rijkswaterstaat

three bridges over the maas-waal canal

7 english edition

bridge department voorburg

Three bridges over the Maas-Waal canal near Nijmegen

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Contents

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1. The bridges

Some 45 years ago a canal was cut to the West of Nijmegen to carry ships of up to 2,000 tons between the River Maas and the River Waal.
The growth of push-towing now necessitates the widening of the Canal from appr. 65 m to about 92 m, and, as a consequence, the rebuilding of two bridges which were in any case outdated.
A further bridge is also required owing to the growth of Nijmegen (figures 1 and 2).

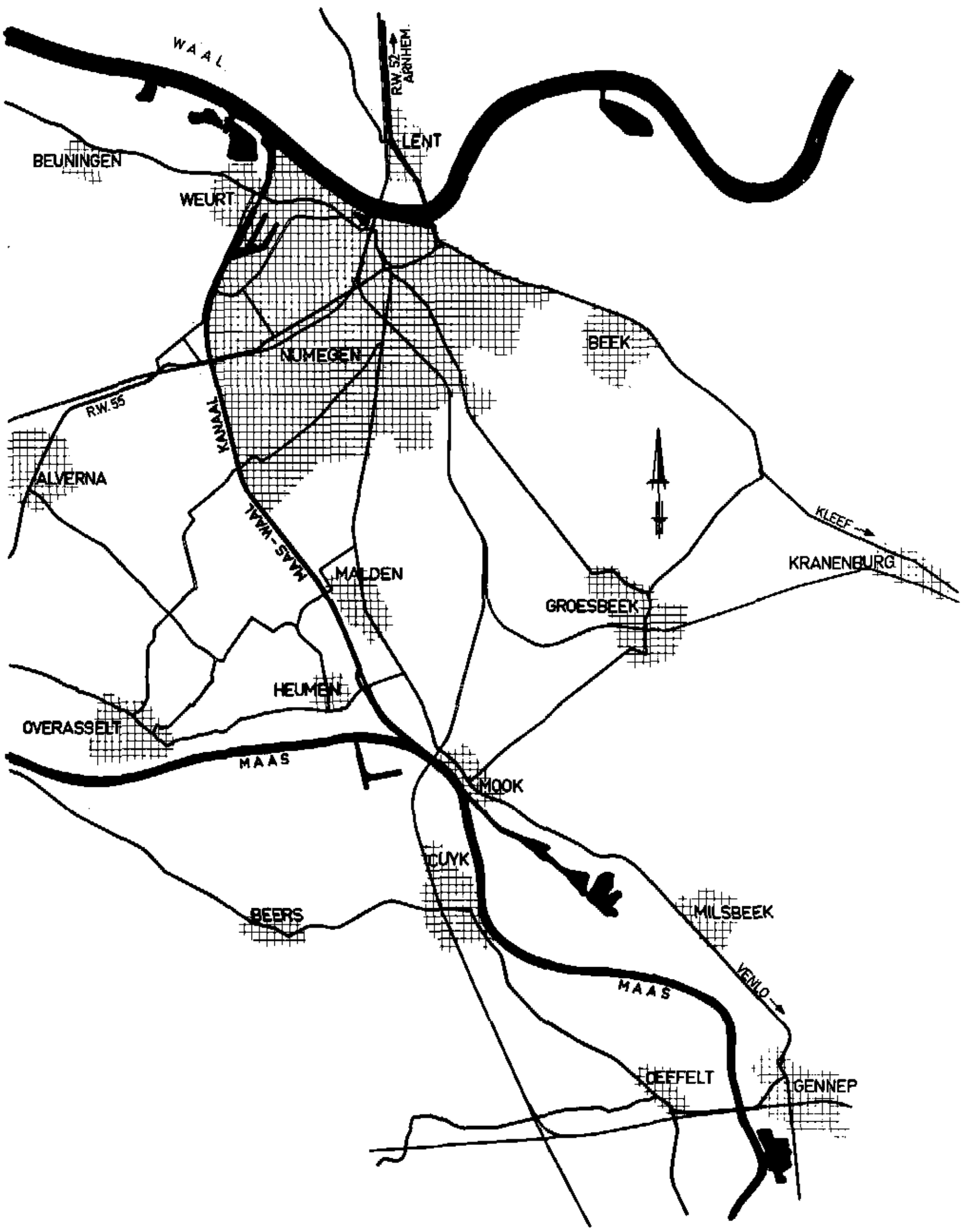


Figure 1. The Maas-Waal Canal

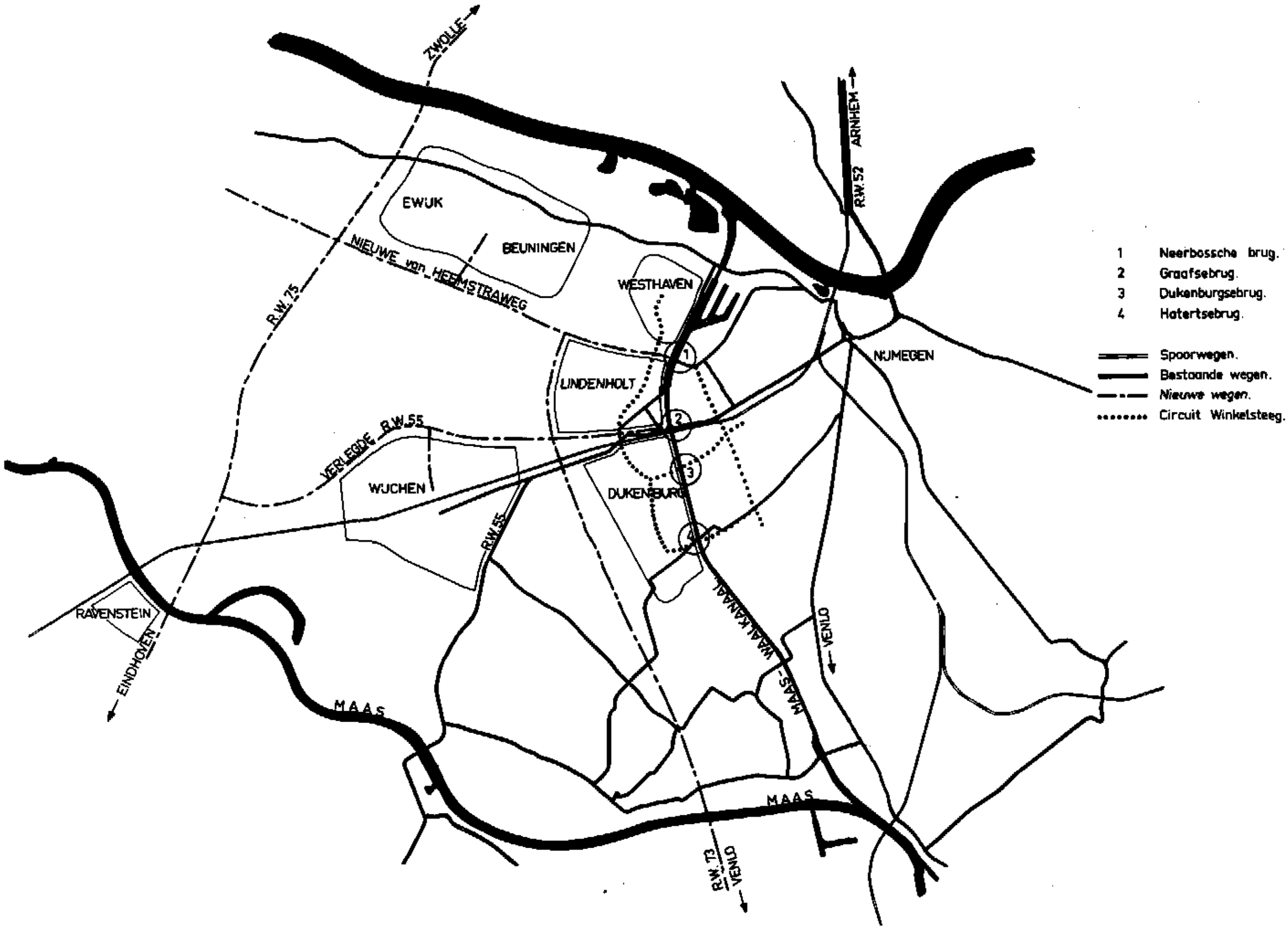


Figure 2. Main communication routes

*Spoorwegen = *Railways*
Bestaande wegen = *Existing Roads*
Nieuwe wegen = *New Roads*
Circuit Winkelsteeg = *Winkelsteeg „Circuit"*

The three new bridges are all of the same design, 28.7 m wide, the only difference being the lay-out of the traffic lanes on the bridgedecks. They have been designed to comply with the standards for bridges in the Netherlands of the highest load category (Category 60). Tenders were orginally invited by the Bridge Department for three different designs of three-span bridges, viz:

a. with a steel superstructure with spans of 37.4 m, 112.2 m and 37.4 m;
b. with a gravel concrete superstructure with spans of 47.6 m, 112.2 m and 47.6 m;
c. with a part gravel concrete, part lightweight concrete superstructure with spans of 37.6 m, 112.2 m and 37.6 m (figure 3).

Design c. specified that a 105.4 m section of the central span must be of lightweight concrete and the remaining parts of gravel concrete. Thus the lenght of the side spans could be reduced, since the support moment for the dead weight using lightweight concrete is some 26% lower than for gravel concrete.

When the tenders were opened in April 1970, a. proved to be the most expensive method and c. the most economical (see Table 1). The three bridges are now being constructed by method c. As can be seen from figure 3, both the piers and abutments have spread footing foundations on sandy soil. A 3 m thick underwater concrete layer was placed for the piers within a cofferdam. Otherwise, there is nothing remarkable about either the piers or the abutments.

Table 1

	Design		
Quantities:	A	B	C
Subaqueous concrete	5,580 m3	5,580 m3	5,580 m3
Concrete substructure	5,808 m3	8,880 m3	8,820 m3
Reinforced concrete superstructure		19,260 m3	10,350 m3
Reinforced lightweight concrete superstructure			6,660 m3
Dywidag prestressing steel bars Ø 32		223,890 m^1	186,600 m^1
Reinforcing steel	594 t	2,440 t	2,475 t
Sheet piles	8,169 m2	8,444 m2	8,169 m2
Cost price	D.fl. 18,100,000	17,400,000	16,800,000

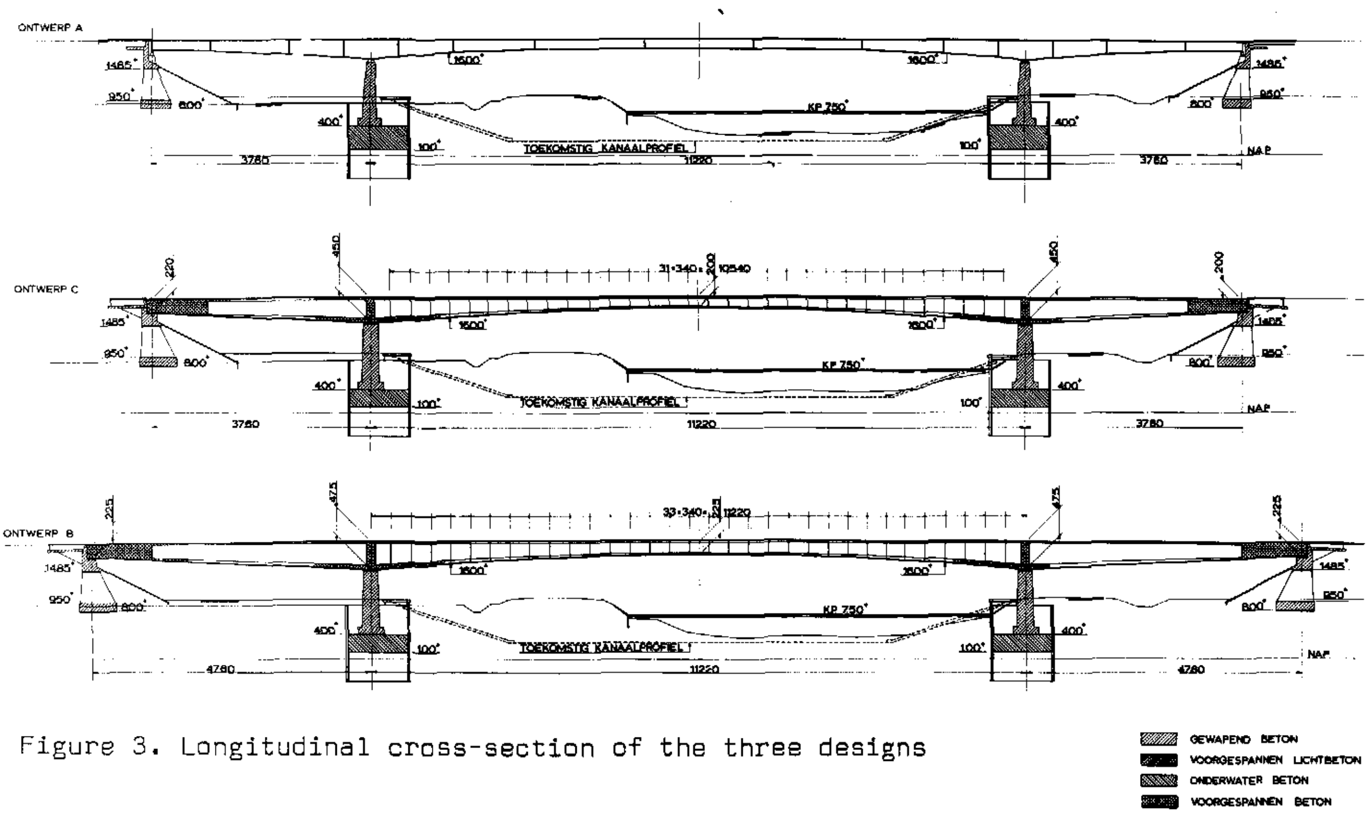
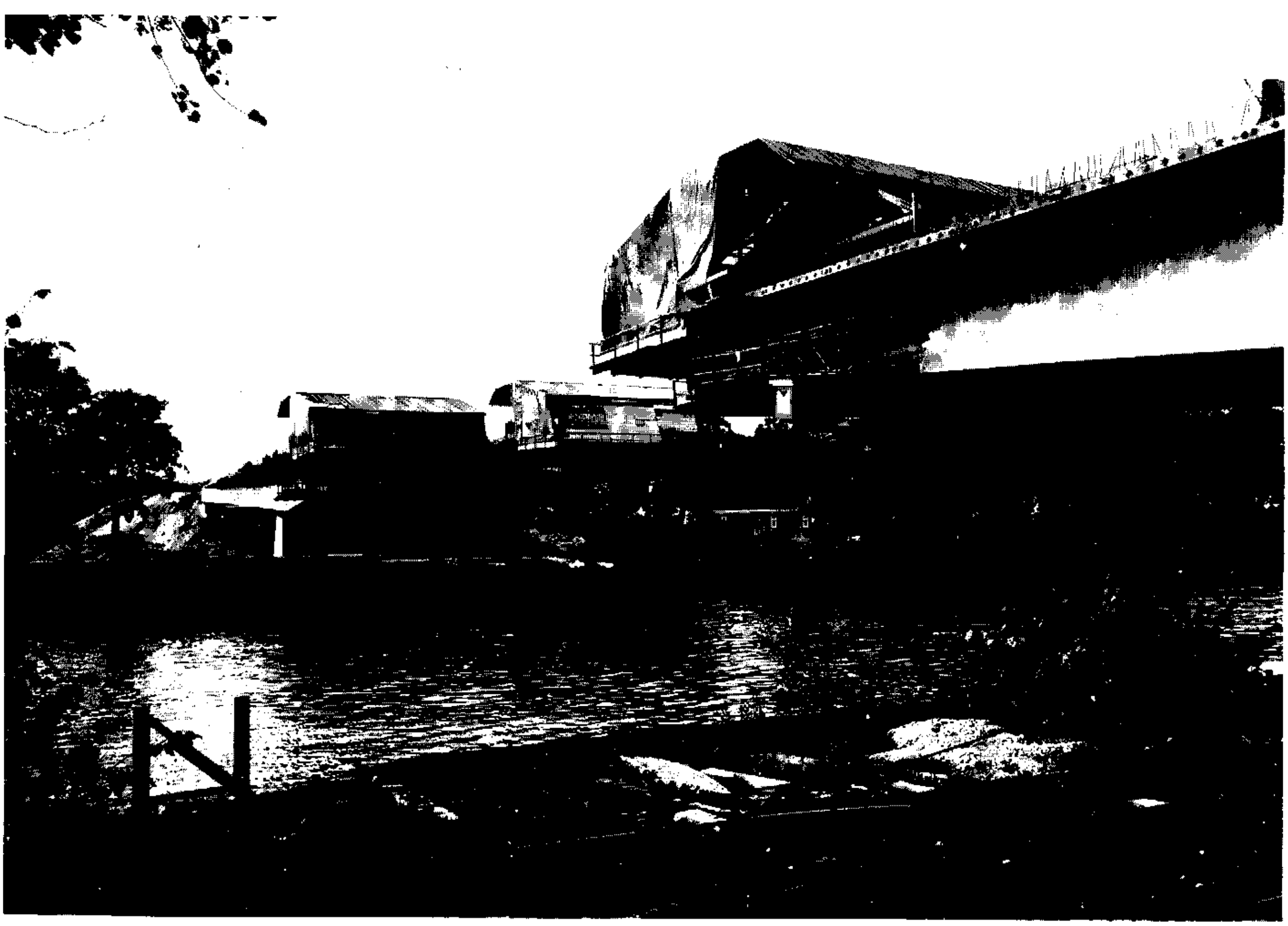


Figure 3. Longitudinal cross-section of the three designs

* Gewapend beton = *Reinforced concrete*
Voorgespannen lichtbeton = *Reinforced lightweight concrete*
Onderwater beton = *Subaqueous concrete*
Voorgespannen beton = *Prestressed concrete*

The superstructure is of course being prestressed. The side spans and the initial sections of the central span are being built of gravel concrete with the aid of scaffolding, and the 105.4 m lightweight concrete section is being constructed by the cantilever method using 3.4 m sections (figure 4). The end of the side spans is being built out to their full width so that even with maximum load on the central span the vertical reaction on the abutments is positive, well within the limits of safety. The side spans continue to be supported at an appr. central point, until the cantilevering has progressed far enough to eliminate the risk of setting up any excessive bending moments. The central span is then joined in the middle with continuity prestressing bars. Normal Dywidag bars (St 80/105 Ø 32) with anchorages are used for the transversal and longitudinal prestressing of the webs and the cross-girders above the piers.

Figure 4. Cantilever construction of first bridge (October 1971)



2. Lightweight concrete

To enable the mobile gantry to continually move forward without delay the bars concerned are stressed some 36 to 48 hours after concreting. This means that the lightweight concrete must by then possess a compressive strength of appr. 240 kg/ cm2.
Once this strength has been obtained the tranversal prestressing bars are first subjected to a lateral stress of about 30 tons per bar. The compressive stresses thus induced in the bridge deck reduce the split stresses set up in it by the longitudinal and web prestressing (55 t per bar). After these bars have been tensed the transversal bars are then also fully tensed (up to 55 t).
Table 2 shows the lightweight concrete mix proportions taken as a basis for the final mixes.
In the case of concrete applied on the site it is clear that the rapid attainment of a specified strenght will depend greatly on outside temperatures, especially when the concrete hardens quickly.
Tests showed between 220 and 300 kg/cm2 after 36 hours (average for 6 cubes). At the same time it should be borne in mind that the concrete of the bridge

Table 2

	Volume (dm3)	Net/Crude density (kg/dm3)	Weight kg
Portland Cement (rapid hardening)	116	3.1	360
Water in sand and) water/cement	163	1.00	163
mixing water) ratio: 0.45			
Plastifier (0,2%)	1		1
Air	10		
Dry sand	225	2.64	595
Efa filler	10	2.50	25
Korlin 5/10 (dry)	300	1.25	375
Korlin 8/18 (dry)	175	1.25	218
Water absorbed in Korlin 3-4%		1.00	23
	1,000		1,760 fresh concrete density

sections will generally show greater strenghts since the smallness of the cubes makes them over-sensitive in many respects.

The lightweight concrete sections were concreted using the mix specified in table 2. The concrete is prepared in a nearby concrete plant and carried to the building site by truck-mixers, which drive onto the side spans of the bridge and discharge the lightweight concrete into small motorised silo trucks which carry it to the place required. The lower floor and the webs of the box-girder are concreted with the aid of discharge hoppers and pipes (figure 5). High frequency internal vibrators are then used to compact the concrete.
Fresh lightweight concrete has proved most suitable for prestressing. Table 3 shows the results obtained from 59 cantilever segments.

Figure 5. Placing the lightweight concrete

Table 3

Test	Age of concrete	Number of samples	Average value	1% limit	5% limit	99% limit
Density before hardening (kg/m3)		165	1,755	1,695	1,713	1,815
Cube compressive strength	24 h	48	165	80	102	250
(Cubes 15.8 cm)	36 h	19	240	130	160	350
(kg/cm2)	7 days	105	324	228	255	420
	28 "	116	385	305	327	465
Splitting tensile strength (kg/cm2)	14 days	29	29.2	10	15.4	49
	28 "	26	29.7	13	17.8	46.7

3. The aggregates

The lightweight aggregate used, Korlin, is a clay expanded in a rotary kiln as produced in a new workshop of the Dutch State Mines (D.S.M.). Although several lightweight aggregates are available in Holland for the production of high-quality lightweigh concrete, Korlin was selected as it has produced the best results in both tests and building projects. When the type of building work undertaken permits low water-cement ratios, cube strenghts of 450-500 kg/cm2 can be obtained with it.

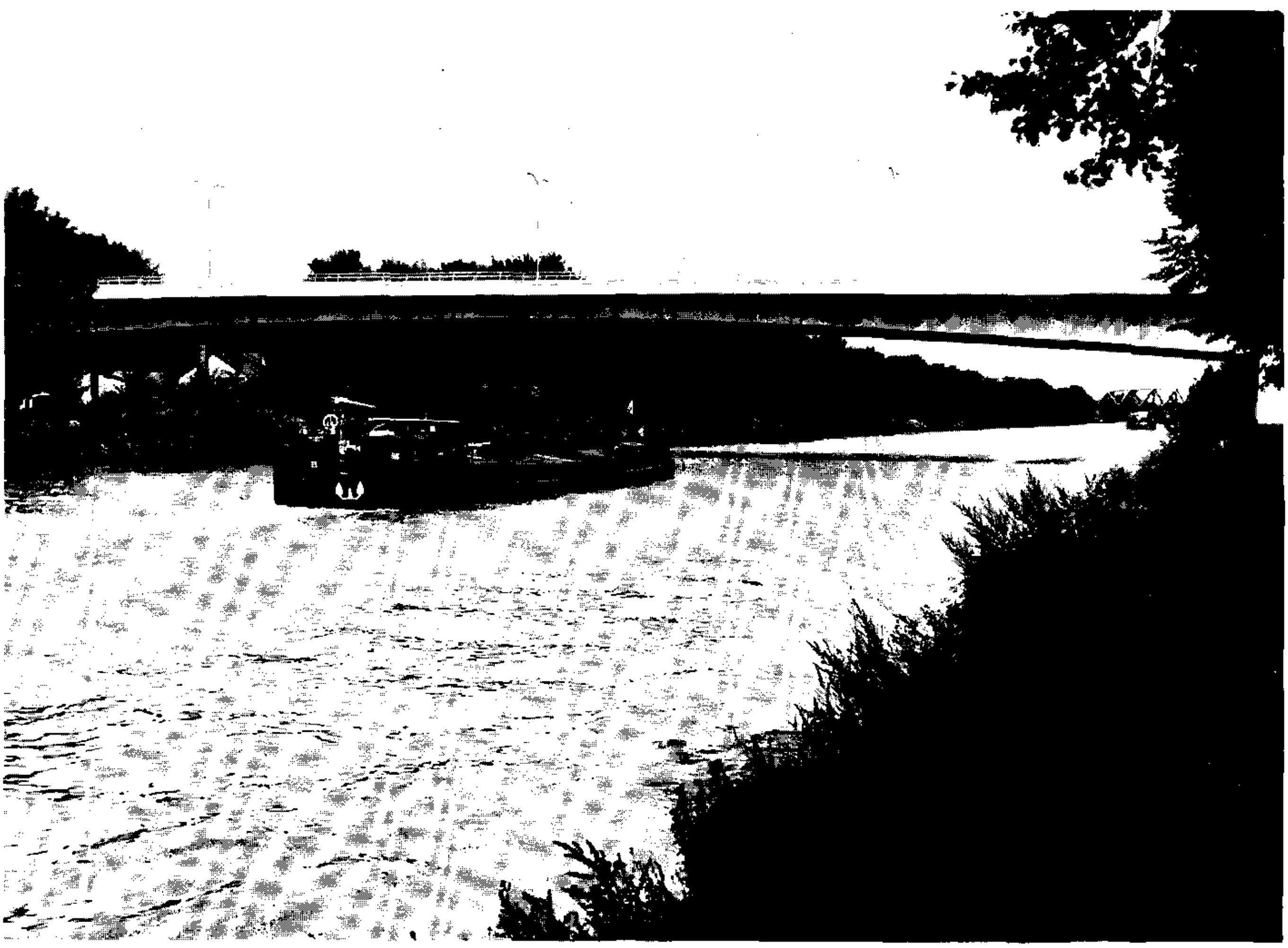
Furthermore, Korlin granules absorb relatively little water and have a good rounded shape, which is advantageous when placing the concrete. Efa filler is a flyingash used on account of the better surface sealing effect and better workability obtained, which makes possible a lower water/cement ratio.

4. Calculation assumptions for the use of lightweight concrete

Deadweight	1900 kg/m3
Elasticity module	210.000 kg/cm2
Permissible stresses	- 130 and + 5 kg/cm2

Creep and shrinkage: 20% higher values than those for gravel concrete of the same strength.

Figure 6. The first bridge completed (August 1972)



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