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Non-linear Dynamic Analysis of Bridge Piers Subjected to Ship Impact

Abstract

The complex non-linear numerical models for non-linear dynamic analysis of ship-pier impact were developed and validated by Wei Wang during his PhD study using finite-element software ANSYS and LS-DYNA. The crushing behavior of the ship during impact was thoroughly investigated using the complex models with consideration of important factors including ship mass, impact velocity, impact angle, pier shape and pier size. To reduce the computational cost, a non-linear mass-spring model (MSM) was developed to replicate the complex finite-element ship model with an optimization model to determine the model parameters introduced in MSM whilst RC pier columns were simplified into lumped masses and fiber beam elements. By coupling the non-linear MSM with the pier column at the impact position, a simplified impact model was developed to predict pier responses during ship impact. The prediction quality of the simplified model was thoroughly assessed for a wide range of impact scenarios considering material non-linearity of piers. In addition, a novel energy-dissipation steel frame crashworthy device was developed and investigated using the proposed simplified models, and results showed that the device can absorb a large portion of energy during ship impact due to the formation of many plastic hinges and is thus effective for both pier protection and ship protection. Reliability analysis of bridge piers subjected to ship impact was conducted with consideration of the stochastic properties of impact scenarios and structural parameters.

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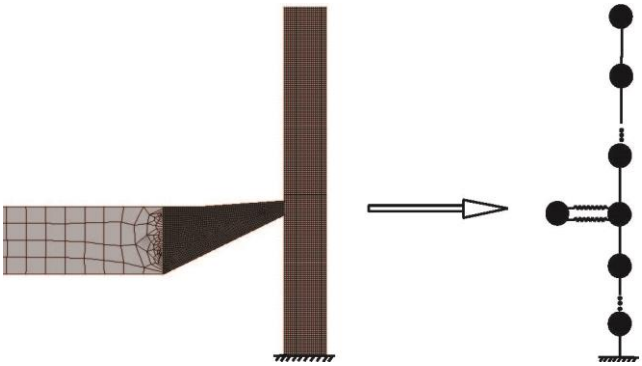

Transformation of the complex ship impact model (left) into a simplified multi-degree-of-freedom model (right)

Related publications

1. Wang, W., Morgenthal, G., Dynamic analyses of square RC pier column subjected to barge impact using efficient models, Engineering Strucutures, 151 (2017), pp. 20–32
2. Wang, W., Morgenthal, G., Novel Crashworthy Device for Pier Protection from Barge Impact, Advances in Civil Engineering, Vol. 2018 (2018)
3. Wang, W., Morgenthal G., Reliability analyses of RC bridge piers subjected to barge impact using efficient models, Engineering Structures, 166 (2018), pp. 485–495
4. Wang, W., Morgenthal, G., Development and assessment of efficient models for barge impact processes based on nonlinear dynamic finite element analyses, Engineering Strucutures, 175 (2018), pp. 617–627
5. Wang, W., Morgenthal, G., Parametric Studies of Pile-Supported Protective Structures Subjected to Barge Impact Using Simplified Models, Marine Structures, 63 (2019), pp. 138–152
6. Morgenthal, G., Wang, W., Kraus, M., Numerische Untersuchungen einer energiedissipierenden Schutzvorrichtung gegen Schiffsanprall, Stahlbau, 88(4) (2019), pp. 314–323