Seismic behaviour of a certain type of Tower Cranes

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ABSTRACT

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 50 m around a central tower standing alone. They are very convenient 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 spanning a few tens of meters. In some cases they are used to carry loads in high-rise buildings, large dams and bridges, etc. We will look only to cranes with 30-50 m height and jibs of 30-50 m long. Towers have square cross sections with corners made of vertical tubes welded to inclined tubes at angles of approximately 60º in a spiral format giving the three dimensional behaviour. In many cases the same sections are kept along the height. The jib is a structure with triangular cross section made of three main elements at the vertices of the triangle and supported by diagonal elements keeping the integrity of the whole system. This structure takes the loads at great distances from the tower with the help of a counter weight on the other extremity of the jib. Steel cables at a low angle give some important support to the jib. As referred above this structure usually is placed in a narrow space simply supported at a foundation made of counter weight at the base.

These structures are very light, slender and flexible and, of course, they are designed in first place to carry the loads for which they were contracted.

Additionally they can be subjected to winds and earthquakes. Even though there are thousands of these structures all over the word 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 has 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. For earthquakes the main problem is the existence of large mass (a few tons) placed at a high position at an eccentric location.

We developed a 3-D mathematical linear model of the structure and compare analytical frequencies with "*in-situ*" measurements. Maximum error for the first 6 identified modes in X-Y was 7%. 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). We applied ground motion at the base to understand the dynamic 3-D behaviour of the whole system, with mass at top and also large mass at the bottom. Some preliminary results indicate that, due to the great flexibility of the tower crane, moderate ground shaking does not pose safety problems for this type of structure.

REFERENCES

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