Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 47 (1983)

Artikel: Collapse of the bridge at Pulle

Autor: Vandepitte, Daniël

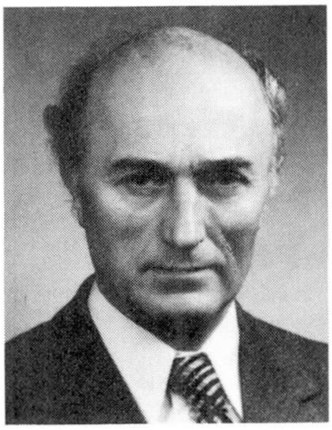
DOI: https://doi.org/10.5169/seals-36651

Collapse of the Bridge at Pulle

Effondrement du pont de Pulle

Einsturz der Brücke von Pulle

Daniël VANDEPITTE
Professor
Ghent University
Ghent, Belgium



Daniël Vandepitte, born 1922, got his civil engineering, master's and doctor's degrees at Ghent University and at Yale University (USA). He designed many bridges and supervised bridge construction, during 10 years as a civil servant in the Ministry of Public Works. He teaches structural analysis at Ghent University.

SUMMARY
The bridge at Pulle and its sudden failure after 8 years of service are described. The mechanism of the collapse is explained. As the investigation showed, the failure was due to the organizational set-up. The lessons that can be learnt from the collapse of the bridge at Pulle are not strikingly novel.

RESUME
Cette contribution contient une description du pont de Pulle. Le pont s'est soudain effondré après 8 ans de service. Le méchanisme de l'effondrement est expliqué. En dernière analyse le désastre était dû au mode de gestion de la réalisation et de l'entretien de la construction et de ses abords.

ZUSAMMENFASSUNG
Der Beitrag gibt eine kurze Beschreibung des Einsturzes der Brücke in Pulle. Acht Jahre nach ihrer Inbetriebnahme stürzte die Brücke plötzlich zusammen. Der Mechanismus des Einsturzes wird erklärt. Letztlich ist die Zerstörung der Brücke in Pulle auf die Art der Organisation der Erstellung und der Instandhaltung der Brücke und ihrer Umgebung zurückzuführen.

DESCRIPTION OF THE BRIDGE

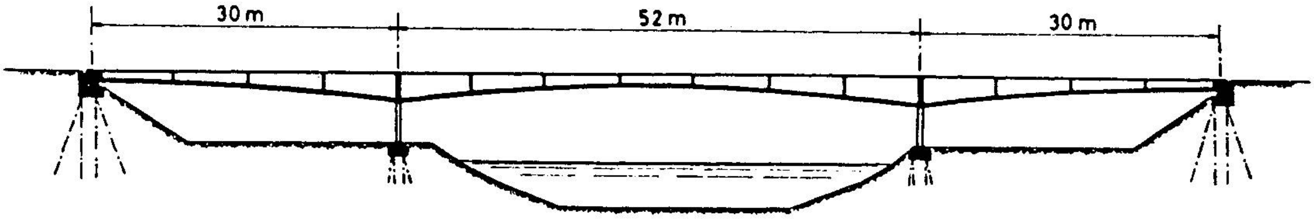


Fig. 1

The bridge at Pulle carried the Antwerp-Liège motorway across the Nete canal. Its spans were 30 m, 52 m and 30 m long (fig. 1). The concrete superstructure had 11 continuous prestressed longitudinal girders. The abutments and the piers were small concrete bodies supported by concrete piles. An unusual feature was the shortness of the piles under the piers : those under the east pier were only about 2.5 m long. This was due to the fact that a layer of sand was come upon which was so dense that the contractor was unable to drive the piles through it. The bridge at Pulle and 19 other bridges had been designed and built simultaneously under pressure of time in order to enable a section of the Antwerp-Liège motorway to be opened for traffic before a certain date. If the geotechnical report had reached the designers in good time they would probably have designed the piers with spread footings resting directly on the soil.

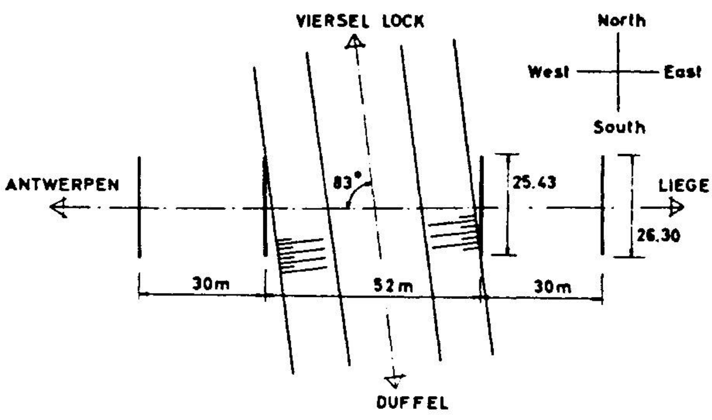


Fig. 2

The angle between the centre-line of the bridge and that of the canal was 83° (fig. 2). The centre of the east pier coincided at its southern end with the crest of the theoretical talus profile. Figure 3 is a vertical cross-section showing the relative position of the southern end of the east pier and the bank of the canal, drawn with its theoretical shape. The side slopes of the cutting were not protected by a lining of any kind. The newly completed bridge at Pulle was subjected to loading tests in September 1958. Its behaviour under a live load almost equivalent to the full (unfactored) design live load was entirely satisfactory.

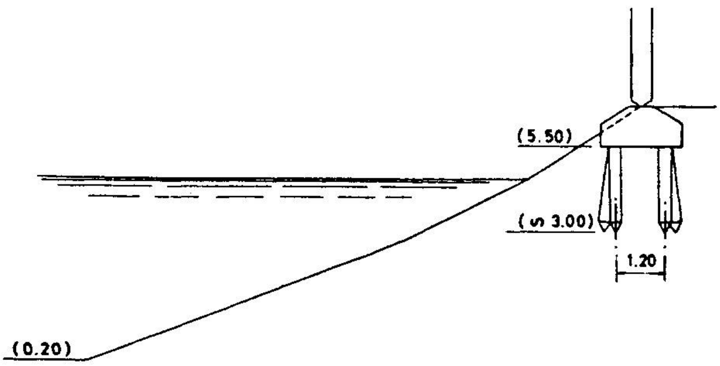


Fig. 3

THE COLLAPSE AND ITS CAUSE

Eight years later, on 12 November 1966, the bridge collapsed without warning in het middle of the night while no vehicles were passing over it. An investigation showed that the bridge had been well designed and built, that the concrete was of excellent quality, that the prestressing steel possessed the necessary strength and that it had not been weakened by corrosion. Measurements revealed that the east pier had moved considerably towards the canal, settled and tilted. This is visible in figure 4, which consists of 3 cross-

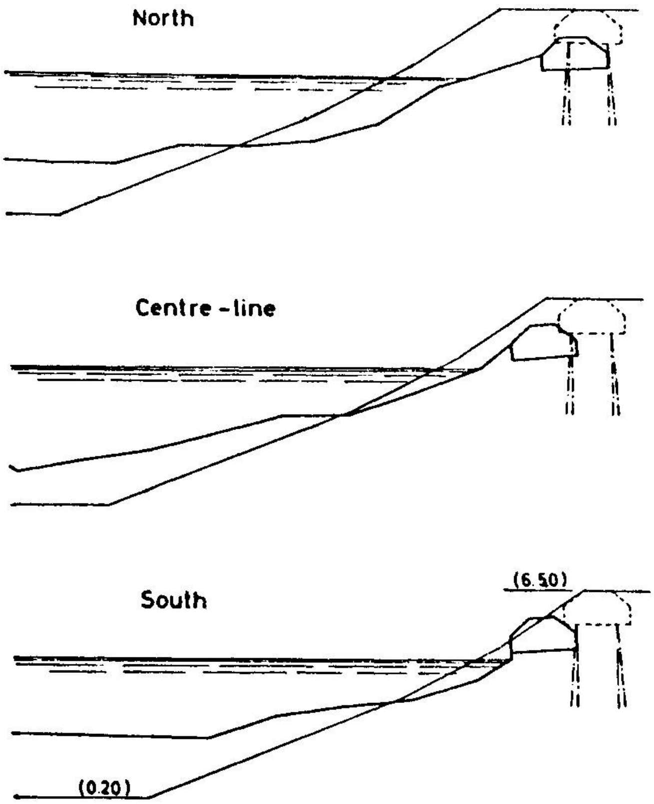


Fig. 4

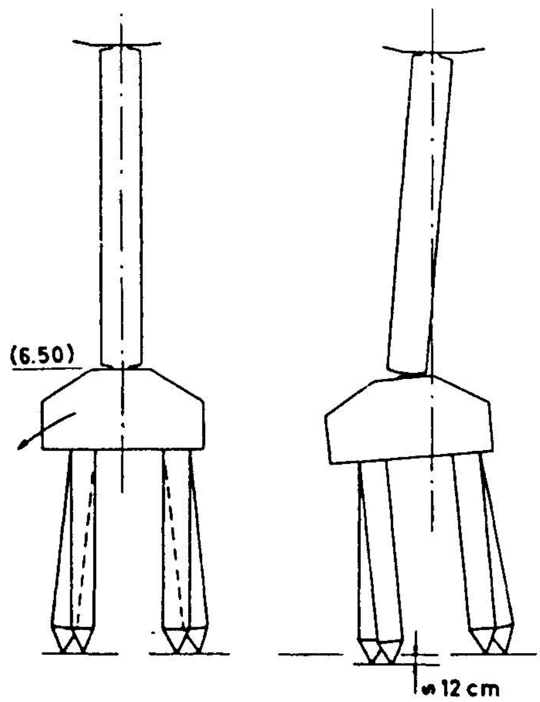


Fig. 5

sections and which shows the theoretical and the actual profiles of the canal, and the initial and the actual positions of the east pier. The amplitude of the displacement of the east pier was the greatest at its southern end.

The east talus of the canal was in very bad shape over the width of the bridge and also immediately to the south of it. The severe local scour which the east bank had undergone was mainly due to the proximity, just to the north of the bridge, of the Viersel navigation lock in the Nete canal. Barges awaiting their turn to lock through halted under the bridge or just to the south of the bridge, alongside of the east bank. When their turn came they started off and it is easy to imagine that the stir caused by their propellers a few metres from the bank slowly eroded the unprotected talus.

The scour gradually removed the soil near the points of the left hand piles in figure 3 . As a consequence the carrying capacity of those piles decreased. Figure 5b shows the configuration of the piles, the east pier and the concrete rocker bearing corresponding with an assumed 12 cm settlement of the piles on the canal side. The resulting inclination of the rocker increases the load acting on the left hand piles, thus accelerating the subsidence and the whole displacement of the body of the pier. Hence, once the settlement of the piles and the movement of the pier had begun, its horizontal displacement increased so rapidly that the foot of the rockers soon slid off the pier and that the main girders came crashing down.

So the cause of the collapse was erosion of the east bank of the canal in the immediate vicinity of the points of the canalside piles under the east pier. The bridge would not have failed if *either one* of the following situations had obtained :

1) Piles long enough to extend a few metres below the theoretical level of the bottom of the canal.
2) Canal banks efficiently protected against scour under the bridge and on either side of the bridge.

ORGANIZATIONAL SET-UP - RESPONSIBILITY FOR THE COLLAPSE

The engineer who was responsible for supervising the construction of the bridge and who was a civil servant in the Roads Division of the Ministry of Public Works was indicted. He was acquitted by the court. In the opinion of the writer acquittal was the proper verdict because the bridge possessed the required carrying capacity when it was built and because its foundations, in particular, did not constitute weak points at that time, in spite of the unorthodox shortness of the piles under both piers. The Nete canal and its banks, whose gradual deterioration had eventually caused the failure of the foundation of one of the four supports of the bridge, were the responsibility of another agency, the Navigable Waterways Division, of the Ministry of Public Works. Apparently the Roads Division did not know that the Navigable Waterways Division did not plan to protect the canal banks against scour, and the latter agency presumably did not suspect that the tips of the piles under both piers were situated close to the slopes and several metres above the level of the bottom of the canal.

The files pertaining to the bridge contained design drawings showing pier foundation piles having the originally intended length, i.e. piles much longer than the actual ones. After the failure no drawing was found similar to figures 1 and 3 and showing the real position of the tips of the piles with respect to the theoretical profile of the canal. The mere existence of such a drawing might have been sufficient to make someone realize the potential danger and induce him to ward it off. In the last analysis the collapse was due to fragmentation of responsibility and of the power of initiative and decision. Far too many different parties were in some way connected with the project : the contractor, an independent civil engineering design office, and no fewer than 4 agencies of the Ministry of Public Works : the Soil Mechanics Laboratory, the Bridge Design Bureau, the Roads Division and the Navigable Waterways Division. It was, more specifically, the poorness of communication between the two latter agencies which turned out to be fatal.

CONCLUSIONS

The lessons to be learnt from this failure are not strikingly novel. They can be phrased as follows :

1) mainly, the danger inherent in dispersion of responsibilities,
2) the imperative need of effective communication between all the parties involved, if responsibility for the creation and for the upkeep of a structure cannot be concentrated in a single spot for whatever insuperable legal or organizational or other reason,
3) the necessity for scale-drawings showing, without distortion, the configuration and the proportions of the whole real structure and of its parts,
4) and the vital importance of maintenance extended to the environment of the structure proper.