Evaluation of design wave conditions for a floating breakwater to be installed in front of San Marco square (Venice, IT)

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ABSTRACT

The flooding of San Marco square (Venice, IT) during high tide is not entirely prevented by the Mo.S.E. system: in fact, the elevation Marciano quay (the quay in front of S. Marco square) is just at the safeguard threshold guaranteed by the Mo.S.E., the highest accepted water level (“design water level”) corresponding to a null quay freeboard. Hence, the wave action becomes critical for the flooding of the square. Specific mitigation measures involving a combination of sheet piles and floating breakwaters to be placed in front of the quay are under investigation, aiming at reducing the flooding discharge within acceptable limits.

The specific aim of this note is to evaluate the design wave conditions in front of the quay, assuming the Mo.S.E. is operating according to the design strategy. In order to achieve this aim, the wind-generated wave statistics in the Venetian lagoon is predicted assuming the “design water level” and using a consolidated spectral wave model (SWAN) based on updated statistics of the winds. The adopted model calibration is specific for enclosed basins. Comparisons of the model result with available measures show a good agreement. The design conditions have significant wave height of order 0.5 m and peak period of 3 s. Although such wave conditions are apparently mild, it is difficult to find mitigation measures that limit possible flooding while respecting cultural heritage and environmental constraints.

KEY WORDS: design wave; Venice; SWAN; floating breakwater; enclosed basin.

INTRODUCTION

The Venetian lagoon is a fragile environment characterized by an irregular morphology, and the city of Venice is a UNESCO world heritage site. At the three inlets that connect the lagoon with the Adriatic Sea, a system of storm surge barriers named Mo.S.E. (from the Italian acronym for “Experimental Electromechanical Module”, www.mosevenezia.eu) is present and crucial to prevent urban flooding caused by high water levels during extreme storm events. The system started to be operative in October 2020 (Mel et al. 2021) and since then the barriers were activated more than 40 times. The storm surge barriers defend the city of Venice and the lagoon islands from forecasted water levels above 110 cm (Umgiesser, 2020) over the local datum. This value is selected on the basis of several considerations and it is not sufficient to prevent the flooding of San Marco square. Additional and specific mitigation measures are under design to prevent the flooding of S. Marco square, which is potentially caused by back-flow through the drainage system, filtration (Ceccato et al., 2021), overflow and wave overtopping (Ruol et al., 2020). The design includes the upgrading and renovation of the ancient drainage system with the installation of valves that will be closed during extreme events, the upgrade of portions of the square boundaries, and a combined system to reduce the waves incident the San Marco quay.

The present study focuses on this latter part of the project. In fact, the San Marco quay is the sole portion of the square subject to wave overtopping. Possible mitigation of the overtopping discharge involves the reduction of the incident wave height, through a structure placed in front of the quay that combines a floating breakwater (FB) with submerged sheet piles. The combined structure meets with environmental constraints which preserve the inestimable historical and cultural value of the square.

The specific aim of the study is to evaluate the design wave conditions for this combined structure. The issue is the lack of suitable wave data to cope with this aim. A dataset of waves recorded by the Centro Previsioni e Segnalazioni Maree (CPSM) is available at Punta della Salute (located in front of San Marco square) since 2013. However, the recording of this data was designed to study the waves generated by the intense boat traffic. The waves are recorded for only 4 minutes every 15 minutes and therefore the measured significant wave height $H_s$ is highly variable and not entirely suitable to describe wind-generated waves.

Recently, Favaretto et al. (2022a) installed a pressure wave gauge in front of the square recording the waves between July 2020 and December 2021, i.e. partially during the Covid19 pandemic. This dataset, which can be used for numerical modeling validation, is too short to provide a reliable extreme-value statistical analysis.

The method used in this paper defines a synthetic time series of waves based on simulations carried out with a spectral wave model (SWAN, Simulating WAves Nearshore, Booij et al. 1996, 1999) The method takes