

Bow Impact Forces in Steep Waves

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Following the 1998 damage to the Floating Storage and Offloading barge 'Schiehallion' work was undertaken for BP, the HSE and the UK research funding council EPSRC in a project which ran in parallel with and provided data to the SAFEFLOW project (reported by Buchner and Voogt at this conference).

The Glasgow work involved 1:80 scale wave tank testing of heavily instrumented models of Schiehallion and a tanker with a more conventional bow shape – the Loch Rannoch (Figures 1 and 2).

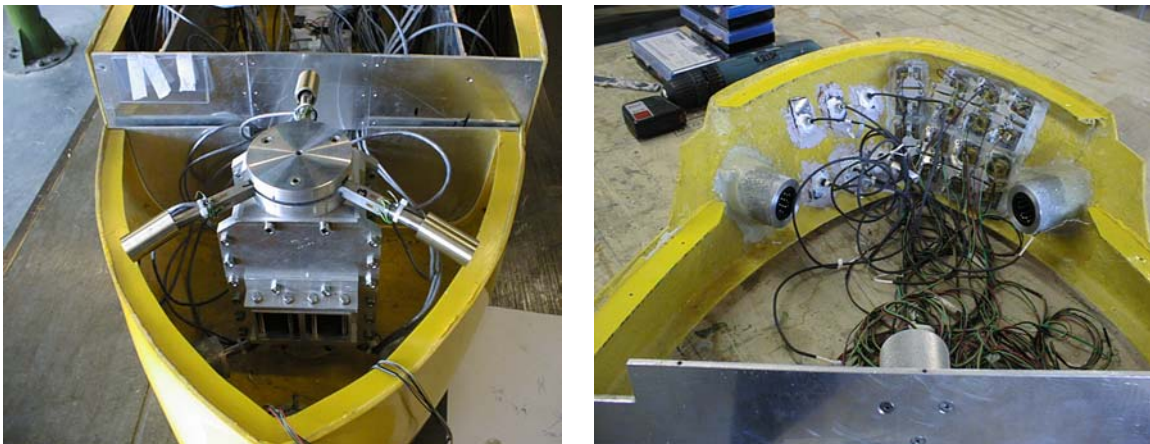


Figure 1 The Loch Rannoch Model showing the bow force, pressure panel and local pressure transducers

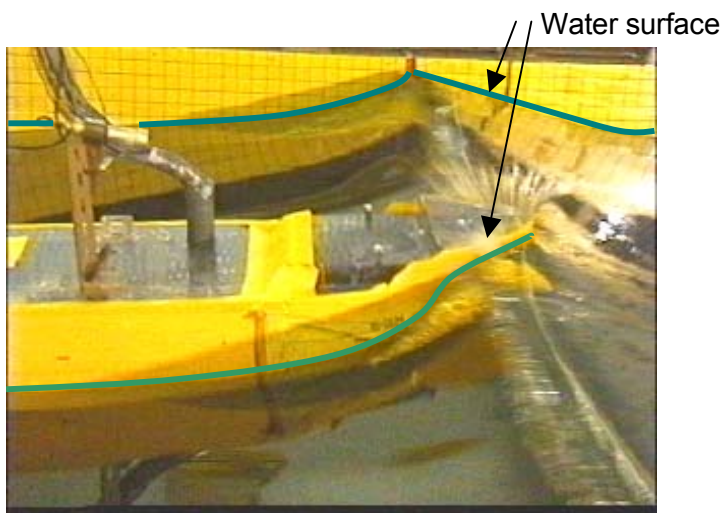


Figure 2 The Loch Rannoch model subject to a wave impact

The work identified the typical wave shapes that caused the highest pressure loads and proposes a simple method (based on the linear wave particle kinematics) (Figure 3) of estimating the change in surface slope and hence the non-linear slope and impact pressure statistics in a sea state or the time history of water surface shape for time history modelling of wave impact pressures. (Note there is a dependence on the time step which is not shown in Figure 3)

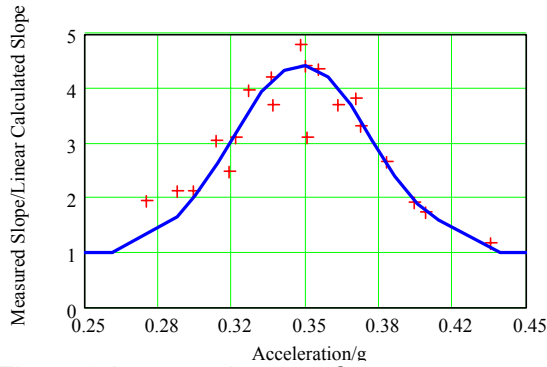


Figure 3 Increase in wave front steepness relative to a linear random model of the water surface

The bow forces may be calculated using a rate of change of added mass calculation in conjunction with the wave shape data (Figure 4). Alternatively pressures may be calculated using a slam force equation with additional terms to account for the size of the panel (non dimensionalized by bow width and wave height) for which the pressure is required.

$$P = \frac{1}{g} CE(S)F(W)G(Z)V_s^2 DAF$$

Where P is the estimated pressure in m head water

C is a constant

$E(S)$ is dependent on sea state steepness (S)

$F(W)$ is dependent on panel width (W)

$G(Z)$ is dependent on panel height (Z)

V_s is the slam velocity ($\sqrt{\text{celerity} \times \text{particle velocity}}$)

DAF is the dynamic amplification factor

The results were input to a reliability analysis (performed with other SAFEFLOW partners) to estimate combinations of sea state return periods and safety factors that should be used for structural design. As a result of the larger uncertainties in impact loads than in ordinary wave loading, slightly larger safety factors are recommended.

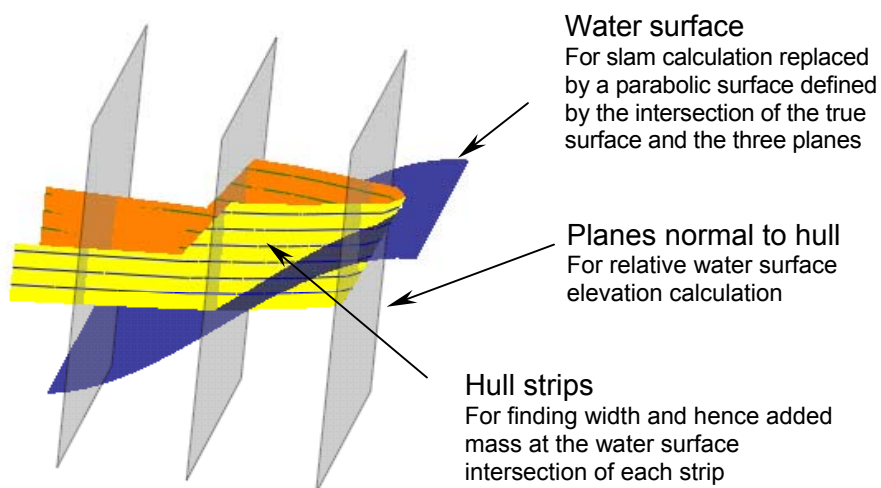


Figure 4 Visualisation of mathematical model used in conjunction with a rate of change of added mass calculation of slam force