Title: **Floor response spectra of WWER-1000, NPP Kozloduy generated from local seismic excitation**

Contributor: **Z. Boyadjiev and M. Kostov**

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FLOOR RESPONSE SPECTRA OF VVER-1000, NPP KOZLODUY GENERATED FROM LOCAL SEISMIC EXCITATION

Zahari Bojadziev
Research and Development, NPP Kozloduy

Marin Kostov,
Central Laboratory for Seismic Mechanics and Earthquake Engineering

Introduction

The seismic review level characteristics for the site of Kozloduy NPP have been set to 0.2g and a respective free field acceleration response spectra have been derived after a profound site conformation project. According to the conclusions of that project a separate investigation is recommended for local seismic excitation. This requirement complies with 50-SG-01 and has been newly initiated. The goals of the analyses are:
- to define the seismic motion characteristics from local seismic sources (30km zone);
- to perform structural analyses and in-structure spectra generation for local seismic excitation;
- to compare the forces (spectra) from local events with those generated as seismic design review bases.

Database

The seismological information needed for the execution of the project has been derived from the available tectonic, geological and seismological information compiled in the overall seismic hazard project. According to the former project the local zone (30km) around Kozloduy (fig.1) is characterized by low seismicity and relatively stable tectonic settings. There are only a few small earthquakes registered in that zone for the instrumental period of observation in Bulgaria. Conservatively it was assumed that the maximum magnitude expected is 4.5. Because of the lacking data of observed events in the local zone, the frequency-magnitude relation was derived from the database for the Moezian platform. There are no capable faults in the zone, however the so called weaken lines have been used as probable sources. The closest weaken line to the site is placed about 7km east. The average depth of the local seismicity is assumed to be about 5 km.

For the aim of a seismic time function modelling a sample of 43 three component acceleration records have been compiled. The content of the sample is as it follows: 20 records , Italy; 6 records, California; 5 records, Turkey; 3 records, Bulgaria, 9 records, Japan.

Attention has been paid to proper selection of the soil condition of records (medium to weak soil).

Characteristics of the ground motion

A conventional hazard analysis with an assessment of the uncertainties has been used to determine the maximum acceleration from local seismic sources. The input data described above are used for the purpose. The following key parameters are varied:

- attenuation law: 2 alternatives: Ambraseys, Bommer and Stamatovska, Petrovski;
- standard deviation: 0.4 and 0.6;
- maximum magnitude: 4, 4.5 and 5;
- minimum magnitude: 3.5 and 3.75;
- frequency of occurrence: 2 alternatives;
- space distribution of seismicity: 2 models.

According to that logic scheme 96 results are generated. The statistics id given in table 1.

The frequency content of the review ground motion is determined by statistic of the acceleration response spectra derived from the compiled sample of records. The statistics of the spectra is given in fig.2. The statistics of the maximum acceleration of the records is given in table 2.

For review of the structures and the equipment from local seismic excitation is selected the mean normalized spectrum, scaled by the mean plus one standard deviation maximum acceleration (fig.3 and 4).

In-structure spectra

For the in-structure spectra generation the 3-D finite element model is used (fig.5). The same model is used also for the design in-structure spectra computation. The soil is represented by spring and dashpot system. The material damping in the structure is 4% (5% for the design spectra). The radiation damping in the soil is respectively: 70% - vertical vibration, 42% for horizontal, 35% for rocking and 21% for torsional motion. The composite damping is limited to 30% for vertical and to 15% to horizontal vibration.

The computed in-structure spectra are compared with the design spectra . An additional test has been performed with three real accelerograms. The accelerograms are forming the maximums of the envelope of the sample acceleration response spectra. The results of these computations are shown in fig. 6,7,8.

Conclusions

The performed calculations are leading to the following conclusions:

1.The local seismic excitation could be characterized by a horizontal maximum acceleration 0.16g with an annual probability of exceedance 10-4. The corresponding vertical acceleration is assumed on the base of the statistics performed 0.8 from the horizontal one.

2.The spectral acceleration for horizontal motion from local sources will be lower than the respective design free field spectrum in the whole frequency range of interest. The vertical acceleration spectrum will be partially higher than the vertical design spectrum - for frequencies about 10HZ and higher, the spectral values of the local excitation are higher than those, prescribed by the deign spectrum.

3.Although there is difference in the input motion, the calculated design floor acceleration spectra are covering the values of the spectra, generated from local excitation. The reasons for those results are the intensive soil-structure interaction effects which are determining the seismic response of that building.

Table 1. Seismic Hazard from Local Seismic Sources

Annual Prob.	Mean [g]	Sigma [g]	Median [g]	15% [g]	85% [g]
10^{-2}	0.016	0.009	0.015	0.009	0.024
10^{-3}	0.056	0.025	0.051	0.032	0.083
10^{-4}	0.128	0.033	0.124	0.096	0.162
10^{-5}	0.227	0.073	0.216	0.156	0.299
10^{-6}	0.341	0.125	0.320	0.221	0.462

Table 2. Statistics of accelerogram sample

Component	Mean a_{max} [g]	Sigma [g]	Mean+1.sigma [g]
Horizontal	0.059	0.056	0.116
Vertical	0.041	0.053	0.094

Literature:

Safety Guides, Safety Series No 50-SG-S1, 1991. Earthquakes and Associated Topics in Relation to Nuclear Power Plant Siting, IAEA, V.,60.

Initial Data of Seismic Input and Soil Conditions of Kozloduy NPP Site, Extention to Part II Soil Conditions, Report, NPP Kozloduy, 1994

Kostov et al., Floor Response Spectra of Unit 5/6, NNP-Kozloduy, Riskengineering Ltd., 1994

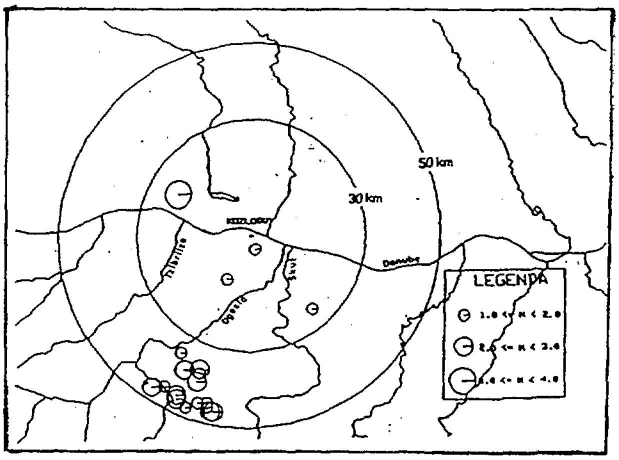

Fig.1.Local Zone of NPP-K.
Epicentral Map

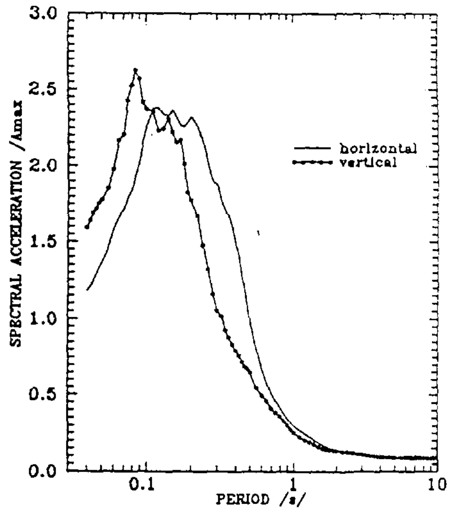

Fig.2. Normalized Sa from
Local Sources, Statistics

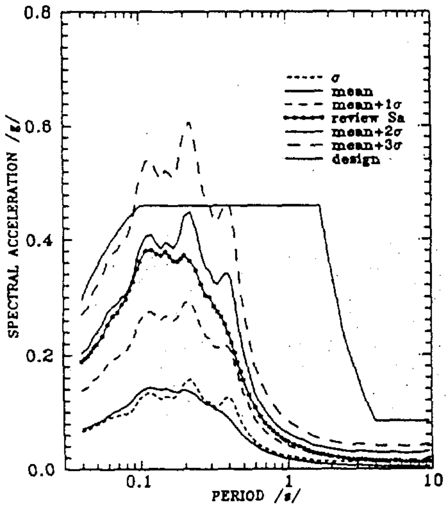

Fig.3. Comparison between local
and dsign spectra, hor.comp.

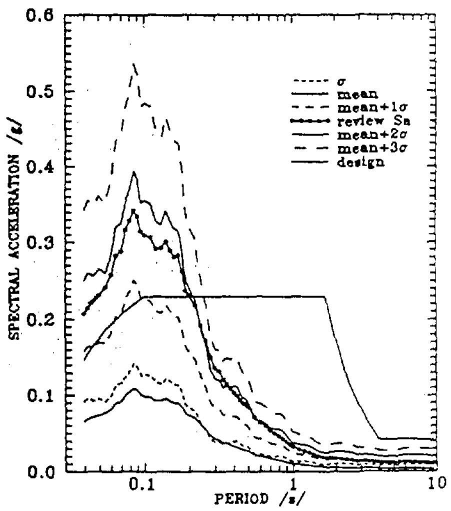

Fig.4. Comparison between local
and dseign spectra, ver.comp.

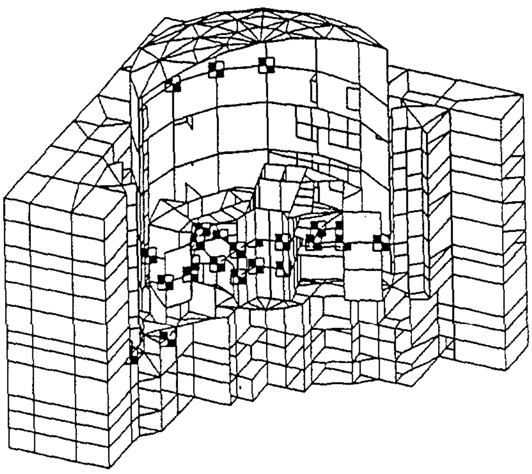

Fig.5. FE Model of VVER-1000, NPP-K

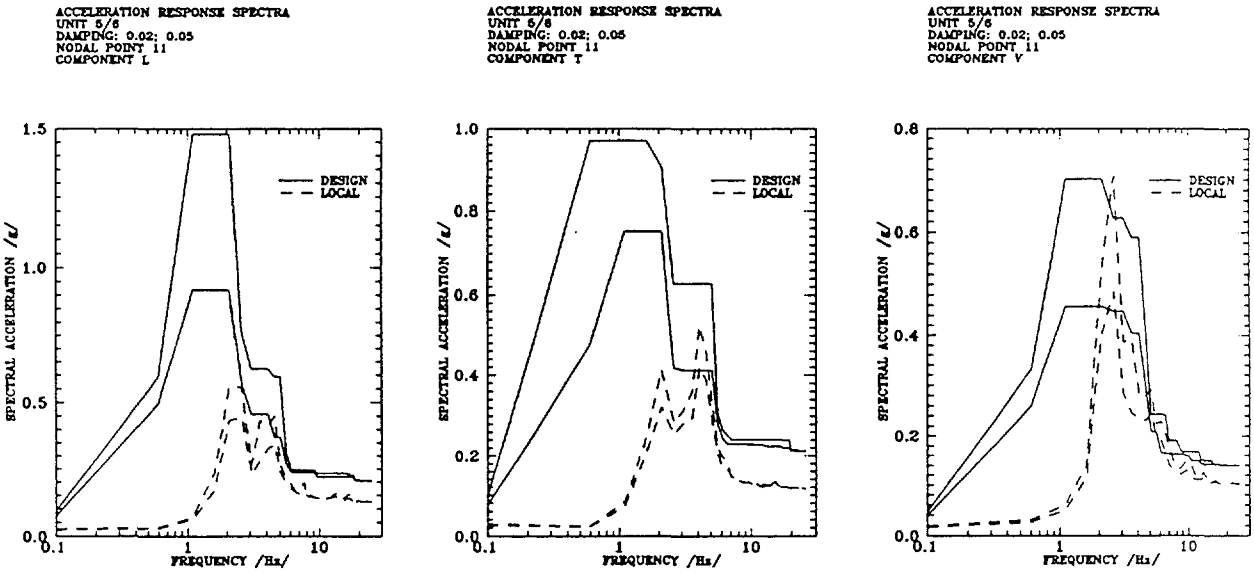

Fig.6.Comparison between design and "local" spectra, foundation level

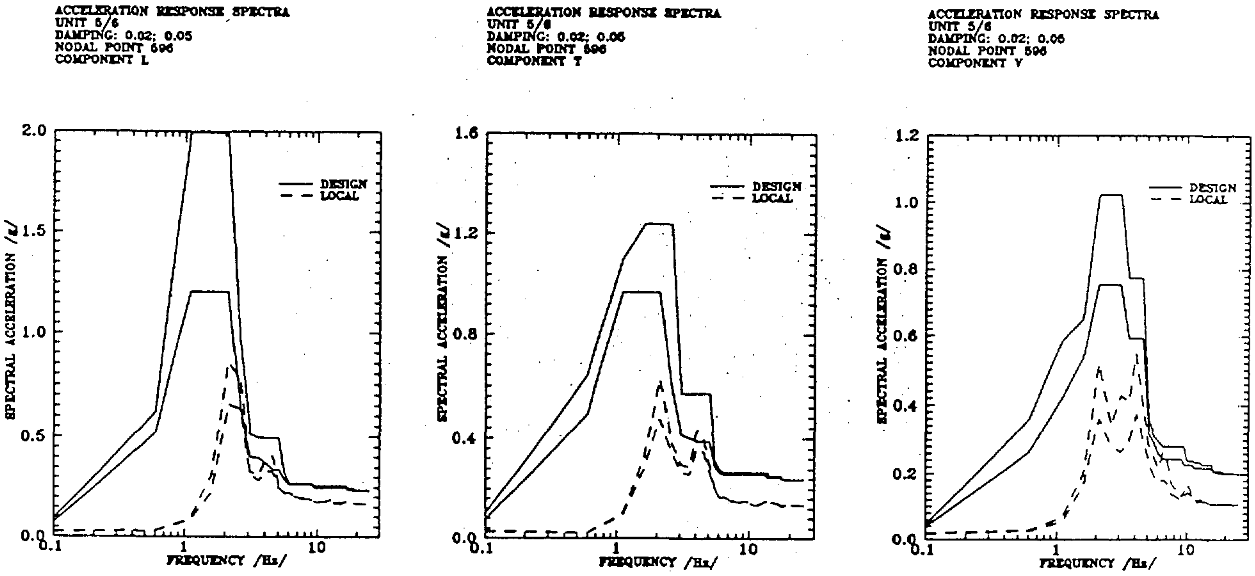

Fig.7 .Comparison between design and "local" spectra at level 13.00m.

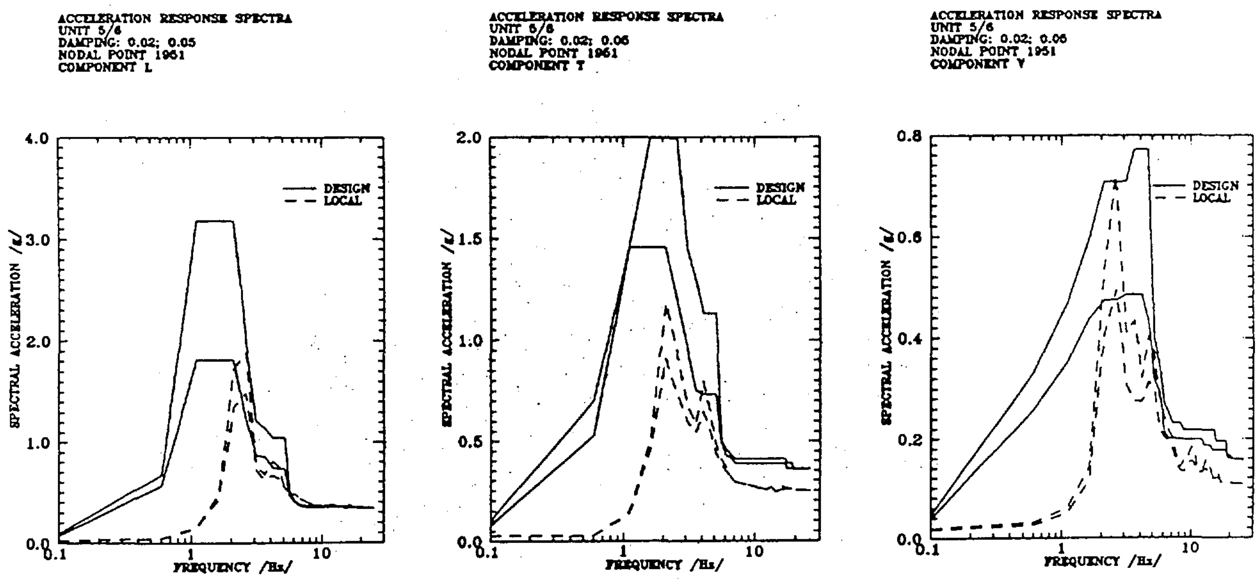

Fig.8 .Comparison between design and 'local' spectra at crane level.