Seismic qualification by analysis of an overhead crane for nuclear industry

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1. Introduction

The seismic qualification for the structural strength it is an issue for the assessment of the seismic safety of the Nuclear Power Plants. As regard the seismic strength of the Cranes, it has to be demonstrated, via (mostly) a numeric analysis, that in the case of the unlikely event of an earthquake, the crane is not breaking apart affecting thus the safety related neighboring equipment. The crane is required to maintain its integrity when subject to the Design Basis Earthquake when it is supposed to hoist the rated load.

The goal of this study is to underline the procedure to be followed for nuclear industry cranes, in order to obtain sound and credible results for equipment seismic qualification by using the unique analysis features of ANSYS 19 software.

2. Material and methods

The solving strategy is following a series of fixed stages, in order to have the right results.

Firstly, the CAD geometry of the crane will be generated by using SolidWorks 2018, as seen in the following figure.

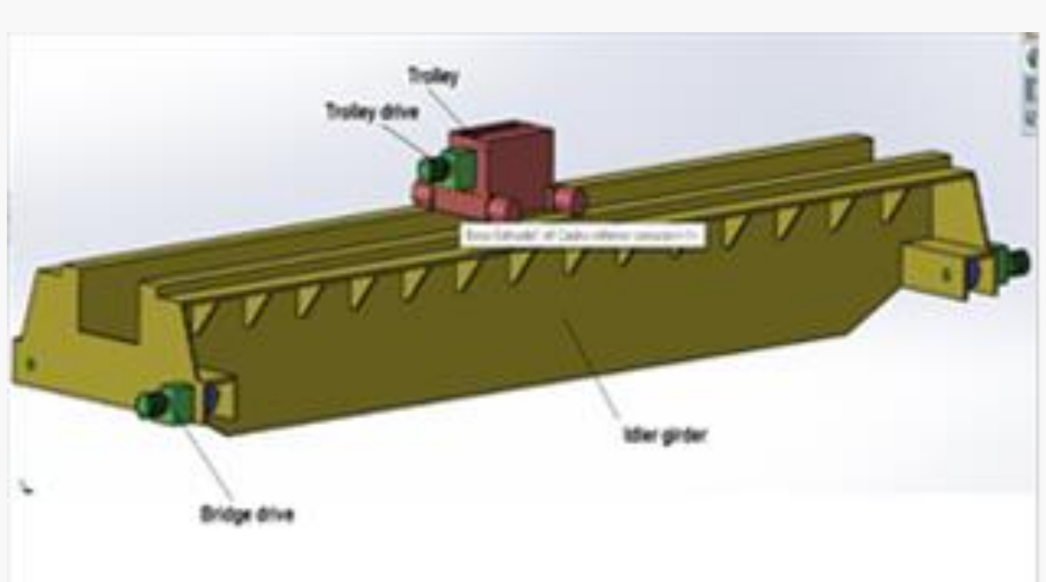

Figure 1. The CAD geometry of the crane on subject

The geometry is somehow simplified targeting only the major structural features and neglecting small details, as bearings or fasteners. The span of the bridge is 6 m and the distance between the girders is 0.5 m.

The electrical motors and reducers of the drives were generated simplified keeping in mind to have approximatively the same mass and centre of gravity of the model as the real objects.

The CAD geometry is then imported inside the ANSYS 19 software for further processing.

The material imposed is the structural steel with density of 7850 kg/m3, Young modulus of 2e11 Pa, Poisson ratio of 0.3, tensile yield strength of 2.5e8 Pa and the ultimate strength of 4.6e8 Pa.

For the static structural module, the loads are as seen in the Figure 2:

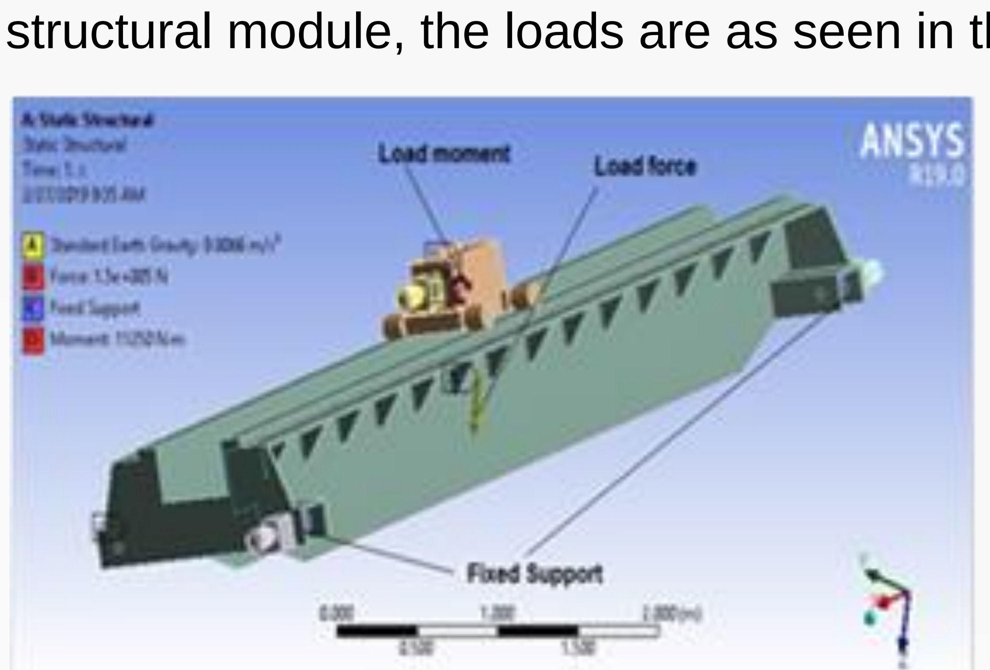

Figure 2. The boundary conditions

The four rolls transmitting the load from the crane to the rail will be set as fixed supports by supposing that the crane's brakes will function properly. Through the same fixed supports, the seismic excitation will be imposed from the building to the crane.

3. Results and Discussions

After running the model, some important results were retrieved in the structural and response spectrum modules and in the Design assessment module .

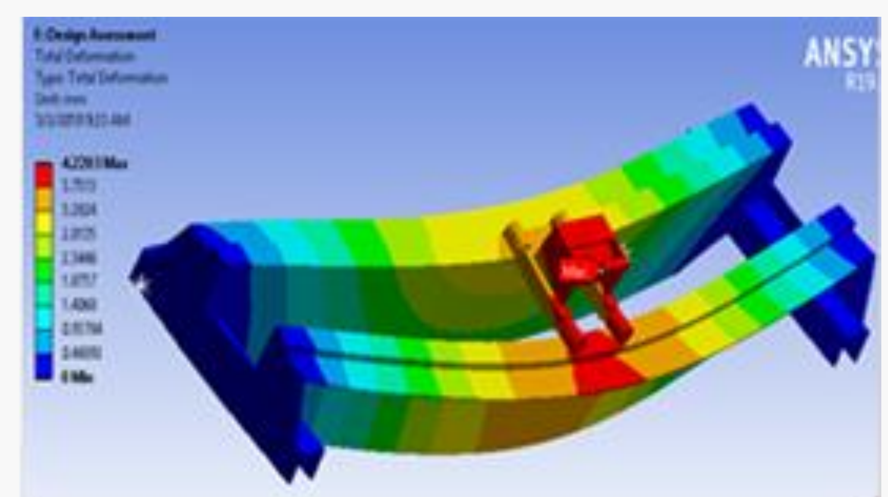

Figure 3. The overall total deformation

The Design assessment module is taking all the results from Structural and response spectrum modules and is consolidating everything into one single structure state by combining them.

The overall total deformation is showing that the crane structure suffers an bending and rotation over Ox axis yet the value is not big, only a 4.2 mm deformation is recorded for the upper side of the trolley.

4. Conclusions

The nuclear sector represents an important source of electrical energy, since nuclear power stations currently produce around a third of the electricity consumed in the European Union.

The accidents and nuclear disaster showed that the nuclear components in all the structure are very important and must pay attention to them.

This study is meant to show how a complex structure as an overhead crane might be treated in order to have meaningful results for a decision whether or not such a structure is able to withstand the loads generated by a seismic event.

After running the model, some important conclusions were retrieved in the structural model.

The peak stress of 88.6 MPA calculated stays close to the one calculated in structural module (78 MPa) and is a way smaller than the tensile yield strength of 250 MPa. So that the seismic event is not overloading the crane structure an in comparison with the hoisted load, the seismic stresses stay quite modest.

Since the loads are acting in the vertical direction, the middle section of the crane bridge will deform in this direction with an amount of 3.3 mm. This is in accordance with any simple engineering educated guess.

The girder stress is approximately 40 MPa which is far lower than the tensile yield strength of 250 MPa. The maximum stress of 78 MPa is calculated for back-left roller axle which is most of the moment developed by the hoisted load.

The seismic event is not overloading the crane structure an in comparison with the hoisted load, the seismic stresses stay quite modest.

By comparing the overall calculated equivalent stresses with the tensile yield strength, the conclusion is that the structure will resist.

Based on all the above, the crane is considered to be seismically qualified.

References

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