SEISMIC ANALYSIS OF CATEGORY I OVERHEAD CRANES CONSIDERING STRUCTURAL NON-LINEARITIES

M. BRACCIO, G. RIGAMONTI

Mechanical Analysis Group, United Engineers & Constructors, Inc., 30 South 17th Street, Philadelphia, Pennsylvania 19101, U.S.A.

SUMMARY

This paper presents a simplified analytical approach which can be applied to the problem of determining impact loads induced in overhead cranes from structural non-linearities. The loads considered in this paper result from the non-linear behavior of a hoisted load subjected to seismic excitation. The need to consider this type of loading is based on the recommendation by the United States Nuclear Regulatory Commission that certain cranes in nuclear power plants handling critical loads be classified as seismic category I and be designed to retain the hoisted load during a safe shutdown earthquake.

Prior to this recommendation, most overhead cranes were postulated to be unloaded and in a parked position during a seismic occurrence. This configuration allowed the crane to be modelled as a multi-degree-of-freedom linear elastic system, using computer techniques which rely on the response spectra method to determine its seismic loading.

For cranes where the hoisted load must be retained during a seismic occurrence, and the response spectra method shows unacceptable compressive loads in the cables, an analytical procedure, which uses gap elements to account for structural non-linearities and uses time history as a forcing function, must be employed. The analytical approach presented in this paper provides the crane designer with a convenient tool which is simple to use, yet performs an analysis whose results are deemed to be sufficiently accurate so that they may be applied to achieve an optimum design of the structural members of the crane.

This paper presents the mathematical model which was used for the non-linear dynamic analysis. The paper also discusses the approach and assumptions which were made to transform the crane structure from a complex multi-mass, multi-degree-of-freedom system to one represented by an equivalent single-degree-of-freedom spring mass system. A second spring which has non-linear characteristics is modelled as a gap element and is used to represent the hoist cables. A computer program which performs piece-wise non-linear analysis is used to determine the vertical seismic response.

Results of the non-linear analysis are presented and compared to those generated using a similar crane model but treating it as a linear elastic system with response spectra input.