Performance Verification Act of Harbor Structure towards Further Streamlining

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1. Importance of Design Engineering View

Designing is an act to determine cross-section surface element that gives structure stability for assumed action. Margin is set with consideration such as various uncertain factors and variation to secure necessary safety. Indicators that indicate margin are various such as safety rate, proof stress action ratio, reliability indicator and fracture probability (for comparison, safety rate is not used for the harbor performance verification). In designing, it is needed to set margin along with assessment of action and assessment of response of structure for action. These assessments and setting all should reasonably be done.

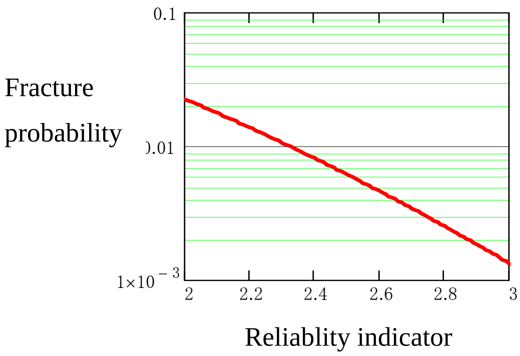
Assessment of action and assessment of response of structure have been improved by a pile of engineering research. In port and harbor field, regarding input earthquake motion traditionally, the measure below has been adopted. level 1 earthquake motion is assessed as coefficient which is dived 5 block from all parts of the country, and level 2 earthquake motion, representative example is selected from past earthquake motion records, and acceleration is adjusted in response to assumed earthquake size. Today, based on the way of thinking of earthquake-resistant design guideline of civil structure of Society of Civil Engineers, time history crimp with consideration of amplification characteristic by source property, propagation path characteristic, deep layer ground in each port and harbor are set in both level 1 and level 2).

Research for response of structure has been improved. In earthquake-resistant design of quay, the following measure has adopted. For level 1, performance verification is done by setting intensity for verification that responds to deformation amount of quay 2). For level 2, effective stress analysis by 2D finite element procedure is normally used.

Research regarding action and response has been proceeded, but setting of margin ratio is the one that eventually determines reliability of structure, and setting of margin is needed to be done carefully in consideration of technical level of action and response in a standpoint of design engineering. Traditionally, it may have been a lack of view of the design engineering.

Chart-1 is a comparison of system reliability indicator for wave action of each breakwater 3). Reliability indicator is the indicator that indicates indirectly fracture probability of structure, and the relationship of them is indicated in graphic-1.Difference as reliability indicator between the lowest reliability indicator 2.04 and the highest reliability indicator is 30%. However actual stability of structure is assessed in fracture probability. Fracture probability is 0.021 / 0.004 referring chart-1, and the difference is 5 times.

Structure format	Average of reliability indicator
Caisson type compound bank	2.11
Wave-dissipating block cleading bank	2.64
Superior slope bank	2.16
Upstand vanishing wave bank	2.04
Vanishing wave caisson bank	2.05



Graphic-1 Relationship between reliability and fracture probability

Required performance for breakwater is to maintain quiet in harbor, in this regard, there is no difference for required safety level for each structure format. However, there is actually a difference of safety level as above. The difference comes of the way of thinking of the proposer of wave power calculation formula for each structure. It occurred, because it was a different way of thinking, but it was used for the same performance verification calculation. Effort will be needed in the future to resolve such mismatch.

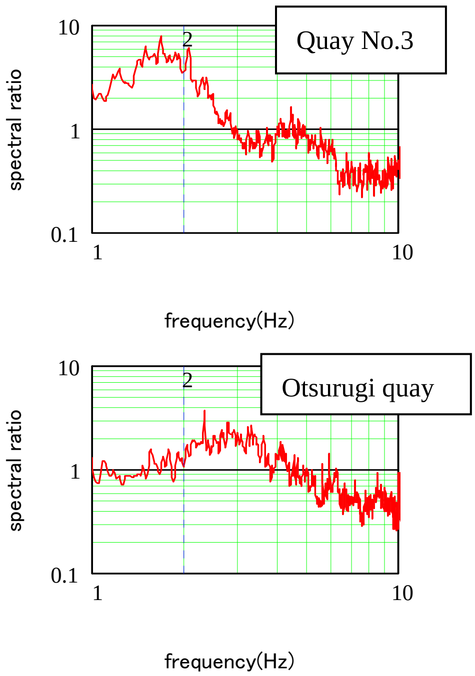
2.Further streamlining of action assessment

Regarding further streamlining of assessment of action and response, it will also be needed to proceed. Due to a space constraint, it's stated regarding action is as follows; The 2011 off the Pacific coast of Tohoku Earthquake occurred in 2011, a lot of damaged not only by tsunami, but also by the action of earthquake motion. Especially, situation of damage by district in the same harbor was very different, and it was the feature of the seismic damage. It is thought that because amplification characteristic in sedimentary layers from seismic basement to ground level is different in points that have almost same distance from seismic center.

For example, in Onahama harbor, a great damage occurred at No. 3 quay, but at Otsurugi quay, there was not damage (picture-1). Microtremor H/V spectrum (Ratio of horizontal component and vertical component of microtremor H/V spectrum amplitude) is indicated in graphic-2. Peak frequency of microtremor H/V spectrum responds to frequency that earthquake motion is amplified. Therefore if the frequency is less than 2Hz and has a great impact on deformation of quay, it is said that damage usually occurs during earthquake. The peak, at the quay no.3 less than 2Hz and at Otsurugi quay more than 2Hz, is approved, and it responds to the difference of damage. Based on the results, in Onahama harbor, zoning of input earthquake motion has been done, and it has reflected to designing. High assessment of accuracy of amplification characteristic of earthquake motion is very important to structure a strong country, and research will be needed to proceed in the future.

(a) Quay No.3

(b) Otsurugi quay



Graphic-2 Onahama harbor microtremor H/V spectrum

Reference

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