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20. Viaduct of Lake Gruyère / FR

Owner: Canton Fribourg
Consulting Engineers: E. & A. Schmidt, Basle
B. Bernardi, Zurich
I.C.A. SA, Fribourg
Contractors: Losinger SA, Fribourg
Antiglio SA, Fribourg

Years of construction: 1975 – 1979

Design of the Bridge

On the west bank of Lake Gruyere between Fribourg and Bulle the national highway N 12 lies on a viaduct of 2043.75 m length and 23.70 m width. The viaduct crosses a first inlet of the lake at a height of approx. 70 m and extends across country at a height of 5 to 35 m to cross a second inlet at a height of approx. 80 m. The structure is visible in its full length from the east bank of the lake and it has a strong influence on the landscape. From the west bank, only sections of the bridge can be seen and especially where it crosses the inlets the lower parts of the piers are hidden by forest.

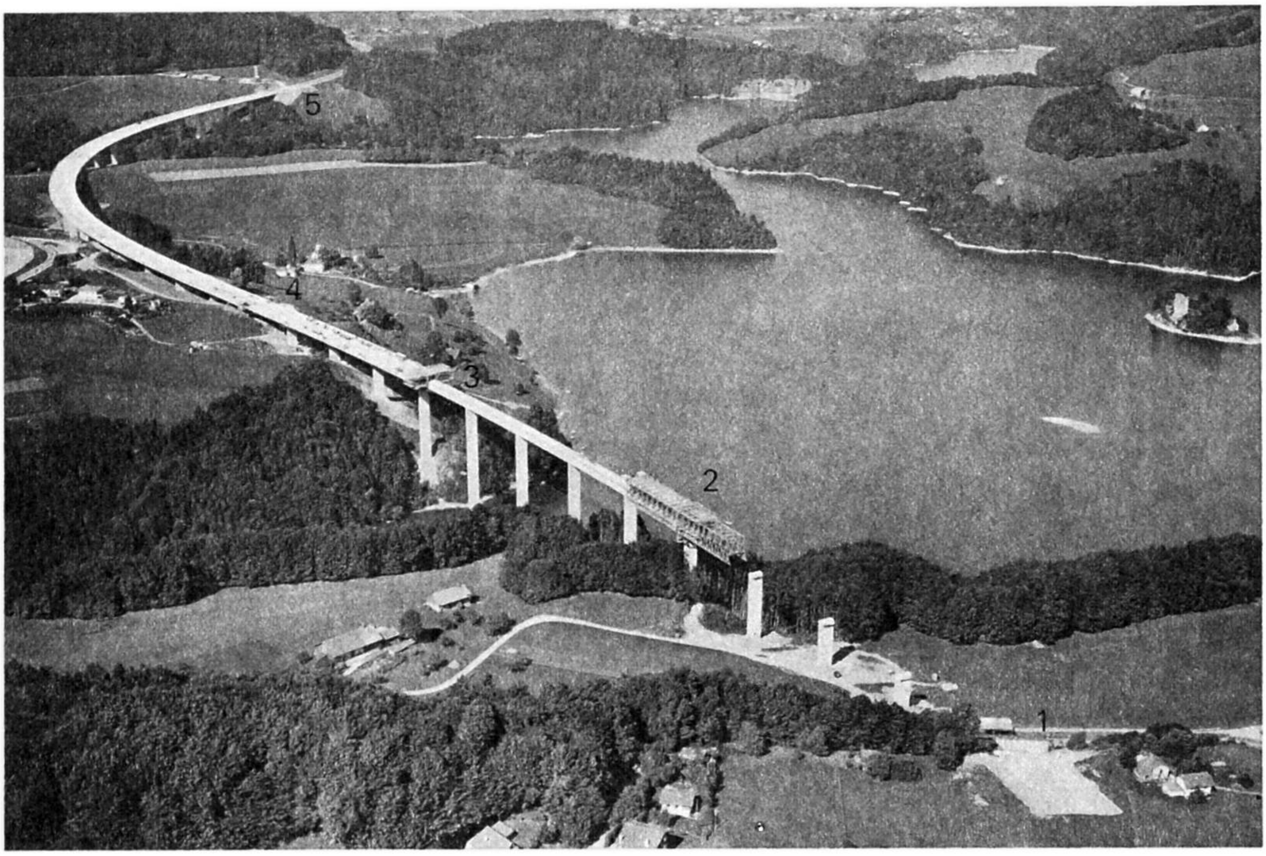
The main idea of the architectural design of the bridge was the harmonic unity over the total length of the structure. An enlargement of the spans in the area of the inlets was omitted, because the resulting necessity to increase the height of the beams through splays by the piers would have considerably disturbed the overall picture of the viaduct.

Considering the large number of supports required by the equal spans, a bridge system was chosen which allowed an arrangement of a central row of columns, so that even by an oblique view-point of the structure the impression of a forest of columns would not occur. It consists of a torsional resistant box girder of constant height with widely projecting cantilever beams which support the deck slab. The total length of the bridge, with spans of 45.78 m, 32 x 60.48 m and 62.61 m, is divided in three sections of similar length. The two expansion joints have been designed as hinges in the 1/5 point of a span and are hardly visible from a distance. Caused by the equal spans on the uneven terrain, the height of the 33 columns range from 6 to 77 m, whereby two columns are based in both lake inlets.

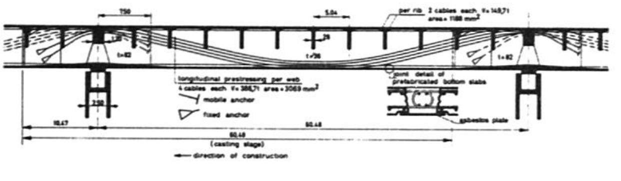
In order to achieve an even overall picture, all columns are of equal rectangular shape despite their largely varying heights.

Construction

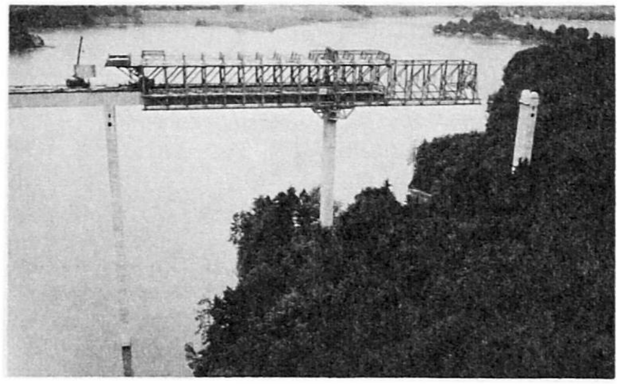
The **main beam** consists of a box girder with a width of 6.00 m and a height of 4.00 m. It is prestressed by 385 t cables (VSL System). It was not only strived for a statically favourable arrangement of the cables, but also for one which was simple and foolproof regarding the positioning and tensioning procedure. In each span there are eight cables (four per web) which are subsequently anchored beyond the supports. This arrangement leads to double as many cables over the columns (16) as there are at mid span (8). This is not disadvantageous for the structure, because over the supports a



1) abutement Bulle side
2) mechanized launching beam for box-girder
3) mobile scaffolding for cantilevers
4) mobile formwork for edge-beam
5) abutement Fribourg side

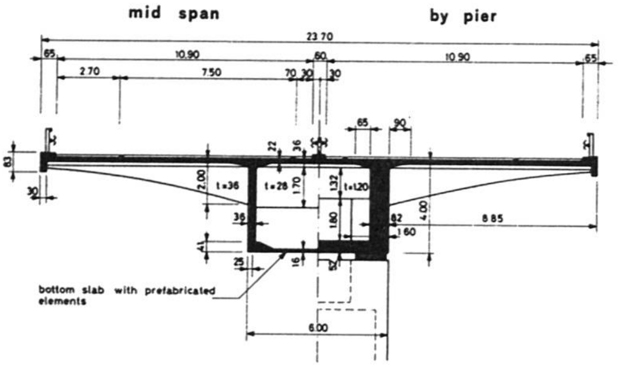


scheme of cable layout with casting stage of box-girder



Launching beam in casting position over the large lake inlet

Positioning of prefabricated bottom slabs



cross section

larger compression reserve in the tensile stress zone of the deck slab is obtained. All four cables of a web are anchored with movable anchors 7.50 m behind a column. The necessary space for the anchors is provided by increasing the thickness of the web from the normal 36 cm to 82 cm. The stressing points remain accessible till the end of construction, so that all cables can be restressed at any time.

The **cantilever beams** project laterally 8.85 m from the box girder at a spacing of 5.04 m and support the deck slab. Each is prestressed with two 149 t cables (VSL). The **deck slab** has a thickness of 22 cm which is enlarged at the connections with the webs and transverse beams by splays to 36 cm.

There are a large number of re-uses of the formwork, as the superstructure consists of equal stages (60 m stage length for the box girder, 10 m stage length for the lateral overhangs and 5 m for the edge beam). The statically most favorable dimensions of the concrete sections could therefore be chosen (e.g. deck slab with splays). The increased expense of the partly complicated formwork is of no consequence in comparison with the corresponding savings in weight, reinforcing steel and numerous re-uses of the formwork.

The **columns** have a rectangular cross section of 2.50 x 6.00 m and are hollow. The largest column height is 77 m, the smallest 6 m. The highest columns are connected monolithically with the superstructure, the others support the main beam by either fixed or unilateral or multilateral movable sliding pot bearings. All piers are connected rigidly to their foundations. The largely varying stresses, caused by differing heights and constant shape, are taken into account by variation of wall thicknesses and amounts of reinforcing steel.
In view of the very heterogeneous soil conditions the **foundations** are either based on bored piles with a diameter of 1.25 m or are founded on elliptical wells. Their largest dimensions are 13.5 m x 17 m x 2.5 m.

Building procedure

The columns are cast with slip-forms, giving a daily production of 4 to 6 m. Continuously during the construction of the higher columns prestressing cables, located at the four corners, were placed and stressed. This longitudinal prestressing force (max. three 237 t cables per corner) was required, in addition to the massive reinforcement, to ensure that these free high rising columns maintained sufficient stability under large wind pressures during construction.

The main beam is cast on a superposed launching girder in stages of 60.48 m (= length of one span), commencing after a cantilevering main beam at 10.12 m from the column axis. The launching beam is supported by the existing cantilevering main beam at the rear and the column in front. In order to omit the lower shuttering for the main beam, which would have rendered the advancement of the launching beam and the erection of the formwork more difficult, the bottom slab of the box girder consists of prefabricated elements. These elements (5.5 m width, 3 m length and 16 cm thickness) are transported over the existing part of the superstructure and located in the outer formwork of the webs which are fitted with consoles at the bottom. The joints between the elements are bridged with strips of asbestos sheeting and subsequently filled with concrete. The box girder is then cast in two stages, first the webs and the inner transverse beams second the deck slab. After the stressing of the longitudinal cables, the scaffolding is lowered and advanced to the next casting position.

The launching beam has been developed especially for this viaduct. Optimal statical conditions for the bridge as well as the launching beam could be found by choosing suitable casting and advancing procedures. There was no additional prestressing steel or ordinary reinforcement steel required for the various construction stages. The launching beam, with 50 m span, has to support only 45 % of the total weight of the superstructure (bottom slab, webs and part of the deck slab of the box girder and the inner transverse beams).

The lateral overhangs consisting of cantilever beams and deck slab are concreted later on to the existing box girder with the aid of a travelling scaffolding in stages of 10.12 m. In a last working operation the edge beams are cast in stages of 5 m length with the help of a mobile mould. The efficiency of the launching beam and the travelling scaffolding was coordinated. During three weeks a 60 m span of the box girder is completed and in the same time 6 x 10 m = 60 m of the lateral overhang is cast.

(R. Plattner)