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Dynamic Response of Belene VVER-1000 to Seismic Loading Conditions

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Summary

Within the framework of investigating of the capacity of the VVER-100 at the Belene site, an analysis was performed using revised seismic input data as well as two alternative foundation concepts (natural soil and soil exchange).

The starting point for the analysis was the development of a suitable model of the coupled structures (base building, external building, containment, internal structure) and soil taking into account the real properties of the originally layered as well as the exchanged soil.

The soil-structure effects were considered according to the analytical method employed, either through soil impedance (substructure method) or explicitly by a complex (direct method).

On the basis of the results obtained by the two methods (substructure and direct method) the seismic safety of the complex structures for different foundation concepts was evaluated. By comparing the calculated structural response with the design spectra originally used for the design of components and systems the available safety margin was estimated.

1 Introduction

In mid-1990, two of the four Type VVER-1000 units to be built at Belene Nuclear Power Station site were under construction.

The objectives of the reassessment of the seismic design of these units, which had been stipulated by the Bulgarian Government, were to verify the site-specific soil-dynamic and seismological parameters and then to assess by analysis the seismic safety of the main buildings at this site.

The reassessment of the seismicity and the derivation of site-specific input data for the requisite structural analyses were performed in cooperation with the Institute of Earthquake Engineering and Seismology (IZIIS) in Skopje and in agreement with the Bulgarian Academy of Science as well as the Building Research Institute in Sofia.

At the center of the task to be performed were preliminary analyses of the dynamic behavior of a partially-completed reactor building under the specified seismic loads (standard spectrum) and of new input data derived in the framework of this study for the site of Belene Nuclear Power Station and taking into account two options related to the soil conditions, i.e. natural soil (profile 1) and soil replacement plus soil compaction (profile 2).

The structural analyses were performed using state-of-the-art techniques and software codes which had been validated through application in several licensing procedures.

Starting point of the analyses was a detailed mathematical model of the coupled vibrating structures (base structure, reactor auxiliary building, containment and internal structures) and the layered soil, which realistically represented the properties of the substructures.

In order to validate the results, it was suggested that analyses be performed using two different methods (direct and indirect calculational method). Depending on the method used, the soil properties were determined by means of soil impedances (equivalent stiffnesses and damping values; indirect method) or explicitly (direct method).

The results of the preliminary analyses were to be used in the subsequent steps to evaluate the seismic safety of the structure and to assess the existing safety margins by comparing the calculated structural responses with the design spectra (provided by the customer) of the components and systems.

1.1 Design and Foundation Concept

The VVER-1000 reactor building (Fig. 1) essentially comprises a concrete containment with internal structures, which is supported on a square base structure. It is enclosed by a reactor auxiliary building which likewise rests on this base structure.

The base structure is 66 m long and 66 m wide. The total height measured from the top edge of the 2.80-m-thick foundation plate to the top edge of the stiff top slab, which is roughly of the same thickness, is approximately 9.0 m. The base structure is adequately stiffened by several walls (Figs. 1 and 2) and floors.

The total height of the reactor auxiliary building is approximately 45.6 m, and the highest point of the containment is approximately 65.95 m above plant grade.

The base mat measures 72 m x 74 m. Load transmission into the soil is via a second concrete slab located underneath the base mat.

The containment is made of prestressed concrete and lined with 8-mm-thick steel plates. The walls of the base structure are made partially covered by 8-cm-thick prefabricated, reinforced concrete panels.

In the area of the reactor building foundation, the soil was excavated to a depth of approximately 19 m below plant grade. The pit (Fig. 1) was backfilled with gravel which was compacted to achieve an adequate load-bearing capacity.

In order to improve the transmission of loads and the stability of the structure, a 2.30-m-thick concrete bottom slab measuring 80 m x 80 m was placed on top of the gravel.

Following placing of the base mat and construction of the lower section of the building, the area surrounding the structure was backfilled to elevation 0.0 m (i.e. 7 m above the top edge of the concrete bottom slab) and compacted.

2 Input Data

2.1 Seismological Data

The seismic loads for the Belene site were defined using a smoothed standard free-field spectrum (hereinafter referred to as seismic excitation A, Fig. 3).

In order to verify this assumption, a second seismic load was derived within the framework of this study on the basis of existing seismic records (hereinafter referred to as seismic excitation B, Ref. 1). As mentioned above, these analyses were performed in cooperation with IZIIS in Skopje.

IZIIS (in cooperation with seismologists from the Bulgarian Academy of Science) performed in-depth analyses based on available information and seismic records (in particular those for Bucharest and Nish). These data (Figs. 4 and 5) were initially deconvoluted to a fixed horizon (bedrock) which then allowed determination (taking into account the soil layering and the scattering of the soil parameters at Belene site) of the site-specific free-field spectra. The free-field spectra (Figs. 6 and 7) derived for Belene by enveloping the data from the Bucharest earthquakes and the soil parameter variations formed the second basis (load definition B) for the plant design. The free-field spectra shown in Figures 3 and 8, as well as the intensity function shown in Figure 9, formed the basis for deriving a set of spectrum-compatible time histories for each type of seismic excitation. Three time histories of each set were eventually used for the analyses.

2.2 Soil-Dynamic Data

The information regarding the soil structure, and the dynamic parameters of the individual soil layers were based on the data accessible at the time of beginning of the studies.

According to these data, the soil profile consists of marl at depths greater than approximately 28 m below grade, and of sand, clay and gravel layers above.

In order to improve this soil, the sand and clay layers in the area of the foundation were replaced with a well-compacted gravel layer down to a depth of approximately -19.0 m.

The original grade elevation of approximately -6.5 m at the Belene site was raised to elevation 0.0 m using an artificial gravel fill. The effects (scattering of the properties) of the replaced soil layers were analyzed using two specified soil profiles (profiles 1 and 2, Figs 14 and 15).

Iterated shear moduli, impedance functions and frequency-independent stiffnesses and damping values were derived for the VVER-1000 reactor building from the soil-dynamic analyses. Tables 1 and 2 show the spring stiffnesses and damping values derived for the three soil profiles mentioned above.

3 Building Model

The type of mathematical model to be selected does not only depend on the objective and the type of information required but also on the structural design and the mass distribution of the structure in question as well as on the characteristics of the loading functions. When selecting the mathematical model and the degree of discretization, particular consideration was given to the fact that this would enable reliable determination of the mode shapes of the associated structure in the relevant frequency range. Another decisive factor however was the number of locations for which data had to be obtained.

In view of the geometric configuration, stiffening, mass distribution and the frequency content of the excitation functions of the reactor building to be examined, a representation using an equivalent beam model appeared admissible and appropriate (Fig. 10).

The mathematical model combines the substructure models of the reactor auxiliary building, the internal concrete structures and the base structure to form a coupled vibrating system. The derivation of the equivalent stiffnesses and masses was performed by means of a code based on engineering decisions which had to be taken for each floor and building section.

4 Methods of Analysis

The soil structure at the site and the properties of the soil layers have a predominant effect on the mode shapes and the structural responses of rigid structures, and the damping capacity of the coupled system.

In special cases, particularly in cases where the free-field spectra in the significant frequency range display a steep curve (as with seismic excitation A and B), even a slight variation of the soil parameters means that the scattering of the structural responses at the system and component locations in the structure can be considerable.

It is evident that the mode shape behavior of the structure can affect the seismic free-field response. This results in an exchange of energy between the soil and the structure as well as between the structure and the soil.

An exact analysis of the soil properties and the soil-structure interaction effects on the structural responses can only be carried out using coupled mathematical models (direct method) which consider both the soil and the structure (Fig. 11).

Since this mathematical method is more complex in terms of the processing effort, it was not, until recently, used to the same extent as the indirect method (substructure method) which has become much more commonplace when performing analyses of the soil-structure interaction effects because this method analyzes and solves the structure problem and the soil problem separately (Fig. 12).

However, the crucial step of this method, i.e. the derivation of the equivalent stiffnesses and coupling matrices, was made, in this case, using an adequately detailed soil model and appropriate computer codes /2/.

In the present case, i.e. in the case of the VVER-1000 reactor building at Belene, the situation was relatively unusual (because of the local soil conditions and the existing soil layering).

In order to allow a realistic determination of the dynamic processes and to permit the results to be verified in terms of the loads acting on the structures and the earthquake-induced vibrations to be expected at component locations, the analyses were performed using the indirect and direct mathematical methods. The mathematical models used for the above analyses are shown in Figures 10 and 13.

5 Parameter Variations

In order to investigate the effect of the specified soil parameter variations, particularly in the regions of the replaced layers, and to examine the effects of both (A and B) seismological load specifications, the analyses were performed for the soil profile and seismic excitation combinations listed in Table 3.

Figures 14 and 15 show the properties of the three soil profiles (1 and 2) as a function of depth.

The excitation functions AM and BM, which result from the free-field histories at the embedment level (comparison X̃ and Ö in Fig. 12), represent the second category of variable parameters in case of indirect calculation procedure.

Another parameter, which is however determined indirectly, is the system damping. On the basis of the stipulations set forth in the relevant codes and standards (USNRC, KTA and IAEA), modal damping should be limited as follows when using the indirect method:

- horizontal vibration mode	15%
- vertical vibration mode	30%.

The above standards do not stipulate that the damping be limited if it is possible to provide proof of a better damping capacity using more precise mathematical methods.

Such a limitation is not required for the direct method because the energy dissipation is measured explicitly on the basis of the soil parameters and the material parameters of the structure.

6 Typical Results

6.1 Structural Responses

Some characteristic results of the analyses performed (by means of direct and indirect method) to determine the structural responses at component locations in typical sections of the structure were evaluated and compared as shown in Figures 16 through 31.

Due to the more realistic determination of the soil-structure interaction effects and particularly of the damping capacity of the coupled system, the direct method predictably yields lower results.

For an characteristic region of the building the influence of the soil profiles on the dynamic response has been demonstrated (Figs. 32 and 33)

In Figures 34 and 35 the results of the analyses performed for soil profile 1 and seismic excitations A and BS using the indirect method are shown.

Figures 36 through 39 finally show a number of plots which, for typical building sections, compare the response spectra determined using both the direct and the indirect mathematical methods with the design spectra.

6.2 Internal Forces and Moments

In order to determine the loads acting on the building during a safe shutdown earthquake, the global floor forces (normal forces, shear forces, and bending and torsional moments) were determined. The maximum values of these forces and moments over the building height were compiled separately for the containment, the reactor auxiliary building, the internal concrete structures and the base structure.

The analysis was based on site-specific seismic excitations acting in three orthogonal directions (two horizontal and one vertical).

The earthquake induced forces and moments, as well as all other forces and moments were also used as loads acting on the structures in order to verify or complete the existing safety analyses. In order to perform analyses, which used load components from different directions, the maximum seismic loads were combined in accordance with statistical formulae (e.g. the SRSS method).

7 Evaluation of Results

The results derived within the framework of the preliminary analyses are based on the site-specific input data. Additional seismological input data based on available records of the Vranchea earthquake from 1977 (and particularly those concerning the Bucharest and Nish areas), were also included in the analyses.

The structural dynamics analyses were performed by means of two mathematical methods using different approaches for determining the soil-structure interaction effects and the damping capacity of the coupled vibrating system.

In order to allow as realistic a consideration of the properties of the replaced soil as possible, a wide soil parameter variation was assumed (for the top layers of the replacement soil).

7.1 Seismicity and Earthquake Hazard at Belene Site

According to an up-to-date map of earthquake zones, Belene belongs to Zone VII on the Modified Mercalli scale (Fig. 6-1). To date, neither the Geological Institute of the Bulgarian Academy of Science nor any other authority has been able to register a local earthquake with its focus in the area of Belene Nuclear Power Station. Any earthquakes that were recorded, were located at a distance of 15 to 50 km from the Belene site, were of a lower intensity (magnitude 1.4 - 2.0) and did not have any macroseismic effects on the surface.

The results of the additional seismic analyses performed in the area of the Belene site as part of this study, led to the conclusions that this region does not have any seismo-tectonic faults which could cause earthquakes with significant effects.

However, in order to requalify the safety of the structure in line with more stringent requirements, the analyses were based on a hypothetical local earthquake of a magnitude of 4.0. The source of this earthquake was assumed to be located 9 km away from the site of the nuclear power plant at a depth of 3 km.

The results of analyses, which were performed in order to enable a categorization of Bulgaria into seismic zones, show (Fig. 40) that the Belene site is located in a region where an earthquake with a maximum anticipated intensity of VII on the Modified Mercalli scale will occur with a probability of once per 100 years. This means that an earthquake with an intensity of VIII is expected every 10,000 years.

The earthquake probability analysis of the Bulgarian Academy of Science, however, led to the following results:

a = 0.105 g (in a period of 100 years)
a = 0.165 g (in a period of 10,000 years).

These accelerations are equivalent to the intensity levels VII and VIII on the Modified Mercalli scale.

As regards the use of the recommendations (in terms of the zero period value and the spectrum shapes) made by a team of experts, the following load cases were defined as a basis for the analyses to be performed:

a) Seismic excitation (A) as per the defined standard free-field spectrum (Fig. 3).

B) Seismic excitation (B) as per the free-field spectrum derived from the Bucharest records (Fig. 5) (with an increase in zero period acceleration to 200 cm/s^2).

BS) Seismic excitation (BS) as above but with a specified zero period value of 163 cm/s^2.

7.2 Assessment of the Existing Foundation Concept

The structural measures implemented in respect of the building (base mat enlarged to 74 m x 74 m) and the introduction of an additional base mat which was enlarged by a further 6 m contribute significantly to an improved stability and load transmission into the soil.

The soil profile of the site shows that the soil replacement, i.e. the backfilled and compacted material, leads to a further improvement of the load distribution and stabilization of the structure in the event of ground motion.

The soil-dynamic analyses with three-dimensional representation of the conditions prevailing in the areas of the foundation and the replaced soil lead to the conclusion that (in respect of profile 1) the damping capacity of the site has been improved for all translational directions following soil replacement. The damping capacity is increased from 21% to 38 for the horizontal vibrational directions and from 39% to 51% for the vertical direction (Table 5.2).

7.3 Structural Response of the Building

The analyses were performed using direct and indirect mathematical methods.

The direct methods (coupled mathematical models) use the artificial time histories derived from the specified free-field spectra as excitation criteria whereas the indirect method (decoupled mathematical models) uses the above time histories deconvoluted to the embedment level. Both methods take into account the altered shear moduli in the soil under the base mat and the expected change in stress due to the seismic load (Figs. 14 and 15) for all profiles.

An analysis of the derived response spectra for the typical building sections leads to the conclusion that the zero period values exceed the building height by a moderate amount (Fig. 41) and that the resonant amplifications of all spectra for the reactor structures are relatively low. This indicates that the structure is adequately designed for the absorption of seismic loads. The results of both analyses are in good agreement.

Owing to the damping limits specified for this procedure, the indirect method predictably yields higher values in terms of both the zero period amplitude and the amplification range.

In order to demonstrate the effect of the site-specific free-field spectrum for the Belene site (load definition B and BS), which was calculated as part of this study, a comparison was made of the spectra derived from the structural analyses using the direct method.

It is notable that, in some frequency ranges, seismic excitations B and BS generate higher acceleration values than those spectra generated by calculations on the basis of the standard spectrum (seismic excitation A).

If the results of the analysis with seismic excitation B (with an increase in the zero period value from 1.63 to 2.0 m/s^2) are neglected initially and if the spectra determined using both methods are compared with the design spectra, the following conclusions can be drawn (Figs. 16 to 31):

- In the zero period range, the spectra calculated on the basis of both methods using different soil profiles and seismic excitations, are enveloped by the design spectra.
- In the entire area of the building (except for top edge of internal concrete structures), the design spectra, which are specified with 2%, are only exceeded in a very narrow frequency range in the acceleration amplification range of the spectra.
- In the case of the more realistic results (direct method) which were obtained on the basis of seismic excitation BS, the acceleration values are expected to exceed the design spectra even in the amplification range only by a small amount.
- The results of all calculations show that the acceleration values significantly exceed the design spectrum specified for the top edge of the internal concrete structures in the horizontal directions, thus rendering this spectrum unreliable.

8 Conclusions

The results of the reassessment of the available seismicity data for the Belene site allowed the existing input data of 2.0 m/s^2 to be regarded as the maximum ground acceleration limit.

The realistic acceleration at this site is approximately 1.65 m/s^2. This means that, owing to the use of the specified standard spectrum, all design steps for the reactor building were based on an amplification factor of 200/165 = 1.2.

Due to the difference between the curves for the standard spectrum and the site-specific spectrum in the range of the lowest building frequency, the above-mentioned factor is lower.

An analysis of the design characteristics of the VVER-1000 reactor building leads to the conclusion that the design takes into consideration the most important factors affecting the dynamic behavior of a structure.

A very positive effect is achieved by the relatively high stiffness and the low center of gravity of the mass. The load estimates for the structure lead to the result that the seismic loads can be absorbed.

With regard to the existing and the additional seismological specifications, the reactor building is stable.

The acceleration values exceed the design spectra in the low frequency range and it is, therefore, not expected that this will present any problems for in terms of system and component design. It is further expected that any measures (such as additional support points, reinforcement of anchorages and supports) required during the construction phase can be implemented without any problems.

9 References

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[4] SHAKE
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(B. Schnabel, J. Lysmer, B. Seed, University of California, Berkeley)

[5] STRUDYN
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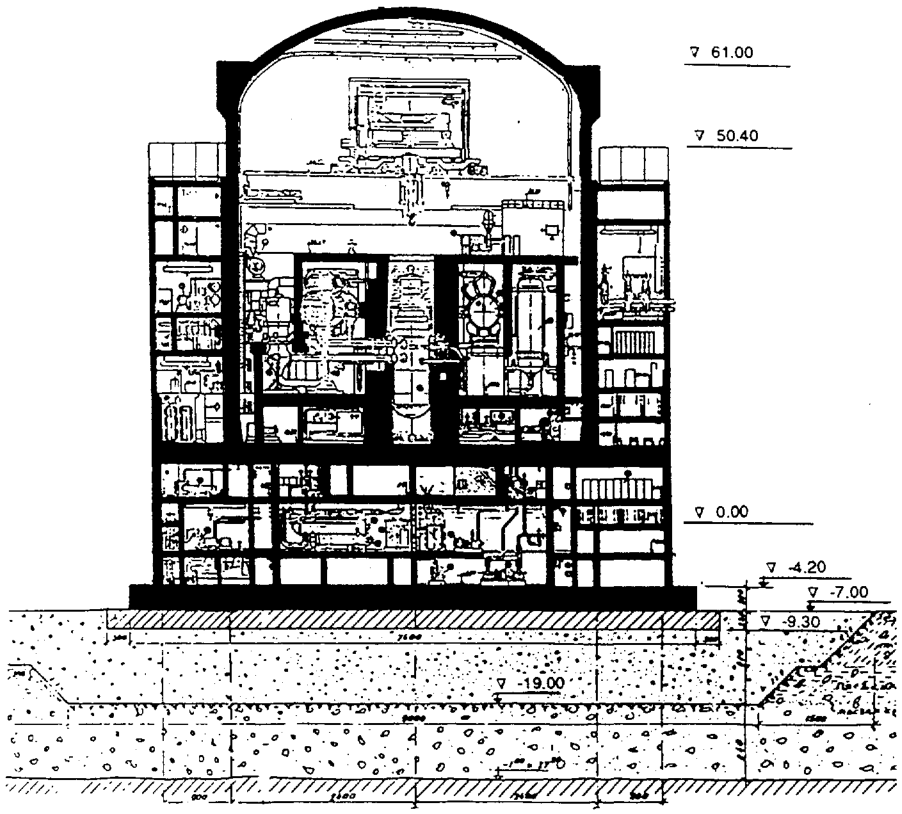


Fig. 1 VVER-1000 BELENE, Reactor Building Overview and Foundation Concept

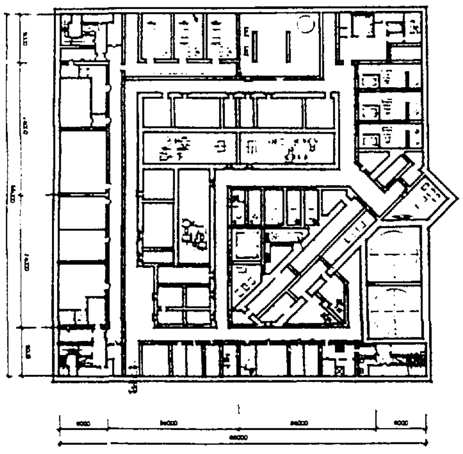


Fig. 2 VVER-1000, BELENE Plan View

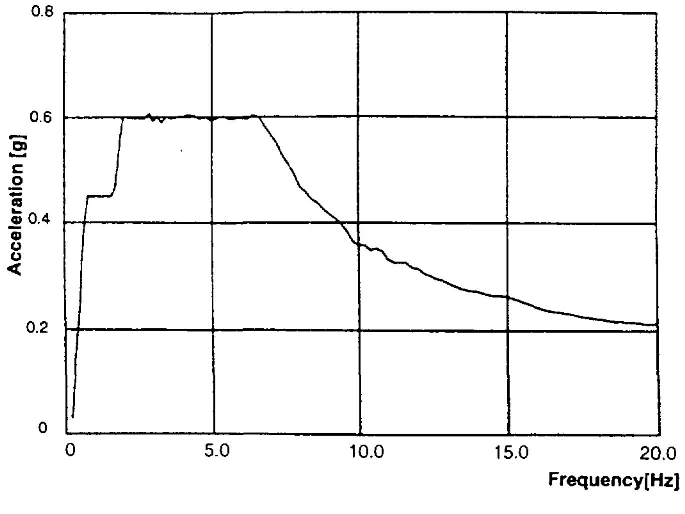


Fig. 3 Standard Free-Field Spectrum Bulgaria (5% Damping) (Load Definition A)

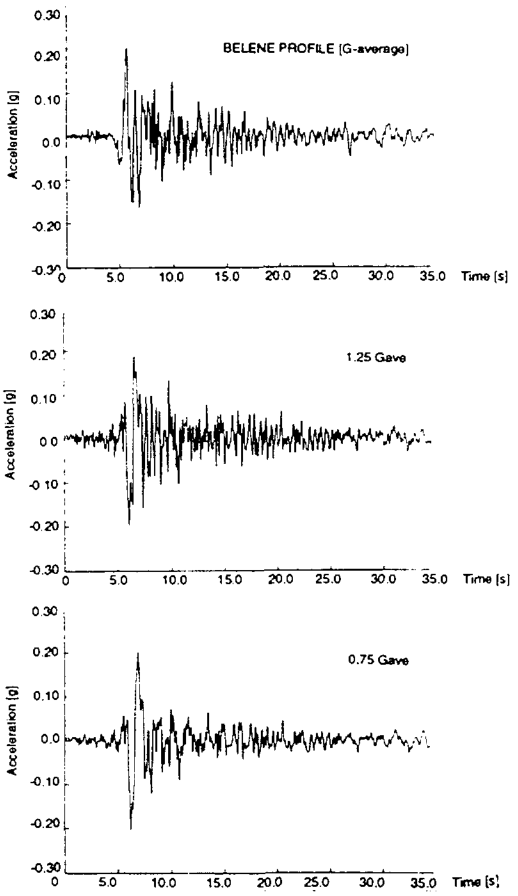


Fig. 4 Free-Field Time Histories BELENE (E-W) Derived from Bukarest Earthquake Records

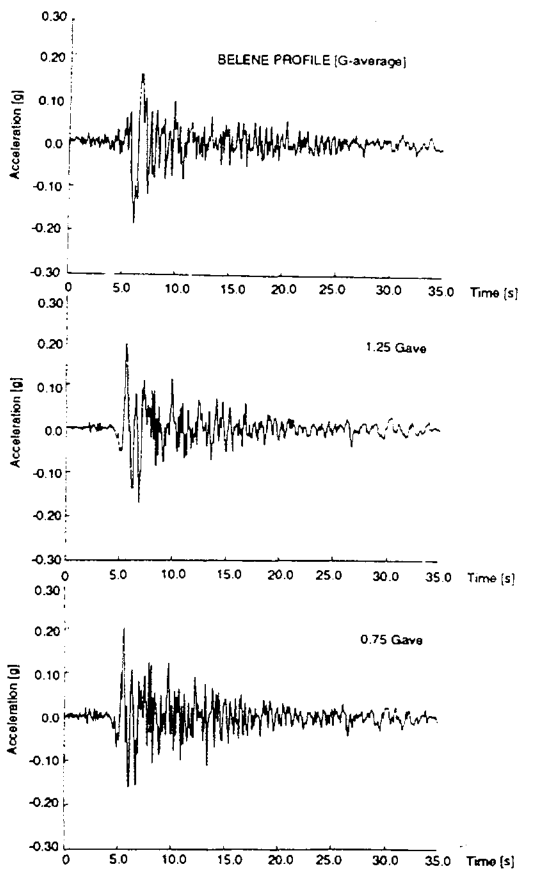


Fig. 5 Free-Field Time Histories BELENE (E-W) Derived from Bukarest Earthquake Records

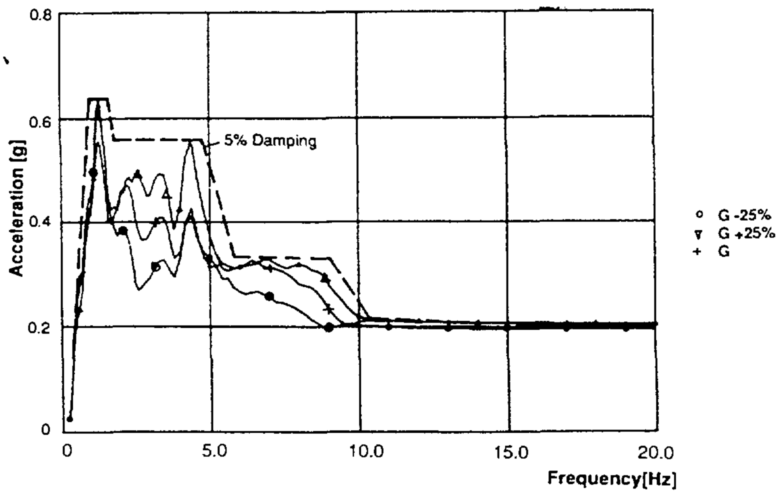


Fig. 6 Comparison of Site Specific Free-Field Spectra (E-W)

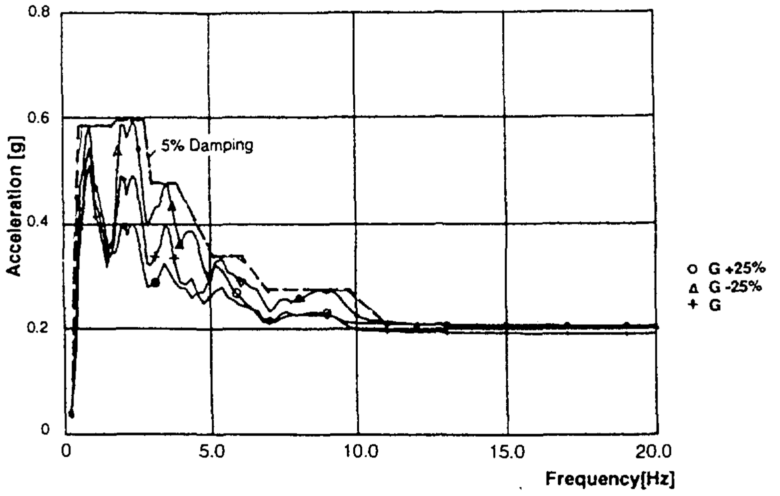


Fig. 7 Comparison of Site Specific Free-Field Spectra (N-S)

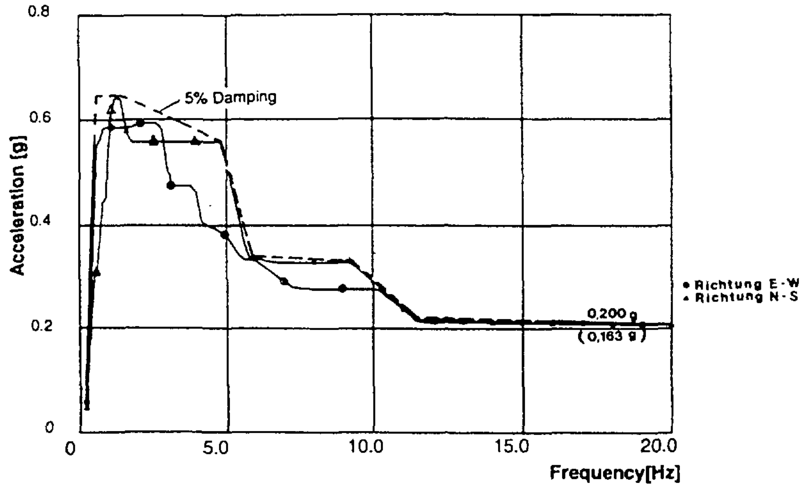


Fig. 8 Site Specific Free-Field Spectrum (Load Definition B)

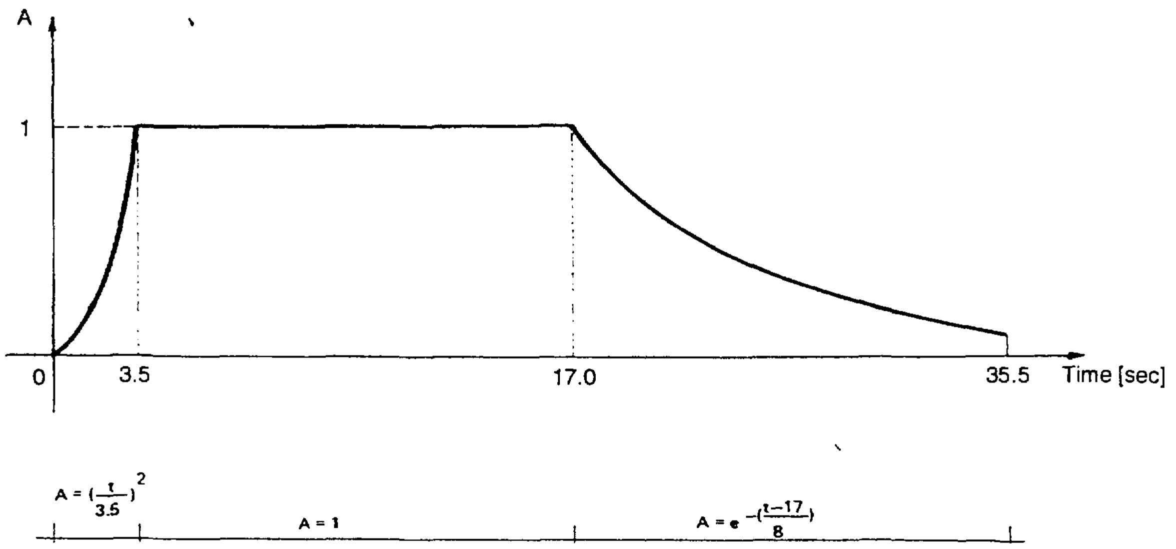


Fig. 9 Intensity Function,BELENE

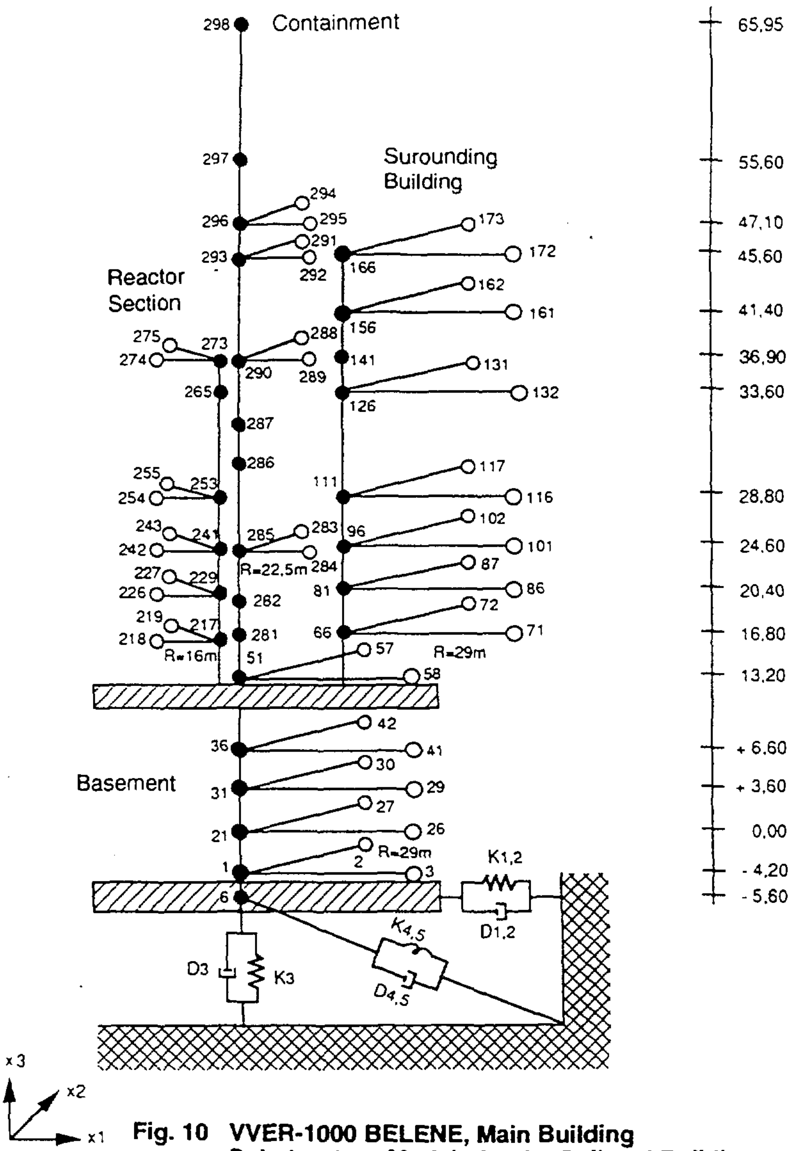


Fig. 10 VVER-1000 BELENE, Main Building Substructure Models for the Soil and Building (Indirect Method)

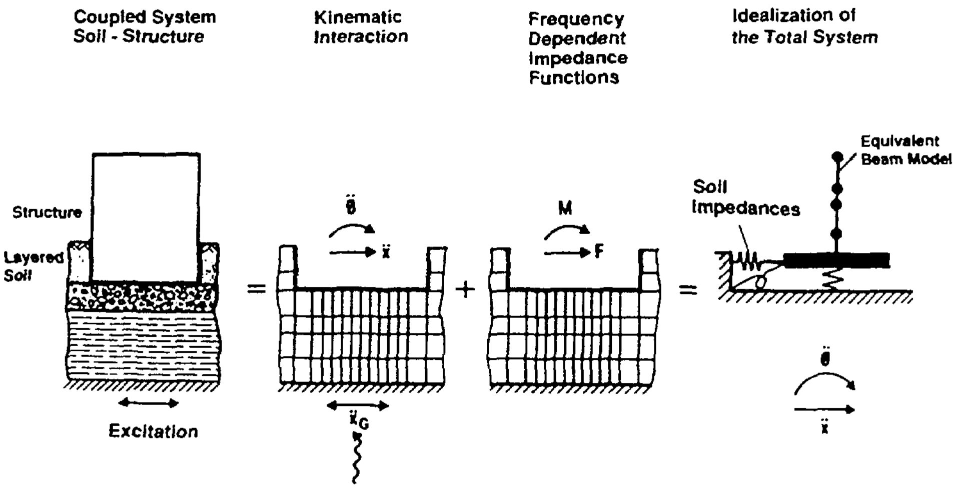


Fig. 11 Indirect Method of Analysis of the Soil-Structure Interaction Effects (Decoupled Models)

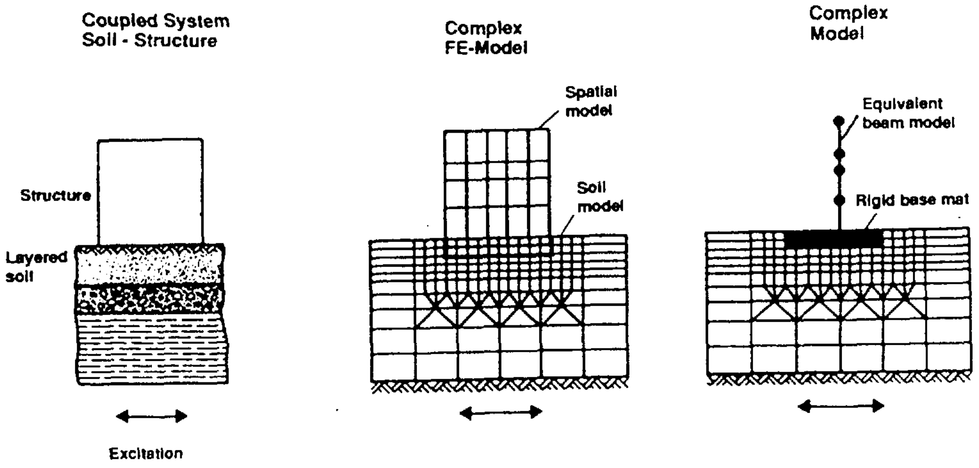


Fig. 12 Direct Method of Analysis of the Soil-Structure Interaction Effects (Coupled Model)

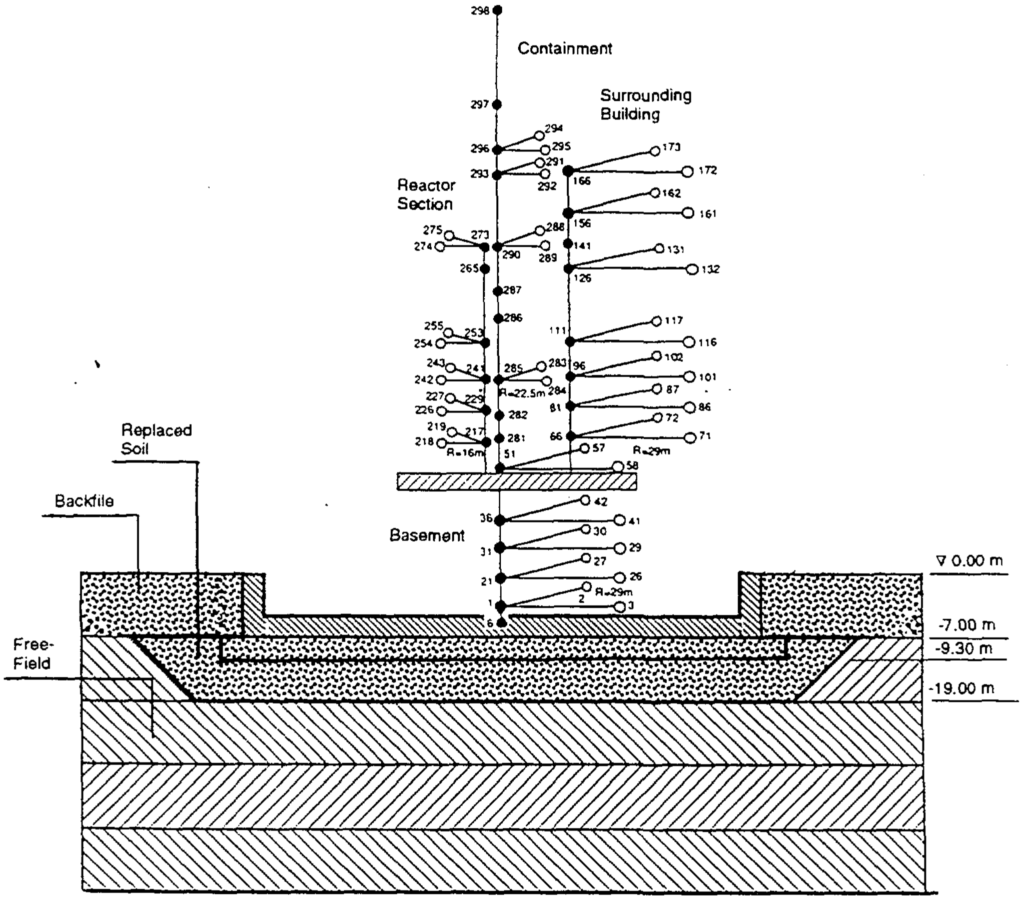


Fig. 13 VVER-1000 BELENE, Main Building Complex Mathematical Model (Direct Method)

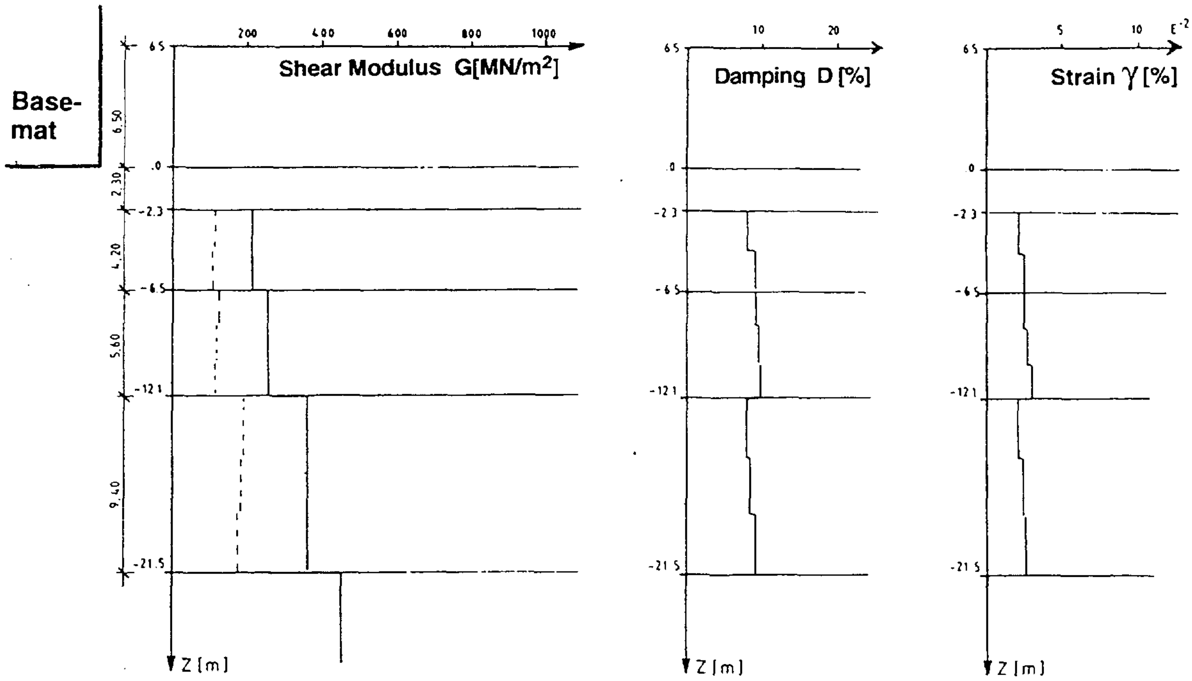


Fig. 14 Soil Data, Profil 1

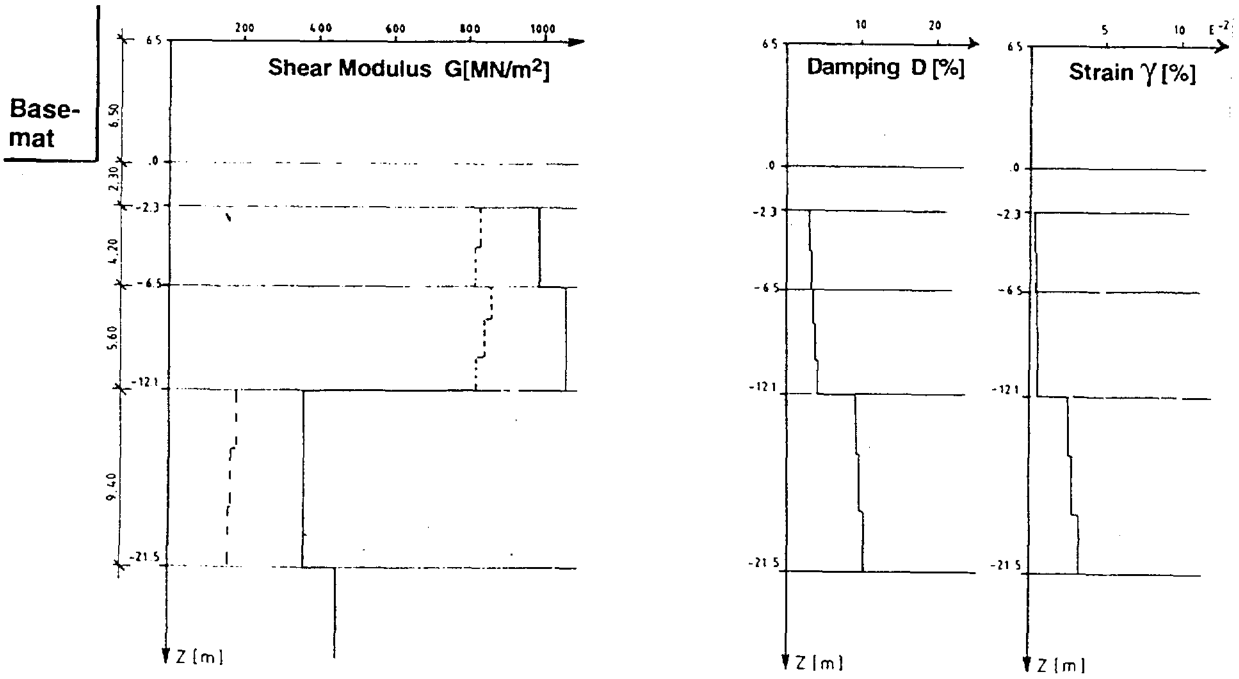
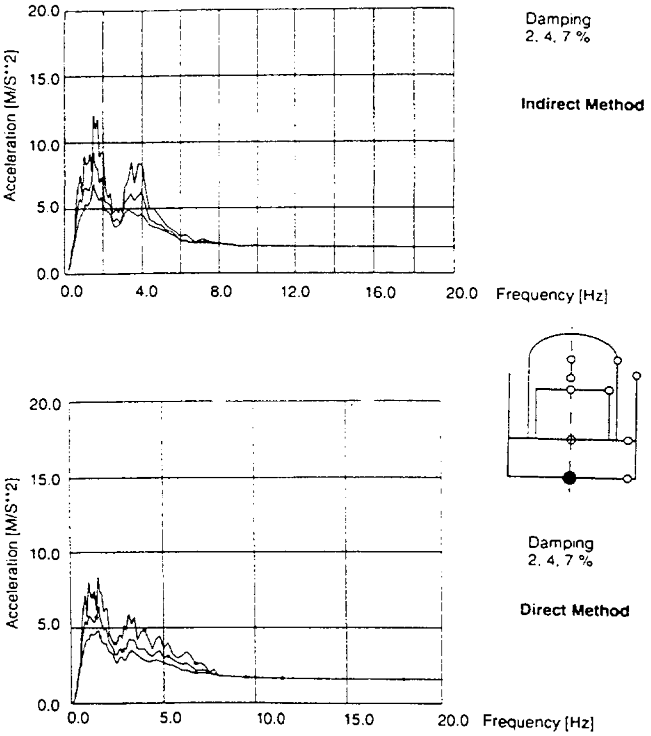
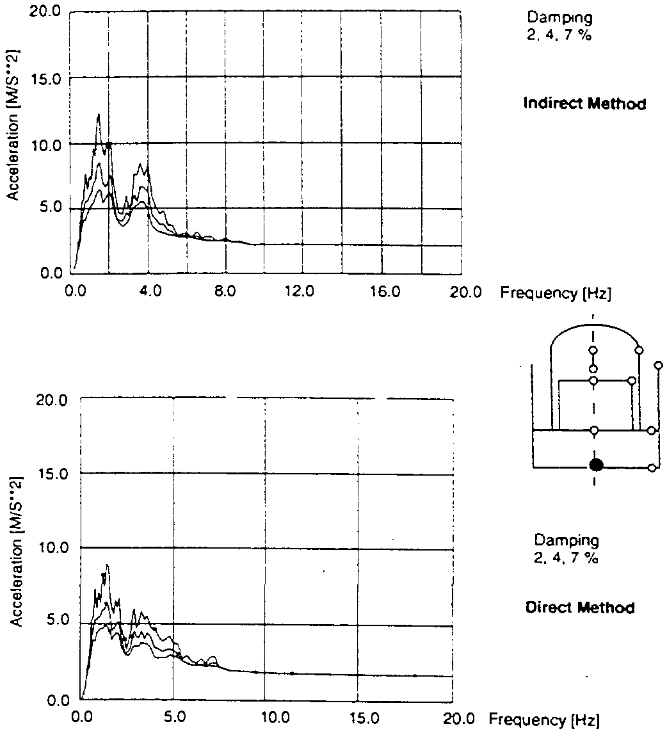


Fig. 15 Soil Data, Profil 2



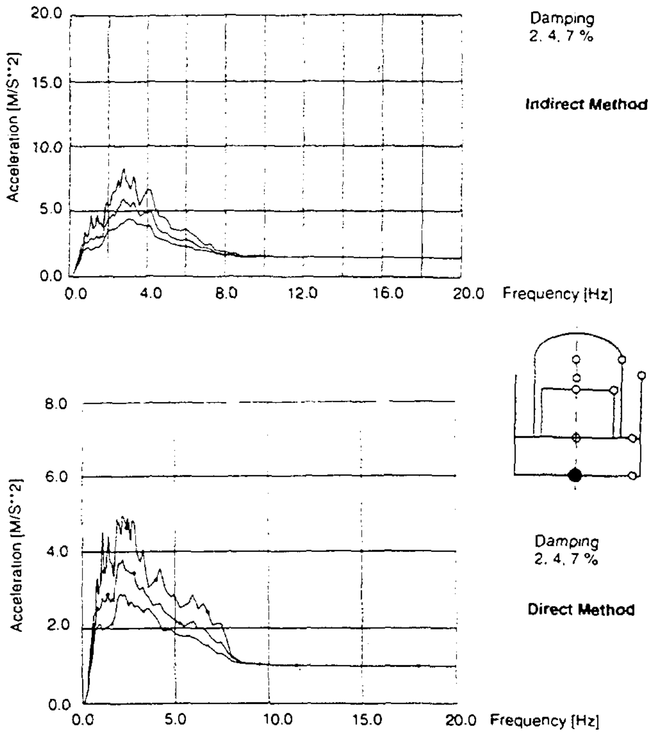
Horizontal Direction X1

Fig. 16 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



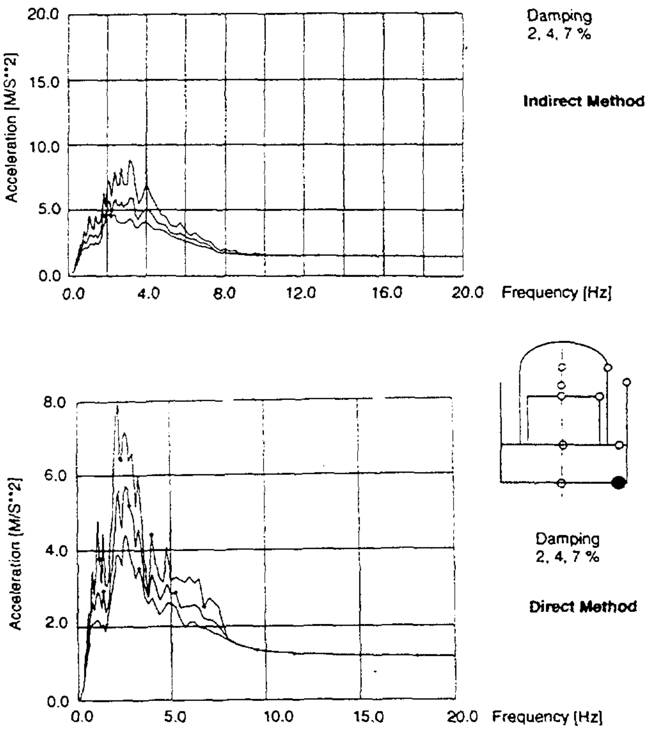
Horizontal Direction X2

Fig. 17 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



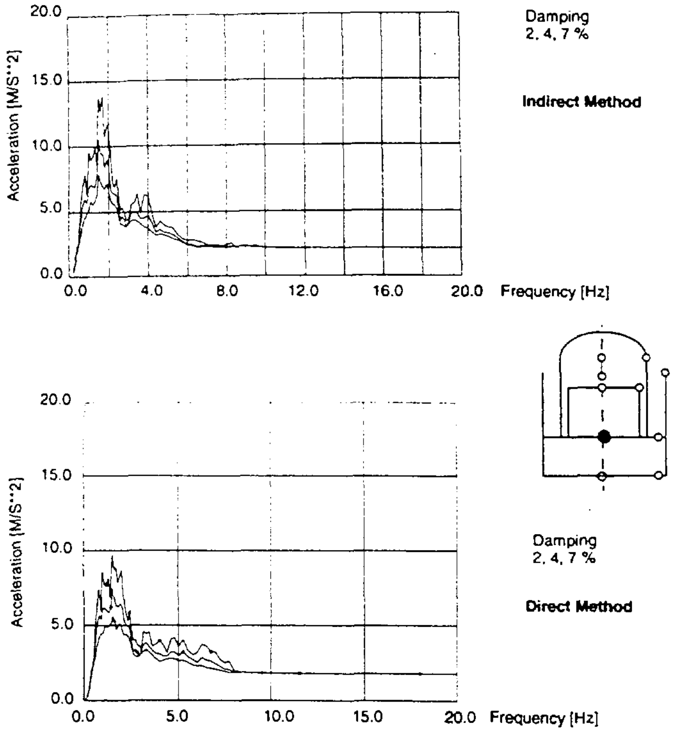
Vertical Direction (Centre)

Fig. 18 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



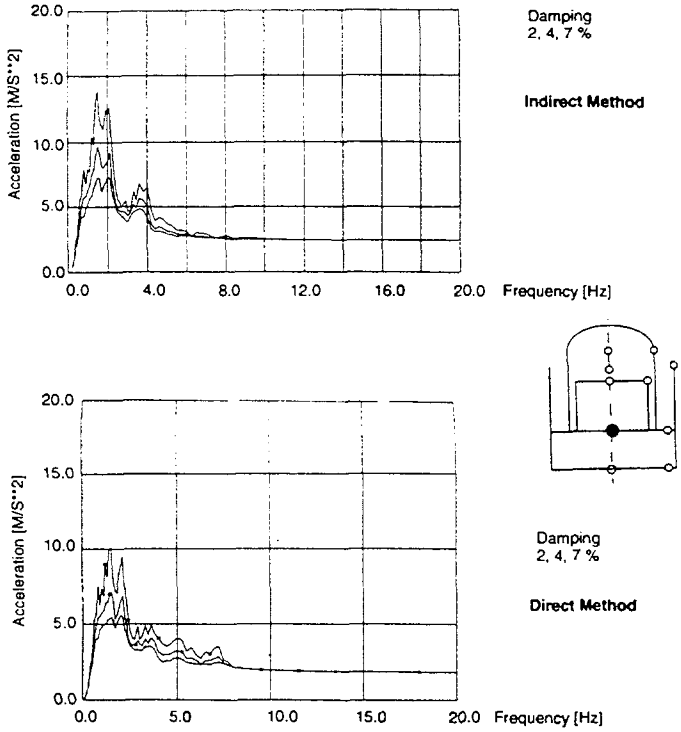
Vertical Direction (Edge)

Fig. 19 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



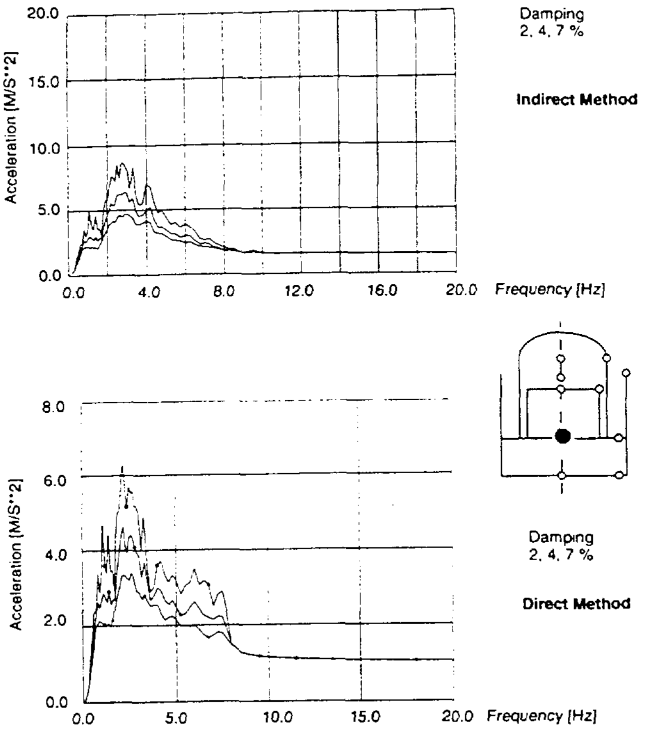
Horizontal Direction X1

Fig. 20 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



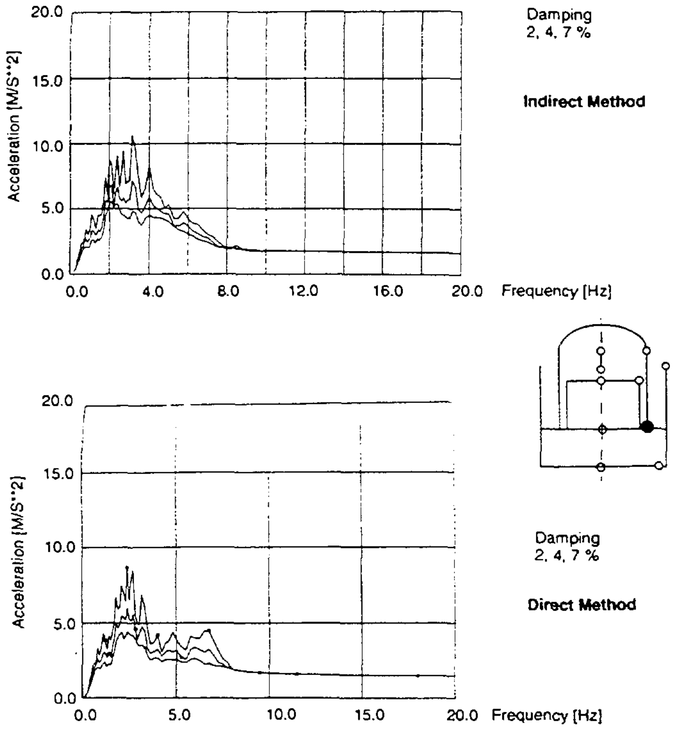
Horizontal Direction X2

Fig. 21 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



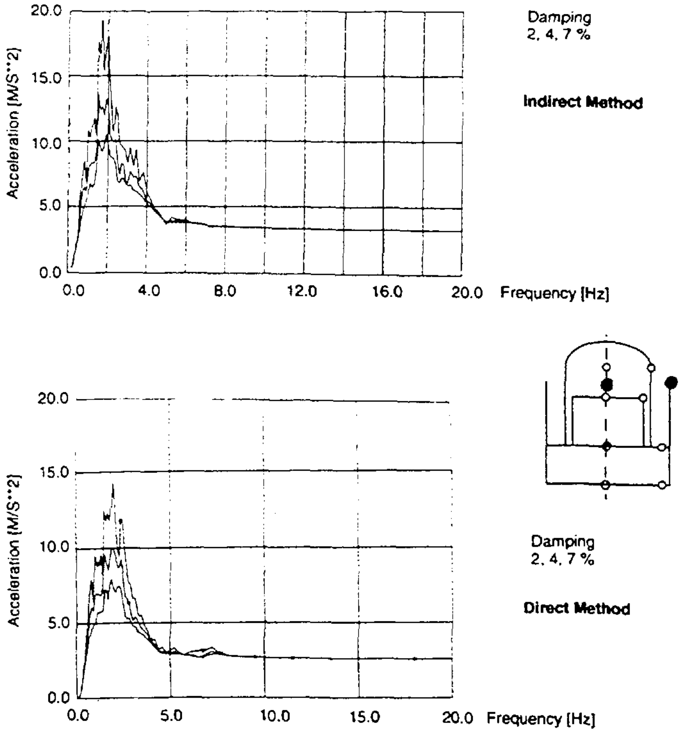
Vertical Direction (Centre)

Fig. 22 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



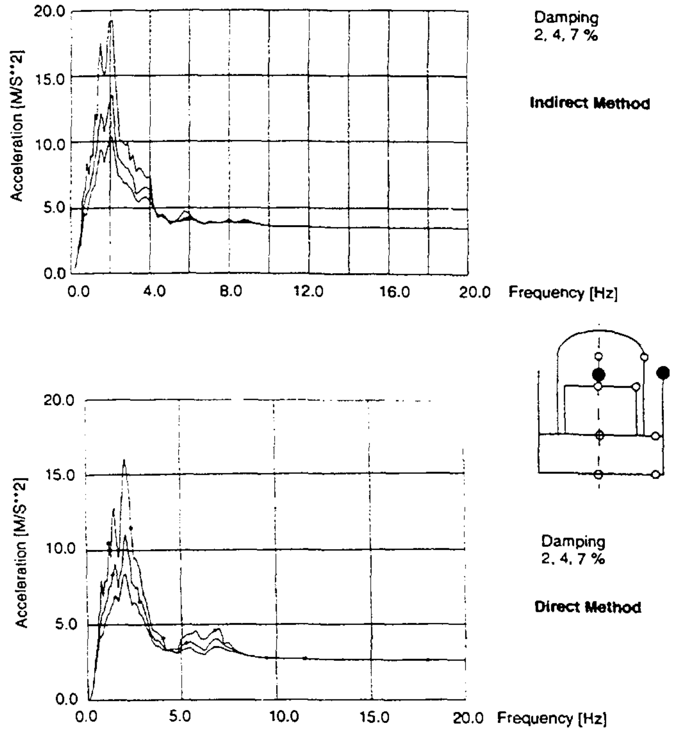
Vertical Direction (Edge)

Fig. 23 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



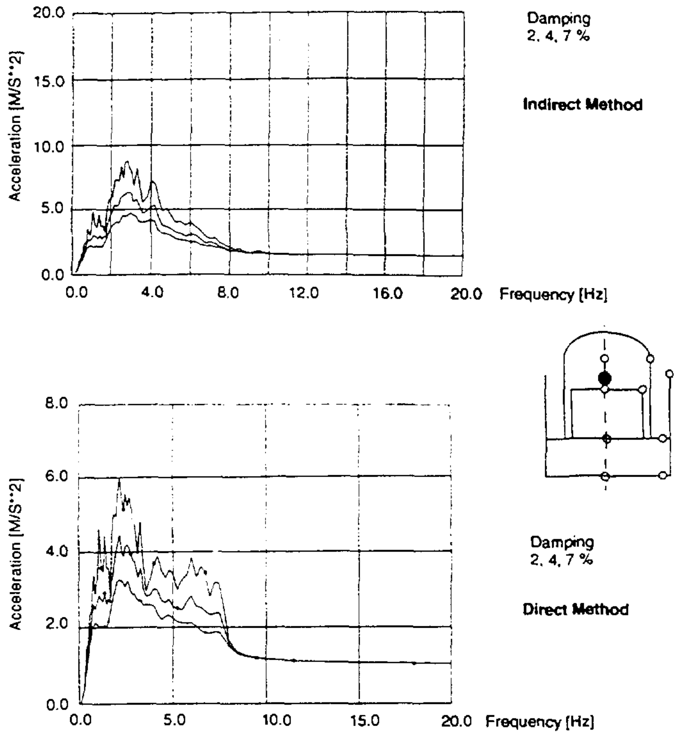
Horizontal Direction X1

Fig. 24 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



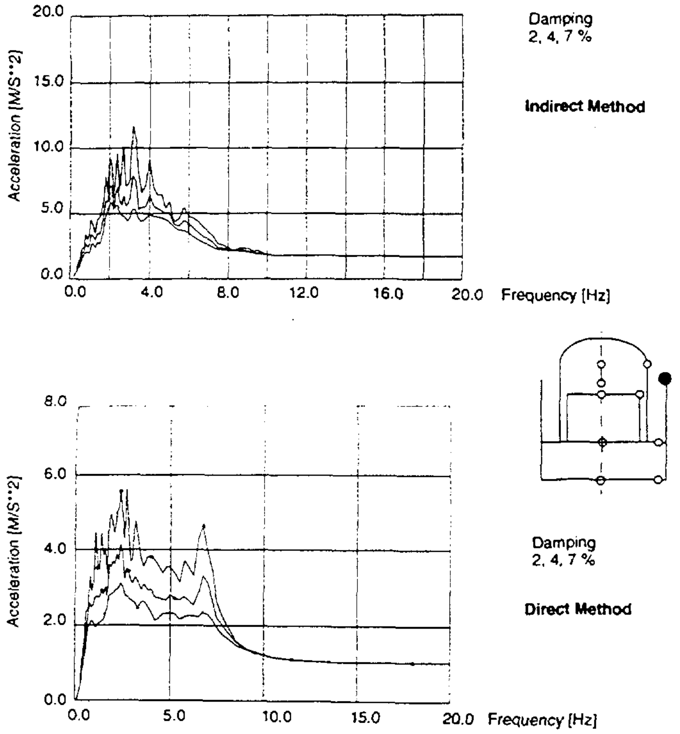
Horizontal Direction X2

Fig. 25 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



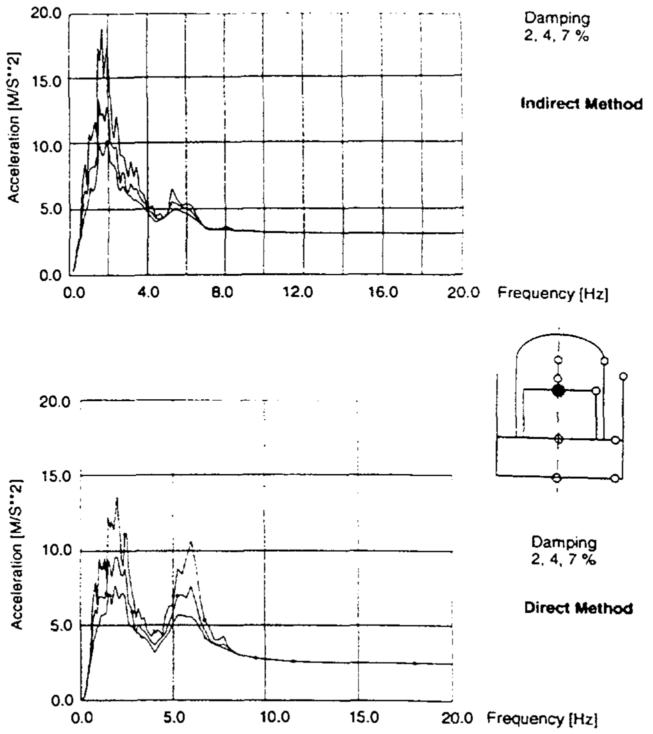
Vertical Direction (Centre)

Fig. 26 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



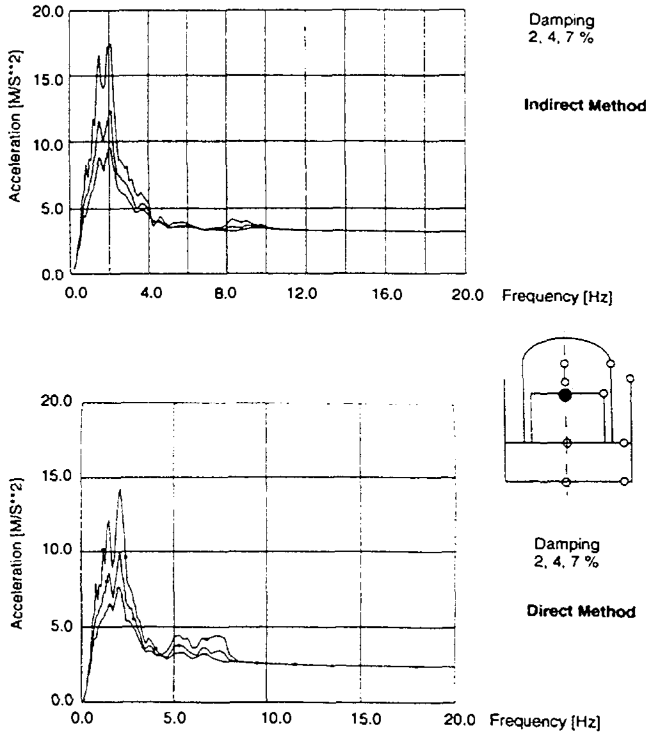
Vertical Direction (Edge)

Fig. 27 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



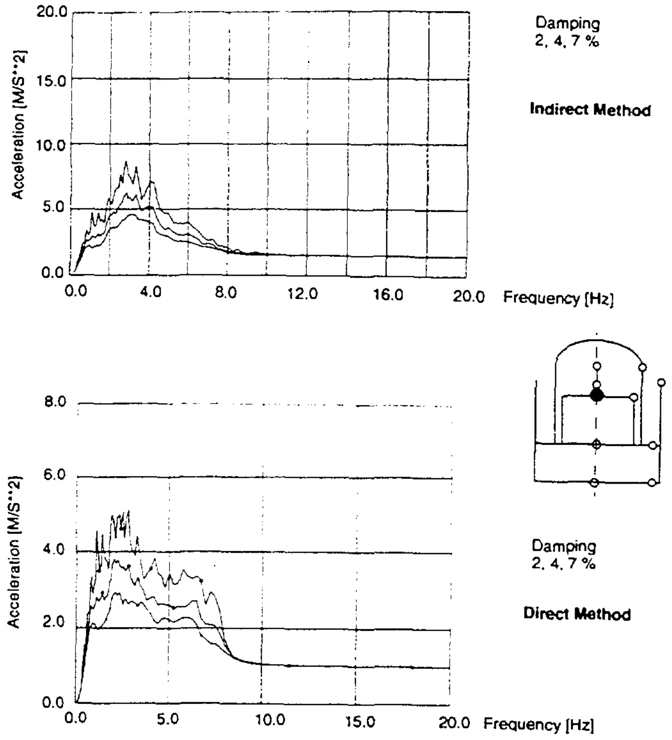
Horizontal Direction X1

Fig. 28 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



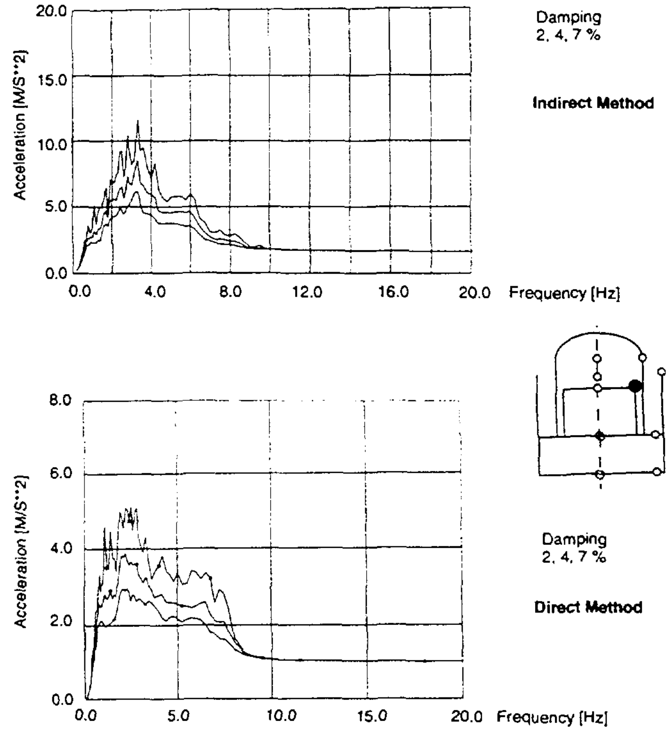
Horizontal Direction X2

Fig. 29 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)



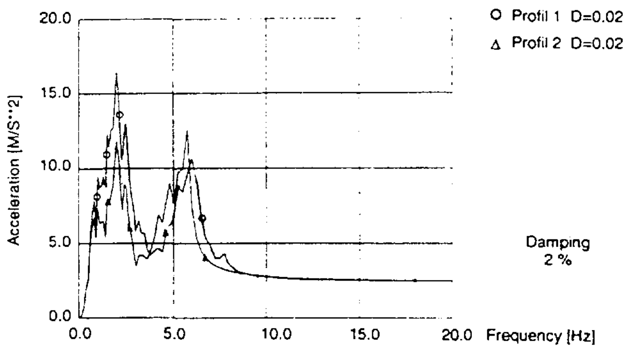
Vertical Direction (Centre)

Fig. 30 **VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)**

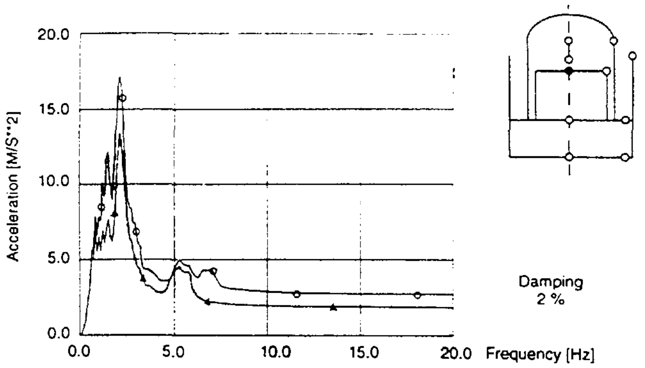


Vertical Direction (Edge)

Fig. 31 **VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method)**

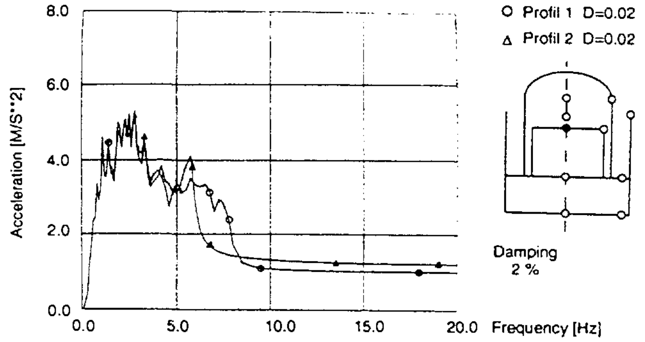


Horizontal X1

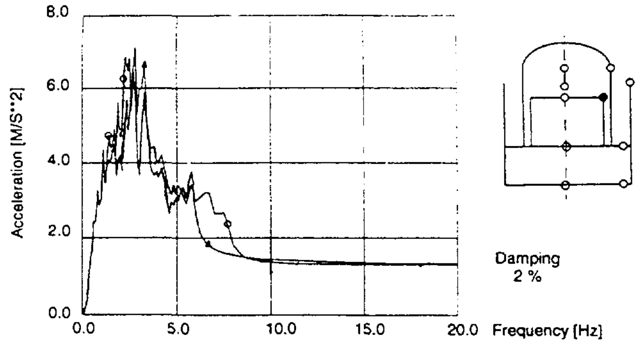


Horizontal X2

Fig. 32 **VVER-1000 BELENE, Main Building Comparison of Response Spectra Obtained for Different Soil Profiles (Load Definition A)**

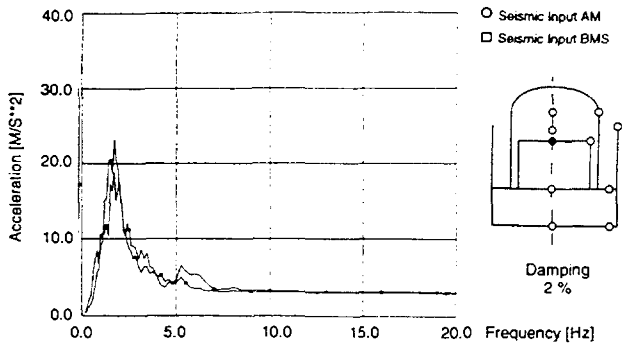


Vertical

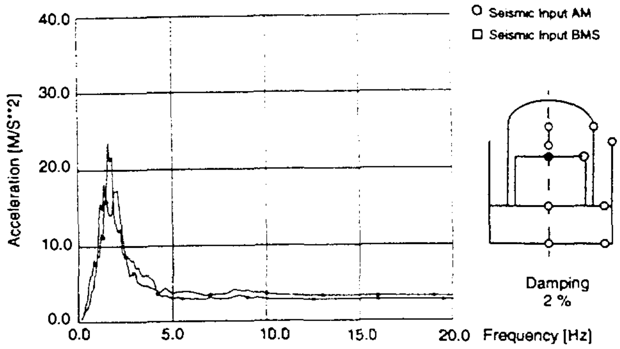


Vertical

Fig. 33 **VVER-1000 BELENE, Main Building Comparison of Response Spectra Obtained for Different Soil Profiles (Load Definition A)**

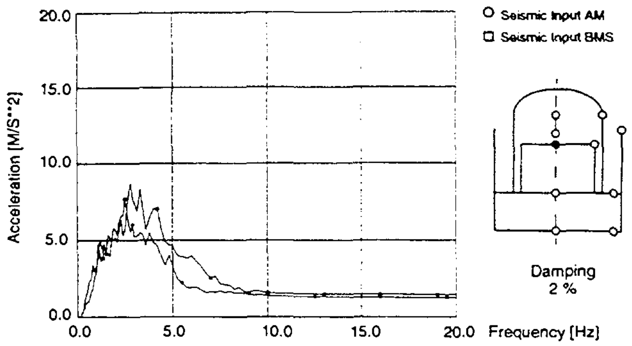


Horizontal X1

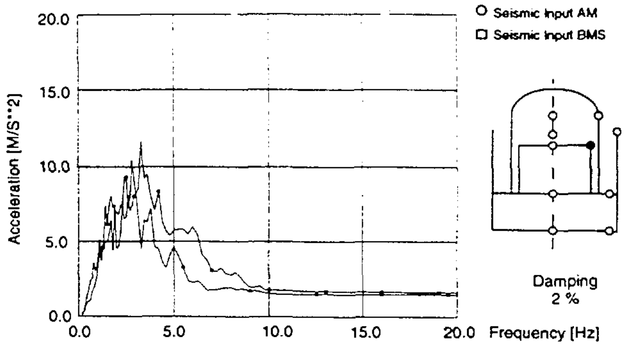


Horizontal X2

Fig. 34 **VVER-1000 BELENE, Main Building Comparison of Response Spectra obtained for Different Seismic Input Definition (Profile 1)**

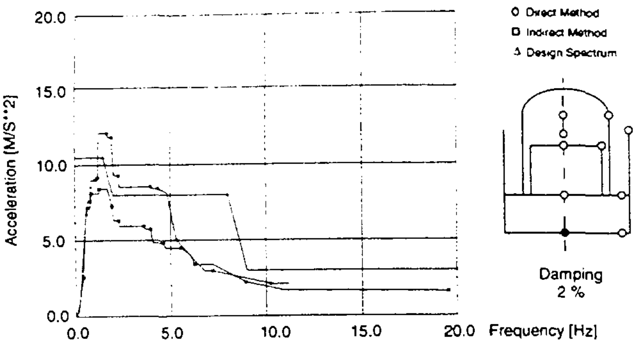


Vertical

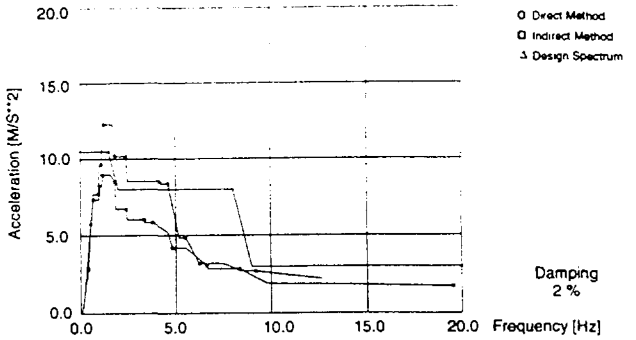


Vertical

Fig. 35 **VVER-1000 BELENE, Main Building Comparison of Response Spectra obtained for Different Seismic Input Definition (Profile 1)**

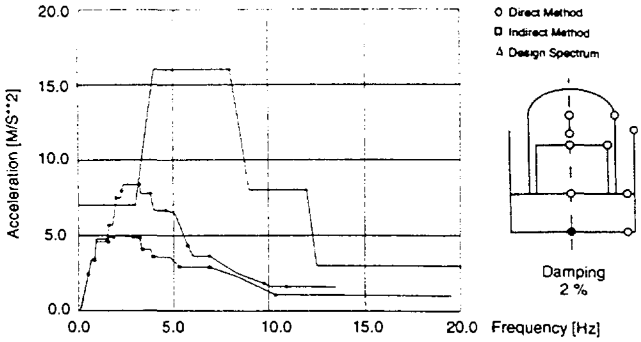


Horizontal X1

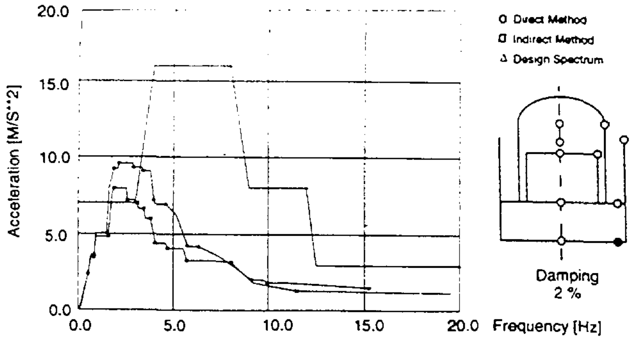


Horizontal X2

Fig. 36 **VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method and Design Curves)**

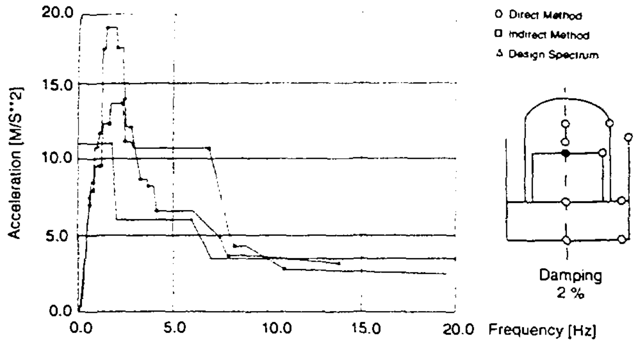


Vertical

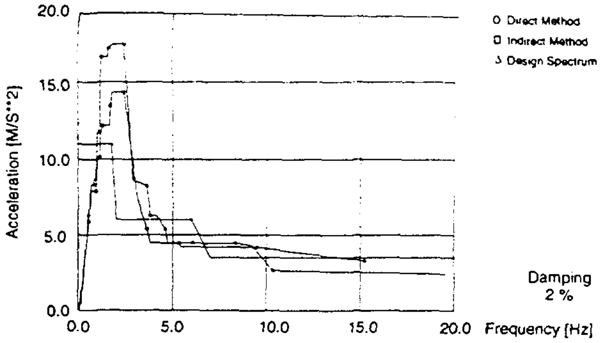


Vertical

Fig. 37 **VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method and Design Curves)**

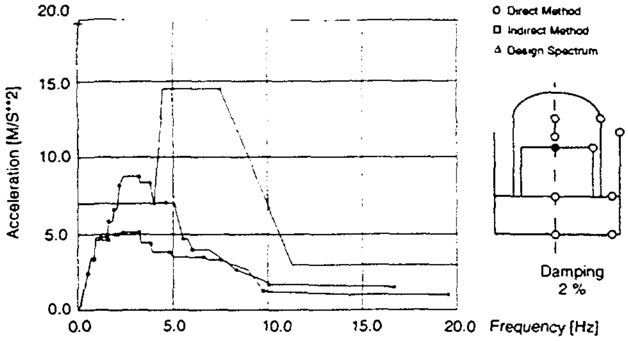


Horizontal X1

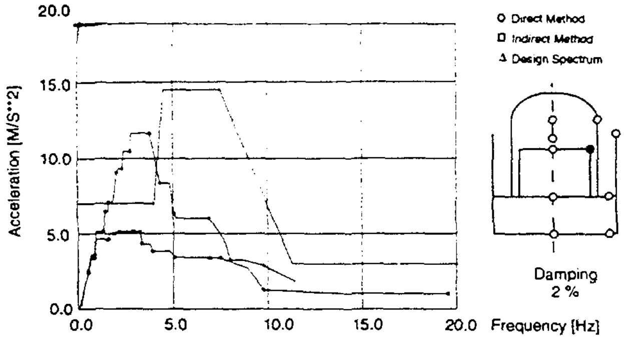


Horizontal X2

Fig. 38 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method and Design Curves)



Vertical



Vertical

Fig. 39 VVER-1000 BELENE, Main Building Comparison of Response Spectra (Direct/Indirect Method and Design Curves)

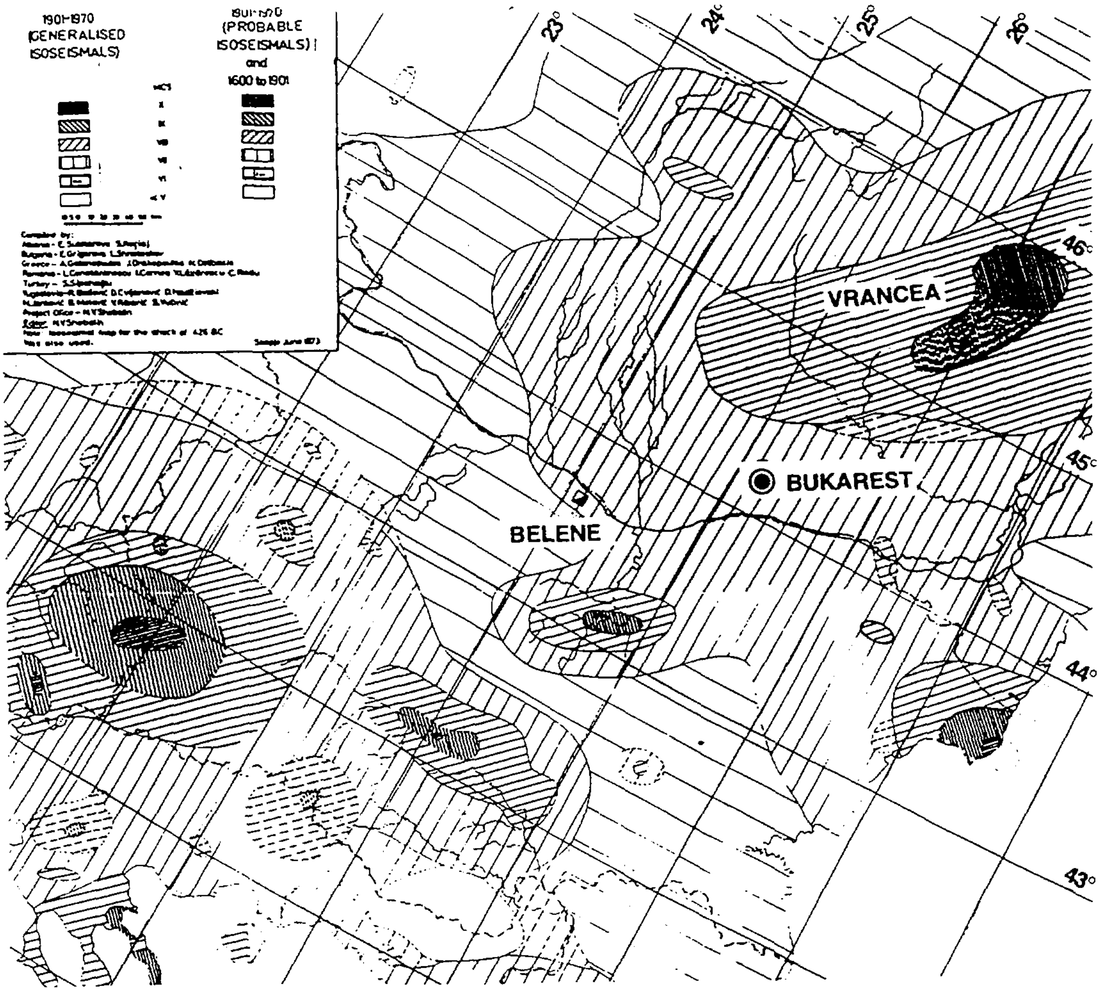


Fig. 40 Earthquake Zones Bulgaria/Romania

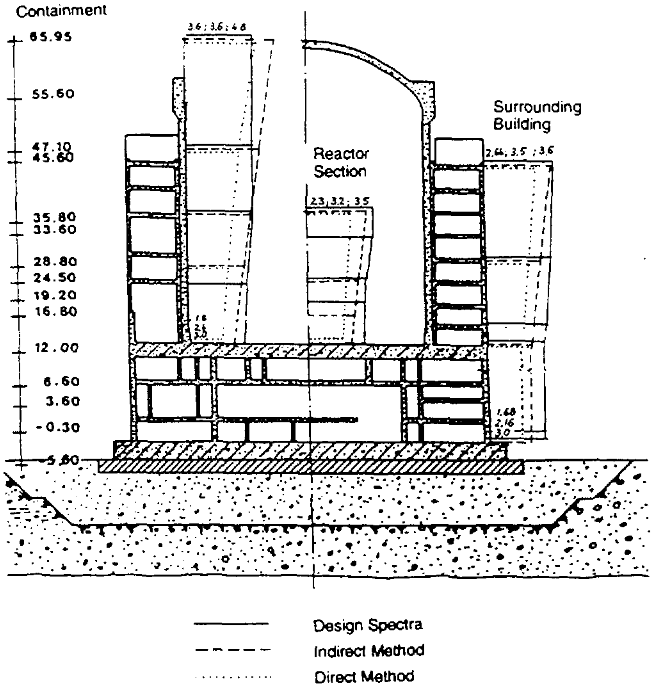


Fig. 41 Comparison of Rigid Body Accelerations

Tab. 1 and 2 VVER-1000, BELENE
Stiffnesses and Damping Values

Stiffnesses kN, m:

Direction	Profil		
	0	1	2
X	47 E6	35 E6	93 E6
Y	47 E6	35 E6	93 E6
Z	95 E6	89 E6	104 E6
XX	90 E9	81 E9	128 E9
YY	94 E9	85 E9	133 E9
ZZ	74 E9	49 E9	200 E9

Damping Values [%]

Direction	Profil		
	0	1	2
X	21	21	32
Y	21	21	32
Z	42	39	51
XX	4	6	6
YY	4	6	6
ZZ	7	9	9

Tab. 3 VVER-1000 BELENE
Load Cases Investigated

Method of Analysis	Input Definition	Excitation A		Excitation B	
		Profil		Profil	
		1	2	1	2
Indirect Method	Free-Field	A			
	Embedment Level (-7.00 m)	AM		BSM	
Direct Method	Free-Field	A	A	B BS	B BS

Excitation A	Standard Spectrum (Fig. 3), (0.2 g Free-Field Acceleration)
Excitation B	Site Specific Spectrum (Fig. 8), (0.2 g Free-Field Acceleration)
Excitation BS	Site Specific Spectrum (Fig. 8), (0.163 g Free-Field Acceleration)