COASTAL CONCRETE STRUCTURE DESIGN AGAINST DESTRUCTION BY IMPULSIVE WAVE

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INTRODUCTION

The design method for impulsive wave pressure with very short duration time is important to prevent material destruction but is not establish yet, though there is a possibility that the coastal concrete structures will be destroyed by waves or tsunami. In this study, we proposed a simple method to design structure for impulsive wave pressure and confirmed the validity of this method by large flume experiments.

DEVELOPING DESIGN METHOD

Figure 1 shows the proposed procedure to design coastal concrete structures against impulsive wave pressure based on the existing methodology of impact design by Ishikawa et al (2008). A simple evaluation of impact response in a single mass system problem was applied. The ratio of duration time and natural period determines whether to examine by impulse damage or dynamic expansion. In the latter case, M_{static} × L_{max} is compared with the bending strength. By this method, we can evaluate simply without dynamic analysis.

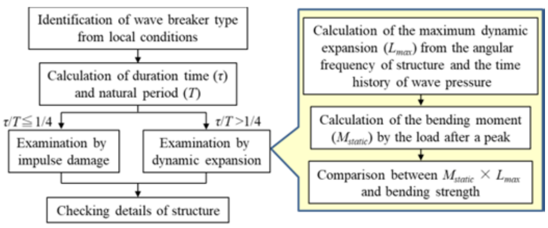

Figure 1 - Proposed procedure to design coastal concrete structures against impulsive wave pressure

VALIDATION OF THE DESIGN PROCEDURE

To confirm the validity of the design procedure, hydraulic experiments were conducted and the results were applied to the procedure. In order to eliminate the problem of similarity law, the experiments were conducted on a large scale. The flume is 184m long, 3.5m wide and 12m deep. A piston-type wave plate is used and amplitude, period, water depth in front of the seawall model, etc. were changed variously. Three L-shaped concrete models with a width of 1.12m were installed in the width direction of the flume. While the two models at both sides were 2.15m high, the one at the center was 1.65m high and concrete plates were attached on the front so that the height was the same as the adjacent models. As a result, when the waves collide, a large bending moment is generated at 0.5m from the top. The concrete plate is 6-10cm thick, and the strength is over 22.8N/mm^2 developed in 7 days. Reinforcing bars are D6 of SD295A, and the distance between the bars is 75 or 150mm, or unreinforced. Wave pressure gauges and strain gauges were attached to the models.

RESULTS

The natural period T for concrete plates with a thickness of 6cm and the main reinforcing bars pitch of 75mm is calculated as 0.03 seconds. The duration time τ when regular waves collide is at least 0.12 seconds that was measured at 0.5m, 0.3m and 0.1m from the top. In all experimental conditions, τ/T was larger than 1/4, then dynamic expansion in Figure 1 is applied. Next, the maximum dynamic expansion L_{max}, M_{static} and M_{static} × L_{max} are calculated. Figure 2 show the time series of calculated bending moment and measured strain, and dynamic expansion when regular waves collide. The bending moment is the value at 0.5m from the top and calculated from the measured pressures. M_{static} is decided as the bending moment when the pressure at 0.1m from the top becomes constant after a peak. The strain was measured in steel bar at 0.5m from the top. The only difference between the upper and lower in Figure 2 is the situation of collision, for example wave breaker type. However, only in the lower figure, residual strain occurred. From the upper figure, the maximum dynamic expansion L_{max} is 3.14 and M_{static} × L_{max} is 2.17kN·m/m. From the lower figure, L_{max} is 7.02 and M_{static} × L_{max} is 9.62kN·m/m. Comparing M_{static} × L_{max} with bending strength 3.5kN·m/m when the reinforcing bar will yield, the calculation result of the upper figure fit the reality that no residual strain occurred that is shown in the upper figure. The calculation result of the lower figure also fit the reality that the reinforcing bars yielded that is shown in the lower figure. Many other experiments were conducted, and when the proposed design procedure was applied, the trend was found to fit the experimental results.

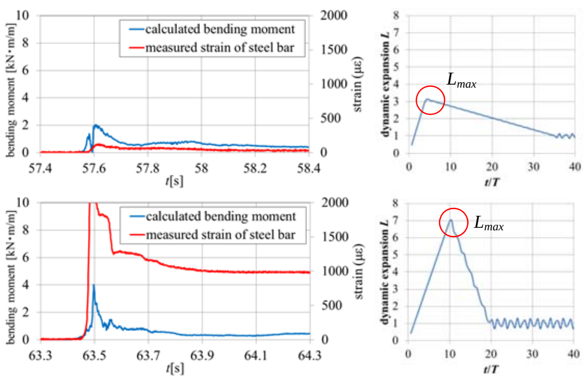

Figure 2 - Time series of bending moment and strain, and dynamic expansion for different breaker type.

REFERENCES

Ishikawa, Ono, Fujikake, Beppu (2008): Impact Engineering fundamentally (in Japanese).