FAST-ASSEMBLY BRIDGE OVER THE AEGIDIENTORPLATZ IN HANNOVER

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•WITHIN our large cities, the sudden increase in motor traffic during the past years has very often resulted in bottlenecks that lead to traffic congestion, especially at peak times. Responsible building authorities had to find means to both open new ways for the increasing traffic and obstruct as little as possible the traffic in the vicinity of the construction site while new roadways have been built. The solution of these novel building problems requires a novel bridge type, and in recent years there have been developments of this kind in various countries. This paper outlines how such urban bottlenecks can be overcome speedily and without major traffic impediments by steel bridge construction and briefly gives a typical example of building the fast-assembly bridge across the Aegidientorplatz in Hannover.

"Fast-assembly bridge" means a bridge structure that can be quickly procured and rapidly assembled and disassembled. It must be versatile and conveniently adaptable to changed traffic conditions. Contrary to permanent bridges, fast-assembly bridges are intended for uses limited in time, and it frequently happens that the bridge has to be adapted to changing site situations during its first term of service. After the first job has been completed, the fast-assembly bridge must be capable of being reused quickly without loss of material and without difficulties under greatly different conditions at another place.

What are the properties that a fast-assembly bridge must have to meet the requirements just stated? The bridge must be designed on the sectional principle so that it can be put together from a few different standardized components. By means of jigs and fixtures the components must have been manufactured so accurately that they can be assembled without reaming of fitted holes and, therefore, can be interchanged. Components have to be connected and disconnected in the simplest way. Connection of the components is mostly made by fitted bolts. Because friction faces would require special treatment, there is no advantage in using high-strength friction grip bolts. Riveting and welding also do not offer any advantage because they do not permit an easy disassembly. In order to make the equipment versatile, the bridge must be variable in its cross-sectional width and span lengths. For the same reason, it should be possible to locate the main girder supports at any point on the main girder. The bridge may have to be curved in both its vertical and horizontal planes, the curvature being variable. Previous experience in building the bridges shows the necessity for having wide variations in the bridge layout because of factors, such as traffic areas below the bridge, utility lines, trees, and the like, that must be considered when the bridge is erected. The fast-assembly bridge systems of the Rheinhausen type, used for the bridge across the Aegidientorplatz in Hannover, fulfills all of these conditions.

The basic elements of the fast-assembly bridge of the Rheinhausen type are the main girders (Fig. 1). These main girders are designed with an open cross section and consist of the upper roadway plate with transverse roadway ribs, web plates, lower flanges, and welded-in cross girders in the main girder center. Four alternatives are manufactured: 2-web, 12 m long; 1-web, 12 m long; and 2-web and 1-web, 6 m long.

Main girders 6 m long will mostly be assembled at the bridge ends. They can be supplied with a uniform web height and with a raised web. The height of web plate is

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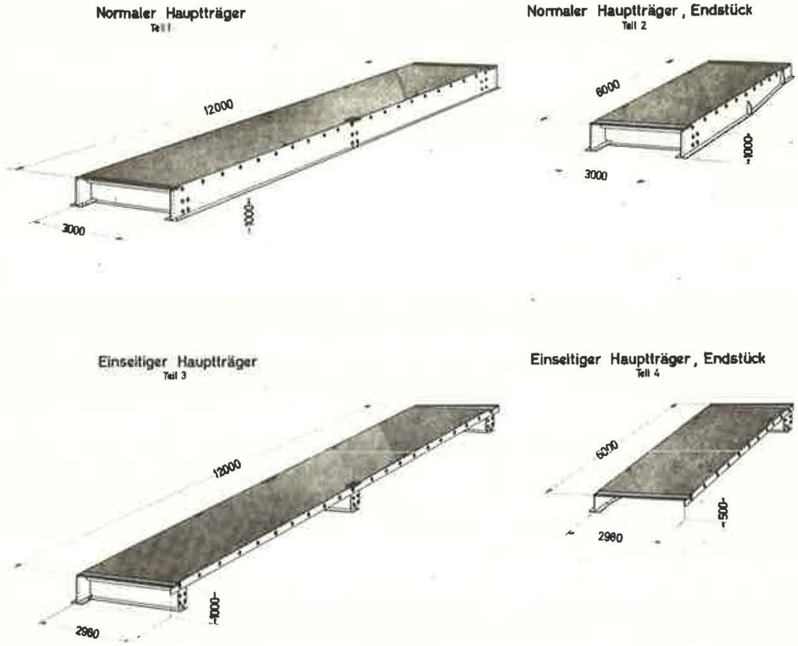

Figure 1. Main girders.

uniformly 1 m for all main girder types. Variation in the design of the bridge cross section is possible with the use of these main girder components. The variation is shown in Figure 2. For the 1-lane bridge cross section, a 2-web main girder component is used. Should the useful lane width of 3 m be insufficient, the roadway width could be increased up to about 3.20 m, as has been done in Hannover, by enlarging the component, or up to about 3.80 m by arranging a special curb. Two-lane and multilane bridge cross sections can be obtained by combining the required number of 1-web main girders with the 2-web main girder component. In this way useful roadway widths of 3, 6, 9, or 12 m are reached.

Roadway widths in between these figures are also feasible. For the fast-assembly bridge of Hannover, for instance, it was necessary to have 2-lane roadway widths of 7.50 m (Fig. 3). They were formed by arranging two 2-web main girders of 3.20 m each on the outer edges of the cross section and installing an intermediate plate of 1.10-m width. This cross section design also offers the advantage that the 7.50-m wide 2-lane cross section can be split up into 2 separate 1-lane roadways of 3.20 m each.

As a rule, the main girder components are completely welded ready-made units of the stated sizes. They can be transported on trucks or by rail without complications. For transport to very distant places, say, overseas countries, however, they should be sent in smaller shipping units. In such a case, the fast-assembly bridge system offers the possibility of disassembling the main girder into the individual elements: roadway plate, cross girder, and main girder web with lower flange. These can be shipped separately and assembled in the field by means of fitted bolts into 1-web or 2-web main girder components.

Of the cross girders spaced 6 m apart, every second cross girder is securely shop-welded into the main girder elements at the main girder center. The cross girders located at the joints are delivered as separate units and assembled when the main girder transverse joint is closed. All field connections are made by fitted bolts of 40-mm diameter and material quality 5 D. They are galvanized.

The bridge when fully completed forms a longitudinally and transversely continuous, flexurally rigid beam grillage. Under service conditions, a jointless roadway deck over the whole bridge area is thus obtained. The static computation is based on Bridge

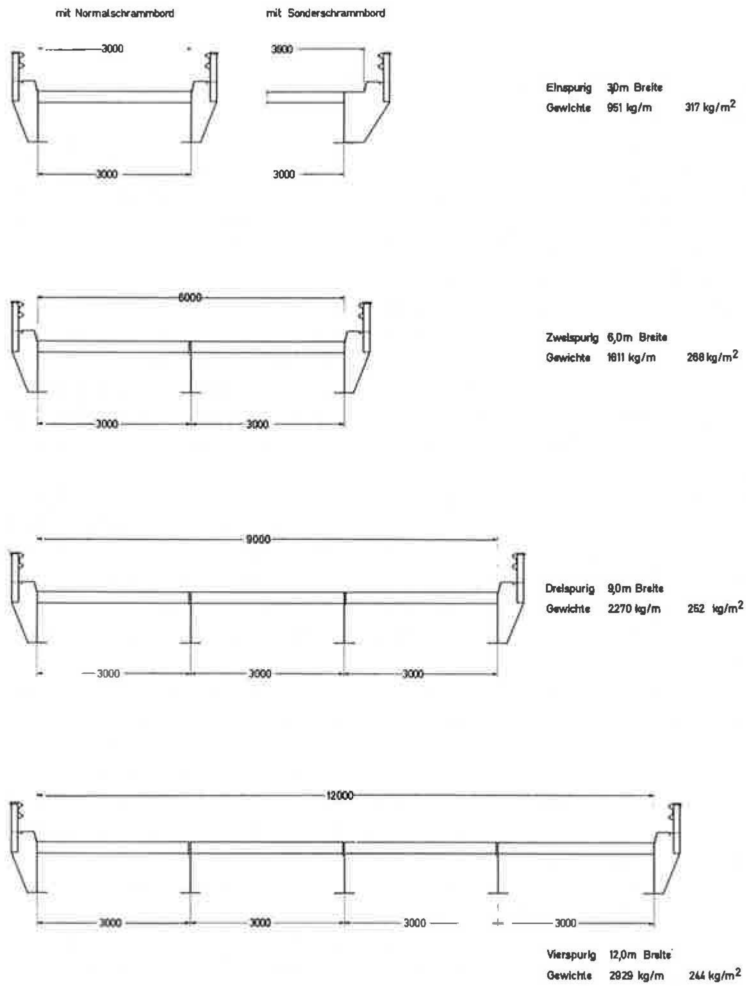

Figure 2. Variation in design.

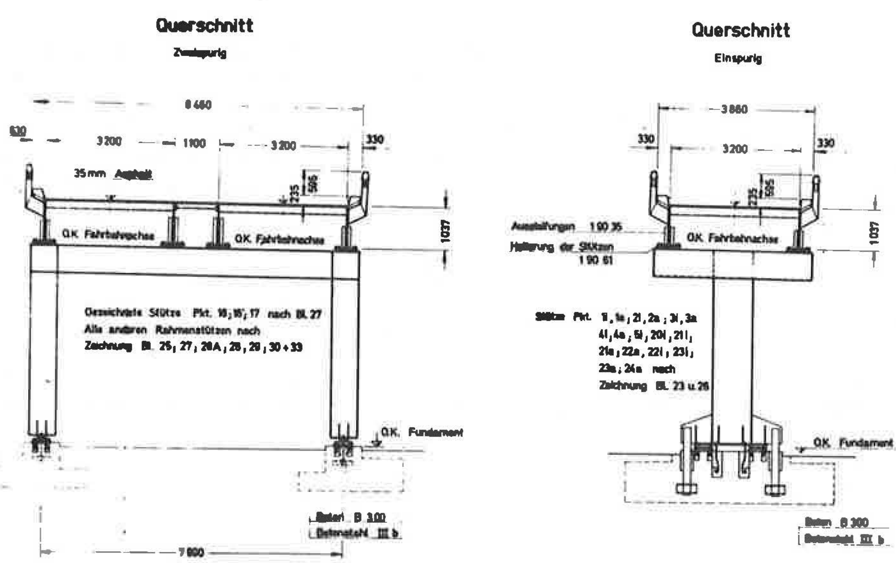

Figure 3. Design of fast-assembly bridge in Hannover.

Class 30 of the German DIN 1072. With variable bearing positions, the standard type permits span lengths up to about 30 m.

The main girder elements normally are fabricated as straight units. If bridges are to be curved in their plan view or elevation, a curvature is sufficiently approximated for practical use by a broken polygon course with breaks at the joints at intervals of 12 m. Vertical curves have large radii of curvature, and the breaks at the joints can be achieved by a wedge type of drilled-web splice plates. Plan view curves, however, can have very small radii. In those cases, a wedge type of drilled splice plate arrangement generally will not do. Special wedge plates have to be provided at distances of 12 m to form the curvature required. The wedge plates are variably dimensioned and can be suited to any curve. As compared with the design for a continuous curve, this design with a polygon-shaped approximation of curvature offers the great benefit that, on reuse of this bridging equipment, splice plates and wedge plates need only be exchanged to overcome curves of great variety and all main girder elements and cross girders need have no modification.

In addition, the design of the main girder units allows giving the completed bridge any one-sided crossfall. If necessary, this can be changed in longitudinal direction of the bridge in accordance with the horizontal curvature. The one-sided crossfall is achieved by appropriately inclining the support points of the main girder webs. Because the completed bridge structure represents a torsion-soft structure, transverse inclination is possible by twisting the bridge while it is being erected, without appreciable additional stresses.

Within the limits of the maximum span lengths the fast-assembly bridge system of the Rheinhausen type largely grants freedom with regard to the arrangement of bearings. Bearings can be provided at any point on the main girder web or below the cross girders. The axes of the support frames need not be at right angles to the longitudinal bridge axis but may be set in oblique-angled arrangement. When the bridge is being erected on the site, bearing stiffeners are mounted by way of additional bores for force transmission purposes. When the equipment is used at several places, the same main girders allow different positions of bearings. It is also not necessary that, on a support frame, all main girder webs be supported on the bearings directly. If it is required by traffic below the bridge, outside main girder webs can be supported indirectly by additional cross girders within the superstructure, whereas the inside webs arranged over bearings directly transmit their forces to the support frame. Tie rods can be installed easily.

At the ramp ends, the bearing bodies are designed as fixed, knife-edge, rocker type of bearings or roller bearings moving on one side and made of steel. Bearings provided between superstructure and steel rocker posts are fixed, knife-edge rocker type of bearings made of steel or reinforced neoprene. Because of impact and noise suppression, softer supports are preferred.

For roadway transitions subject to major movements, finger-grip constructions have successfully been applied. At the bridge end with fixed bearing, a simple edge protection is sufficient.

Depending on local conditions, the fast-assembly bridge of the Rheinhausen type can be delivered with longitudinal continuous drainage piping or individual downpipes along the whole bridge. The gap approximately 10 mm wide arising between the individual main girder elements is suitably sealed off by a permanently flexible synthetic cement so that the decking is made completely watertight.

As a standard feature, the fast-assembly bridge of the Rheinhausen type is provided with guiding devices that consist of about 12-cm high curbs and crash barriers of cap section opened downward and that were made especially for this bridge type. The crash barriers are supported at intervals of 3 or 6 m. At the crash barrier posts and, if existing, on the footpath brackets, provision has been made for the attachment of light poles. When there are sidewalks or bus stops below the fast-assembly bridge, it is recommended that special splash protection be provided. It consists of a sheeting arranged between curb and crash barriers and prevents pedestrians from being splashed by water from the roadway surface.

Great flexibility and variability are demanded of the fast-assembly bridge. This condition especially applies to the supports of a fast-assembly bridge. Normally the support arrangement consists of 1-leg or multileg steel frame structures. Their shape greatly depends on different local conditions so that standardization does not offer any benefit; it is better to study and redesign the support frames for every new requirement. For intermediate supports of the fast-assembly bridge in longitudinal direction, the frames are designed as rocker frames with a point rocker type of bearing at the frame bases. Where traffic areas below the bridge have to be kept clear of bridge structures, it is often necessary to provide frame legs not only below the bridge but far outside of the bridge by using large transom span lengths or frames with cantilevering transoms.

Because the traffic conditions in the vicinity of a fast-assembly bridge seldom allow sand-blast derusting and painting work to be done at the site, anticorrosion work must be carried out as far as possible in the fabrication shops and any field work must be limited to a minimum. The extent of the corrosion protection largely depends on the local circumstances. Basically, however, paint materials should dry and harden quickly. Only in this way can damage to the shop coats during transport and erection be reduced to the unavoidable minimum. Two-component resin paints with zinc chromate and iron mica nearly comply with those requirements.

Surfacing work, too, must in many cases be done in the shops. Under design aspects of the steel structure, both thin plastic surfacing with minerals sprinkled in and asphalt surfacing in thicknesses ranging between 3 and 6 cm are suitable for the fast-assembly bridge of the Rheinhausen type. The choice of roadway surfacing depends on the time the bridge is to be in service. For a short use of 1 to 2 years, synthetic surfacing offers the advantage that it can be applied under controlled working conditions in the steel fabricating shops and requires little site work afterward. Because these surfaces are wear-prone, especially when spiked tires are frequently used, and can be repaired only in favorable weather, this surfacing should be adopted for short-term use only. For long-term use, an asphalt surfacing is recommended. In this case, too, an essential portion of the surfacing work, i.e., derusting and application of the adhesive primer, can be done in the fabricating shops. On the other hand, the mastic layer and asphalt should preferably be applied on the site, although, in principle, it is technically possible to apply asphalt surfacing on the main girder units prior to erection work. Apart from a better and less weather-dependent repair possibility, asphalt surfacing offers the advantage of impact cushioning and noise suppression.

The fast-assembly bridge system of the Rheinhausen type has been built by Krupp several times. Bridging equipment of this kind was delivered to Barcelona, Caracas, Rotterdam, Hannover, and Duisburg. The installations in Essen, Duisburg, and Caracas are shown in Figures 4, 5, and 6. The best example of the versatility in design is the bridge across the Aegidientorplatz in Hannover. This installation is shown in Figure 7.

Figure 4. Fast-assembly bridge in Essen where, because of traffic areas underneath, supports are located away from bridge.

The Aegidientorplatz is an important traffic center in the city of Hannover. Altogether, 7 streets converge into the roundabout. Two of these are 1-way streets; the remaining five have 2-way traffic. Five 2-way tram lines pass to and from the Aegidientorplatz. The trams run for long distances below the fast-assembly bridge parallel to the longitudinal bridge axis and also in the zones of the end ramps. Therefore, the end ramps had to be split into 4 separate branches to provide passages for the trams. The fast-assembly bridge crosses 4 motor roads and 3 tram lines and has to allow for

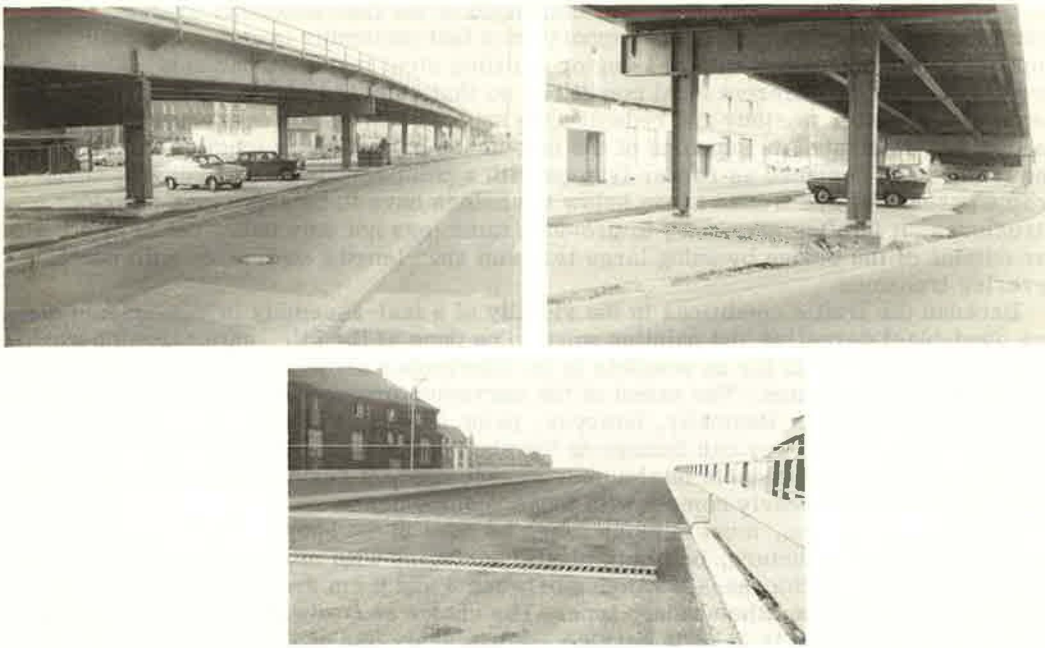

Figure 5. Fast-assembly bridge in Duisburg.

2 thread-outs of tram lines at the bridge axis. In addition, urban utility lines and old trees represent other factors that had to be considered in the design.

The fast-assembly bridge was built to create a relief roadway for one of the main traffic flows. Streets at the ground level remained unchanged. A subway construction site is expected to appear in the area of the Aegidientorplatz in the near future. The bridge is scheduled for 10 years' use at this location.

The fast-assembly bridge is composed of a 2-lane central portion having a travel way 7.50 m wide and four 1-lane descent branches 3.20 m wide each. The 2-lane central roadway is 222 m long, and the total length of the 1-lane descent branches is twice 253 or 506 m; the length of the fast-assembly bridge is thus 728 m. The 1-lane concrete ramps are 2 by 106 or 212 m long. The span lengths are between 11 and 28.5 m. The structure consists of 78 two-web main girders, 18 intermediate plates,

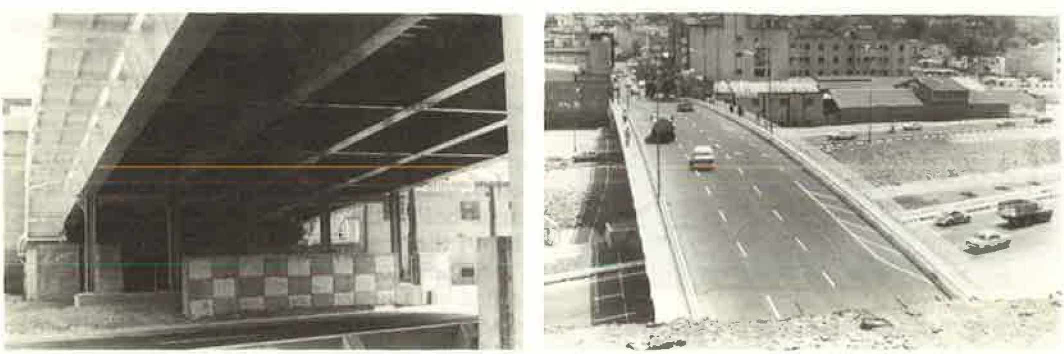

Figure 6. Fast-assembly bridge in Caracas.

Figure 7. Fast-assembly bridge in Hannover.

and about 40 wedge plates. The steel superstructure weighs about 1,023 tons corresponding to 311 kg/m^2, and the supports weigh 175 tons corresponding to 53 kg/m^2. The longitudinal grade changes from 0 to 6 percent. Maximum change in longitudinal grade at a bending point is 1 percent. Transverse grade is designed from 1 to 3 percent in accordance with the horizontal curves. In horizontal plane, the fast-assembly bridge is considerably curved. The angle at the center of the curvature circle is about 80 deg, and the curvature radius is about 90 m. Because of the length and considerable horizontal curvatures, the bridge was subdivided into 3 sections, which are separated from each other by expansion joints of a finger type of transition. Roadway surfacing consists of the adhesive primer already applied after sandblast derusting in the fabricating shops, a 1-cm thick mastic layer, and a 2-cm thick melted asphalt layer. Mastic and melted asphalt layers were applied when the bridge was erected.

The individual components of the superstructure were fabricated by Krupp in its Rheinhausen plant and by MAN in its Gustavsburg plant. By rail and road, the components were brought to a branch factory of Krupp in Hannover where the support frames were made and where the individual components were preassembled into erection units, each consisting of one 12-m long main girder with brackets, curbs, and crash barriers. As far as necessary, the intermediate plates were also attached to the main girders.

Erection at the site was completed on 5 weekends; in each case work was done from 4 o'clock on Saturdays until 3 o'clock on Mondays. A rigid time schedule was necessary, and punctual execution of the erection work could only be achieved with the extensive assistance of all municipal authorities. Subdivision of the 5 erection sections was made according to the traffic requirements so that car and tram traffic was only interrupted in the respective erection section during one weekend whereas, in the remaining sections of the Aegidientorplatz, traffic continued to run smoothly. The order was awarded to Krupp on May 17, 1968. The steel structure was erected on 5 weekends from September 21 to October 20, 1968. Prior to that time, foundations and concrete ramps were already made. The melted asphalt work was carried out from October 8 to October 30, 1968. As planned, the fast-assembly bridge was opened to traffic on November 1, 1968. There were 5½ months between order placement and opening. For fabrication and erection, about 4 months only were available.

In 1968, the contract price amounted to 1.785 million DM for the superstructure and the supports and to 285,000 DM for the foundations and concrete ramps, a total of 630 DM/m^2 of roadway area of the fast-assembly bridge. The fast-assembly bridge has been in service without interruption for 2 years. It is readily accepted by drivers, even by bus and truck drivers, although ground-level travel is still possible. Because of the melted asphalt surfacing, there is scarcely any traffic noise.

Despite the asphalt surface thickness of only 3 cm and a 6 percent longitudinal grade, the melted asphalt surfacing so far has shown only minor damage, which was easily repaired, although there were unusual climatic conditions during the winter of 1969-1970 and the summer of 1970. There have also been no difficulties with snow. At the bridge, an ice-signaling instrument has been installed; it measures the air humidity and temperature and, when the measure values are critical, signals the traffic service crew to sprinkle sand or clear the bridge.

According to the municipality's information, the fast-assembly bridge has been a success and has met all expectations. Fast-assembly bridges are a valuable help in overcoming innercity traffic problems.