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Small concrete pedestrian bridge with integral abutments – An alternative solution for pedestrian bridges over highways

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ABSTRACT: Although modern computer calculation methods allow checking upper and lower boundary conditions of a structure – such as influence of different states of earth pressure on abutment walls - quickly and easily, most bridges are still planned with joints at abutments to ensure an easy planning and to be conform with German road authority regulations. This is inefficient for smaller bridges as joints at abutments and their maintenance are of significant costs looked upon from a life-cycle point of view. This paper describes the elegant solution for a small, 2 field pedestrian bridge (length 37,10 m) with integral abutments over a 4-lane highway that could serve as a model for highway bridges and replace the regular solutions - often heavy and clumsy – for such structures usually used in Germany. A simple structural solution with a soft sandwich panel behind the end walls and the earth and a stabilized earth-fill dam allows the deformation of the bridge deck for temperature loads. Calculations with different earth pressure distributions behind the walls proved the serviceability without joints for winter and summer conditions. The Y-shaped middle column adds to the architectural concept of a minimalized and tailor made concrete structure to make concrete structures more positively accepted in public.

1 DESIGN AND STRUCTURE

The initial design idea of the bridge is shown in figures 1 and 2. The concrete deck is rigidly connected to the end walls. Beside the principle of integral abutments, the characteristic of the bridge is the Y-shaped center column (fig. 3). The total length of 37,10 m was subdivided in two fields by this column. Its form suits to the possibilities of using concrete as a formable material. An important aspect was to use rounded corners wherever possible to allow a smooth stress distribution.

Between end walls and the concrete-stabilized earth-fill dams behind them, a soft interlayer consisting of a sandwich geotextile drainage material, thickness 20 mm (fig. 4), was used to allow a deformation for the "summer" temperature load case. For the "winter" temperature load case, the partially mobilized active earth pressure (Berger et al., 2004) was considered for the additional triangular earth – fill dam in front of the walls.

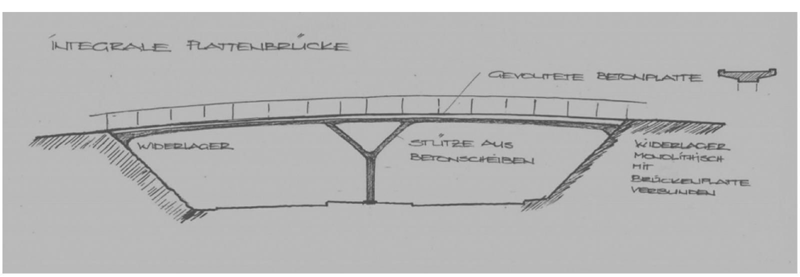

Figure 1. Initial design idea.

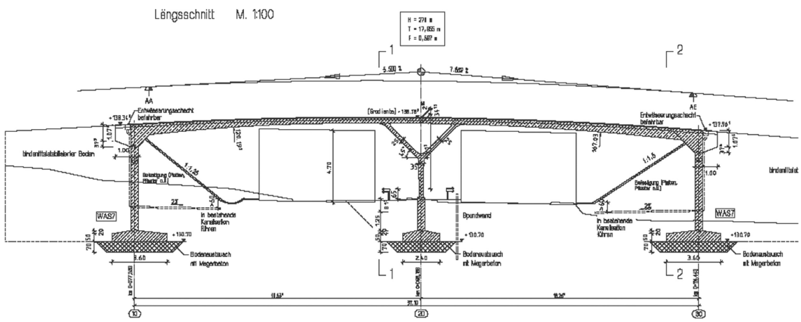

Figure 2. Longitudinal section.

Figure 3. Detail of the column during erection.

Figure 4. Geotextile drainage material behind end walls.

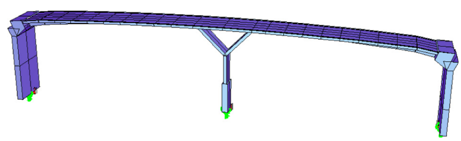

Figure 5. Simple finite element model.

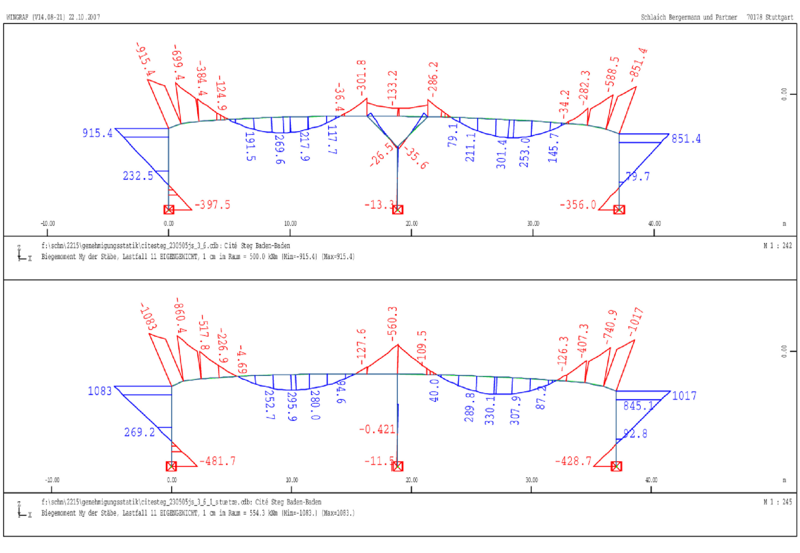

Figure 6. Moment distribution with a Y-shaped column in comparison to a simple column.

Figure 7. Formwork and reinforcement for the Y-shaped column laying on side.

Figure 8. Column is moved by a crane to its place.

2 CALCULATION

A simple finite element model with conventional strut elements as shown in figure 5 was used. The combination of dead load, temperature loads, earth pressure and live load governs the design. Figure 6 shows the moment distribution of the bridge with the Y-shape in comparison to a simple column. The negative moment in the deck above the column is almost twice as high for the simple column. Hence, the thickness of the concrete deck could be minimalized to about 30 cm.

3 MATERIAL AND CONSTRUCTION

Concrete C40/50 and reinforcement S 500 were used for the walls, deck and column. To guarantee a perfect concrete surface, the Y-shaped column was produced on site lying on the side (fig. 7). It was later moved to its place by crane (fig. 8).

Figure 9. On-site construction of the concrete deck.

Figure 10. Final bridge.

The concrete deck and the walls were constructed conventionally on site by using an additional steel substructure for the deck as the traffic below was ongoing during construction (fig. 9).

Figure 10 shows the final bridge, a minimalized, tailor made concrete structure.

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