LCM 2019 WORKSHOP — ialcce —

Workshop on
Life Cycle Management
27-29 October Rotterdam

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Quantifying the effect of foundation stiffness on offshore wind turbine dynamic response

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ABSTRACT:

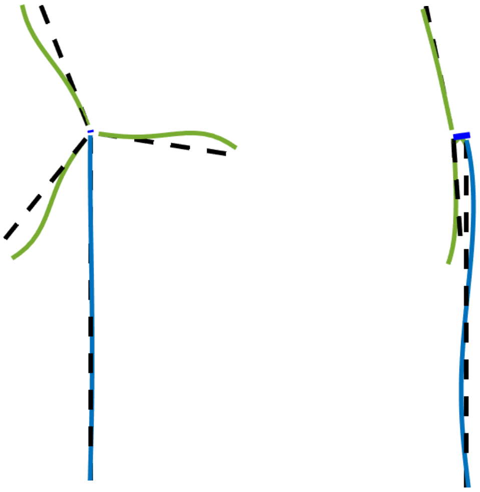
There are inherent uncertainties relating to the structural properties of offshore wind turbines (OWT), particularly with regard to the foundation. It is hypothesised that inaccuracies in foundation design models commonly result in over-conservative monopile designs and incorrect prediction of the dynamic behaviour [1]. This in turn causes erroneous fatigue life prediction, which dictates the perceived service life of the structure.

This current work investigates the effect of OWT foundation characteristics on data obtained from dynamic sensors, such as accelerometers along the tower. Various foundation models and soil stiffnesses are compared, using the wind turbine simulation tool FAST to model the structure and generate synthetic data. The sensitivity of particular dynamic characteristics, i.e. natural frequencies and modeshapes, of OWT structures is assessed. For example Figure 1 shows the modeshape of an OWT vibration mode that contains contributions from the foundation rotational compliance, as well as the flexibility of the blades and tower.

The results are assessed within an indentification framework, investigating the feasibility and robustness of identification methods to properly track the foundation properties of OWT monopiles from monitoring data. The long term goals of this work are to facilitate the:

- remote detection of foundation damage, for example scour,
- assessment of the remaining operational life,
- optimisation of future monopile designs.

These applications contribute towards the life cycle management of OWT and offer significant potential for both CAPEX and OPEX savings.



a) Front view b) Side view

Fig. 1. *Example of an OWT modeshape with contribution from foundation rotation*

References:

1. Kallehave, D., Byrne, B.W., LeBlanc Thilsted, C. and Mikkelsen, K.K., 2015. Optimization of monopiles for offshore wind turbines. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 373(2035)

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Damage detection in bridges by means of structural monitoring: problems and possibilities

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ABSTRACT:

The early detection of critical states in bridge structures is a problem of paramount importance for the safety of the road users. Furthermore, the capability of grading the health state of infrastructures can drive a more effective maintenance planning with a cost saving. Starting from the early aerospace and mechanical applications [1], a huge literature dealing with bridge structures has been set out, including some full scale testing of decommissioned bridges such as the one of Z24 bridge in Switzerland [2]. However, the signal modifications due to damages are very small, the detection errors can be large, and dynamic nonlinearities play a very important role when cracking in prestressed or reinforced concrete structures is the focus [3]. Finally, fatigue of corroded elements is far to be fully understood. Inside the SHAPE project of the ERA Net Infravation 2014 call, the research group decided to build two specimen bridges in scale 1:4 (6x3 m2) in order to assess experimentally the dynamic changes due to imposed subsequent loading levels producing damage in the structures. Although realistic models have a consistent cost and require huge testing facilities, it seems that at the present stage of development of the damage detection techniques a common effort of the interested researchers in building a larger number of scaled down experimental bridges could be helpful in comparing different detection tools and techniques. Sovranational organizations with experimental stations could agree in sharing a set of bridge specimens covering the most common geometries and structural types. Furthermore, some typical damage causes could be definied and applied at different extent or level, in order to set out a repository of signals recorded on the different models. By this way, a common basis could be established finalised at the evaluation of the powerfulness of the damage identification techniques in a more realistic way with respect to the use of numerical models, certainly easier to use, but in many cases unrealistically simple.

Fig. 1. *The 1:4 scale model bridges (above). The composite bridge (left). The concrete bridge (right)*

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1. S.W. Doebling, C. R. Farrar, M. B. Prime, D. W. Shewitz (1996) Damage Identification and Health Monitoring of Structural and Mechanical Systems from Changes in Their Vibration Characteristics: A Literature Review. LA-13070-MS, UC 900, Los Alamos National Laboratories, New Mexico US.
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Effective risk management of embankments along transport networks using InSAR monitoring

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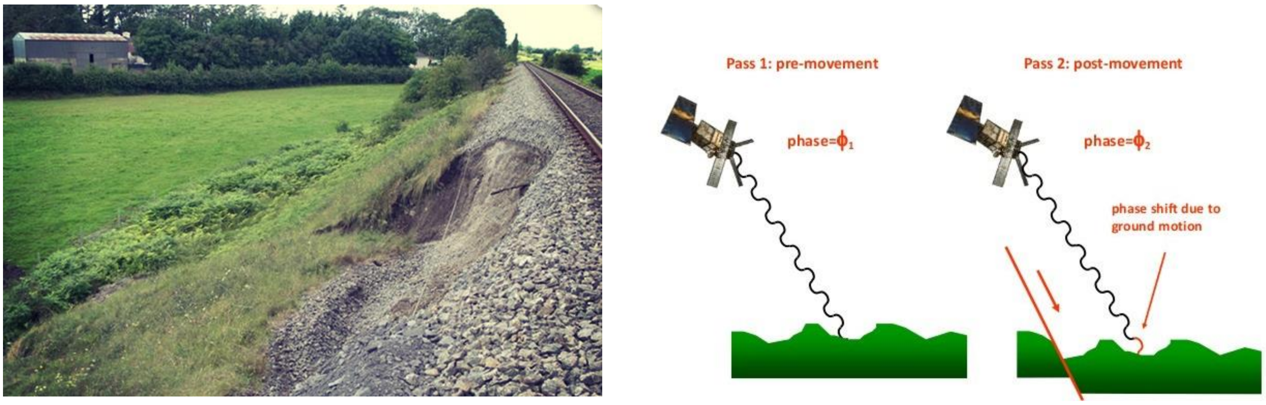
ABSTRACT:

The effective management of earthworks along transport networks, including road, rail and inland waterway networks, is necessary to ensure the reliability of network services and the safety of transport users. Networks generally comprise a large number of earthwork assets and, furthermore, infrastructure owners are faced with limited annual maintenance budgets. As such, a risk management approach should be adopted to ensure the reliability of earthworks along transport networks. This can be used to quantify the risk of slope failure for individual assets (see example failure in Figure 1a) and, therefore, to prioritise slope remediation works to prevent failures. As part of this risk management strategy, asset monitoring may be employed for embankments that are of particular concern to the infrastructure owner. However, traditional in-situ monitoring is costly, time consuming to install, and is generally limited to a small number of assets. Remote sensing, including interferometric synthetic aperture radar (InSAR) monitoring, offers the potential of a cost effective, high frequency monitoring dataset that can be employed as part of a risk management strategy for earthworks along transport networks to detect ground movements (Figure 1b). This study has investigated the ability of InSAR data to detect pre-failure displacements for a number of embankments where slope failures occurred in recent years. The aim was to demonstrate the ability of InSAR monitoring to detect pre-failure displacement, which could be employed as part of a risk management strategy for embankments to prevent failures in the future. Specifically, a Permanent Scatterers (PS) InSAR method of analysis was employed since this method has been shown to be capable of detecting millimetre scale displacements for large areas over long observation periods. This study has compared the results of a PS-InSAR analysis to in-situ measurements for a number of embankment locations along the railway network in Ireland.



a) b)

Fig. 1. *a) Example embankment failure at Manulla Junction, Co. Mayo Ireland in 2007 [1}, b) InSAR measurements to detect movements at the Earth's surface.*

References:

2. Joyce, C. (2016) Improving the resilience of Ireland's rail network: a decision support tool for slope assets. Engineers Journal, 13th December 2016.

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Life cycle model for railway tunnel Brajdica in Croatia

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ABSTRACT:

Tunnels are one of the most critical structures on transport infrastructure networks, especially in the context of being vital links for the society, having huge impact on the economy and environment. They are designed and built for a very long life cycle of which a major part is the operational phase with all related maintenance activities.
This work presents the implementation of structural health monitoring in the railway tunnel Brajdica which is a part of Zagreb-Rijeka railway line and connects port of Rijeka with the TEN-T network. The tunnel was built between 1897 and 1900 amd it is currently undergoing a major reconstruction project, during which an extensive embedded monitoring system will be installed. The monitoring system includes a large range of equipment including inclinometers, extensometers, micrometers and survey markers which will be supplemented with periodical scanning of the tunnel interior using laser scanners. Measurement profiles will be set along the tunnel bore and the data collected will be used for the validation of geological and structural models, updating it over time with the newly collected monitoring data. Finally the structural performance model will be used for the development of life cycle cost model, and for the optimization of maintenance planning and identification of short and long-term risks. The aim of the project is also to demonstrate to the owners the value of embedded structural health monitoring systems.
This work is a part of European H2020 SAFE-10-T project.

Fig. 1. *Tunnel Brajdica before reconstruction.*

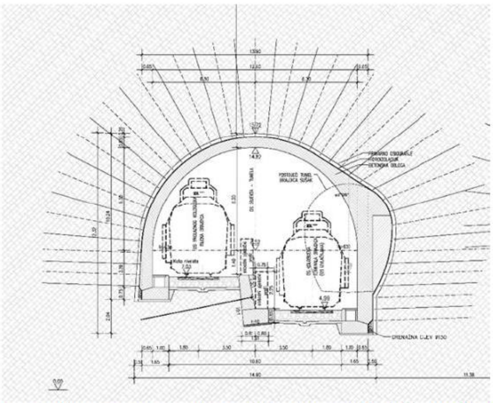

Fig. 2. *New cross section of the tunnel Brajdica with anchors, along which the sensors are embedded*

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