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Global and Local Scour at Pile Groups

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This paper presents the results of an experimental investigation on scour around pile groups with different configurations exposed to steady current. Two kinds of tests were carried out: rigid-bed tests and actual scour tests. In these, the mean and turbulence properties of the flow were measured across the pile groups. The pile-group configurations were such that the global scour was distinguished from the local scour. The results show that the global scour can be quite substantial.

INTRODUCTION

Pile groups are widely used in practice to support hydraulic and marine structures. Extensive scour around piles may reduce the stability of these structures.

Scour around pile groups is caused by 2 mechanisms: Those causing local scour at individual piles, and those causing a global scour (the general lowering of the bed) over the entire area of the pile group.

Scour around pile groups has received considerable attention in the past. Hannah (1978)—see also Breusers and Raudkivi (1991) and Raudkivi (1998) for a partial account of the work—studied 2-pile tandem, 2-pile side by side, 2-pile staggered, 3-pile tandem, 4-pile square and 6-pile rectangular arrangements in steady current. Breusers (1972) reported hydraulic-model experiments on scour at 2-leg and 3-leg offshore platforms due to waves and current. Chow and Herbich (1978)—see also Herbich et al., 1984, page 148—studied the wave scour around 3-, 4- and 6-legged pile structures. Sumer and Fredsøe (1998) studied wave scour around groups of piles with different configurations (2-pile, 3-pile including the triangular group, and 4×4 arrangements). Mory et al. (2000) studied the wave scour at a piling with 2 rows of piles. Field results also have been reported, by Posey and Sybert (1961) and Bayram and Larson (2000 a, b). Detailed accounts of the subject can be found in Whitehouse (1998) and Sumer and Fredsøe (2002).

Although quite a substantial body of knowledge has accumulated on scour around pile groups, to the authors' knowledge, no study is yet available investigating in detail global scour and local scour separately. The present study makes an attempt to address this question.

EXPERIMENTAL FACILITY

The experiments were carried out in a current flume 2.0 m wide, 0.5 m deep and 23 m long. Two kinds of experiments were carried out: the rigid-bed experiments, and the actual scour experiments.

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Rigid-bed Experiments

The water depth was maintained at 0.40 m. The bed acted as a hydraulically smooth bed. The measurement section was located about 15 m from the inlet section.

Seven different configurations of pile groups—including the reference case, a single pile (Fig. 1)—were tested. The pile models were $D = 32$ mm in diameter, smooth-surface, circular plastic pipes.

The circular group configuration in Fig. 1 was designed such that the density of piles in the arrangement was equal to that of the 5×5 group, in order to observe the influence of the shape of the pile-group arrangement, i.e., A_{pile}/A remained the same, A_{pile} being the total area occupied by the piles and A the total area occupied by the entire pile group. The radius of the pile group was 0.16 m, 0.23 m and 0.38 m for $G/D = 1$, 2 and 4, respectively.

The mean and turbulence velocity profiles were measured across the width of model structures at a distance 14.5 cm above the bed, using a DANTEC fiber-optic LDA system with a submersible pen-size probe. (Incidentally, the velocity at the distance 14.5 cm from the bed in the undisturbed case with no model structure present is actually equal to the undisturbed depth-averaged flow velocity.)

Scour Experiments

A 4-m-long and 0.10-m-deep sandbed section in the flume was formed, which was protected at the upstream/downstream ends with sections of 3.5-cm crushed stones with 1 : 6 slope. The upstream end of the sandbed section was 11 m from the inlet. The test section itself was 3 m from the upstream end of the sandbed section. The water depth was 0.25 m at the sandbed section. The flow velocity was measured at the distance of 9.2 cm from the bed, using the same LDA equipment as in the rigid-bed experiments. (Similar to the rigid-bed experiments, the velocity at the distance of 9.2 cm from the bed is equal to the depth-averaged flow velocity in the undisturbed case.) The sand size was $d_{50} = 0.2$ mm.

The same model structures as in the rigid-bed experiments were used. The structures were placed in the sandbed, the piles extending down to the actual bottom of the flume.

The procedure used in the tests is:

- Level off the bed.
- Place the pile group and the single pile (the reference pile) in the sandbed. (The single pile was placed sufficiently away from the pile group and with an offset in the transverse position so that no interference between the pile-group scour and the single-pile scour is experienced.)
- Fill the flume gently so that no scour occurs.