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PROTOTYPE MONITORING OF SHIP WAVE ACTION ON A NATURE FRIENDLY BANK PROTECTION IN A NON-TIDAL, CONFINED WATERWAY

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1. Introduction

The road towards a sustainable inland waterway network entails the installation of an ecologically sound and technically effective bank protection. A lack of information regarding design and installation criteria still results in repetitive construction and installation mistakes, especially where a harsh hydraulic climate limits the environmental carrying capacity of the waterway.

Heavy shipping traffic is the key opposer for nature friendly bank protection on confined, non-tidal waterways. Because ship characteristics vary with ship design and operation, interact with topographic boundaries and locally change hydraulic conditions, ambiguity is likely to persist in absence of direct field measurements. Accordingly, an innovative stand-alone prototype monitoring system is designed and installed on-site. It is primarily developed to quantify the ship wave-generated loading and forcing on the nature friendly bank protection and to assess the technical performance of its structure and configuration both on short and long term. That's why, next to a fixed monitoring system, a mobile, easy-to-use system is also worked out by re-engineering the instrumentation. Data acquisition started as from 2010 onwards. Since June 2011, a few test cases with varied configurations of the prototype were additionally monitored.

2. Site selection

In the seventies, the river Lys was straightened and canalized to allow inland navigation up to ECMT-class IV. Nowadays, the demand of benefit maximization in goods traffic urged the waterway administration to allow ships up to ECMT-class Va (up to 3000 ton). Heavy shipping traffic resulted however in failure of the rigid armoured concrete slabs. The revetment became undermined and broke, which resulted in progressive bank erosion. Within the framework of the Seine-Scheldt project, a more nature friendly solution for embankment restoration was opted for (Maes et al., 2006). The selected technical-biological method consists of off-bank timber piling in combination with (reed) vegetation.

Site selection was guided by the need to find a location in a rather straight section of the waterway in order to maximize the ship-induced forcing, where ships can sail on the maximum allowed speed of 12 km/h (taken into account that the potential critical speed is further restricted with roughly 30% because of the reduced water depth given the drawdown (PIANC, 2008). A site in Zulte (Belgium), southwest of the city of Deinze, satisfied the criteria. It is located in the most downstream part of the canalized river Lys, 1.5 km before the river's splitting into the Schipdonck channel and the Tourist Lys.

3. Prototype monitoring systems

Because of the confinedness of the waterway, the primary wave system of a ship, propagating in the navigation direction, transfers the largest amount of erosive energy towards the river bank. It is characterized by a significant water level depression along the hull of the ship and a surge of water. Neglecting the Kelvin's angle at which the cusp locus line of the secondary waves propagates, a perpendicular cross-shore set-up is chosen for the measurement setup.

3.1 Fixed monitoring system (Figure 1)

A variety of physical processes related to ship-generated waves are taken along the design of the fixed monitoring system: 1. Incident ship wave characteristics, measured in the fairway in front of the off-bank timber piling using a pressure sensor; 2. wave-structure interaction, measured just after the off-bank timber piling with a pressure sensor; 3. wave refraction and reflection by bottom friction and bank proximity, measured in the shallow water environment applying pressure sensors; 4. Ship excentricity, registered with a laser distance meter; 5. sediment (re)suspension and transport on a per ship base, monitored in the shallow water environment using optical backscatter devices and 5. local hydrodynamic velocities, recorded in the shallow water environment making use of an acoustic Doppler velocimeter (ADV). Next to continuous high-frequency data acquisition of the processes under 1 to 4., physical properties related to 4. and 5. are temporarily measured.

The continuously monitoring devices deliver an output signal that is transmitted through cables to locked storage boxes located on the river bank, containing the data logger, battery power supply and solar panel charger. Off-line, the raw data is prepared for processing by reorganising it from a per time in a per channel structure. The analysis methodology for the pressure time series is thoroughly commented in De Roo & Troch, 2010.

3.2 Mobile monitoring system (Figure 2)

The mobile measurement system is designed for swift and easy-to-handle installation. Made out of aluminium parts, a lighter, more modular method of mounting is chosen. Using pressure sensors on both sides of the off-bank timber piling, wave-structure interaction is investigated. Data acquisition and storage are assembled in a compact waterproof PVC housing which can easily be transported and even mounted underwater.

Figure 1 Large stand-alone prototype monitoring system.

Figure 2 Mobile, easy-to-handle monitoring system.

4. Conclusions

To mend the knowledge gap regarding design and installation criteria of nature friendly bank protection, a twofold experimental approach is opted for. Firstly, an extensive, large and stand-alone monitoring system is installed on a prototype of the selected sustainable bank protection. Instantaneous, high-frequency data on water level fluctuations are continuously recorded, together with ship characteristic features (speed, excentricity). In combination with short-term measurement campaigns to identify the ship wave's signature regarding flow velocity alterations and sediment transport, a complete outline of the impact of shipping traffic is achieved. Secondly, an easy-to-use mobile monitoring system is developed to carry out additional measurements on various configurations of the off-bank timber piling.

From 2010 onwards, a detailed data base is set up and serves in-depth research into the physical processes related to ship passage on confined waterways as well as supports further improvement of technical feasibilities for nature friendly bank protection in this riverine environment.

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