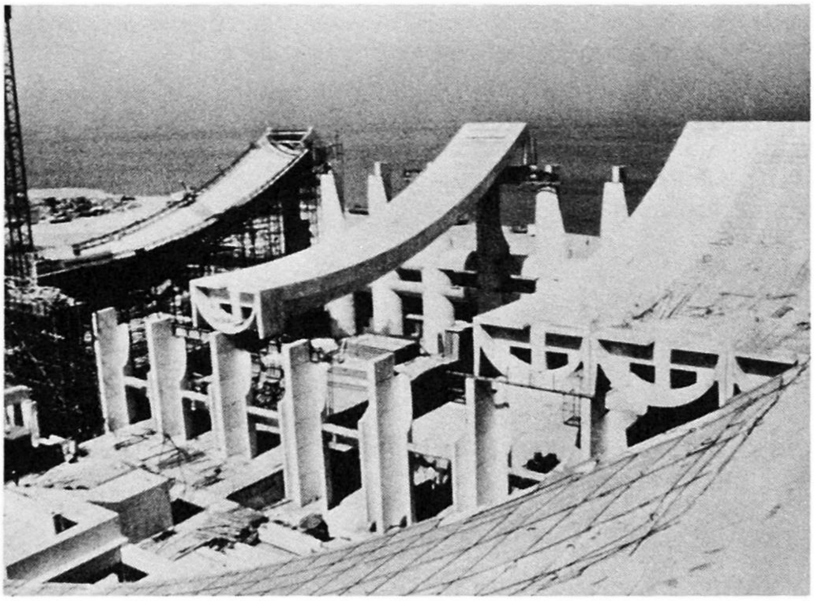

Figure 1

– the bridge over the S.N.C.F. railway lines, for the deviation of the R.N. 504 at Rossillon (Ain). Each beam is constructed on the edges, in order not to disturb the railway traffic, then is set in place by rotating shifting, around an axis located on the abutment, the central bearing sliding on a track.

INCREMENTAL LAUNCHING

The principle of this method which consists in prefabricating the structure in its prolongation axis, behind the abutment and to slid it forward progressively, following its longitudinal axis, is well-known. We shall only study here the last evolutions of this technique.

– geometrical constraints :

Till now, the bridges constructed by incremental launching were made up of either an upright deck, or a circular one in elevation or on an even plan, that is to say inscribed in a plan.

Geometrical studies have demontrated that a structure could be launched :

– following an helix the intrados surface is no more an even one but a regulated one,

– on a truncated cone, which permits to obtain a curvature at the same time on an even plan or in elevation.

– considerations on transversal segments :

Actually, the tendency is of abandoning little by little the ribbed slab segments, to the benefit of case segments that offer a greater strength to twisting, and behave better to the launching stresses.

In answer to the problem of continuous broadening of roadways, rather than 3 or 4 cell boxes, these being statically indeterminate, we cannot know in a precise way how the distribution of transversal stresses is operated between the different cells during the launching, we prefer to keep wide double-cell box girders (as done on the 18,40 m width Drac bridge in Grenoble), or to add transversal ribs or struts for widths that are superior to 20 m.

— Studies for the improving of launching noses :

Rather complete studies have been done on the launching nose/deck interaction and on the incidence of this launching nose upon the behaviour of the structure during the launching.

They have proved that there was an optimal length for the launching nose, that was almost equal to 0,65 times the span reach, as well as an optimal tightness for it, as the curvings on figure 2 prove it.

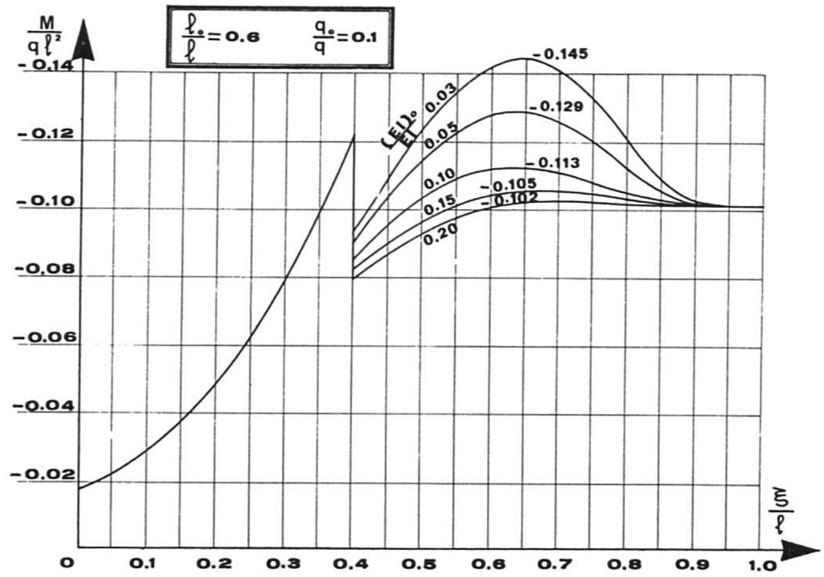

Figure 2

— Temporary prestressing during launching operations :

Another interesting investigation concerns the prestressing during launching operations. It consists in placing inside the deck, as it is being constructed, the definitive prestressing undulated cables and to add for the launching operation, a temporary inverse undulating prestressing that emerges from the structure in the upper part, in order to increase its efficacity as figure 3 proves it.

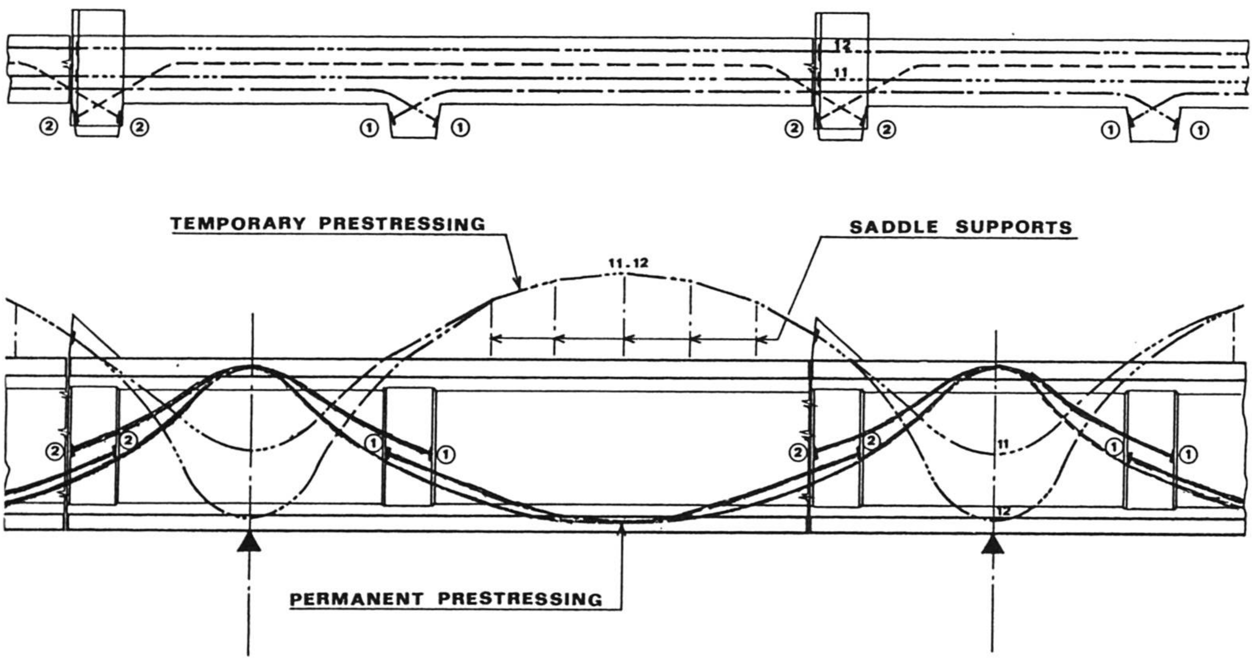

Figure 3

This temporary prestressing is removed, when the structure has reached its definitive position, by the end of launching operations.

This method has been used for the construction of Sathorn viaducts in Bangkok (Thaïlande) (figure 4), there the temporary prestressing has been dismounted and used again four times.

— Launching jacks :

Last interesting idea concerns the deck launching jacks. This method being different from the classical mechanism of "cable pulling", consists in pushing the deck, thanks to a jack that bears upon the longitudinal sliding beam, to which it is tightened (figure 5). The launching jack moves together with the deck as it is launched forwards.

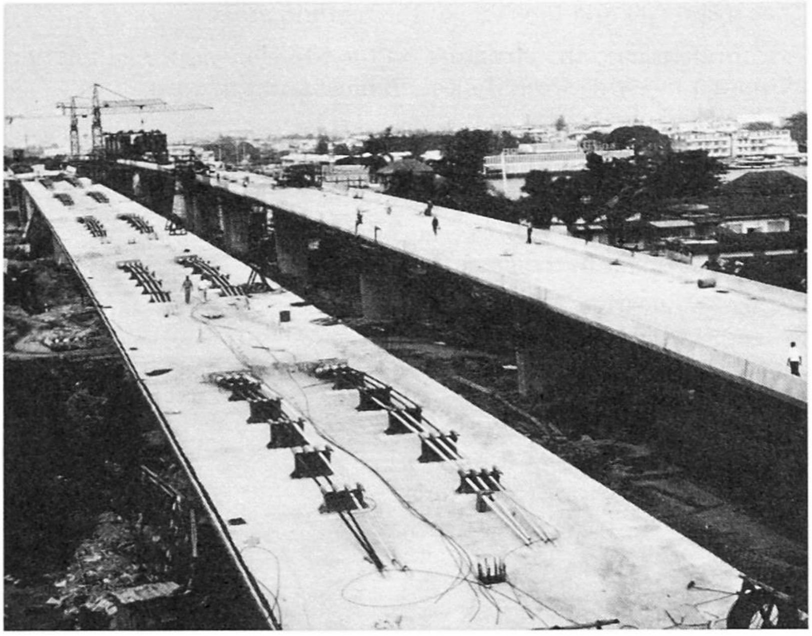

Figure 4

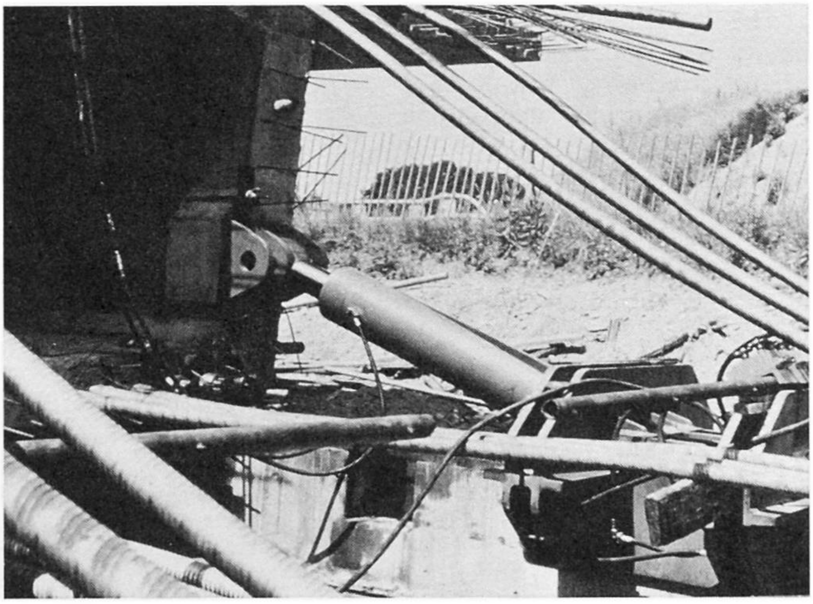

Figure 5

LIFTING

This interesting construction method is based upon a simple principle : it consists in prefabricating the structure on the ground, below its future site, and to lift it up to its definite position. The aim there is to avoid using big and expensive arches and bearings for formworks.

This method requires :

. to have below the structure, a convenient ground surface (as far as geometry and lift are concerned).

. to carry out the definitive bearings below the lifted structure.

. to possess an important lifting equipment, that bears upon the definitive foundations.

. that the structure should be isostatic, at least during the lifting operations.

An interesting application of this method is the construction of roofing hulls for the air terminal N° 2 at Charles de Gaulle Airport in Roissy en France. These light concrete hulls of 1.200 tons were prefabricated on the pavement slab of the air terminal, then lifted up with the help of four temporary metallic rack bearings, till their definitive position.

ROTATION

This last construction method using displacement, consists in prefabricating the structure on the edge of the breach to be crossed over, and concurrently to it, to set it into its place, by rotation around its main bearing, the latter used as a rotation bearing and as rotation axis.

The advantages and interests of the method are :

- to prefabricate the structure on the site where optimal safety conditions are present, and where it is more interesting from the economical point of view,
- the static scheme of the structure does not change, its bearings stay in the same position, contrary to the launching method,
- the important bearing on the ground corresponds to the definitive one, and the mobile one is just a stability bearing that exerts a feeble stress, which needs no temporary bearing with important foundation, as in the case of shifting,
- three interesting applications of this method are :

. Meylan footbridge over the Isère :
a three span structure with spans of 20,00 - 79,00 - 20,00 m, two rigged beams, out of light concrete, that have been prefabricated each one on one bank and set into place rotating around each pylon, and by central joint.

. The Illhoff footbridge in Strasbourg, a double-span structure. The rigged beam, out of light concrete is prefabricated on one bank, then set into place by rotation, around the vertical axis formed by the pylon.

. The Loir bridge in La Flèche, a three-span structure out of light concrete, with spans of 28 - 63 - 28 m length - each rigged beam constructed on a bank is set in place by rotation, on a precise bearing located on the pier, the longitudinal and transversal stability being assured by a rear prop.

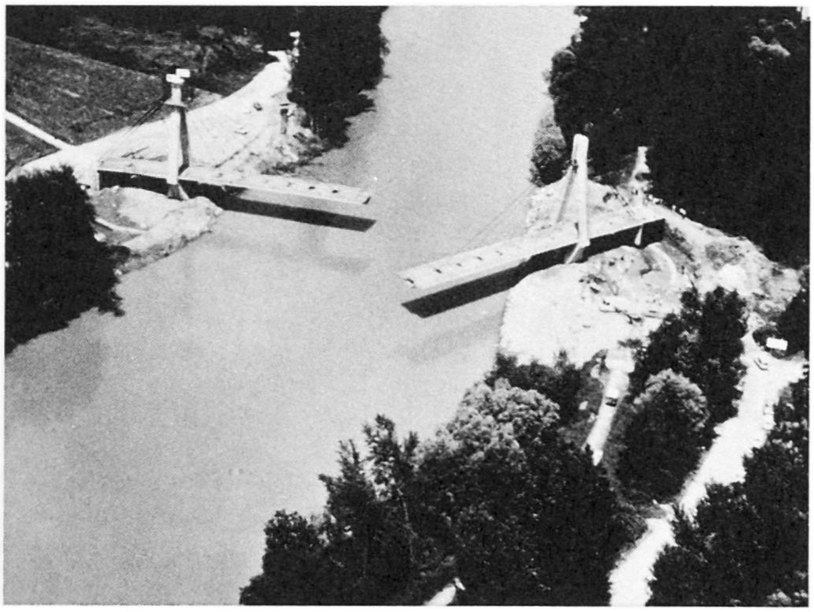

Figure 6

As a conclusion to these reflexions, we can assert that the construction methods that consist in prefabricating the structure next to its definitive site, and setting it into its site by shifting, permit to carry out works, sometimes important ones, under the most favourable conditions as far as work and safety conditions, as well as economical conditions are concerned. They permit to utilize very limited means as for the equipment. The research for new ideas, their adjustment to structures and sites should even permit to extend their applications.

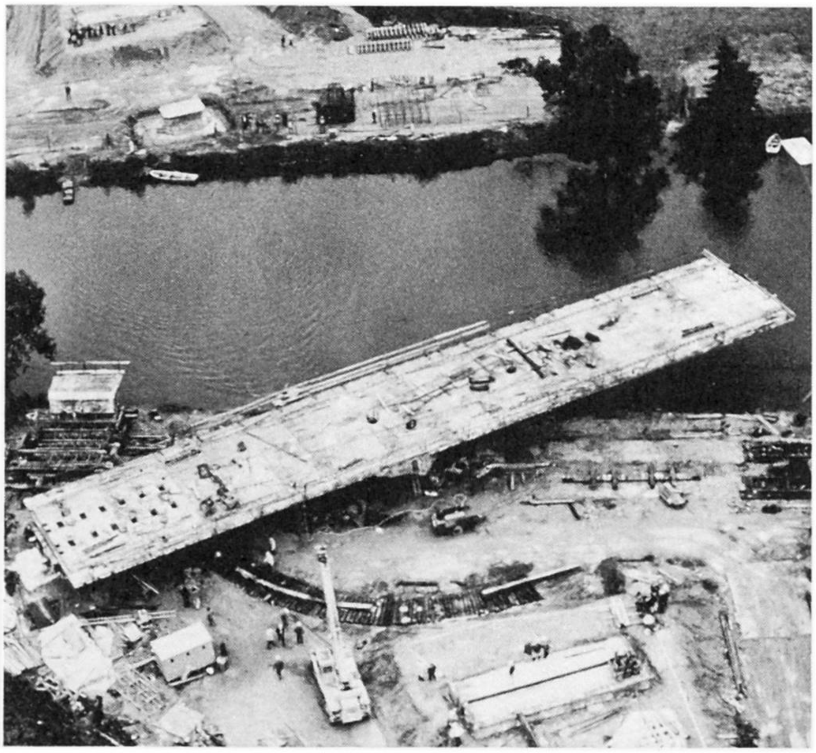

Figure 7