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Autor: Saul, Reiner / Zellner, Wilhelm
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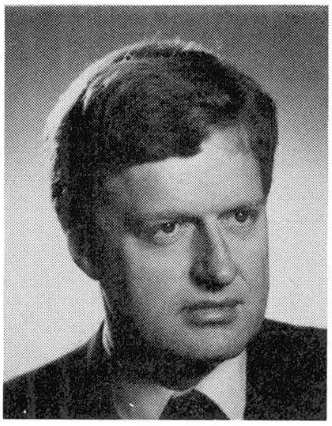
The New Galata Bascule Bridge at Istanbul

Le nouveau pont basculant Galata à Istanbul

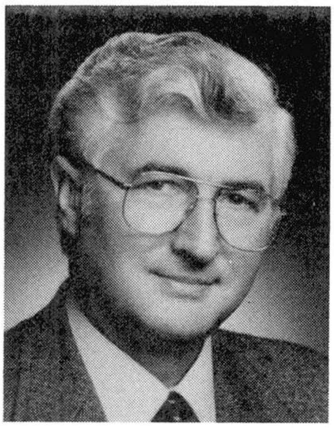
Die neue Galata-Klappbrücke in Istanbul

Reiner SAUL
Senior Supervising Eng.
Leonhardt, Andrä & Partner
Stuttgart, Germany

Wilhelm ZELLNER
Managing Director
Leonhardt, Andrä & Partner
Stuttgart, Germany



Reiner Saul, born in 1938, Dipl.-Ing. of Civil Engineering, Univ. of Hannover in 1963. Four years with a steel contractor, since 1971 senior supervising engineer with Leonhardt, Andrä & Partner. He was responsible for the design, technical direction and checking of numerous long-span bridges, including also major rehabilitation works.



Wilhelm Zellner, born 1932, got his civil engineering degree at the University of Vienna, Austria. For two years he was in charge of the supervision of a big prestressed concrete viaduct in the Vienna Woods. In 1962 he moved to Leonhardt & Andrä to Stuttgart and in 1970 he became partner in this firm.

SUMMARY

The centre piece of the New Galata Bridge at Istanbul is a bascule bridge with a clear span of 80 m and a width of 42 m. It consists of 4 flaps with TT-section and orthotropic deck. The two flaps corresponding to the traffic direction are coupled at the centre for shear and moments. Opening and closing of the flaps is done by hydraulic cylinders and takes only 3 minutes. The counterweight of heavy weight concrete is not the traditional pendulum, but is fixed directly to the steel structure.

RESUME

La partie centrale du nouveau pont Galata, Istanbul, est un pont basculant de 80 m de portée et de 42 m de largeur. Le tablier comporte 4 nervures basculantes, dont la section est en forme de TT, et une dalle orthotrope. Le joint central à mi-portée permet la transmission des efforts tranchants et des moments. L'ouverture et la fermeture du pont sont assurées hydrauliquement et ne durent que 3 minutes chacune. Le lourd contrepoids en béton ne correspond pas à la conception traditionelle en pendule, mais est directement relié à la structure métallique.

ZUSAMMENFASSUNG

Das Mittelstück der neuen Galata-Brücke in Istanbul ist eine Klappbrücke mit 80 m Spannweite und 42 m Breite. Sie besteht aus 4 Klappen mit TT-Querschnitt und orthotroper Platte. Die Verriegelung an den Klappenspitzen überträgt Querkräfte und Momente. Die Klappen können mit hydraulischen Zylindern in nur 3 Minuten geöffnet oder geschlossen werden. Das Gegengewicht aus Schwerbeton ist kein übliches Pendel, sondern mit der Stahlkonstruktion verbunden.

1. INTRODUCTION

The New Galata Bridge across the Golden Horn links the quarters of Eminönü and Karaköy directly on site of the existing steel floating bridge built in 1912.

The 42 m wide bridge, Fig. 1, consists basically of

- the centre bascule bridge with a clearance of 80 m and the corresponding bascule bridge piers, as described in more detail hereunder.
- the double deck approach bridges with 7 spans of 22.3 m each, with the road and light railway traffic on the upper deck and shops, restaurants and the like on the lower deck, Fig. 2.
- the abutments.

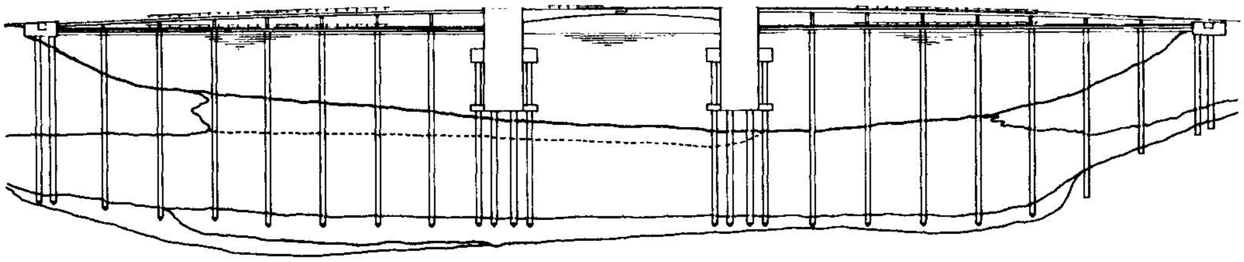
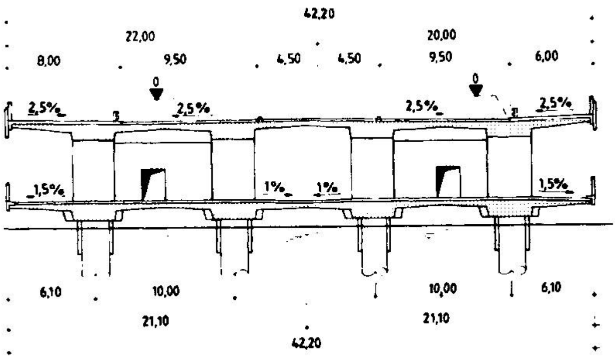


Fig. 1: General Layout



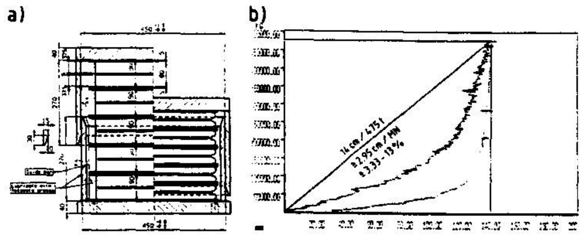


Fig. 2: Cross-Section of Approach Bridge

Fig. 3: Earthquake Buffer
a) Design b) Hysteresis

In between these 2 x 3 elements, buffer bearings are provided, which consist of rubber discs and have pronounced hysteresis, Fig. 3.

Due to a water depth of up to 40 m and poor soil of another 40 m, the bridge is founded on driven or drilled hollow steel piles, with a diameter of 2 m, a wall-thickness of 20 mm and cathodic corrosion protection.

2. DESIGN

2.1 General

The free span of 80 m and the total width of 42 m render the bascule bridge the world's largest, Fig. 4. The total length of the flaps, 54.5 m each, is divided by the axis of rotation into 2 cantilevers of 42.8 and 11.7 m.

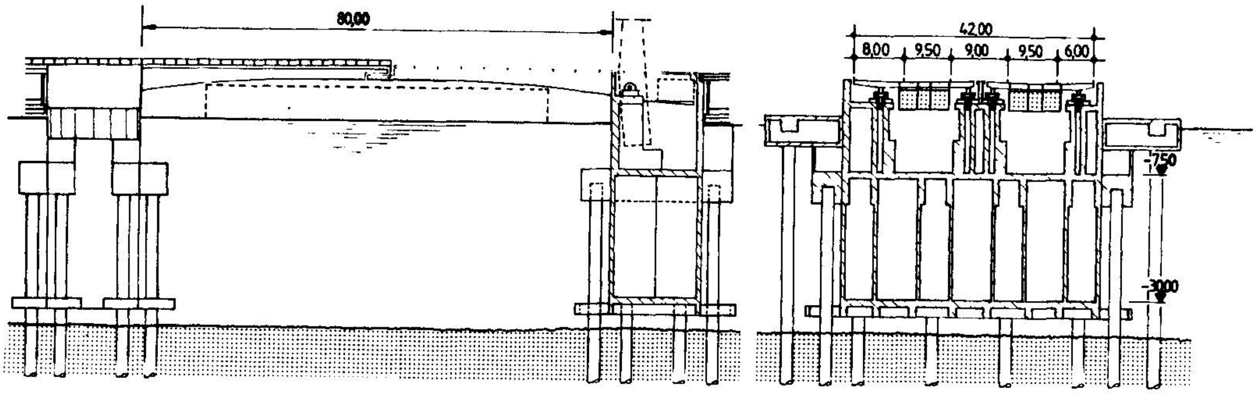
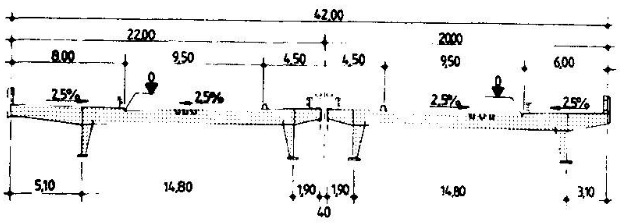


Fig. 4: Bascule Bridge, General Arrangement



Due to the unsymmetric arrangement of the pedestrian footways, the twin flaps have widths of 22 m and 20 m respectively, Fig. 5.

Fig. 5: Bascule Bridge, Cross-Section

2.2 Bascule Bridge

2.2.1 Steel Structure

The steel structure consists of
- the deck plate, with a minimum thickness of 12 mm in the roadway area and 10 mm in the walkway area,
- the trapezoidal ribs,
- the cross girders at regular intervals of 3.96 m; special cross girders are needed at the centre and at the rear,
- the main girders, with a depth varying between 2.3 and 5 m, and a 800 mm wide bottom chord with a thickness varying between 30 and 90 mm.

The total steel weight is 1600 tons corresponding to 350 kg/m^2.

The wearing surface is a 30 mm thick epoxy modified asphalt layer.

2.2.2 Mechanical Equipment

The main bearings are busher bearings, transverse forces are absorbed by both bearings. At the rear end, a neoprene bearing takes the uplift forces and a pin moved by a hydraulic cylinder the downward forces. At the centre, a double shear connection - retractable by hydraulic cylinders - assures the transmission of shear forces as well as of bending moments, Fig. 6.

The opening and closing of the bridge is performed by a hydraulic cylinder with a diameter of 650 mm, a length of 5 m and a stroke of 4.5 m. In order to open or close the flaps in 3 minutes, a maximum oil volume of about 5 litres per second is needed.

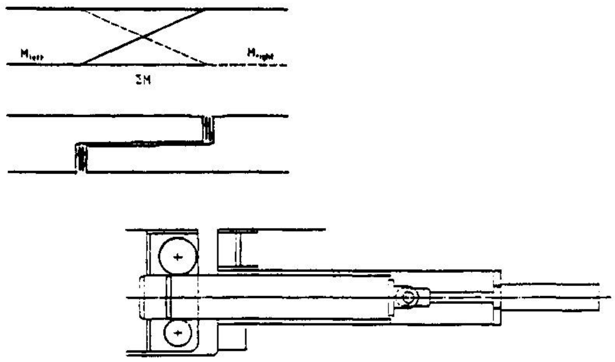


Fig. 6: Centre-Joint Interlocking

2.2.3 Counterweight

The counterweight is fixed by stud shear connectors and 20 prestressing bars Ø 26 mm St 1080/1230 through intermediate longitudinal girders and specially designed cross girders directly to the rear arms. The dimensions of the counterweight are about 7.3 x 3.8 x 9.8 m, its specific weight is 35 kN/m^3 and its total weight - variable from flap to flap - about 1000 tons.

2.3 Piers and Foundation

In the design of the bascule bridge piers, two contradictory requirements had to be fulfilled: For the absorption of the ship impact they had to be stiff and for that of the earthquake flexible. This could be achieved by a pier going down to the seabed and founded on 12 piles, which are fixed to the pier between -13 m and -7,5 m and elastically supported at -32 m, Fig. 7.

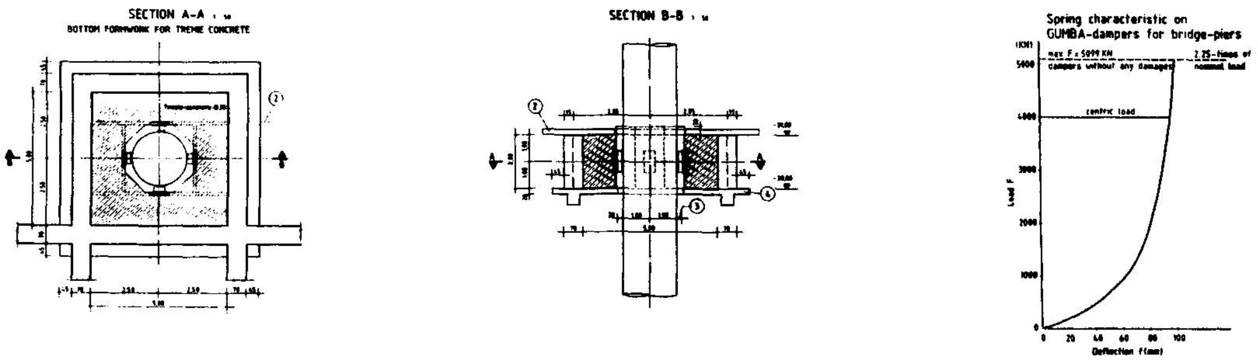


Fig. 7: Bearings at -32 m

In order to avoid an overloading of the piles - or additional piles - the piers are made hollow. In spite of being exposed to a water pressure of up to 35 $tons/m^2$, the pier walls are not waterproofed, but are reinforced for a crack width of w_{95} = 0,2 mm.

The piles of the bascule bridge pier are filled with tremie concrete B 35 and reinforced in the upper part. They are designed as composite columns, shear connectors were needed at both ends only.

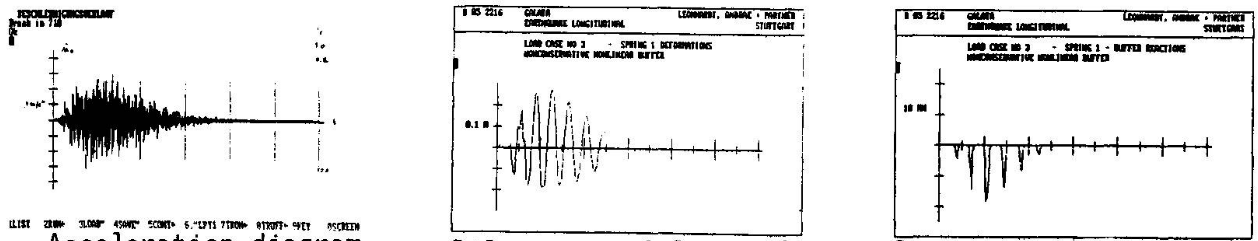
3. SPECIAL ASPECTS OF DIMENSIONING

3.1 Earthquake

The bridge had to be designed for an earthquake with PGA = 0,35 g. For the seismic design, two different approaches were used:

In a first step, a response spectrum calculation was performed, assuming that the different elements of the bridge are completely independent in the longitudinal direction. This calculation was performed for closed flaps, opened flaps and erection stages.

In order to determine the displacements of bearings and jointings and the forces acting onto the buffers, a time-history calculation was performed in a second step. For this calculation, up to 6 time-acceleration diagrams, compatible with the energy content of the response spectrum were generated. The results are given graphically, Fig. 8.



Acceleration diagram Dilatation of Spring 1 Spring 1 Force

Fig. 8: Time-history calculation

3.2 Ship Impact

The bridge had to be designed for the head on impact of a 8000 dwt ship sailing at 2.5 m/s. The corresponding impact force is, according to the "Nordic Road Council Regulations for Ship Impact"

$$P_{[KN]} = 500 \times \sqrt{dwt} = 500 \times \sqrt{8000} \times 1.05 = 40{,}000 \text{ kN.}$$

As a consequence of an eventual ship impact, the loss of buoyancy of the upper or lower part of the pier due to breaching had also to be considered.

As the bascule bridge could, of course, not be designed against ship impact, two worst case scenarios were investigated, Fig. 19:

- the formation of a hinge in front of a pier,
- the loss of a flap between this hinge and C.

These scenarios did not lead to a loss of the other flap and the rear arm with the counterweight respectively.

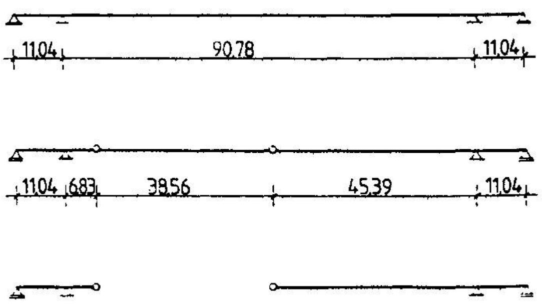


Fig. 9: Worst Case Scenarios

4. CONSTRUCTION

4.1 Piers

The bascule bridge piers were built by the "Lower Slab" method, Fig. 10.

Utmost care had to be given during the complete lowering procedure to the equilibrium between

- weight of the structure, including inside ballast water,
- force in the lowering equipment and the capacity of the piles,
- uplift forces due to bouyancy, increased by air pressure for special steps.

The pier was lowered by a total of 60 DYWIDAG jacks with a nominal capacity of 0.5 MN each, acting onto threaded bars Ø 36 mm of St 835/1030.

The lower pile bearings were provisionally fixed to a steel structure which was lowered together with the pier. Rollers kept the steel structure in position with respect to the piles and so adjusted the pile driving tolerances. After the pier had reached its final position, the gap between the steel structure and the walls of the pile anchorage was filled with tremie concrete by divers.

In oder to pour the reinforced concrete of the upper anchorages in dry, the anchor boxes of the piles were extended up to the sea level. The lower part of the plug was first poured as tremie concrete to seal the pit, and later the water was pumped out.

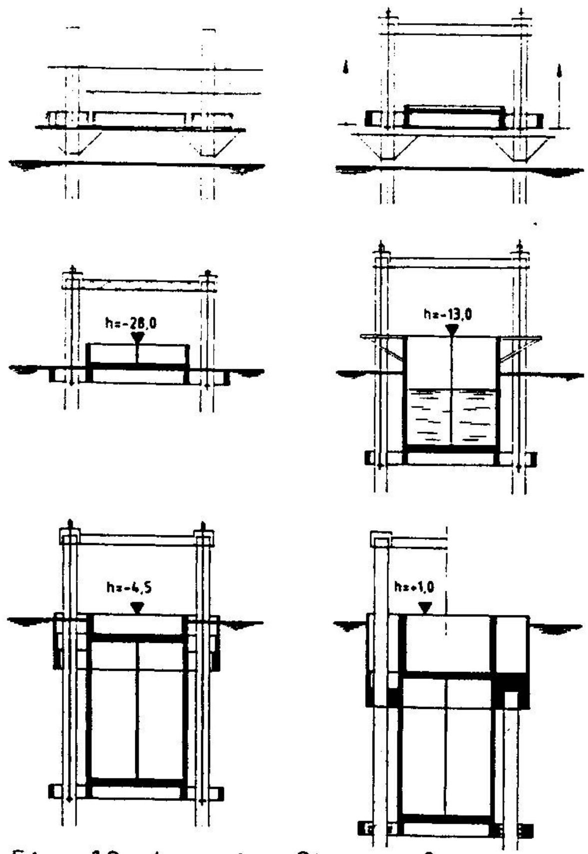


Fig. 10: Lowering Stages of Bascule Bridge Pier

4.2 Flaps

The bascule flaps were fabricated in a specially built up yard about 30 km away from the site. The main girders and the intermediate and outer parts of each element were first fabricated; they were later assembled and put together, with the other elements, according to the sequence indicated in Fig. 11.

The finished flaps were rolled onto a 15,000 t pontoon and floated. They were then rolled off to their final position, where they were adjusted by means of hydraulic jacks and a hold-down of prestressing bars.

Finally, the scaffolding for the lower part of the counterweight was fixed to the intermediate longitudinal plates and the counterweight cast in several layers and prestressed.

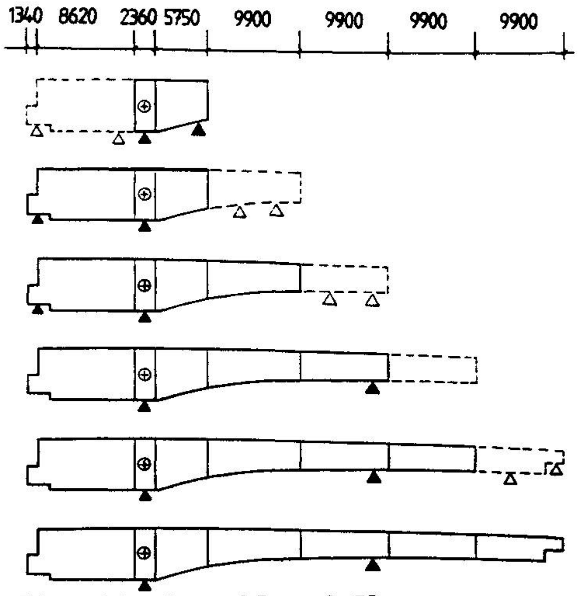


Fig. 11: Assembly of Flaps

5. ACKNOWLEDGEMENT

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