Structural Response due to Violent Wave Impacts on a Vertical Structure with a Cantilevering Slab

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Summary

The Pier of Blankenberge, located along the Belgian coast is a structure consisting of a vertical core attached to an overhanging horizontal slab, which is exposed to violent wave impacts on the vertical and horizontal parts. This introduces an important uplifting force. The lift forces consist of impact loads of high magnitude and short duration. As opposed to purely vertical or horizontal surface type structures, structures consisting of both vertical parapets and horizontal cantilever slabs have rarely been considered. The behaviour of cantilever structures above sea level is similar to bridge conduct, since the incident loads vary with time and space. The effect of wave impact on the lower side and the vertical parts of a cantilever structure above sea level, results in local patch loading on a swaying system, introducing local deformations, stresses and accelerations, whose peak values are not necessarily relevant for the entire structural behaviour. This patch loading, moving rapidly with time, as an upward pressure front, acting on the lower side of the cantilevering platforms may cause local deformations, but does not necessarily cause collapse or endanger neither structural equilibrium nor stability. The pressure wave is a frontally moving load, limited in time and space, its sign instantaneously being reversed immediately nearby the maximum wave amplitude. Fundamental insight in the structural response of cantilever structures above sea, subjected to wave impact, is being developed in the research for this manuscript. The main objective of this article is the study of the structural response of the monolithic overhanging structure. The focus is on the structural response of the structure. This is analysed by numerical modelling of the structural response based on recently proposed design values for such wave loading.

Keywords: Wave impact, cantilevering slab, dynamic loading, prototype measurements, finite element modelling.

1. Experimental set-up

Physical model tests have been carried out in the wave flume (30 m x 1 m x 1.2 m) of Ghent University (Belgium). The flume is equipped with the testing technology including an advanced wave generator system for regular and irregular waves, active wave absorption, data acquisition system and wave data analysis software.

The Pier of Blankenberge which is located along the Belgian coast is shown as an illustrative example of a vertical structure with an overhanging horizontal cantilever slab. This building (Figure 1 & 2), constructed on piles in the intertidal zone, has been renovated between 1999 and 2002. The renovation consisted partly of constructing a concrete core for the building from the sea bottom up

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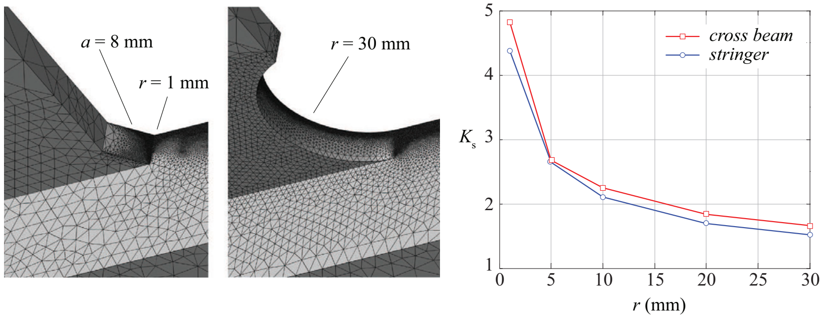
2. Fatigue assessment

A fatigue assessment is performed based on measured strain data. Long term continuous measurements have been performed, from which the response of passing trains are extracted. The stress collective is calculated based on Rainflow cycle counting. The fatigue service life is estimated based on Palmgren-Miners linear damage rule and available data on daily traffic intensity.

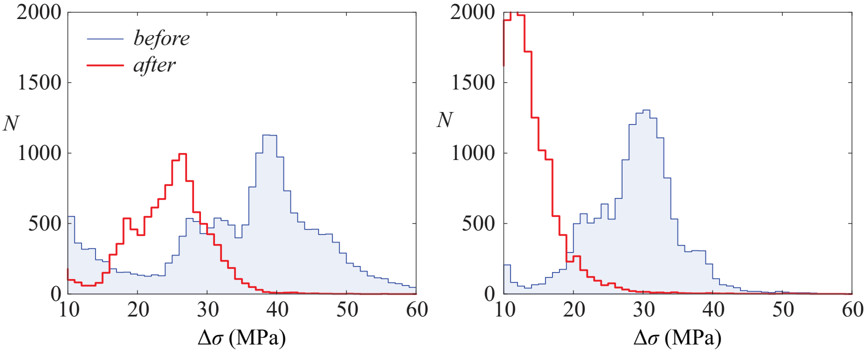
Geometrical improvement by a radius transition of the transverse gusset plate is proposed. The geometry of the gusset plate to cross beam flange is shown in *Fig. 2a*), the resulting notch stress concentration factor K_s as function of the radius r is presented in *Fig. 2b*).



a) b)

Fig. 2: Stress concentrations evaluated based on FE-analysis, a) detailed model of the transverse bracing on the cross beam lower flange, b) resulting stress concentration factors at the weld toe as function of the radius r.

A geometrical improvement by cutting a 20 mm radius was performed on two locations on the bridge. Additional field measurements were performed before and after the improvement. From the obtained stress collectives, *Fig. 3*, a large stress reduction was achieved, resulting in a significant improvement of the remaining fatigue service life.



a) b)

Fig. 3: Stress collective based on measured strain before and after geometrical improvement, a) stringer, b) cross beam.