INTERNAL FLOW WITHIN RUBBLE MOUND BREAKWATER

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INTRODUCTION

Rubble mound breakwater (RMB) is still widely used for many coastal defense structures due to its simple shape and simplicities in construction. Nevertheless, currently available design criteria are many still based on hydraulic model tests and empirical formulas. This kind of design criteria will be limited applicable. An efforts to quantify the detail processes involved in the wave ~ structure interaction become significant in order to generate more general applicable design formula. Therefore a rational design criteria must be derived through combination of mathematical quantification, laboratory experiments, and if possible, field data collection. Definitely, development of rational design criteria needs proper understanding of the involved detail processes.

Internal flow within RMB, i.e., the movement of fluid inside the rubble mound porous, had been known to have important role in overall stability of the structure. It affects the wave reflection from and transmission through the structure, pore pressure field inside the structure, and additional force on the armor units. These mentioned phenomena will in turn influence the energy dissipation of external flow on and into the structure, and eventually the stability of the structure. Proper simulation of this phenomenon will give more better understanding about the processes.

INTERNAL FLOW PARAMETERS

Many factors influence the behavior of internal flow. It involves hydraulics parameters, structural parameters, and geotechnical parameters. Hydraulics parameters are regarding with the characteristics of incoming waves (height, length, period, etc.). Structural parameters are related to any physical matter of the structure. Some important of them are the geometry of the structure, rock or grain shape, surface smoothness, porosity, permeability and mass density. Geotechnical parameters include mainly dynamic gradient and excessive pore pressure.

GENERAL MECHANISM OF INTERNAL FLOW WITHIN RMB

The most important hint in understanding the mechanism of internal flow is its interdependency with the external wave action. A complete model ~ scaled model or mathematical model ~ requires the simulation of both flows.

As an incident wave encounters a permeable breakwater face, part of the wave is reflected back out to the sea, some energy is lost due to breaking, and the remaining energy is transmitted to the breakwater interior.

The wave inside the structure decays as it propagates through the pores. Upon reaching the leeward face, the wave is partially transmitted to the leeside of the breakwater and is partially reflected back to the interior of the structure. This process yields two wave trains propagating in opposite directions within the structure.

As consequence of these wave propagation, the internal free surface of water will displace up and down. The magnitude of transmission, reflection, and displacement are influenced by the characteristics of the medium parameter and flow field parameter. Further, reciprocally, the internal flow appearances such as flow velocity and surface elevation will induce the absorption capacity of the external flow into breakwater. It will, in turn, affect hydraulic response to the external wave reflection, runup, and rundown on the breakwater seaward face.

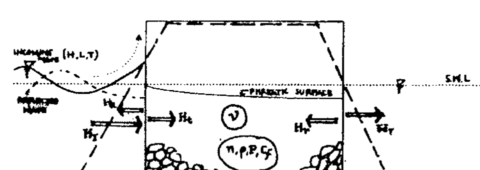

Fig.1. Typical wave induced internal flow within RMB

SOME HINTS IN MODELING WAVE INDUCED INTERNAL FLOW

Physical Scale Model and Scale Effect

It is admitted that the most critical problem in modeling the internal flow within rubble mound structure is the scale effect, especially for small scale model. In such case prototype non-viscous flow fall to be viscous flow. Hence, different flow characteristics appear and affect the hydraulic stability.

Reynolds number of $Re=6\times10^3$ and $Re=3\times10^4$ subsequently was proposed by Jensen and Klinting (1983) and Dai and Kamels (1969) as a bottom limit to avoid viscous effect in the internal flow model. However, wave induced internal flow are naturally unsteady non-Darcy and with large variation of hydraulic gradient and vary Reynolds Numbers. Due to this complication, Burcharth (1983) stated that generalization by modeling only with single Reynolds number is unsatisfactory.

Mathematical Model

Quoted Sun et.al. (1992), a complete model needs to incorporate all of the following physical processes : random wave motion external to the breakwater and uprush onto the breakwater face; energy dissipation caused by wave breaking and friction at the breakwater surface; the transport of water through the front face of the breakwater; the flow of water through the porous material of the breakwater core; the effect of entrained air in the flow of water through the porous material; also, it must be able to deal with complex breakwater geometries, such as berms and layers of armor and filter materials. No model is presently able to incorporate all of these processes.

A 2-dimensional numerical simulation by using Volume of Fluid method (Hirt & Nichols, 1981) is successfully applied on the computation of wave action on and in the permeable structure (van Gent et.al., 1994). This program is capable to compute free surface flow when the fluid domain becomes multiply connected, i.e. when for example an overturning breaking wave hits the free surface.

REMAINING PROBLEMS FOR FUTURE RESEARCHES

a) *Description of the external flow field* : The present knowledge on the wave kinematics in front of a rough permeable structure is almost nil.

b) *Interaction between external and internal flow* : Almost nothing is available on the physical processes involved at the boundary between two layers of different porous materials (discontinuities) and their mathematical formulation (coupling problem).

c) *Energy dissipation on the slope* : How to account for this dissipation in case of breaking is still an unresolved problem.

d) *Porous flow equation* : It still not clear whether a Forchheimer-type equation will apply for the flow in the armor layer and filter layer.

e) *Air entrainment* : The air entrained by waves breaking on the structure is expected to strongly affect the internal flow. No attempt has yet been made to account for this effect in a numerical model.

f) *Internal stability of the porous medium* : Generally the porous matrix is assumed to be fixed. Actually, however, this is not the case.

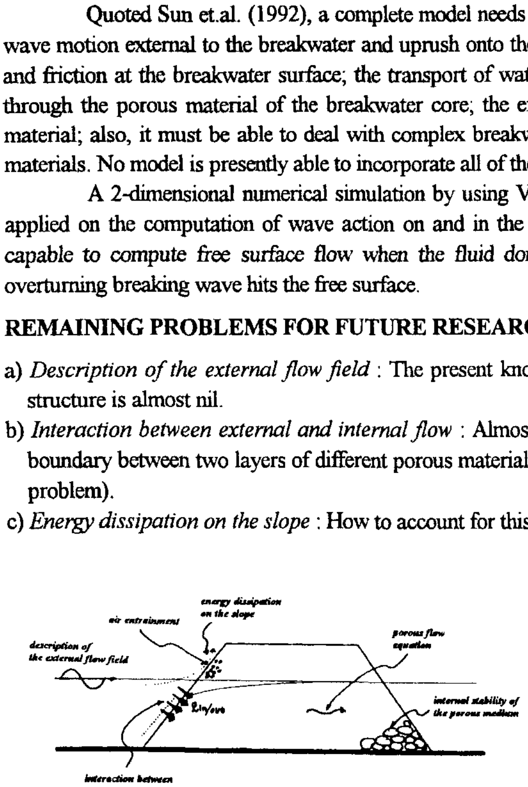

Fig.2 Scheme of Remaining Problems for Researchs

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