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EFFECT OF TURBULENCE ON LOCAL SCOUR

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INTRODUCTION

Flow and the resulting scour processes around marine/hydraulic structures may be investigated theoretically, using analytical, theoretical or numerical methods, the mathematical modeling (Sumer and Fredsøe, 2002). A mathematical model typically comprises two components, hydrodynamic model and morphologic model, the latter involving a sediment transport description. The key component of the sediment transport description is a sediment transport formula for the bed-load transport. The sediment transport formulae used in the morphologic models so far do not include the effect of externally generated turbulence. These formulae were developed for flows where turbulence is generated "internally" under fully developed turbulent boundary layer conditions. In the case of scour around a marine object, an additional field of turbulence is generated due to processes such as the horse-shoe vortex and the vortex shedding, and therefore the sediment transport caused by this additional turbulence needs to be taken into account to simulate the scour process more accurately. Roulund et al. (2005, p. 395) attribute the difference between the numerically and experimentally obtained scour characteristics (although not radically large) mainly to the effect of turbulence. The purpose of the present study is to incorporate the effect of externally generated turbulence in scour calculations.

NUMERICAL MODEL

The marine object considered in the study is a half-buried sphere, subject to a steady current. (This configuration has a wide variety of applications: Scour protection of marine pipelines, offshore wind turbine foundations, etc.; Sea mines on the ocean bottom; and Habitat structures installed on river bottoms to offset fish habitat losses, to mention but a few.) The hydrodynamic and morphologic models used in the study are the same as in Roulund et al. (2005). The procedure in the calculations is: (1) Calculate the kinetic energy of turbulence, *k*, from the hydrodynamic model at each grid point near the bed; (2) Convert *k* to the r.m.s. value of the fluctuating component of the local streamwise velocity, using the relation $\sqrt{u'^2} = (1.1k)^{1/2}$; (3) Go to Sumer et al. (2003) and pick up the value of sediment transport as function of the Shields parameter and the ratio of $\sqrt{u'^2}/U_f$, the turbulence, where U_f is the local friction velocity; and (4) Update the bed morphology.

RESULTS

With the present numerical model, the externally generated turbulence can be switched on/off, enabling us to study the effect of turbulence on scour in detail.

Fig. 1 shows an example where the time development of the maximum scour depth in front of the half-buried sphere is illustrated for two cases, the case where the turbulenc is switched off, and that where it is switched on. Fig. 2 shows another example from the calculations where the turbulent kinetic energy for the initial stage of scour (the plane bed) and the equilibrium stage (the scoured bed) are plotted.

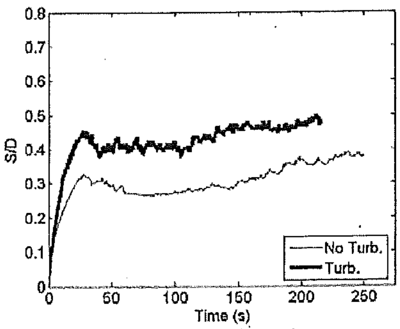

Figure 1 - Maximum scour depth at the upstream side of a half-buried sphere. Velocity= 44.7 cm/s; d_{50}=0.6 mm; the Shields parameter= 0.098 (Live bed). Dixen (2008).

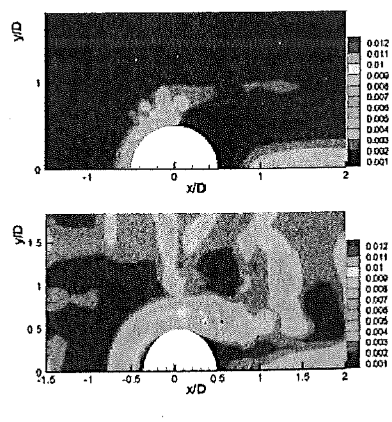

Figure 2 - Turbulent Kinetic Energy, *k*. Top: Initial stage of scour, plane bed; and Bottom: Equilibrium stage, scoured bed. Dixen (2008).

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