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THEME B

Posters

Baubehelfsbrücken für die Österreichischen Bundesbahnen

Temporary Bridges for the Austrian Railways

Ponts provisoires pour les Chemins de Fer Autrichiens

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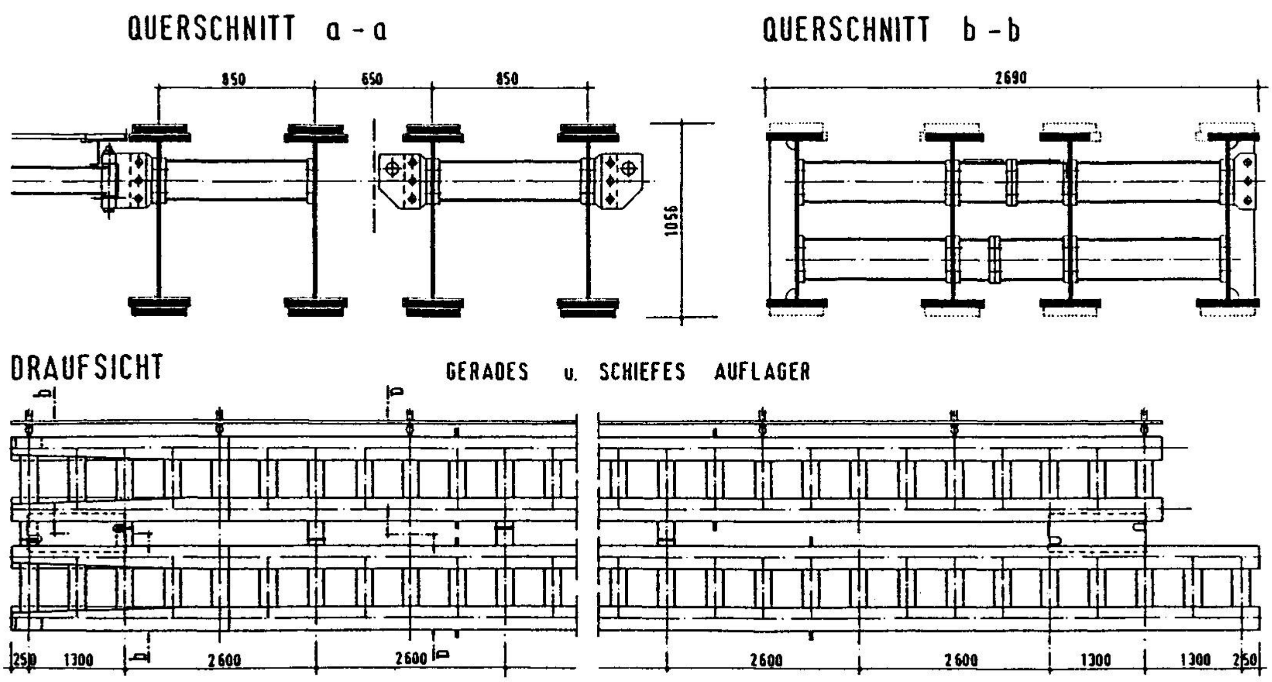
Die neue Serie von Baubehelfsbrücken (SFH) der Osterreichischen Bundesbahnen umfasst neun Tragwerkstypen mit Längen von 10,9 m bis 31,7 m, abgestuft von 2,6 m zu 2,6 m. Sie sind als Zwillingsträgerbrücken mit einheitlichen Quer- und Mittelträgern konzipiert. Brükkentragwerke mit normaler und schiefer Auflagerachse sind möglich. Bei Gleislage im Bogen lassen die kürzeren Brücken einen Gleisradius von R=250 m und die längeren einen von R=500 m zu. Die Geschwindigkeit mit der sie befahren werden können ist auf den Zusammenbauplänen der einzelnen Tragwerke abhängig von der vorhandenen Gleislage und der erforderlichen Brückenschiefe angegeben. Bedienungsstege mit Lichtgitterrosten auf ausschwenkbaren Konsolen und Anhebelaschen für den Einbau gehören zur Standardausrüstung.

Die Brückentragwerke sind für eine Belastung nach ONORM B 4003 so-



wie für einen Schwertransport gem. Lastbild DB 745 sowohl auf Tragsicherheit (Einhaltung der zul. Spannungen) als auch auf Gebrauchstauglichkeit (Begrenzung der Durchbiegung, der lotrechten und horizontalen Auflagerdrehwinkel sowie der Verwindung der Schienen) bemessen. Dabei wurde eine ausgeglichene, an den Grenzwerten liegende Ausnützung beider Bemessungskriterien angestrebt. Für die so bemessenen Brückentragwerke wurde die auf ihnen erlaubte Fahrgeschwindigkeit in Abhängigkeit von der Gleislage festgestellt.

Die Brücken wurden so niedrig wie möglich konstruiert; ihr Gewicht ist mit der Tragfähigkeit der Einbaukräne (70 t) begrenzt. Sie können als Ganzes oder in zwei Hälften eingehoben werden, die in den Mittelträgern zu stossen und zu verschrauben sind. Die nach einem Baukastensystem konstruierten Brückentragwerke bestehen aus nur wenigen Teilen, von denen jeweils nur die Längsträger der Brücken verschieden, alle übrigen Teile jedoch einheitlich sind. Für die Längsträger der kürzeren Brücken werden Arbed-Profile, für die der längeren Brücken geschweisste 2- bzw. 3-lamellige Querschnitte verwendet. Insgesamt gibt es für jede Brücke 19 verschiedene Teile, davon nur fünf für das Haupttragwerk.

Die Brücken sind Einfeldbrücken. Sie wirken für vertikale Lasten als torsionsweicher Trägerrost, der durch die vier Längsträger und die durchgehenden Querträger gebildet wird, und für horizontale Lasten als Rahmenträger. Die Steifigkeit des Rahmenträgers wird durch je eine Blechscheibe an den Enden der Längsträgerzwillinge verstärkt. Die horizontalen Bauwerkslasten werden an den Brückenenden über Rahmen, die durch die Längsträgerstege und eine entsprechende Anzahl von Querträgern gebildet werden, in die Brückenlager abgetragen. Die Trägerrostwirkung ist wegen der Torsionsweichheit der Längsträger erwiesenermassen gering. Bei den schiefen Brücken wird diese zudem durch Weglassen der auflagernahen Mittelträger soweit aufgehoben, als es die Rahmentragwirkung für die horizontale Lastabtragung zulässt. Die Brücken sind auf den Widerlagern frei drehbar und unverschieblich gelagert.

Sowohl für die geraden als auch für die schiefen Brücken gibt es eine Zusammenstellung der für den Entwurf der Fundierung erforderlichen Auflagerkräfte und für vier Fundierungsarten (Blockfundament, Fundamentbalken auf Klein- und Grosspfählen bzw. auf Brunnen) standardisierte Rechenanleitungen zur Bemessung der Fundierung.

Limska Draga Viaduct – Fabrication and Erection of Orthotropic Plates

Viaduc Limska Draga – Fabrication et montage de la dalle orthotrope

Limska-Draga-Talbrücke – Werkstattfertigung und Montage von orthotropen Platten

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1. INTRODUCTION AND DESCRIPTION OF THE VIADUCT

The preliminary design of the Limska Draga Viaduct was made in 9 solutions. The solution chosen was the steel structure with box cross-section (Fig.1). The choice was dictated by the topography and geology of the site as well as the current economic situation. The relation between the design, fabrication, erection and quality assurance is shown on the orthotropic plate.

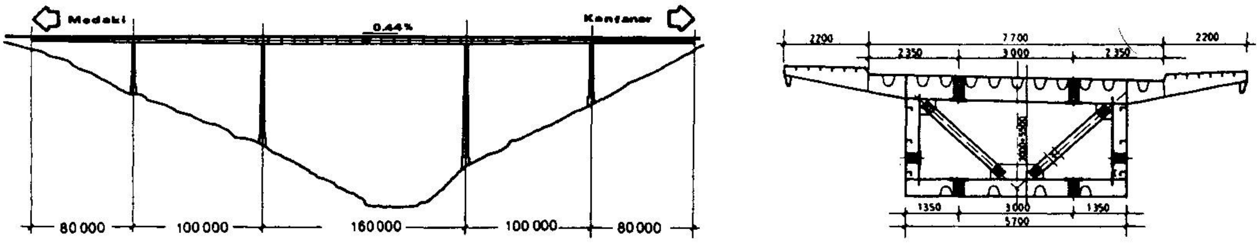


Fig.1 Longitudinal and cross-section

2. FABRICATION

The viaduct consists of 45 assemblies consisting of 8 parts each (Fig.2).

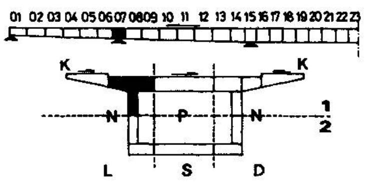


Fig.2 Assemblies

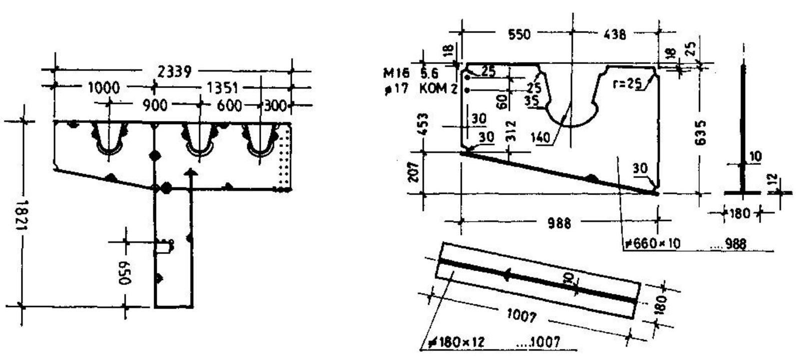


Fig.3 Computer made shop designs

Workshop designs were made by means of computer in three months and include over 2500 tons steel. The material was chosen in accordance with calculations and criteria against brittle fracture.

3. ERECTION

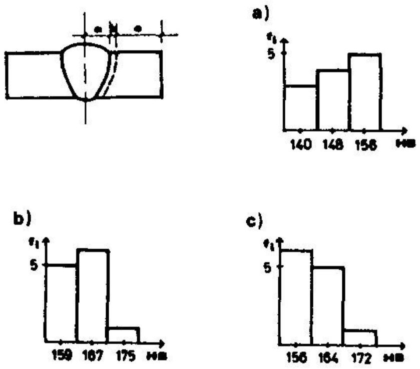
Erection of the assemblies was designed in a way to minimize residual stresses in the orthotropic plate welds. Temporary connection was done by conical bolts over the box ribs. This is done by means of a temporary device which carries the new assembly, which can thus be moved horizontally. The conical bolts along the upper chord were removed and the assembly was moved 3 mm. After welding the upper ortho plate, the same procedure is repeated for the lower ortho plate.

4. QUALITY ASSURANCE

Geometrical deviations are measured during fabrication and erection. Figs.4a and 4b show deviations of longitudinal stiffeners and transversal beams in the upper orthotropic plate for assembly No 38 during pre-erection.

Fig.4 Deviations of transversal beams and longitudinal stiffeners

Quality assurance was done in all stages of construction for welding in installation of high strength bolts, etc. Special attention was paid to non-destructive determination of mechanical properties of welded joints by measuring their hardness. Fig.5 and 6 present the results of hardness of shop and site welds.



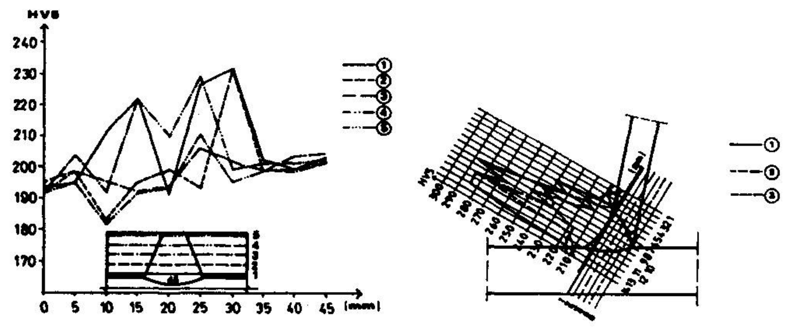


Fig.5 Shop weld

Fig.6 Site welds

The arrangement of hardness intensities are important for the assessment of the welds mechanical properties.

5. FATIGUE ASSESSMENT

Fatigue in an orthotropic plate is analyzed by estimation of traffic, by selecting details of higher fatigue strength and by assessing the location of longitudinal rib splice. Average daily passage of equivalent vehicles is n=1200.

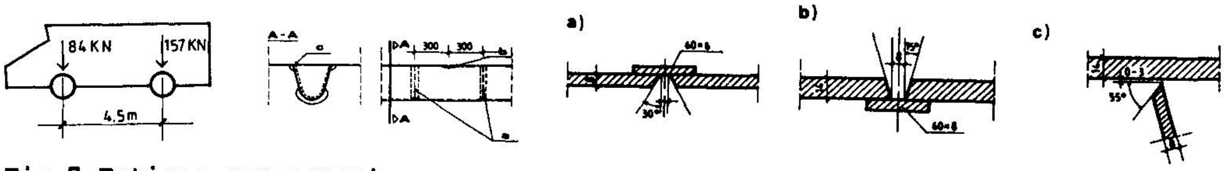


Fig.7 Fatigue assessment

6. CONCLUSION

Bearing in mind the interdependence of design, fabrication and erection of the presented orthotropic plate, together with adequate quality assurance, an effective interaction of design and construction technology has been achieved.

Connecting Short-Span Steel Girders for Continuity

Assemblage pour la continuité de poutres courtes en acier

Verbindungen zur Durchlaufwirkung kurzer Stahlträger

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1. INTRODUCTION

A continuous system of bridge girders has an obvious advantage over a simply supported system by resulting in smaller bending moments and smaller cross section of the girders. Other design advantages include the capability of redistributing the horizontal forces from traffic over a greater number of piers and a reduction in the number of expansion joints in the deck. Against those advantages the engineer must evaluate the benefit of the lower cost of the fabrication and erection of simply supported units.

The best attributes of both systems can be utilized by designing the girders as simply supported for carrying the self weight and concrete deck weight but as a continuous system under the traffic loads. Such design is gaining popularity in Australia due to the development of field connections which make use of the longitudinal deck reinforcement to carry tensile forces in the superstructure over the piers. The sequence of concreting the deck incorporating continuous connections and the concept of girder supports are shown in Fig. 1.

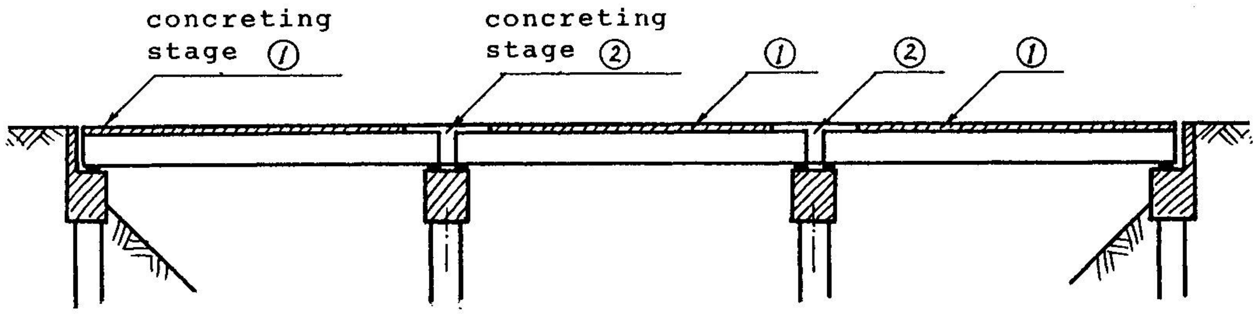

FIG. 1 Sequence of concreting the deck

2. END-PLATE CONNECTION

Laboratory tests on end-plate type connections were initiated in the Department of Main Roads of New South Wales in 1965 and a number of bridges with different variants of the connection were built since then. The connection was found to be structurally adequate but problems were experienced with the design of the end plates of sufficiently small size for a simple fabrication and easy transport. For the above reason the design of a continuous system for the live load only was found to be preferable to the design for the dead load and live load. Also, it was found necessary to provide some form of tensile connection at the bottom of the joint to accommodate stresses caused by the vibration of the deck and the expansion and contraction due to temperature variation. Fig. 2 shows the concept of this type of the connection.

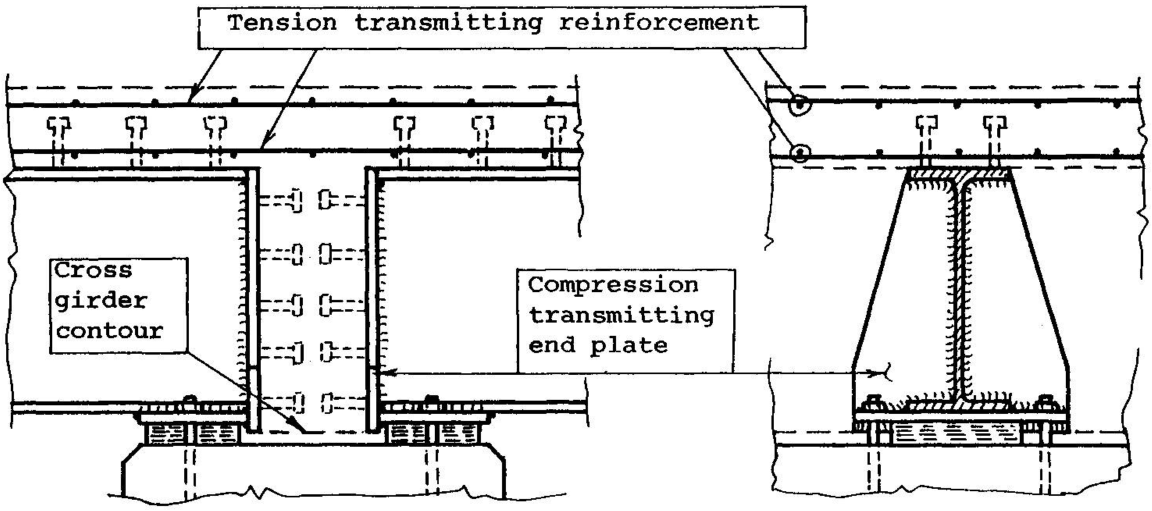

FIG.2 End-plate type connection for continuity under Live Load. (Cross girder reinforcement is not shown for clarity.)

3. CONNECTION WITH WELDED BOTTOM FLANGE

The portability of welding equipment, which became much smaller in the last decade, allowed construction of simple field joints in small bridges at a lower cost. Fig. 3 shows a variant a continuous connection where the bearing plate was utilized for the transmission of compressive forces in the girder. A welded joint of the bottom flange results in a positive connection of the girder. However, apart from the problem of bringing the welding equipment on the bridge during construction, some measures must be taken to protect the bearings from the temperature developed during welding. In spite of the problems mentioned, the type of the connection shown allows a more economic design than the traditional bolted connection which is usually located at the point of contraflexure of the girders. The location of the connection over the piers enables a more expedient construction of the bridge superstructure.

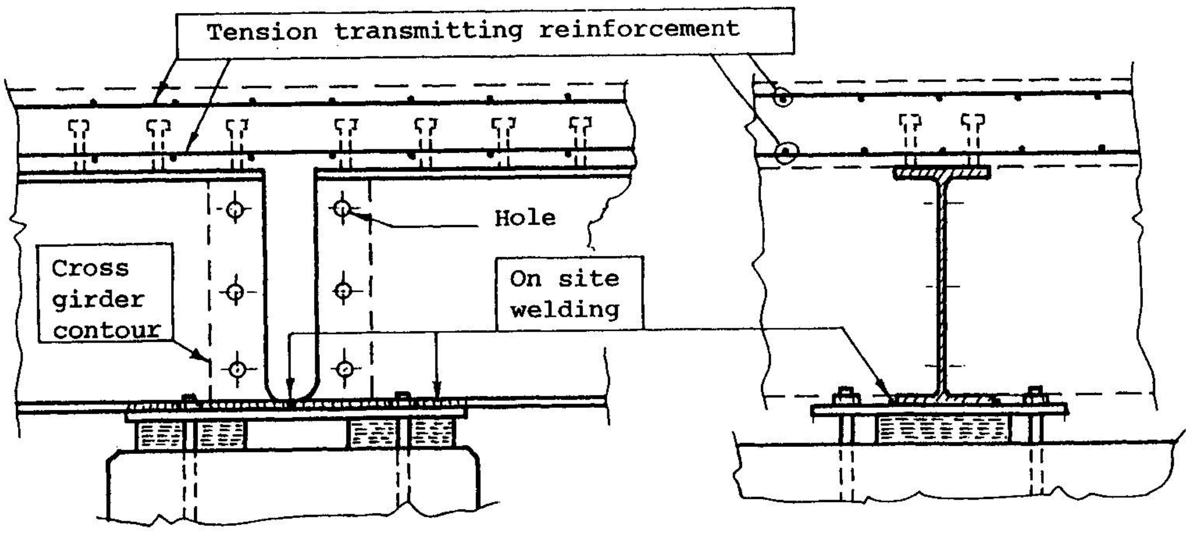

FIG. 3 Welded bottom flange connection for continuity

Constructional Problems in Bridges with Box-Girders

Problèmes constructifs des ponts à poutre-caisson

Konstruktive Probleme bei Kastenträgerbrücken

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The construction of viaducts in a densely populated area of the neapolitan suburbs has given rise to some erection and assembly problems that influenced someway the calculation of the deck structures. These problems have been further emphasized by the cross sectional shape not so usual, as a matter of fact, for composite steel-concrete box girder bridges (fig.1).

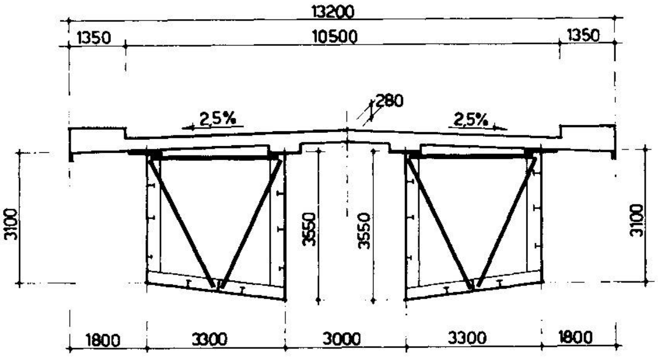

fig.1

The adoption of such a kind of shape has been motivated by aesthetical factors, i.e. the necessity of reducing the visual impact of the bridge in the area. In the sequel it will reported what has been done for the longer spans, whose lenght is equal to 61,10 m. The statical scheme of the bridge is that of a simply supported beam.

The limitated extension of the site and an economic evaluation have led to exclude a sequential erection of individual elements forming the truss, that would have required a greater number of lifting points for the girder and expensive temporary steel truss support. Moreover, the complete assembly of the girders in place and their successive lifting would have required the use of a crane truck of large dimensions, certainaly not compatible with the limited extension of the site and the hardly accessible shape of the area.

Therefore it was decided to completely separate the box girder along the longitudinal axis and to assembly the two resulting parts, after the erection, by means of a joint placed at the internal side of the bottom flange of the box. In this way the total load to be lifted was reduced to a half (500 KN) and it was possible to use crane trucks having dimensions compatible with the extension of the site.

The two parts resulting from the longitudinal cut of the girder were consistently asymmetrical and different from each other (fig.2).

This determined not only different vertical deflections but also displacements in the horizontal plane. In order to reduce their values during this temporary stage the end restraints of the beam, placed under two steel transverse diaphragms, have been completely constrained. Operating in this way the rotation of the terminal cross section were completely eliminated and the statical scheme of fixed ends beam was adopted for calculations. The deflections of the two parts in which the box girder was divided were computed by means of a finite element code. The structure was modelled as follows:

- the longitudinally placed stiffening elements of box and the plates placed at their top have been simulated by means of "beam" elements;
- the diagonal bracings of the transverse diaphragms have been simulated by mean of "truss" elements;
- the webs, the bottom flanges of the boxes and the transversal stiffening ribs have been simulated by means of "shell" elements.

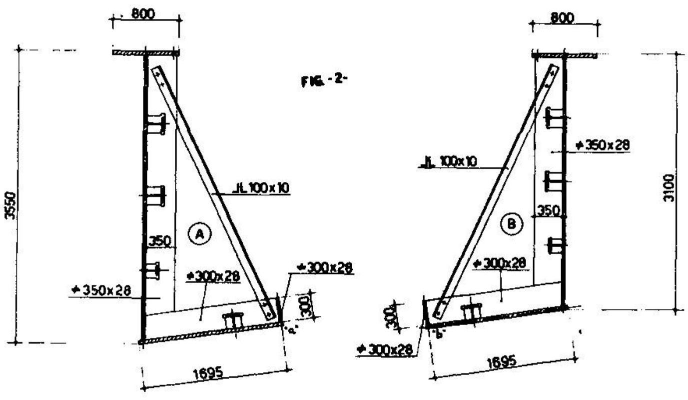

fig.2

The adopted schematization was motivated by the fact that only dead load acts on the structure. The "sub-horizontal" shape of the box bottom flange due to the different heights of the webs required the use of fictitious "bound" restraints without axial rigidity and very high torsional rigidity. In the midspan section the vertical (v) and horizontal (w) displacements of "a" and "b" points turned out to be, respectively:

- side A - v = 12,7 mm w = 13,6 mm
- side B - v = 15,8 mm w = 15,3 mm

In order to achieve the coincidence of the vertical displacements, that turned out to be greater for the part of the box having smaller height (B), a 800 mm - diameter water-pipe was placed as additional load on the outer side of the other part of the box, i.e. that one having greater height (A) (fig.3). The progressive filling-up of the pipe allowed then to obtain on easily controlled vertical displacement up to the exact coincidence with the one of the other part of the box. Fastening the bolts of the longitudinal joint and assembling the horizontal bracing placed in the deek's plane gave to the cross section its final form and increases the torsional stiffness up to the stiffness of a closed section. It is remarked that the fastening tension in each bolt necessary to eliminate the relative horizontal displacements, was less than 3 KN.

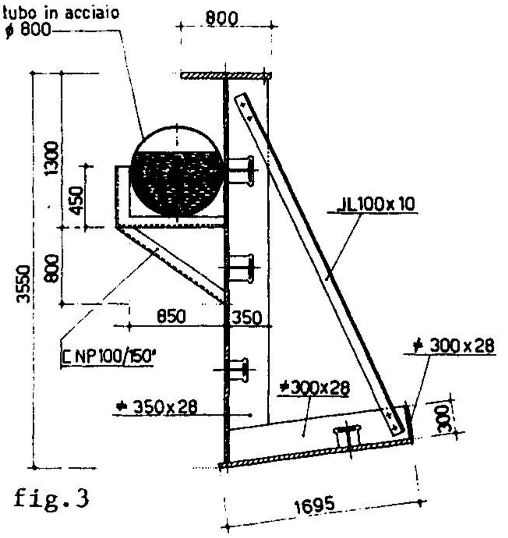

fig.3

Steel and Reinforced Concrete Railway Structures

Structures en acier et en béton armé pour les ponts de chemin de fer

Eisenbahn-Brückenüberbauten aus Stahl und Stahlbeton

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For high-speed construction of railway bridges metal box and two-block steel reinforcement concrete superstructures of high plant manufacture readiness with 23.0 to 45.0 m spans ballast-run, designed for installation on streight and curved (R $\geqslant$ 300) road sections under the conventional and northern climatic conditions, as well as in seismic regions, have been developed.
The superstructures were designed for a single track, that allowed their installation on the multitrack bridges having a common ballast tank. The ballast tank has the width of 4.6 m and is envisaged for the track operations on bridges including cleaning of broken stones with the help of tracking machines.
The structure material - low-alloy steel of grades C35 and C40, concrete of glass B35. For all mounting connections high strength bolts are used.
For maintenance of superstructures, passagess along the lower boom and hatches in the box girder bearing sections have been envisaged.
For the structure Specifications refer to the table.

N	Name	Metal box superstructure, m				Two-block steel reinforcement concrete superstructure, m			
		23,0	27,0	33,6	45,0	23,0	27,0	33,6	45,0
1	Construction height,H,m	2,1	2,6	3,1	3,7	2,2	2,4	2,8	3,5
2	Mass of metal,t	52,0	65,0	87,0	134,0	40,0	50,0	75,0	124,0
3	Volume of concrete,m^3	-	-	-	-	27,0	32,0	38,0	52,0

Table

The superstructure arrangement wholly corresponds to the high-speed mounting without intermediate supports by the jib (type ГЭК-80 and ГЭПК-130) and boom cranes.
Metal superstructure (Fig.1,a) consists of the fully prefabricated erection blocks: main box-section hermetical girder; cantilever elements of the ballast tank, separated according to the transportation conditions from the main girder along the boarding with a longitudinal joint; side-walk blocks and inspection runways.
The roadway has a double-deck construction. Boarding of the ballast tank is made of the double-layer corrosion-resistant steel ensuring an overhaul-free period equal to the service life of the entire superstructure.
The two-block steel reinforced concrete superstructures (Fig.1,b) consist of two steel reinforced concrete fully prefabricated blocks joined in erection with cross linkage,as well as of the precast reinforced concrete side-walk rim. Each block consists of a steel box main girder and engaged into operation of the cast in-situ concrete ballast tank plate having hydraulic insulation and protective layer.

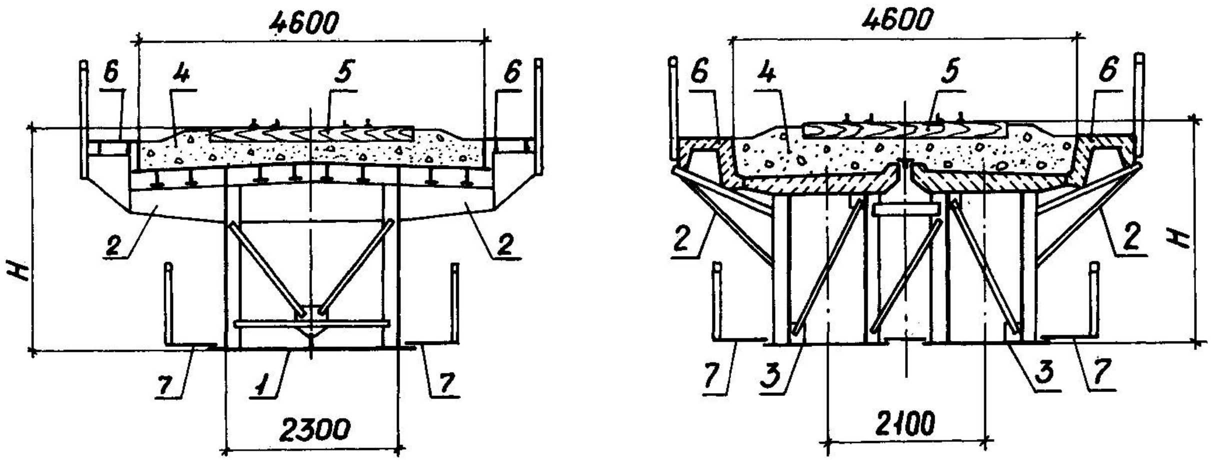

Fig. 1 Cross section of railway superstructures:
a - of the metal box one having the ballast tank of double-layer corrosion-resistant steel; b - of the two-block steel reinforced concrete;
1 - box girder; 2 - cantilever part; 3 - steel reinforced concrete block;
4 - ballast; 5 - upper road structure; 6 - side-walks; 7 - inspection runway.
H - construction height.

Combined Frame-Strut Earthquake Resistant Bridge

Pont mixte triangulé résistant aux séismes

Erdbebensichere Rahmen-Sprengwerk-Brücke

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I. INTRODUCTION

One of the most complicated problems of the transport construction is erection of viaducts across deep mountain canyons and workings.
The considered design-technological solution under the conditions of hard accessibility regions was directed toward reduction of terms required for erection of the above transport structures, and ensures their high reliability in the cours of operation.
The bridge superstructure features:
- a through system of cross-bar and bearing struts allowing passage of railway and motor transport at various levels, excluding in this case erection of high piers;
- engagement of the automatic passage orthothropic plate in a combined operation with elements of main girders;
- method of "downward" strut erection with closing the cross-bar in the middle of the central span.

2. BRIDGE ACROSS THE RAZDAN RIVER (ARMENIA)

Built in 1981, the bridge incorporates a frame-strut steel superstructure and reinforced concrete scaffold parts.
The crossed 250 m wide and 110 m deep canyon featuring steep vertical slopes.
The area seismisity is of 9 number force.
The welded superstructure (Fig.1) uses high strength bolts for erection joints.
The structure material - steels IOXCHD, 12 ХГУАФ of grade C-40, 15 XCHD (C-35), 16D (C-23). The total mass of metal is 3276 t.
The factory made metal structures were manufactured with the use of standard equipment and attachments for standard railway superstructures.
The developed erection method is universal for any climatic conditions.

The bridge rational parameters, the cross-bar strut lattice superstructure, application of plastic material, stability against brittle destruction, despite existing considerable overloads and oscillations made it possible to reliably ensure intactness and stability of the structure.
The design-technological solutions were applied in designing and erection of a number of objects in the USSR and abroad, on the combined bridge across the Red river in Hanoi (Vietnam).

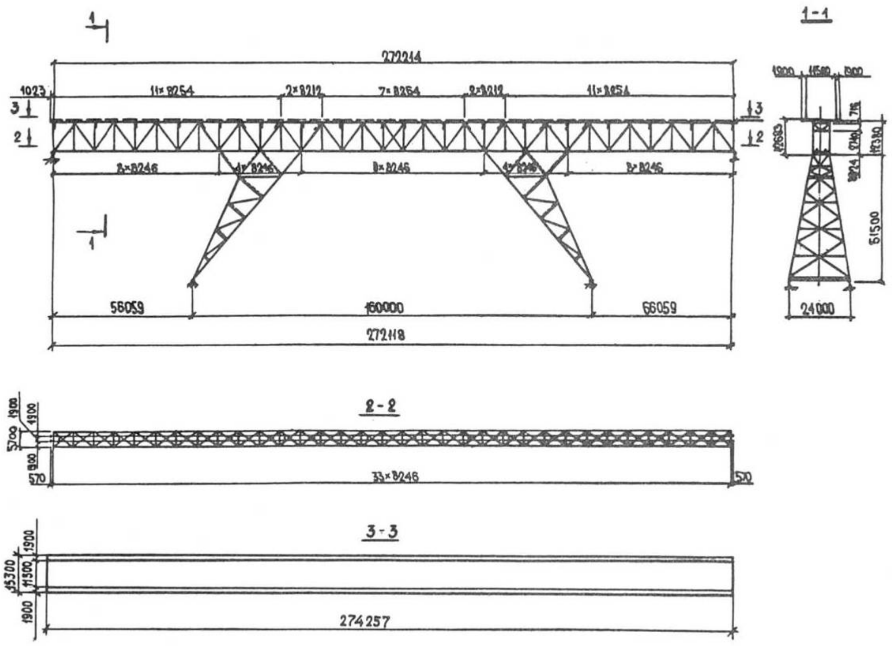

Fig. 1 Diagram of superstructure

The bends, measured in the course of tests, made 80% relative to the design ratings, and the axial stresses in the main girder elements - 70-85%. The bridge was normally operated within 10 years, and during the disastrous earthquake of 1988 the superstructure (Fig.2) suffered no damage.

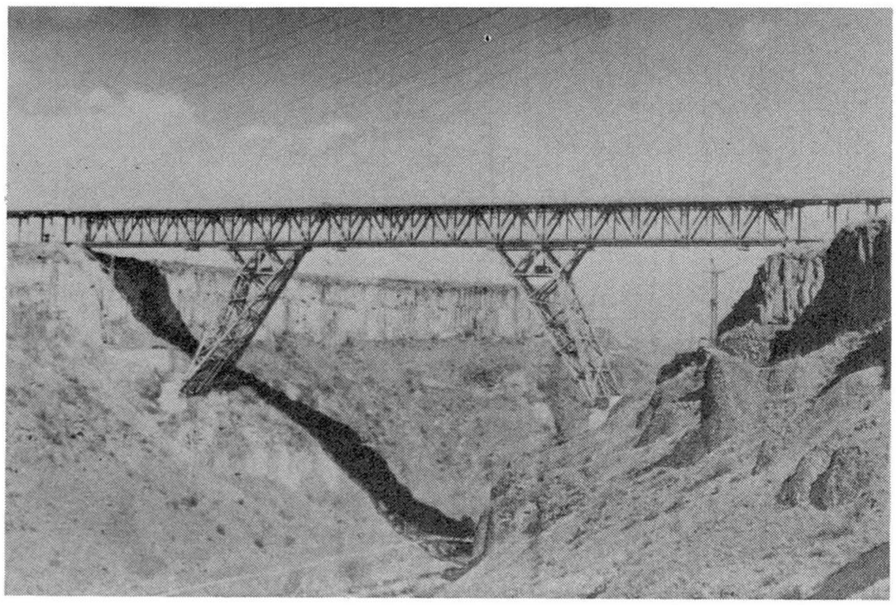

Fig. 2 General view of bridge

Combined Steel Superstructure

Structure métallique pour un pont mixte rail-route

Stahlüberbau für eine kombinierte Brücke

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The 2x220 m superstructure of the bridge passage across the Volga river in town of Uljanovsk is designed for four motor transport lanes and 2 rail (tram and metro) tracks.
The superstructure is a girder with triangle lattice without posts and suspensions of 12 m in height and 13 m between the girder axes. The traffic is accomplished on two levels: motor transport at the level of the upper chord and the rail transport - at the level of the bottom chord of the main trusses (Fig.1).

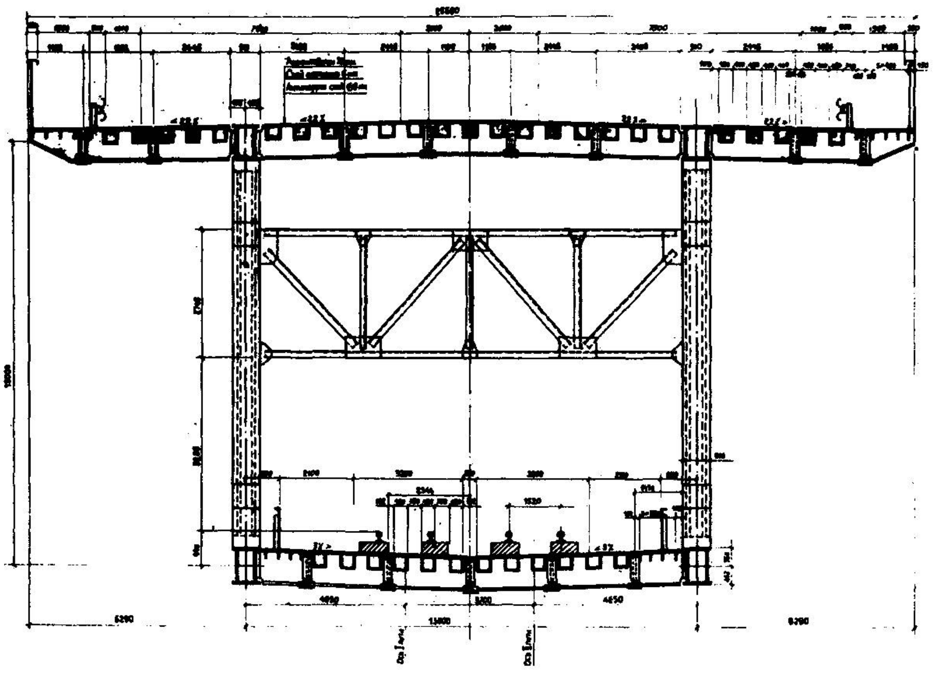

Fig.1 Cross section of superstructure.

The superstructure differs in that, that the roadway for both the motor and rail transport is made in the form of an orthothropic plate engages in a combined operation with the respective chord of main trusses.
The main trusses elements have been hermetically sealed and are not subject to internal surfase painting.
The characteristic feature of the unit design is its form of a hermetic welded shaped box, wholly manufactured at the plant. The chords and struts joints are carried away from the unit centre. Elements of the main trusses lattice have overhangs of horizontal sheets for connection with the orthothropic plate.
Connection of chords and upper unit shaped boxes with the covering sheet of the orthothropic plate is done throught butt welding. The covering sheet of the orthothropic plate is attached to the bottom unit shaped box by means of high

strength bolts.
The erection joints of the upper horizontal sheets of chords and shaped boxes - are butt welded, other erection joints are held with high strength bolts.
The characteristic feature of the orthothropic plate - the longitudinal box cross section ribs of thee sheets joined with welded seams.
Such a powerful section of the longitudinal ribs allows a 5500 mm pitch arrangement of transverse ribs along the bridge. In this case, one of every two plate transverse ribs is attached to the main trusses along the vertical axis of the struts attachment unit, while the other - along the chord middle.
The covering sheet erection joints are butt welded, other erection joints use high strength bolts.
Material of main constructions - steel of 15XCHD and 10XCHD grades. Mass of the 2x220 m superstructure - 7640 t or 17.27 t/r.m.
Part of superstructures are assembled on a jig, and brought floating in 220 m spans and mounted on the bearing part. The other superstructures are assembled suspended with construction of intermediate piers.

Standardized Structures for Rapid Bridge Construction

Eléments standardisés pour une construction rapide des ponts

Standardisierte Elemente für schnellen Brückenbau

Vladimir VORSA
Chief of Dep.
Bridge Design Institute
Leningrad, USSR

The principal task the bridge designers and bridge builders have to solve is to improve the quality of the work to be done, to reduce specific consumption of materials and labour expenditure, and to shorten the bridge construction period.

These taskswhich seem to contain mutually exclusive conditions - e.g. provision of quality alongside with shortening the construction period - may be accomplished by further industrialization of construction technology, the latter being gradually transformed into a unitary industrial-constructional process for the bridge erection using prefabricated unified elements.

To achieve these goals, a project has been implemented to develop unified elements and blocks employed for construction of motor-road and town bridges using a universal technology.

This project included a broad unification of elements and blocks of span structures used for construction of 2, 4 or 6-lane motorways (with common and separate span structures). The spans were from 42 to 147 m long, the main beams being of flange and box section types.

Application of unified elements and blocks used in span structures results in the increase of labour productivity and the improvement of products quality manufactured at metalworks factories. We may as well relate this to the erection stage of the bridge when the positive effect is achieved owing to similarity in repeatedly performed operations.

The next constructive measure directed to the accomplishment of the task stated is to increase the degree of readiness for use of factory-made structures upon their delivery to the erecting site.

The above is achieved by using the main beams which are seen as factory-made box blocks capable of being transported (by railway or motor road) as one-piece units.

Application of these structures results in redistribution of the labour expenditure between the factory and the construction site, to the builders' advantage. The work at factories is characterized by a higher labour productivity and a greater possibility of accomplishing the work with higher quality. This results in decrease of general labour expenditure and, eventually, in shortening the construction period.

Introduction of the factory-made box beams which replaced the traditional box beams assembled at a construction site, made it possible to reduce considerably the volume of erection weldings and to lower sharply the labour expenditure during the assembly period.

The experience acquired during the erection of four bridges shows that the use of metal span structures made of unified elements and one-piece box blocks as main beams, is found to reduce the labour expenditure and shorten the bridge construction period.

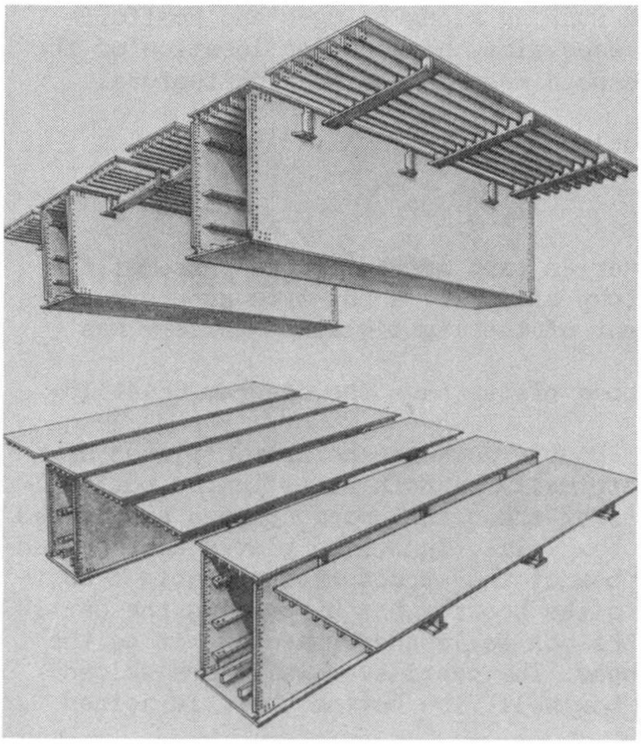

Fig. Formation of cross section of span structure using box blocks

Bridge Superstructure with Environmental Protection

Structure de pont en vue d'une protection contre les agressions du climat

U-Bahn-Brücke mit Schutz gegen klimatische Einflüsse

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1. INTRODUCTION

Under the USSR climatic conditions for reliable operation of the underground railway the trains leaving the tunnel and running along bridges and scaffolds require environmental protection. At the same time, considering location of the metro bridges under the city conditions should meet increased architectural requirements.
The specified work seeks to solve the problem.

2. SUPERSTRUCTURE

For the bridge passage across the Oka river as part of the second phase of the underground railway construction in the town of Gorky, a box-type superstructure allowing cantilever traffic and arrangement of the light glassed gallery was suggested.
The bearing box with a top and bottom ribbed plates have the diagram 66+4*115+2*135+99 m.
Steel cantilever-cross beams bearing the "Double-deck" orthothropic plates of the underground trains are attached symmetrically on both sides to the bottom chord and box walls. The horizontal sheets of the orthothropic plates are joined with longitudinal horizontal ribs of the box walls. Thus, the plates are engaged in a combined operation with the bearing box of the structure.The double T-section cantilever cross beams are attached to the bearing box by passing the cantilever top chord through special cuts in the box walls and connecting it to the chord of the lower rid plate transverse beam. The cantilever walls are welded (or fixed by high strength bolts) to the box wall. The bottom chord is joined with the box lower plate (Fig.1) .
The closed glassed galleries have the Γ-form frames and light-weight fencing structures (roof and wall with windows). The bearing frames of welded I-beams are hinged on the top chord of the cantilever transverse beam and on the box walls. The above fixing of frames increases reliability of the gallery operation at dynamic loads. The longitudinal ties interconnect the frames.
The galleries are erected in 10 m sections, fully shore assembled and delivered to the installation site on flat cars equipped with special girders. The intersection joints are done from especially manufactured scaffold girders travelling along the chord of the superstructure box.

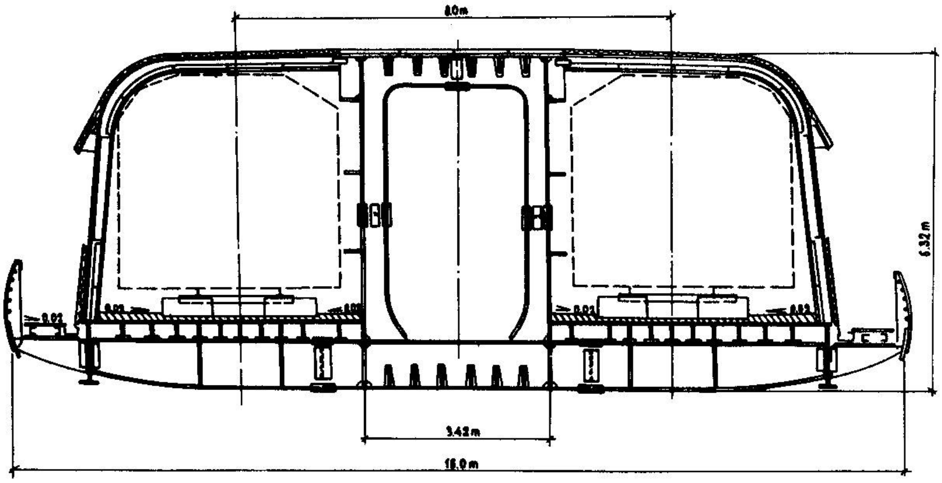

Fig. 1 Superstructure cross-section

The specified design of the superstructure has great potentialities in designing the structure architectural appearance and may be recommended for applicaton on other objects.

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