SEISMIC RESPONSE ANALYSIS OF THE LEVEES OF A DETENTION BASIN ON THE SAMOGGIA RIVER.

Ing. Lorenzo Ruggeri [(1)], Ing. Gianluca Gottardi Ph.D. [(2)] and Dr. Lisa Borgatti Ph.D.[(3)]

[(1)] University of Bologna, Student, lorenzo.ruggeri@studio.unibo.it
[(2)] University of Bologna, Ph.D. DICAM, g.gottardi@unibo.it, Regione Emilia-Romagna (STBR)
[(3)] University of Bologna, Ph.D. DICAM, lisa.borgatti@unibo.it

This work has been developed for an engineering thesis made by joint work with the University of Bologna and Regione Emilia-Romagna.

The Context

The detention basin is 6.5 km from San Giovanni in Persiceto (BO) and occupies an area of about 100 ha in the left bank of the Samoggia River about 1 km downstream of Budrie's bridge.
Springs and snowfields don't feed the River, so it presents an extremely variable torrential activity, with sudden flows of lean practically dry for large part of the year it happens because.

Seismic Analysis

Budrie's detention basin is considered a work of strategic interest, together with all the other national and regional important reservoirs. Emilia-Romagna Regional law nr. 1661 of November 2, 2009 – imposes to do a dedicated analysis of local seismic response for this category of works.
This analysis has already been done for some basins near the main tributaries of the Po River, for seismic verifications of spillway, embankments and other hydraulic structures. These studies have been used as guidelines for conducting the series of seismic tests performed in the master thesis.
Before undertaking the detailed geotechnical investigation, all the data already stored in archives and georeferenced databases have been collected in order to find useful pieces of information for the geological characterization of the area and of the subsurface.

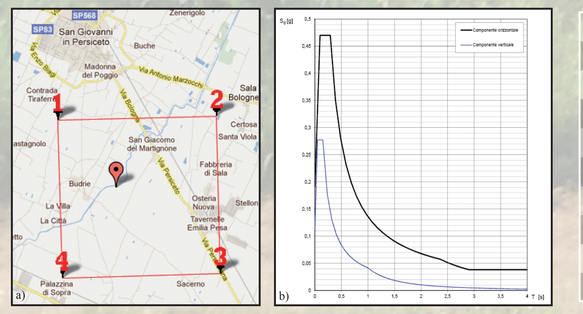

Fig. 1 – Localization grid (a) to define the target spectrum (b) according to NTC2008

Longitude	11.199
Latitude	44.591
Site class	A
Topographic category	T1
Building category	III
Limit state	SLV
Use coefficient (Cu)	1,5
Reference time (Vr)	712 years
Probability of exceedance	10%
Nominal life of the building	50 years

Independent parameters	
LIMIT STATE	SLV
Ag	0,191
F0	2,460
Tc	0,289
Ss	1,000
Tc	1,000
St	1,000

Dependent parameters	
S	1,000
h	1,000
T_B	0,096
T_C	0,289
T_D	2,364

Tab. 1 – Target spectrum selection parameters

The additional investigations consist in:

- SCPTu - Seismic Piezocone Penetrometer with measurement of pore water pressure, extended over 30 m deep to the berm;
- CPTu - Piezocone Penetrometer with pore water pressure measurement, extended 30m deep to the top of the embankment;
- Wire line core drilling with drawing of 10 undisturbed samples; extended 35 m deep to berm of the embankment;
- Seismic MASW HVSR;
- Laboratory tests including static geotechnical soil classification, Oedometer tests, Triaxial tests: consolidated drained (TxCD) and unconsolidated undrained (TxUU);
- Laboratory tests in the dynamic field by resonant column and torsional shear.

All investigations have been performed by Elletipi s.r.l. between July and September 2011 and supervised on site by the authors and STBR engineers. The results of these tests have been used to define the geotechnical model of the area.

Compatible Spectra Selection

The specific software REXEL has been exploited to select compatible response spectra.
REXEL allows the design spectra to be defined according to the Eurocode 8, the new Italian Building Code. It is also possible to set up user-defined spectra. Based on these spectra, the software allows to search for sets of 7 compatible records (recorded accelerograms scaled), in the average. Records may also reflect the seismogenetic features of the sources (in terms of magnitude and epicentral distance), ground motion intensity measures, and soil conditions appropriate with respect to the site.
The European Strong-motion Database (ESD) and the Italian Accelerometric Archive (ITACA) datasets are contained in REXEL.
All 7 selected records have been referred to category A subsurface condition (outcropping rock).

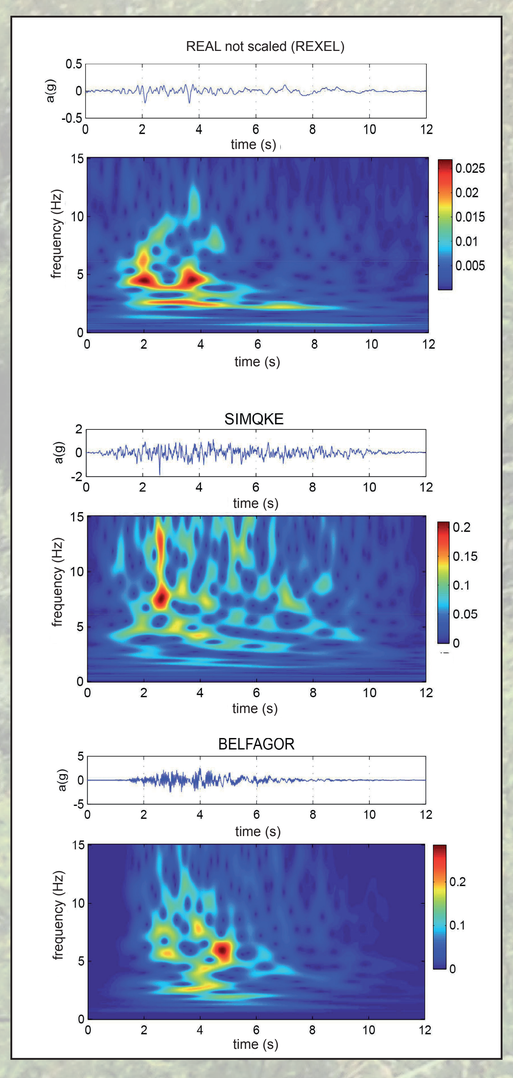

Fig. 2 - Spectrograms, results by time-frequency anali sys.

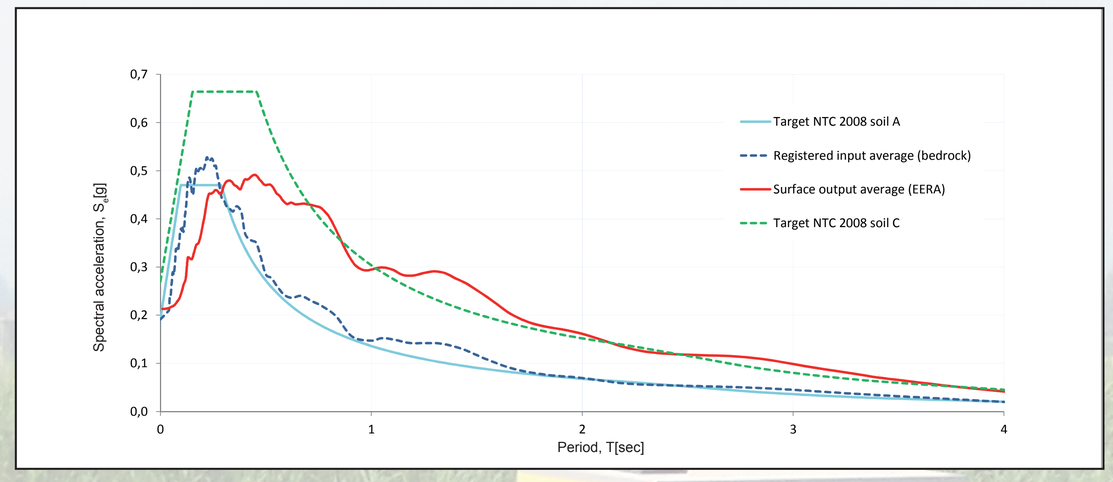

Fig. 3 - Response spectrum

Time-Frequency Analysis

An analysis has been conducted in the time-frequency domain to demonstrate the consistency between synthetic generated signals generated by two different software: SIMQKE and BELFAGOR) and real spectrum compatible signals (from REXEL). The analysis has been done through MatLab function "s-transform".
The results show that synthetic signals are worse than real selected signals in terms of energetic distribution.

Seismic Response Analysis

The seismic site-dependent analysis has been performed by EERA (Equivalent-linear Earthquake Response Analysis) software, which is based on SHAKE mathematical model. A one-dimensional modeling has been chosen because the site doesn't show particularly complex conditions for what concerns the surface and buried morphologies.

$$Fa_{0.1-0.5} = \frac{si_{0.1-0.5}(output)}{si_{0.1-0.5}(input)} \quad ; \quad Fa_{0.5-1.5} = \frac{si_{0.5-1.5}(output)}{si_{0.5-1.5}(input)}$$

Fig. 4 – Spectral amplification factor

	Fa (0,1-0,5)	Fa (0,5-1,5)
SOIL A	**0,96**	**2,23**
SOIL C	**0,67**	**0,99**

Tab 2, – Spectral amplification factors referred to two different categories of soil.

EERA considers the following input parameters:
- Number and thickness of layers;
- physical characteristics of the soil of each layer;
- shear stress (G/G_{max}) and damping ratio (D%) for each type of soil;
- input signal (accelerogram) based on the seismic reflector surface.

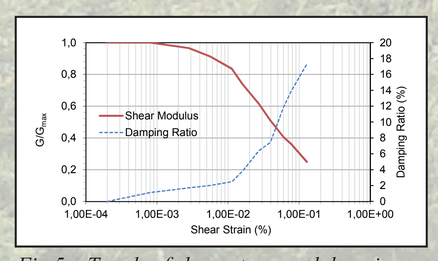

Fig.5 – Trends of shear stress and damping ratio measured by laboratory tests

The output consists in a new seismic signal and considers the modification of the signal occurring in the travel between seismic source and surface.
Spectral site amplification factor (Fig. 4) has been found by comparing the average spectrum of output signals with the target spectrum. The results are shown in Tab. 2.
Figure 3 shows the comparison between average output spectra and target spectrum. It shows that target spectrum is more precautionary in range of periods between 0,1-0,5 sec and almost equal between 0,5-1,5 sec than average output spectrum.

Conclusions

In this site we didn't observe seismic amplification in terms of maximum acceleration, whereas the spectrum shows a general strain to low frequencies. However, the target spectrum on soil C is absolutely precautionary for safety conditions.
Slope stability analyses have been performed on two embankments considering the typical sections in different hydraulic conditions. Safety conditions are verified in all the scenarios. Soil liquefaction susceptibility is also verified.

Acknowledgements

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Fig. 6 - Resonant Column/ Torsional Shear Testing System (TSH-100 & TSH-200) GCTS (Elletipi s.r.l. Ferrara)