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Structural Modelling and Earthquake Analysis of a Hospital Building located within the Tjörnes Fracture Zone in Iceland

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The Tjörnes fracture zone (TFZ) is the one of the two most active seismic regions in Iceland (*Einarsson P.,* 2008; *Stefansson, R. et al.*, 2008; *Metzger & Jónsson,* 2014). It is of vital importance for civil protection and security of the local residents living in that area to have a fully functioning hospital close by, when a major earthquake event occurs within the TFZ.

The main focus of this study is to examine the structural characteristics, dynamic behaviour and structural integrity of the hospital (see Fig. 1) in the town of Husavik in North Iceland. The main objectives of the study are as follows:

- To set up a monitoring system in the 4 storey reinforced concrete building and monitor structural excitation and response.
- To use observed strong ground motion and response to estimate structural characteristics of the building.
- To construct and calibrate a finite element model of the building.
- To use the FE model to examine the behaviour of the building in strong earthquake action.

Figure 1. The Húsavík hospital seen from south west direction

A structural monitoring system was installed in the building in May 2015. The structural monitoring system is a part of the multidisciplinary strong-motion array, ICEARRAY II, which is in operation in North Iceland (*Halldórsson et al.*, 2012). The measurements have been ongoing for one year and three notable events have occurred that provide useful full-scale records of the building excitation and response. The records have been used to determine key dynamic properties and response characteristics, and for validation of the structural model (see Fig. 2 and Fig. 3). The finite element model was constructed using the structural design software Sap2000 (www.csiberkeley.com). The first natural frequency of the building is 7.4 Hz, and the damping ratio at low intensity excitation was found to be of the order, 2 - 3% of critical.

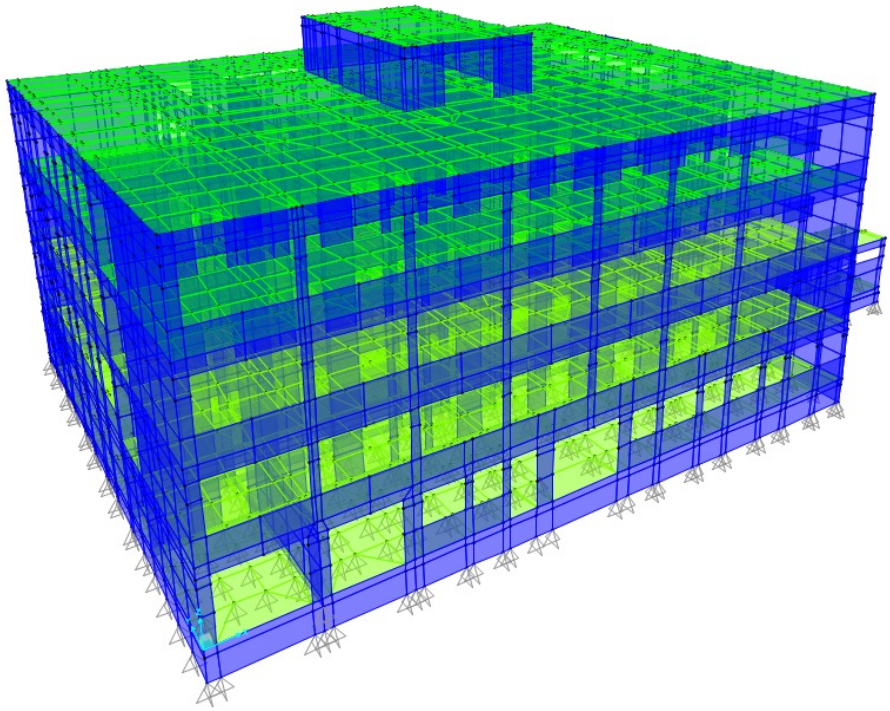

Figure 2. 3D model of the building in SAP2000

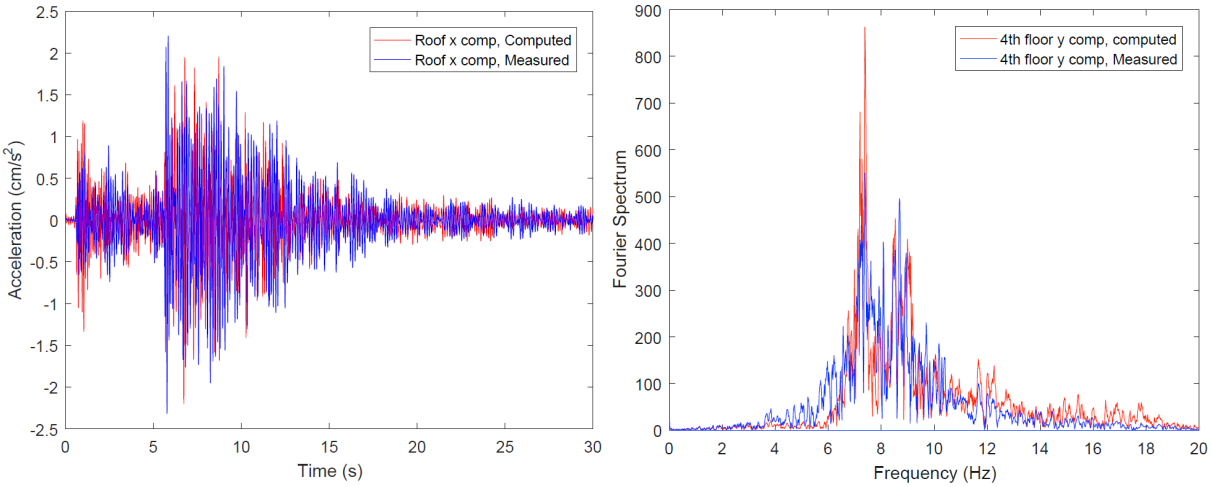

Figure 3. Comparison of recorded and computed response. To the left: Time series from the sensor within the utility building on the roof. To the right: Fourier spectra from the sensor at the top corner of the outer wall on the 4th floor on the right.

Building codes and standard civil engineering practises have evolved considerably since the construction of the hospital (started in 1964 and lasted a few years). Especially with regard to seismic design requirements. Individual building components and details will be examined with this in mind. The earthquake excitation used for the analysis is the EN-1998-1 (*CEN*, 2005) Response spectra and records of strong ground motion from earthquake events that occurred in the South Iceland seismic zone in June 2000 (*Sigbjörnsson et al.,* 2007) and May 2008 (*Halldórsson & Sigbjörnsson*, 2009). Fig. 4 shows an example of results from a response spectrum analysis in the form of a distribution of the vertical design force for concrete design (N_{Des2}) along the face of the south-west wall.

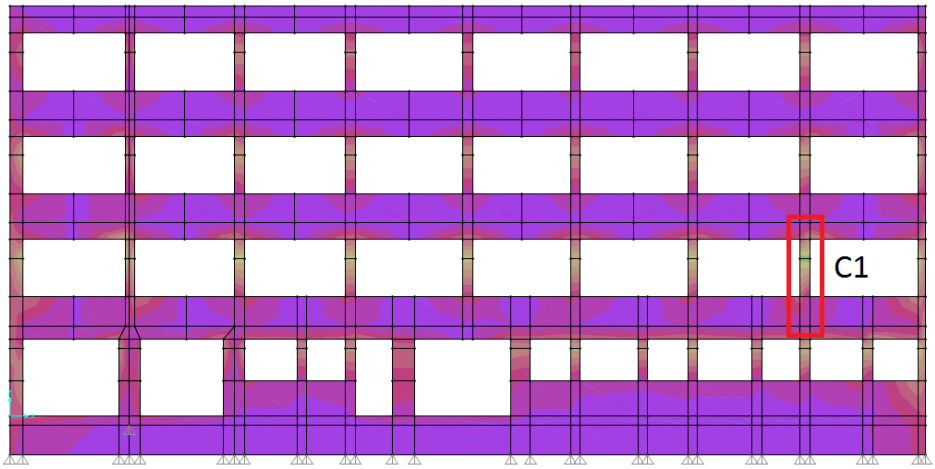

Figure 4. Vertical design forces in the south west wall of the building for a specific load case. The short window column at C1 is a cross section selected for further checking.

The building has many load carrying walls, in a structural system that provides a lot of redundancy. The building deformations are found to be small, or 1 cm or less for a design response spectral analysis. The same can be said about the story drift which is found to be well within the limits prescribed by EN1998. Concrete stresses are also generally found to be low. However, for specific load cases there are some structural elements that need further evaluation.

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