Seismic Vulnerability of Hospitals - Austria

Project Description:

During the design procedure of new buildings usually seismic effects are taken into account, resulting in high safety values for these structures. New design codes are already in line with the European EC8 which is describing a detailed calculation procedure. Main problem in context of seismic events is the effect to existing structures, which are always designed according the current standards. Thus it is clear, that the main part of human and economic losses appear for these old structures, which are not appropriate designed. An assessment and improvement of all existing structures which are subjected to excessive seismic loads is not feasible, but the improvement of major structures which must fulfill their function after a seismic event is an economic approach. In particular this fact is important for hospitals.

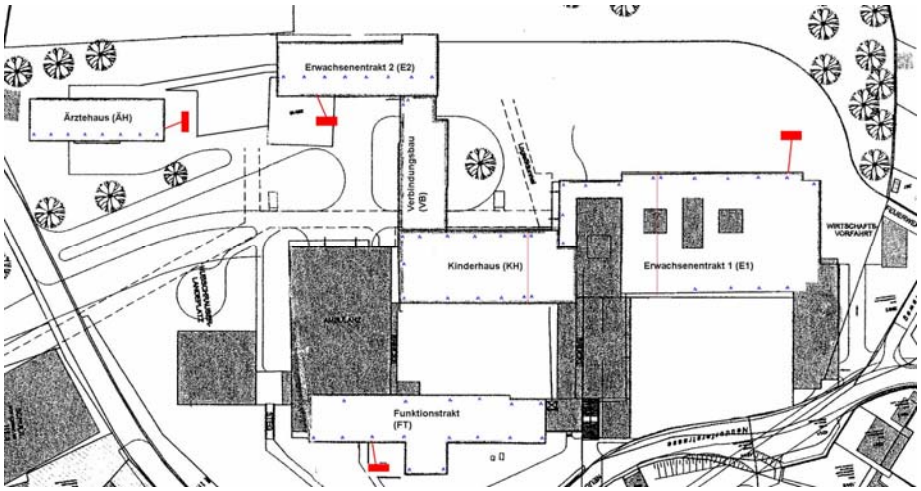
Hospital Leoben, Styria, Austria

Quick Facts:

- **Name and Location:** Hosptial Leoben, Leoben, Styria, Austria
- **Owner:** Stmk. Krankenanstalten GesmbH
- **Structure category:** Hospital
- **Height:** consisting of several buildings between 1 and 6 floors
- **Structural system:** Reinforced Concrete, Masonry Structure
- **Start of SHM:** July 2003
- **Number of measurement points:**
- **Instrumentation design by:** arsenal research, Business Area Transport Route Engineering, Vienna, Austria

Description of Structure:

The hospital Leoben is consisting of several buildings, which are different in case of structural system, construction material, number of floors and age. During the evaluation of the project it turned out, that some single structures are more important because of their structural system, height or condition. From this assessment it was decided to investigate the following structures, also indicated in the plan view of the hospital area: “Ärztehaus”, “Erwachsenentrakt” number 1 and 2, “Funktionstrakt” and “Kinderhaus”. The location of each building as well as the location of the reaction mass exciter is indicated in the plan view of the hospital area.



View of the hospital area

Purpose of Inspection:

First step of the investigation was related to the measurement of the vibration response of major structures. The determined natural frequencies and mode shapes are representative for the current undamaged condition of the buildings. During the next step a numerical analysis was performed for the structures, reaching from simple MDOF systems to advanced finite element models. Consequently, these models are fitted to the measured data (modal updating). These models are used for seismic calculations by the response spectra or the quasi-static method. The capacity of the structures was evaluated in accordance to the Austrian code B 4015, which was described by the “GPR” index. Secondary risks were also considered (GSR-index). Both indices are contributing to the risk index, which was presented by a risk-mapping technique. Main outcome are measures which should be implemented in order to increase seismic safety for identified areas of the structure. In addition a further investigation can be performed after an earthquake in order to assess the structural integrity after such event.

Sensor Details*:

Type of sensors	Number	Location
Dewetron Port 2000 incl. DASYLAB	1	Mobile Acquisition Unit
Oros OR38 Multichannel Analyzer	1	Data Analyzer (mobile)

Geosig Velocity Sensors	6	Each floor of investigated structure
Seismic Sensors	4	Identification of ground response at selected locations
HBM Sensors SMU 30A	6	Each floor of investigated structure

Measurement Equipment and Data Management:

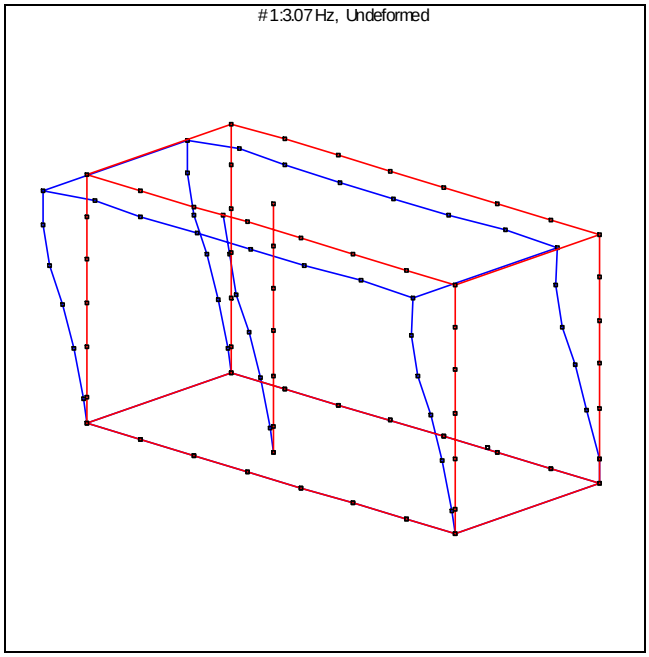
Type of system	Data Management	CMS
Mobile measurement system based upon Ambient + Forced Vibration Technology	▪ data pre-analysis (natural frequencies) on site in order to check the obtained data quality ▪ main analysis, graphical presentation and documentation in office ▪ data transfer by data cables to main station ▪ Forced Testing by Reaction Mass Exciter VICTORIA connected by a chain	

Data Analysis Procedures:

Type of analysis	Software	Additional features
Identification of modal parameters by System Identification	Stochastic Subspace Identification (MACEC)	▪ Identification of ground response by Reaction Mass Exciter VICTORIA ▪ Modal updating of major structures

Examples of Outcomes:

The investigation of the structure results in several results. On one hand the modal parameter of each building were identified by measurements, which have been compared to the results of the finite element analysis. The modal parameters were identified by ambient measurement and by forced vibration testing employing the reaction mass exciter VICTORIA. The exciter was attached to the structure by a stiff chain. Thus, results in sufficient excitation level. On the other hand the ground response was identified, using the exciter as well. A conventional risk study was additionally applied for each structure. By combining all results, a detailed impression from the structures could derived, which is base for seismic upgrading and future monitoring concepts.



Calculated Mode Shape of the Hospital

Benefits of using SHM Technologies in the Project:

Major benefit of this project is to determine structures or areas which are subjected to a higher risk of failure or structural damages. For these problems adequate counter-measures could be performed. Moreover an initial measurement was established, which will be used for further assessment of the structure in case of an earthquake by comparing initial and new vibration data. The updated finite element mode is relevant to estimate the capacity of a structure and to enable damage detection based upon the comparison of measured and simulated data. The identification of critical areas within the structure enables a target-oriented inspection after the next earthquake. Thus, the remaining load carrying capacity could be evaluated, quickly. Application of a permanent monitoring system to the identified areas would be a appropriate solution for very sensitive structures.

References:

Final Report “Earthquake Investigation of Austrian Hospitals” (submitted in German) to the responsible authority (Stmk. Krankenanstalten GesmbH), Graz, Austria

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