EVALUATING THE EFFECT OF SUPPORTING STRUCTURE LATERAL STIFFNESS ON SEISMIC RESPONSE OF HIGH VOLTAGE CURRENT TRANSFORMER

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Lifelines are the facilities that the life in industrial and advanced societies is possible only by ensuring their appropriate and permanent operation and functioning. One of the most important lifelines is electrical power equipment which considering the effects of recent earthquakes in the world, high voltage current transformer, due to limitation of the materials used to manufacture the porcelain insulator part, are the weak and vulnerable parts of the electrical power equipment in earthquakes (Figure 1).

Figure 1. Failure of porcelain insulators high voltage electrical substation (Khalvati et al., 2008).

Figure 2. The studied current transformer (Khalvati et al., 2008).

In this study, firstly, the seismic behavior of the structures and equipment of high voltage electrical substations and their behaviors in the past earthquakes have been investigated. One of these elements, which is the high voltage current transformer 230 kv (Figure 2) has been selected as an important and key element in the electrical power substation. Subsequently, the seismic vulnerability of the equipment due to changes occurred in lateral stiffness of the supporting structure has been studied more carefully. For this purpose, first, the primary data of the equipment, such as technical specifications, dimensions, weight, the elements used and the stiffness of each, etc., have been collected.

Then, with using a finite element analysis software, this equipment has been modeled. The final model is created by joining different parts (Figure 3-a), the most important of which are: bottom box, top tank, porcelain insulator, top flange, bottom flange and members of the supporting structure , that the modeled shape of some of them are shown in Figure 3-b to 3-d. In the meantime, the parts of the bottom box, top tank, porcelain insulator, top flange and bottom flange have been modeled by solid and homogeneous elements through various approaches (Solid Revolve and Solid Extrude). Also, the members of supporting structure used have been modeled by the wire element.

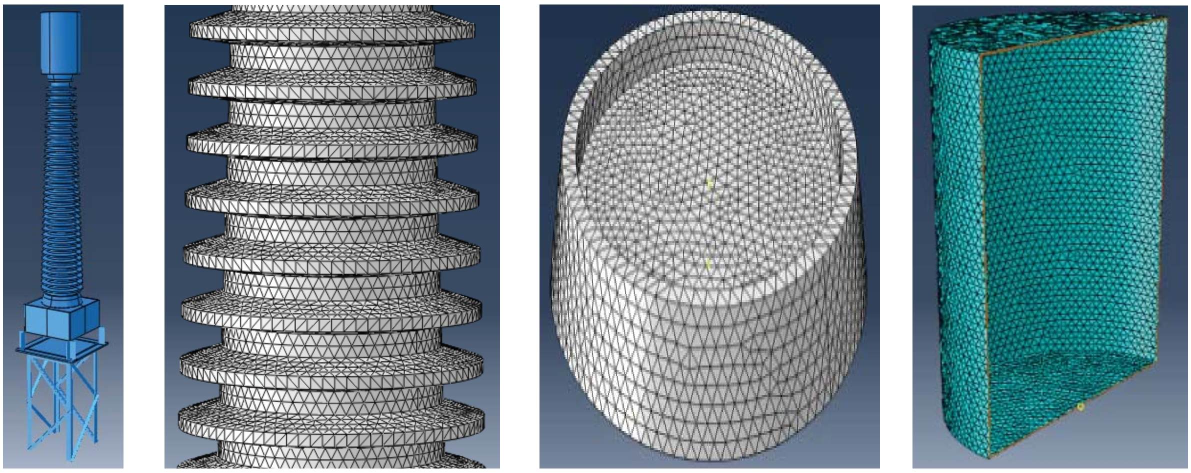
(a) (b) (c) (d)

Figure 3. (a) Modeling of current transformer (b) A part of the porcelain insulator (c) bottom flange (d) A section of the top tank.

In parts of the model that are mostly regular or have regular partitioning, structured mesh is used and in parts without the ability to use structured mesh for any reason, particularly the meshing of the parts created using the revolve technique, the sweep mesh is used. The other important subject that has been mentioned in this study is the size of mesh, which is only obtained by sensitivity analysis for each model. For this purpose, after the finalization of the model, a sensitivity analysis has been carried out as a specific analysis, according to various parameters, including the results obtained, analysis time, the accuracy of convergence of results, etc., the desired size of the mesh was determined and since then, the same size has been used for all analyses.

The type of dynamic analysis is linear time history, because basically, nonlinear analysis is not relevant for the materials of this equipment with an extremely brittle and fragile behavior. Also, the acceleration and displacement at the top of equipment and the maximum stress in the porcelain insulator have been investigated.

After modeling and applying the five selected records from previous earthquakes to the models (with different heights of the supporting structures) and comparison of results, analysis show that increasing the height of the supporting structure increases the acceleration and displacement at the top of equipment and also increases the maximum stress in the porcelain insulator.

According to the results of numerous analyses, various diagrams have been presented to illustrate the changes in acceleration and displacement at the top of equipment head, and the maximum stress of porcelain insulator based on the stiffness of the supporting structure, so that according to them and according to the electrical considerations, one can choose the appropriate and optimal height of the supporting structure.

REFERENCES

Anagnos, T. (1999). *Development of an Electrical Substation Equipment Performance Database for Evaluation of Equipment Fragilities*.

Khalvati, A.H. and Hosseini, M. (2008). Seismic performance of electrical substations' equipments in iran's recent earthquakes.

Khalvati, A.H., Hosseini, M., and Mohammadpour, S. (2012). *Seismic Behavior of 63kv and 132kv Substation post Insulators with Flexible Conductors, an Experimental Approach*.