

## Seismic Analysis of Dockside Cranes

Bennett Associates completed the seismic analysis of 45 tonne and 10 tonne dockside cranes on behalf of the manufacturer, Butterley Engineering Ltd. The cranes will be used at Devonport Docks for the servicing of nuclear submarines. ANSYS (the general purpose finite element program) was used for computer modelling.

The conventional approach for seismic analysis of most structures is to apply the earthquake in the form of a spectrum consisting of a range of frequencies with corresponding accelerations applied to a linear elastic model. In the case of jib cranes this approach would have been too severe and would have resulted in an over conservative and heavy design.

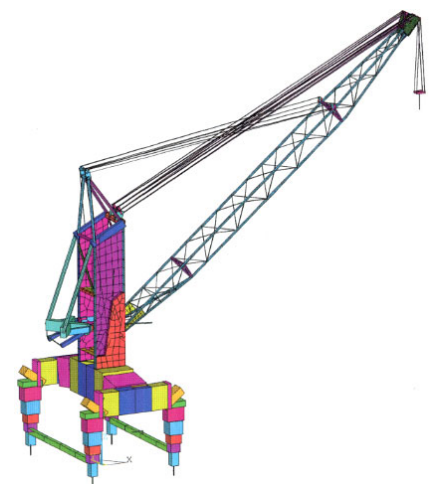
Therefore, in addition to a spectral analysis, Bennett Associates also produced a non-linear time history analysis, using a finite element model which incorporated non-linear features such as wheel lift-off and luff/hoist pulley/rope sub-models. The ropes were unable to carry a compressive load and were therefore modelled on tension only spars. This allows the jib to move in a realistic fashion relative to the mast as the pulleys and ropes rotate and oscillate during the seismic event. These non-linearities contribute to energy dissipation of the earthquake and additional damping during the seismic event. This approach resulted in reduced design wheel loads and a more economical design. It also allowed the rocking behaviour of the crane to be analysed and to predict if the crane would topple over in a seismic event.

A time history approach was also developed to examine the effects of a conventional weapon explosion on the stability of the crane.

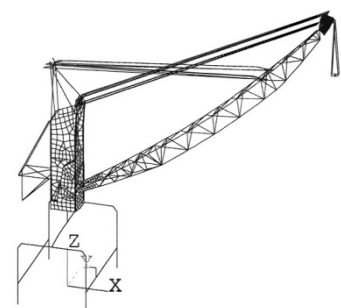
The computer model was highly parameterised, using the ANSYS parametric design language (APDL) in conjunction with the superelement approach, which enabled several configurations of each crane to be considered in the analyses.

Bennett Associates also produced the seismic design appendix for Butterley Engineering's design substantiation reports (DSRs), which were subject to independent assessment by a third party.

Bennett Associates (originally founded in 1984) was acquired in 2008 by Atkins; bringing their proven technical expertise to the UK's leading engineering consultancy.



45 tonne crane



Typical mode shape