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DAFNE SCHIPPERSBRUG: DESIGN AND CONSTRUCTION

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Summary

This paper describes the design and construction of the Dafne Schippersbrug over the Amsterdam-Rhine canal in the city of Utrecht, the Netherlands. This mixed use pedestrian/cyclist bridge provides a new link between the historic centre of Utrecht and the new development area of Leidsche Rijn. The discussion includes the selection of the bridge form, the design of the tuned mass dampers to control pedestrian induced vibrations, the aerodynamic investigations for potential wind induced vibrations as well as the construction sequence implemented for the erection of the bridge.

Keywords: suspension bridge; slender concrete deck; dynamics, lateral lock-in; synchronous lateral excitation; wind tunnel tests

1. Bridge design

The Dafne Schippersbrug is a ground-anchored suspension bridge with a main span of 110 m, the total length including the approaches being approximately 280. The suspension system has an unsymmetrical arrangement consisting of two steel pylons of different height that support the cable system which in turn suspends the concrete deck. The cable system consists of two 105 mm locked coil main cables, with 26 mm inclined spiral strand hangers. Four 93 mm locked coil backstays on each side connect the steel pylons to the anchorage that consists of 16 grout injection anchors, making this the first ground anchored suspension bridge in the Netherlands. The unsymmetrical configuration was chosen on basis of geometrical/site requirements along with architectural considerations. On the side of the city centre (east bank), an existing road and a newly to be designed school were situated very close to the planned location of the east pylon. This put a limit on the height of the pylon as the anchorage cables need to land before the road without making their angle very steep. This would significantly increase the stay cable force and the load on the anchorage foundation. The development area on the west side of the canal allowed for more freedom in the

Fig. 1. Dafne Schippersbrug

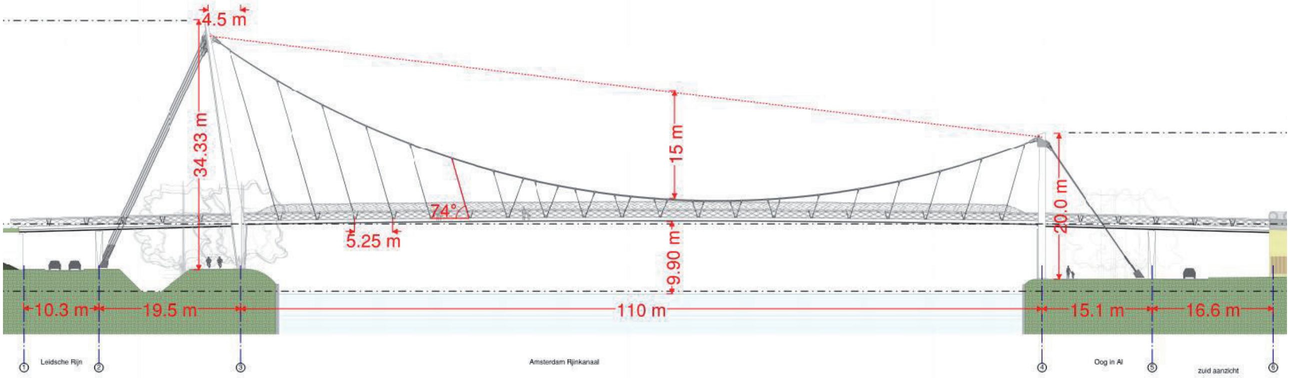

Fig. 2. Elevation of the Dafne Schippersbrug

choice of the pylon and anchorage cables geometry which were determined by optimising the overall structural system by increasing the height of the pylon and thereby also the sag of the main cables, compensating in this way for the limited height of the east pylon.

2. Dynamic behaviour

The expected dynamic behaviour made the requirement for tuned mass dampers (TMD's) very likely. The heavily reinforced concrete deck does not allow for retrofitted dampers, but has been designed with the option to facilitate the dampers by means of providing holes in the deck. As the potential locations of the TMD's needed to be determined before the dynamic measurement of the bridge, a thorough dynamic analysis was performed, including a sensitivity study in order to ensure that the holes were in the right position. This way it is ensured that enough damping can be added in the final situation to tackle all possible dynamic problems, including synchronous lateral excitation.

3. Bridge construction

The challenging geometric constraints, the absence of an architectural edge detail and the limited allowance of the deck for locked-in stresses, required a complex construction scheme. The deck was installed as 10 prefabricated concrete sections of 9 meters long connected by a 1,5 m wide stitch joint. The inclined hanger configuration needs the deck to balance horizontal forces from either side of the deck. The contractor set up temporary frames to deal with these horizontal forces, which were also used to lift the segments in place. The joints between the concrete deck segments were cast in-situ. The shape of the bridge and forces in the different elements during the concrete curing was an important factor for the final shape and stresses in the deck. Detailed analysis showed that the use of ballast was necessary during construction. The weight of the 8 ton curing concrete at the stitch joint needed to be present at the joint locations to keep the whole system balanced throughout the process. The ballast was gradually removed during the casting of the concrete joint.

4. Conclusions

The bridge provides an important link for pedestrians and cyclists between the city centre of Utrecht and the new development area of Leidsche Rijn. The slender deck of the bridge along with the asymmetrical arrangement minimise the visual impact of the bridge on the surroundings and are a good example of how a close collaboration between engineers and architects can lead to an appealing and efficient design that gives a proper response to the local geometrical constraints of the site. Choice of material took into account issues of economy and low maintenance in order to increase the required inspection intervals and hence reduce hindrance to the canal traffic during the in-service life of the bridge as much as possible. Maximum use of prefabrication ensured a high quality finishing and a reduction in canal closure during construction of the bridge. A close investigation of all potential dynamic effects during the in-service life of the bridge is of paramount importance as they can significantly affect the design of a footbridge. A close communication between client and consulting engineer is required to ensure sufficient comfort levels for pedestrians for different scenarios without resorting to overly conservative solutions.