

SEISMIC BEHAVIOUR OF CONSTRUCTION TOWER CRANES AND SHIP CONTAINERS

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Abstract.

This presentation has two parts: first we look to Construction Tower Cranes and secondly to Ship Containers.

Low to moderate size tower cranes used essentially in construction sites are very slender steel structures designed to carry high loads (1 to 3 tons) to distances up to 60 m around a central tower standing alone. They are required in many sites where working place is exiguous and easy to handle construction materials. Essentially they are composed by a tower with height varying according to the height of the construction and by an horizontal jib and counter-jib spanning a few tens of meters. We will analyse two tower cranes, one with 33 m height and a jib with 35 m, and the other with 37 m height and 60 m gib. These structures are very light, slender and flexible. Additionally they can be subjected to winds and earthquakes. Even though there are thousands of these structures all over the world specially in developing areas, there is very few published work for these types of structures. However, many disasters have occurred causing damage to people or urban equipment in the vicinity due to total or partial collapse of the structure. Wind have been in the past probably the most frequent cause of collapse, even though the jib is loose and can rotate freely around the tower axis. Two other problems are foundation settlements and improper maintenance. For earthquakes the main problem is the existence of large mass (a few tons) placed at a high position at an eccentric position. We developed a 3-D mathematical linear model of the structure with a finite element program SAP2000 and compared analytical frequencies with *in-situ* measurements. The minimum and maximum error for the two cases is on the order of 1.9 % and 15%. Frequencies corresponding to the first modal shapes of this type of structure are very low (well below 0.5 Hz, depending on height of tower and counterweight). It has been found that the dynamic behaviour of the crane is largely dependent on the way its foundation is designed, which in this case is made of bogies supported on rails with concrete ballasts providing stability to the structure. Consequently the higher percentages of excited mass of the structure are associated with the more rigid vibration modes. We applied ground motion

at the base to understand the dynamic 3-D behaviour of the whole system. The results indicate that a moderate ground motion ($PGA=1.5m/s^2$) shaking does not pose safety problems for this type of structure. However, caution should be exercised in order to maintain the concrete ballasts located at the foundation in place, to any type of seismic action.

The second case refers to the behaviour of ship containers piled up to 5 units. During the Tohoku earthquake of 2011, many of these structures overturn and fall. We investigate two cases of rotated units for the ground motion recorded in the vicinity. First results showed how these structures can be studied with discrete element models once we have a way to calibrate their main frequencies obtained by *in-situ* testing.