Title: Seismic Safety Programme at NPP Paks

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SEISMIC SAFETY PROGRAMME AT NPP PAKS

PROPOSITIONS FOR COORDINATED INTERNATIONAL ACTIVITY IN SEISMIC SAFETY OF THE VVER-440 V-213

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1. INTRODUCTION

There are four VVER-440 units in operation at Paks NPP site. The units are of V-213 type, i.e. they represent the new design, approaching in many respects the current, demanding western standards. The reliability of the units shown over the 26 reactor-year of operation has been fairly satisfactory. The cummulative load factor is 84.3% (at the end of 1991).

The V-213 version of VVER-440 units has a number of advantegeous features. E.g. the power density of the core is low, and there is a huge water inventory in the primary and secondary circuits for fighting down any possible LOCA cases. The hermetic reactor box, analogous to the containment is also dimensioned to bear a LOCA event.

The V-213 design has also some deficiencies, e.g. practically no impacts of outside events as earthquake, airplane crash, etc. had been taken into consideration.

At the time of site selection the current site was decided suitable, taking into consideration the historical seismic activity data, the seismic hazard was characterized by an intensity of V (MSK-64) at an annual frequency of 10^{-3} and with this values no special seismic design was needed.

Due to the eventual extension of the plant in 1986 a new site seismic hazard evaluation, essentially more detailed than the previous one, was started. These studies are still on, but hopefully the assessment of the seismic hazard will have been completed by the end of 1992. The expected result is well characterized by the recent examination by Ove Arup. According to this, the probabilistic seismic hazard assessment calculations show that the safe shutdown earthquake with annual probability 1 in 10000 has an MSK intensity VIII with a peak horizontal acceleration of about 3.3 ms^{-2}.

Due to the above mentioned, already in 1987 a seismic safety program was established and launched that was redefined year by year in course of the implementation, owing to the from year to year varying, but continouosly „increasing" seismic hazard assessment. Up to 1992 significant preparation work has been done despite of the uncertainity of the site's assessment. Presently there is the seismic safety program based on the above, rather pessimistic assessment, the purpose of which is to determine the actual seismic strength of the plant and work out the neccessary reconstructions.

In this paper we present the Paks NPP's seismic safety program, highlighting the specifics of the VVER-440 type V-213 in operation, and the results of the work up to now.

2. ESTABLISHING THE SEISMIC SAFETY PROGRAM

When establishing the seismic safety program first of all

- the safety phylosophy approved in the design,
- the original assessment of the seismic hazard for the site,
- the safety regulations, design procedures and input data taken into account,
- as built characteristics

should be compared to the up-to-date knowledge and the current safety requirements for the seismic hazard of the site.

The principles and the actual programme of the implementation of the seismic safety at higher level can be formed from this comparision being a qualitative analysis of the issue.

The procedure being followed below is shown in figure 1.

2.1. THE ORIGINAL SEISMIC DESIGN

In the design of the Paks NPP maximum earthquake expected at the site in 1000 years had to be taken into account according to the Soviet regulations and safety ideas of that time.

For the site earthquake of intensity grade V according to MSK-64 was assumed with an annual frequency of 10^{-3}.

Accordingly, the Soviet designer had no special dimensioning for earthquake, in compliance with the norms (e.g. SzNIP-II-A 12-69) in effect.

2.2. CURRENT REQUIREMENTS

2.2.1. Safety regulations

Today the seismic safety of NPP's are defined by rules significantly unified. As presently there is no Hungarian standard or regulation in this field the IAEA recommendations, standards of some countries (USA, GFR), and the regulations in the supplier's country are taken into account in the Hungarian practice.

In accordance with this, in point of the safety for the NPP the maximum design eartuquake (safe shutdown earthquake - SSE or level S2) is regarded to be deciding, when the nuclear safety of the plant is still warranted. At the site this is the maximal earthquake assumable with a frequency of 10^{-4}/year, which is justified by the historical records and the geologic and seismologic conditions of the site.

In order to provide seismic saftey for the power plant a protective system is needed which shuts the reactor down in case of earthquake. Suitable technical solutions have to ensure the operability and integrity of the technological systems, including the associated electric and C&I systems, involved in boration, cooling down the reactor and permanent heat removal from the reactor, as well as the tightness of the containments with radioactive media.

2.2.2 Current assessment of the seismic hazard of the site

According to our present knowledge the most probable value of the maximal design earthquake (with frequency of 10^{-4}/year) is eight degree at the MSK-64 scale, which a maximal acceleration value of 3.3 ms^{-2} (0.34 g) can be ordered to. The acceleration value characteristic for the earthquake with an annual frequency of 10^{-2} can be taken as 0.06 g.

2.3 PRINCIPLES OF SEISMIC SAFETY

As for the realization of the new seismic safety of higher level on one hand the following unfavourable facts should be regarded:

- the power plant was not designed for dynamic effects caused by an earthquake;
- the suppliers did not qualified the equipment and components (except for several ones) for earthquake and this kind of qualification actually can not be obtained from the (ex-Soviet) suppliers any more;
- the dynamic characteristics of the maximal design earthquake (SSE) for the site are high (maximum horizontal acceleration is 0.34 g, significant amplification in the response spectrum between 2 and 10 Hz);
- the maximum acceleration value characteristic for an earthquake with probability of 10^{-2} event/year is 0.06 g which itself can be regarded relatively low, but considering the fact that the power plant was not qualified for earthquake at all, unfortunately this value is very high, too.

On the other hand, the preliminary studies since 1987 shows that the main building and the main safety related components and pipings have significant strength reserves.

Due to the above mentioned the following principles can be formulated:

- The only realistic goal can be to make the power plant safe for a maximal design earthquake;
- The power plant can not be operated during an earthquake smaller than the SSE, and the restart can not be guaranteed, because it would need to redesign the whole plant, to qualify and then to reconstruct all the components.

(Simplified: the nuclear safety is expected to be guaranteed for the SSE but the restart and the operation safety can not be guaranteed in any kind of earthquake.)

- Even the safety requirements for the SSE can be met only such a way that the number of systems and components needed for the realization of the seismic safety are minimized. If the „normal" technology were used for cooling down, boration and permanent cooling then the seismic safety would be impossible to be realized – within reasonable limits – due to the large number of components and pipings to be reinforced.

This requests a specific seismic protection technology to be developed, i.e. the application of a special, cooling down, boration and permanent cooling technology the realization of which needs the least equipment operable during and after earthquake. This technology should be based on existing plant capabilities including the possible use of some systems beyond their originally intended function, to return the plant to controlled state and mitigate the consequence of the earthquake. (This special method and technology for the realization of seismic safety is called seismic safety conception below.)

In the evaluation of the seismic resistance the standards and regulations can be observed only by given justified compromises, thus, the qualification of the buildings, technological components, pipings, etc. should be performed according to a criteria document well established and developed for a special VVER-440 model V-213.

As the NPP in case is a plant in operation which is not designed for earthquake, it is necessary to use parallelly several methods for its qualification, decreasing by this the conservatism of analyses. Therefore, parallelly with the computational analyse, it is reasonable to perform e.g. dinamical experiments.

The coincidence of several events (earthquake, LOCA) should be re-considered.

The basic principles of safety realisation in case of VVER-440 are summarised in Figure 2.

2.4. STRUCTURE OF THE SEISMIC SAFETY PROGRAM

The seismic safety program was launched in 1986 when the seismic features of the site turned out to be significantly different to those taken into account in the design but the progress was slow because the seismic hazard assessment changed from year to year, as the increase of the parameters charaterizing the maximal designe arthquake affected not only the the input of the analyses but also the content of the program.

In defining the activity the known foreign practice was followed as there is no any experience with seismic safety for the nuclear facilities and even for the industrial facilities in Hungary. However, the program has become „tailored" due to the specifics of the Paks NPP and the scientific debate about the seismic hazard.

The program includes three main activities:

examining the seismic hazard;

establishing a seismic safety conception and defining the dynamic features of the systems and buildings given by this conception, as well as the actual seismic resistance; and

developing and realizing the technical solutions needed for the implementation of seismic safety of higher level.

The overall structure of the program is shown in Figure 3.

3. IMPLEMENTATION OF THE SEISMIC SAFETY PROGRAM

3.1. ASSESSING THE SEISMIC HAZARD OF THE SITE

In the site of the power plant geologic examinations have been conducted since the sixties. In 1986 a new site evaluation more detailed than the previous ones was started because of the eventual power plant extension. The first results recieved in 1987 gave an earthquake intensity of degree VII with an expected frequency of 10^{-4} event/year, and a maximal horizontal acceleration of 0.15 g. The examination for the seismic hazard ofthe site have not completed yet due to the scientific debate developed during the evaluation. About 70 papers, research reports have been prepared to support the seismic hazard assessment for the site. The existing papers and reports have been reviewed by the authors and by independent experts. An example is the Ove Arup study quoted above. On the base of the critical analysis additional geologic and seismic examinitions were performed in 1992. The purpose was to precise the geologic structure and tectonics of the site, on the base of which the allowed models of the source of the seismic hazard have to be defined and the hazard has to be determined again. Hopefully the seismic hazard assessment will be completed by the end of 1992 and a qualification based on a scientific consensus will be available. The expected result is well characterized by the recent examination by Ove Arup quoted above.

3.2 DEVELOPING THE NEW CONCEPTION OF SEISMIC SAFETY FOR THE PLANT

With the specifics of the as built state and the new requirements, as well as considering the principles in para 1.3 a special procedure has to be established to shut down, borate and cool down the reactor and for the heat removal, as well as to preserve the tightness of containments with media of high activity, and to eliminate the additional damages caused by the earthquake. The new seismic safety conception for the plant defines this procedures.

The development progress of the conception is shown in Figure 4. According to this the following had or have to be carried out:

3.2.1. Design evaluation

The systems for reactor shut down, cooling down and heat removal were not designed for the dynamic effects caused by an earthquake.

The components of the mechanic systems (equipment, pipelines) were dimensioned for static and heat expansion loads on the base of the Soviet standards and technical norms of that time.

On the base of the preliminary dynamic calculations for the primary circuits piping and for ECC piping it can be stated that in general there are significant reserves in the systems in normal operation, which enables to take the additional dynamic loads into account.

3.2.2. Developing the technology to realize of the seismic safety, defining the set of the earthquake resistant systems

3.2.2.1. Seismic safety system to shut the reactor down

According to the safety requirements a system should be installed on each unit and this system initiates emergency signal if the acceleration measeured at the characteristic points of the main building (on its base plate) exceeds a certain value.This acceleration threshold value is far less than the free field acceleration value caused by the SSE.

The seismic protection system should fit to the existing unit protection in point of channel number, logics, redundancy and reliability.

This system supplied by the Swiss firm SIG SA was installed in the units in 1991. In 1992 an alarm system built in each control room allows the operator to shut down the reactor manually. The experiencies gained with the system will be evaluated in November 1992 and then the decision will be made on the way of integration into the protection system and on the introduction of the automatic operation mode. Of course, this is reasonable only in the case if the unit protection system itself is seismic resistant. This issue will be addressed later, too.

3.2.2.2. Boration, cooling down the reactor and permanent heat removal in case of earthquake

The first essential step to realize the seismic safety is to develop the technology for the boration, cooling down and heat removal of the reactor. This technology will be realized as follows:

Normal state:

The unit operates with the rated parameters, according to the operation instructions in effect. The primary, secondary and electric parameters complies with the nominal parameters. The Diesel generators, as well as the active and passive ECC systems are ready for operation.

Earthquake:

When the set acceleration limit is exceed an „Earthquake" signal is recieved by the reactor protection system.

An emergency signal level 1 generated on the principle „2 from 3" stops the reactor. A command is sent to stop the turbogenerator unit, too. The same time the Diesel generators and stepwise automatic loading program after earthquake start.

When the emergency actions are completed the unit reaches a stable hot condition.

Boration:

The boration and and the compensation for volume decrease of the coolant due to the cooling down are carried out by the operator using the high pressure ECC pumps.

Cooling down:

First stage: cooling down to $T_{pr.\ circ.}$ 130 °C

- controlled steam release through the safety valves of steam generators;
- the level in the steam generators is ensured by the emergency feed water pumps
- the primary side pressure is decreased by steam release through the safety relief valve of the pressurizer into the bubble condenser.

Second stage: Further cooling down below 130 °C, to 60 to70 °C.

- the primary side pressure is decreased to 0.4 MPa;
- putting the low pressure ECC system into operation together with the primary side cooling down system to be installed (cooling the primary coolant through ECC heat exchangers)

Heat removal:

continuous circulation of the primary coolant by the low pressure ECC pumps through the ECC heat exchangers in orderto cool the active zone.

The limits of above technology determines the set of systems and components assured for the maximal design earthquake. At the so outlined system limits a safe isolation should be realized with existing or new quick action valves that close on the earthquake signal.

The outlined seismic safety conception developed in detail was completed in January 1992.

3.2.2.3. Electric and C&I conditions

A safety electric power supply system needed for realization of the seismic safety technology has to be worked out. The power has to be distributed for the consumers identified in the above mentioned conception, the earthquake-proof electric power supply systems have to be determined, and the requirements for the operability of these systems have to be established (operation during the earthquake, function maintenance during the earthquake).

In realization of the seismic safety it is important to provide the necessary C&I conditions for the emergency signal generation, etc. The procedure here is the same as in case of the electric conditions, i.e. the C&I components needed for the implementation of the seismic safety technology have to be identified and the requirements for the operability of these systems have to be established (operation during the earthquake, function maintenance during the earthquake).

This job is planned to be carried out during 1992. It is important to note that in this case it is not a simple compilation of list of equipment and components. In the review of safety related electric and C&I equipment, components, systems the opportunity for reconstructions or quality improving exchanges have to be taken into account, where the demand of seismic resistance can ab ovo be provided.

3.2.2.4. Containments with radioactive media

The list of such containments (systems, tanks, pools) has to be compiled the damage of which would increase the risk of environmental emission in an earthquake, or would hinder the safe operation of the plant after the earthquake. The integrity of the containments with radioactive media has to be maintained and, accordingly, they have to be subject to the same procedure as the mechanic systems (review, reconstruction). The isolation between the containments of significant volume with radioactive media and the seismically non-safe environment has to be provided using suitable existing or newly installed quick action valves.

The list of containments to be protected and that of the isolation valves will be completed during 1992.

3.2.2.5. Additional problems

The analysis of effects not belonging to the range of nuclear safety but substantially affecting the after-earthquake situation (fires, floods) is an organic part of the seismic safety conception. It includes also the suitable amendment of accident management procedures, and the overview of the infrastructural consequences of the accident mitigation after the earthquake.

3.3. ASSESSING THE SEISMIC RESISTANCE OF THE BUILDINGS

The procedure followed is shown in Figure 5.

3.3.1. Selection of the safety related buildings

Actually all the buildings of the power plant has to be reviewed in order to realize the seismic safety, i.e. the main reactor building (which actually takes the role of the containment), the gallery around the main building, the Diesel room, the pump station and the auxiliary building.

3.3.2. Design data

The design was according to SzNIP which was in effect between 1965 and 1982 in the Soviet Union. Regarding that the most important building, the main building, was designed for inner pressure of 2.5 bar there are significant strength reserves for taking the additional dynamic loads into account.

3.3.3. Defining the requirements

The criteria document made specially for VVER-440 type V-213 mentioned in paragraph 1.3 has to contain the classification of the power plant buildings and also the strength requirements for the seismic safety of the buildings.

3.3.4. Qualifying the seismic resistance of the buildings

In case of NPP in operation the conservatism of the analysis has to be decreased as far as possible because there might not be a way to increase the safety arising from that. Thus, the best estimation method is preferable to be applied in each phases of the analysis.

Below the major stages of the seismic resistance review for the buildings of Paks NPP is outlined.

<u>Main building:</u>

Three independent model of finite elements has been made:

two-dimensional model with beams and discs, two different models were made according to the two main axes of the building (see Figure 6.);

lumped-mass, beam model (see Figure 7.);

three-dimensional shell model;

2D model:

Calculations were made for earthquakes characterized with 0.15 g ZPA. On the base of the results the main building could be qualified as appropriate in point of strength for the given dynamic excitation. The model was also completed with a soil model and also pre-calculations were carried out for 0.28 g, in which case the load limits were reached for the steel structure of the main building.

3D lumped-mass, beam model:

Dynamical features and response were determined for earthquake characterized by maximum horizontal accelereation of 0.28 g.

3D shell model:

This model includes the gallery building around the main building and the turbine hall. The calculation will be completed by April1992.

<u>Other buildings:</u>

3D model with shell elements of the auxiliary building (see Figure 8.) and the pump station, as well as the model of the Diesel room has recently been completed.

Presently test calculations are on for 0.3 g ZPA value using US NRC standard response spectrum.

The final dynamic analysis will be made on the base of the response spectrum specific for the site that is to be completed by the end of 1992.

In order to decrease the conservatisms building dynamical experiments were carried out. In the course of the experiments the buildings was excited by blowing explosives of 100 to 500 kg in 20 m depth in a distance of 2 to 5 km and the acceleration in the buildings was measured. On the base of the acceleration signals experimental modal analysis was carried out. The experiments and the comparasion of the calculations to the measurement results are in Appendix 1.

The examinations are expected to be extended for the issue of soil liquifaction in the future.

3.4. EVALUATING THE SEISMIC RESISTANCE OF THE TECHNOLOGY

The procedure followed is shown in Figure 9.

3.4.1. Detailed list of equipment and pipes, list of electric and C&I devices, cables, cabinets, etc.

The seismic safety of the power plant can be achieved by ensuring the operability of

a seismic protection system generating emergency signal level 1 operation,

technological systems needed for the cooling down, boration and heat removal,

quick action valves isolating the seismically safe systems,

and the electric and C&I systems needed for the operation of the above systems,

and further by

making the containments with high activity media earthquake resistant, and using valves to isolate these containments, and operating these valve in seismically safe way.

The first stage of the review is to compile a detailed list of equipment (pipeline, component, device, cable, etc. – in one word: equipment) that contains the followings:

- unit No;
- system identification;
  - identification number,
  - location (level, room),
  - seismic safety class,
  - the demanded requirements (stability, integrity, operation, operation maintenance),
  - criterion of suitability (reference to standard)

  for the equipment.

The list should contain the boundary valves between the seismic resistant and non-seismic-resistant parts. These valves can be:

valves being always closed in normal operation,

check valves,

valves being always open in normal operation; in this casethe seismically safe operation has to be ensured,

valves to be installed.

This list of equipment exists for mechanic systems, for electric and C&I systems it will have been completed by June 1992. The list will be prepared in a form of computer data base. The data base will contain arrangement information related to the accomplishment, beside the technical information.

3.4.2. Review of the documentation, survey of the as-built state

The next logical stage of the seismic resistance review is to collect the design documentation for each items of the list of equipment compiled as given in the previous paragraph.

The documentation has to be reviewed following the aspects below:

- wether the documents contain dimensioning for earthquake;
- what standards were used for the strength design and what loads were regarded;
- What the as built state is like, escpecially as for the anchorage of equipment.

The documentation was checked by site survey in 1991 and thefollowings were checked:

- layouts,
- anchorage
- fix points (in case of pipelines),
- location of potential additional supports,
- location of boundary valves or other additional equipment,
- issues to be dealt by management actions (e.g. obligation to refix after maintenance)

The documentation volume will be compiled for every equipment to be reviewed after the site surveys and the data procession, and this volume is needed for the further examinations with calculation, experimental or other methods, to plan the reconstruction.

This particular stage for the mechanic systems will be completed in 1992.

Similar procedure for the electric and C&I systems will be performed in 1992-93.

3.4.3 Qualification

Qualification of the seismic resistance for a power plant in operation, according to new criteria, and the eventual increase of the seismic resistance is very sophisticated work with very high cost, especially if the particular plant was not designed for earthquake. During the qualification and planning the reinforcement the conservatisms covering the technical uncertainities and inaccuracy should minimize as the conservatism results in additional costs, outage, work in contaminated environment.

Among the methods of the qualification those are to be applied which can be supposed to lead - with the same safety - to minimal reconstruction changes. In order to minimize the interventions particular procedures, redundant check methods, innovative approach are to be applied. In this point of view

- the joint application of experimental and calculation qualification;
- using particulary based „best estimate" data instead of the parameters given in the standards (e.g. damping value) as these latter includes significant conservatism

should be highlighted.

A criteria system which takes the specifics of the power plant into account is absolutely neccessary to be established for the qualification.

Here below two aspects of the qualification are detailed.

3.4.3.1 Experiments

The experimental method is to be used first of all for equipment (devices, components) with relatively low mass where checking the maintenance of operability is an important requirement. This kind of equipment usually is qualified and certified by the manufacturer. In Paks NPP, just like in the other VVER-440 NPP's, the seismic resistance of the equipment is not qualified and certified – except for some very rare cases. In some cases (e.g. the battery plant) the equipment itself is qualified but the way of installation is not appropriate.

The post-qualification by means of vibration table can be used for electric and C&I cabinets, devices, equipment and components and for some mechanic components (e.g. valves). For example the vibration table test of the reactor protection system (sensors, cabinets together with relays and circuits in it) can not be avoided.

The experimental examinations of dynamic features of a particular critical system – which actually are components connected by pipes into a complex system – can become neccessary, especially with the purpose to define individual empiric values instead of the damping stipulated in a conservative way in the standards.

In Paks NPP in-situ experimental dynamic examinations has been performed for the primary circuits, the upper reactor block, and for some typical piping systems such as the pipelines of the ECC. In paralel with these experiments dynamical calculations of finite elements were carried out and the resulst were compared to the results of the experimental modal analysis.

In the units of Paks NPP the pipelines were designed very „soft", thus, the low frequency resonances are characteristic for thepipelines. Due to this flexibility the stresses caused by heat expansion or unit transients are generally moderated. However, the disadvantage of this design conception is that the pipe responses fall in the characteristic frequency range of an earthquake. In this case the realization of seismic resistance will involve an essential redesign of the pipe supports.

In 1991 vibration table tests were conducted to qualify 5 C&I cabinet of different types, the control desk and relays and devices belonging to the reactor protection. In parallel with the tests of the cabinets and the desk dynamic calculations of finite elements were carried out and the results of the tests and the calculations were compared (see Figure 10). Above test had first of all methodological character. The list of seismic safety related electric and C&I equipment and components will be completed in 1992 and this document will determine the neccessity and scope of the further tests.

3.4.3.2. Possible application of the SQUG method

The use of the qualitative method developed by the American Seismic Qualification Utility Group (SQUG) would be very usefeul.

The main problem of the practical use of the SQUG qualification method is that the equipment of the VVER-440 V-213 NPP is substantially different to those in the SQUG data base. In our case a lot of Soviet equipment has to be requalified and there are not even similar ones in the data base based mostly on items of Western make. Despite the expected difficulties a large number of equipment that has not been certified and that can not be post-qualified on test table or at the site can be examined for the seismic resistance only by the SQUG method.

A data bank based on the mutual adventages would be very useful for VVER-440 V-213 equipment tested and checked by calculations.

4. REALIZATION OF THE SEISMIC SAFETY OF HIGHER LEVEL (TECHNICAL SOLUTIONS, EXECUTION DRAWINGS, REALIZATION)

At Paks NPP a large scale program is under way to increase the seismic safety.

The implementation of the program is within reasonable technical limits as there has not been yet the final expert opinion for the seismic hazard of the site. The activities until 1992 give a good methodological preparation and offers many results that can directly be used.

Figure 11 summarizes the activities in an overview logical schedule.

The reconstruction actions for the realization of seismic resistance of higher level can be defined during 1993 and 1994 and this actions can be executed during the period between 1993 and 1996 in several small reconstruction steps.

However, until the completion of the qualifications there is chance to progress in improving the seismic resistance if

- in course of reconstructions or component replacement in the units - as needed - the seismic resistant requirements are considered;
- the connection of the parallel safety improving actions to the seismic safety program and its eventual positive effects are exploited;
- the condition of the fixation for the components, electric and C&I cabinets etc. checked during the maintenance periods is reviewed;

5. IDEAS AND PROPOSITIONS FOR COORDINATED INTERNATIONAL ACTIVITY

Site examination:

in the assessment of the seismic hazards of the sites political issues are often involved so an objective international assessment organized and published by IAEA is very important for the NPPs, so that the financial resources for the safety improvement can be concentrated on elimination of real safety deficiences;

PSA:

According to the latest researches the probabilistic features of the events determining the safety in case of NPP unit of VVER-440 V213 type are as follows:

	frequency of the occurance [1/y]	frequency of core melt due to this [1/y]
large pipe break	10^{-5}	$2 * 10^{-8}$
small pipe break	10^{-3}	$2 * 10^{-6}$
max. design earthquake	10^{-4}	?

For the above figures it is worth noting that the given probability for pipe break relates only to one unit, while the earthquake with the given probability affects the site, i.e. affects all the four units at the same time.

Proposition:

A VVER-440 PSA has to be established with the coordinated efforts of the involved countries to determine the occurance probability of accidents following an earthquake.

On the base of this a Seismic Safety Philosophy has to be developed specially for the VVER's in operation.

Qualifying the seismic resistance:

As the NPP in case is a plant in operation which is not designed for seismicity, it is necessary to use several methods in parallel for its qualification, decreasing by this the conservatism of analyses.

Qualification of the buildings:

Proposition:

Selection of best estimate methods – on experimental base.

Mechanic, electric and C&I components:

Components not qualified by the manufacturer for earthquake:

- in-situ tests are impossible in many cases
- Tests on the spare componenets is not very simple and especially is not cheap

Proposition:

- selection of checked best estimate methods;
- coordinated activity like SQUG, common data base on the base of equal costs and mutual advantages;

The selection of the best methods and means is served by the coordinated research program "Benchmark Study for Seismic Analysesand Testing of VVER-tupe NPP's" suggested by IAEA. In our opinion the experimental experiences and results obtained at Paks NPP can be used for this, especially in the field of the dynamic examination of the main building.

Criteria for the qualification:

Deficient information about the standards, design principles and methods used in the design. In many cases the seismic qualification gives the only information about the strength character of the system.

Problems:

- incompability between the norms and methods of the original design and those of the seismic qualification;
- the material properties used in the design calculations are often unknown;

Proposition:

- A unified criteria document has to be established that takes the norms and methods used in the design and the up-to-date norms and methods into consideration as far as possible.

The propositions above are summarized in Figure 12.

STRUCTURE OF THE SEISMIC SAFETY PROGRAM

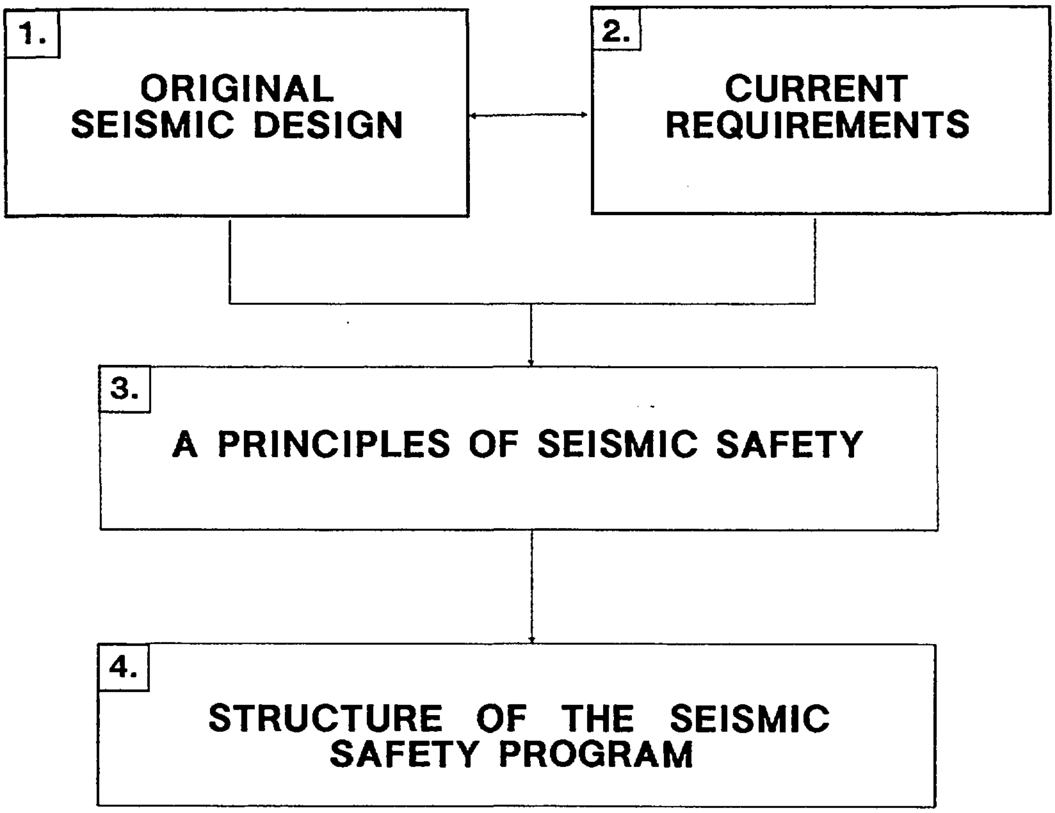


Fig. 1.

BASIC (REALISTIC) PRINCIPLES OF SEISMIC SAFETY OF VVER-440 v-213

GOAL:

- NO REQUALIFICATION FOR OBE
- QUALIFICATION ONLY FOR SSE

HOW TO REACH SAFETY FOR SSE?

— NOT FOLLOW STANDARD WAY IN CLASSIFICATION OF SYSTEMS

— SPECIAL TECHNOLOGY FOR INTRODUCING BORON, COOLING DOWN, AND HEAT REMOVAL REDUCING THE NECESSARY NUMBER OF SYSTEMS AND EQUIPMENTS

— USE FOR SOME SYSTEMS BEYOND THEIR ORIGINALLY INTENDED FUNCTION

— ELABORATE CRITERIA FOR MINIMUM ACCEPTANCE

— USE PARALLELLY SEVERAL METHODS, BEST ESTIMATE PROCEDURES TO AVOID CONSERVATISM

— RE-CONSIDER THE SAFETY PHILOSOPHY

Fig. 2.

SEISMIC SAFETY PROGRAM

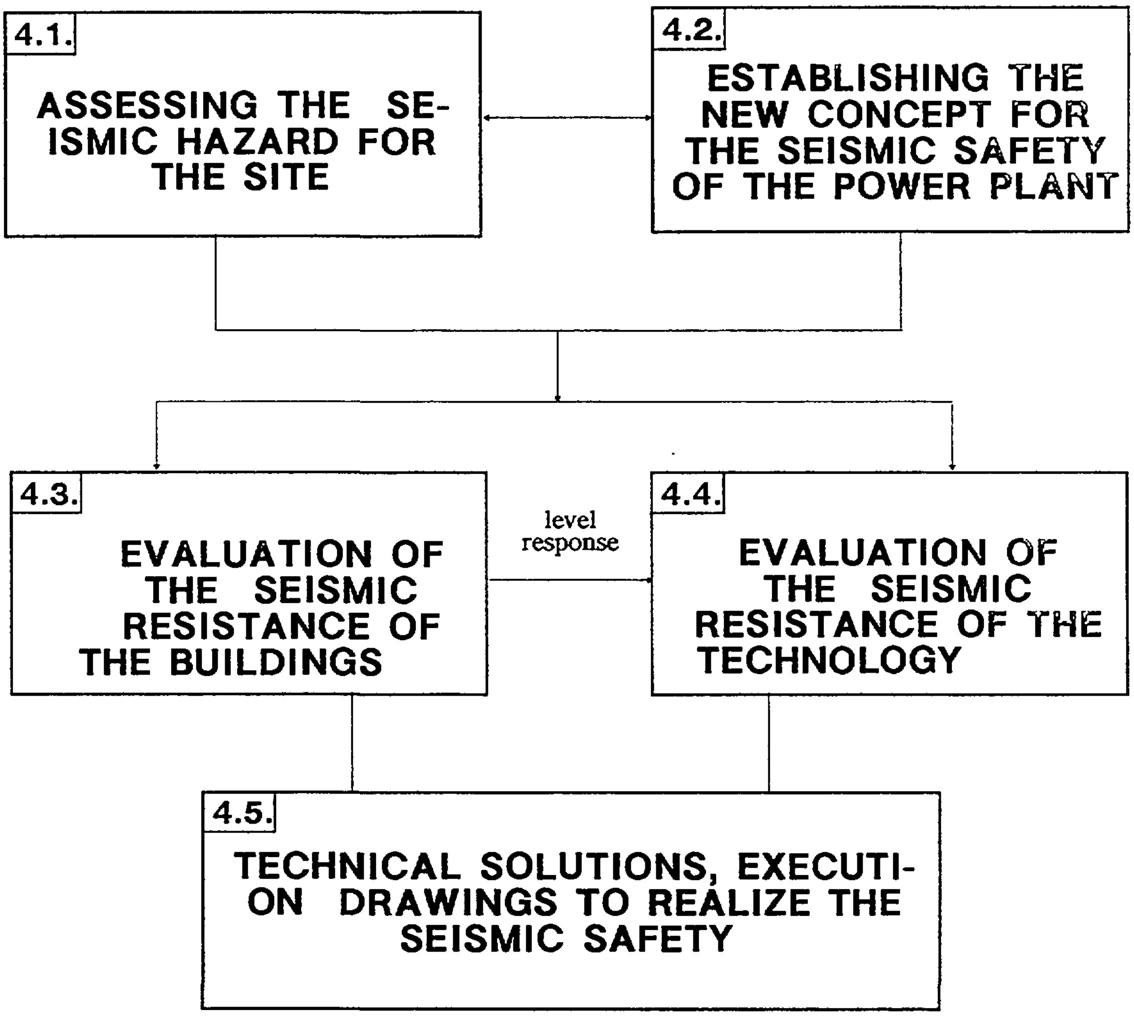


Fig. 3.

SEISMIC SAFETY PROGRAM

4.2. DEVELOPMENT OF THE NEW CONCEPT OF SEISMIC SAFETY FOR THE POWER PLANT (TECHNOLOGY)

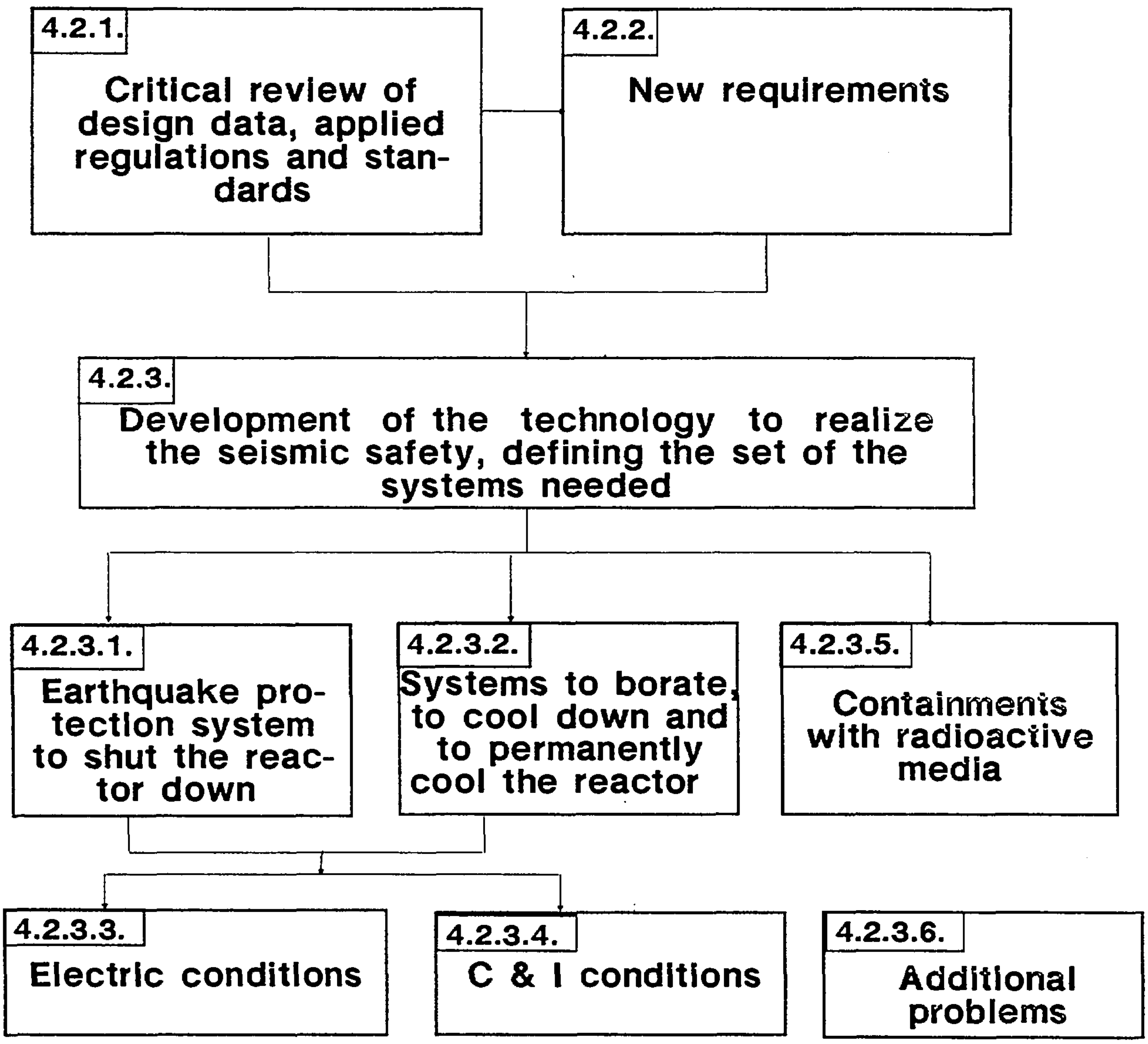


Fig. 4.

SEISMIC SAFETY PROGRAM

4.3. SEISMIC RESISTANCE ASSESSMENTS FOR THE BUILDINGS

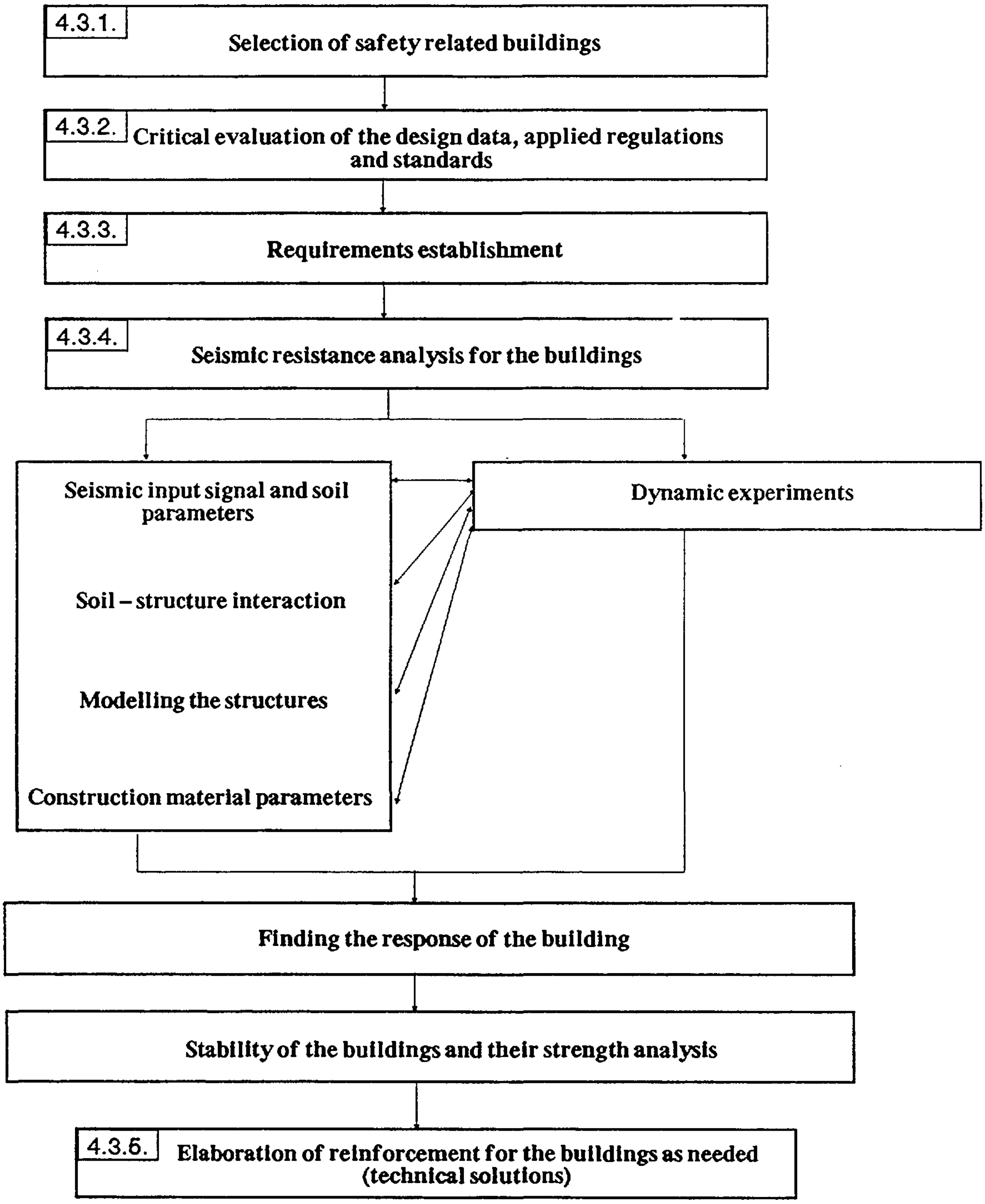


Fig. 5.

NAGYKERET-KERESZTMETSZET

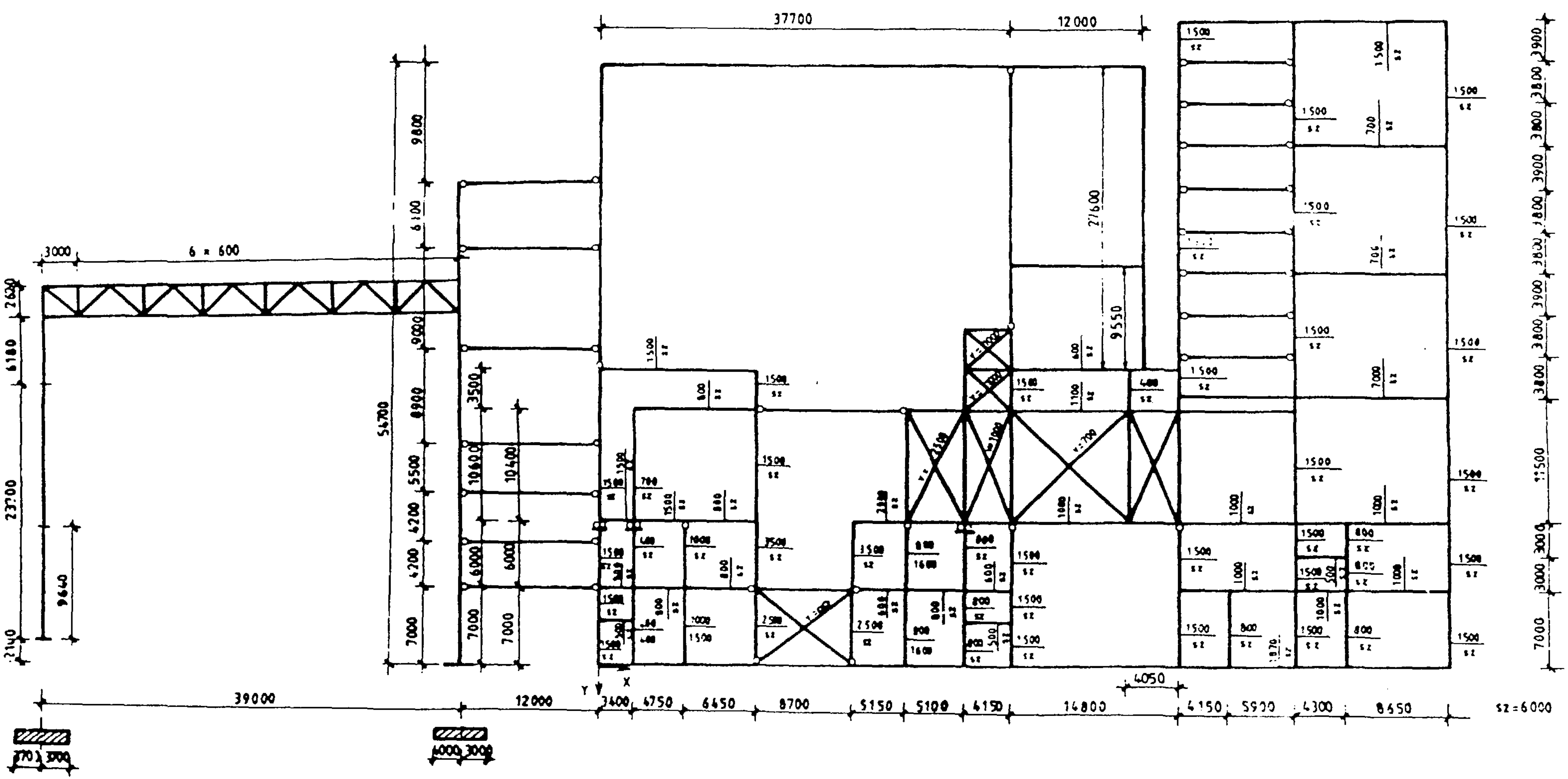
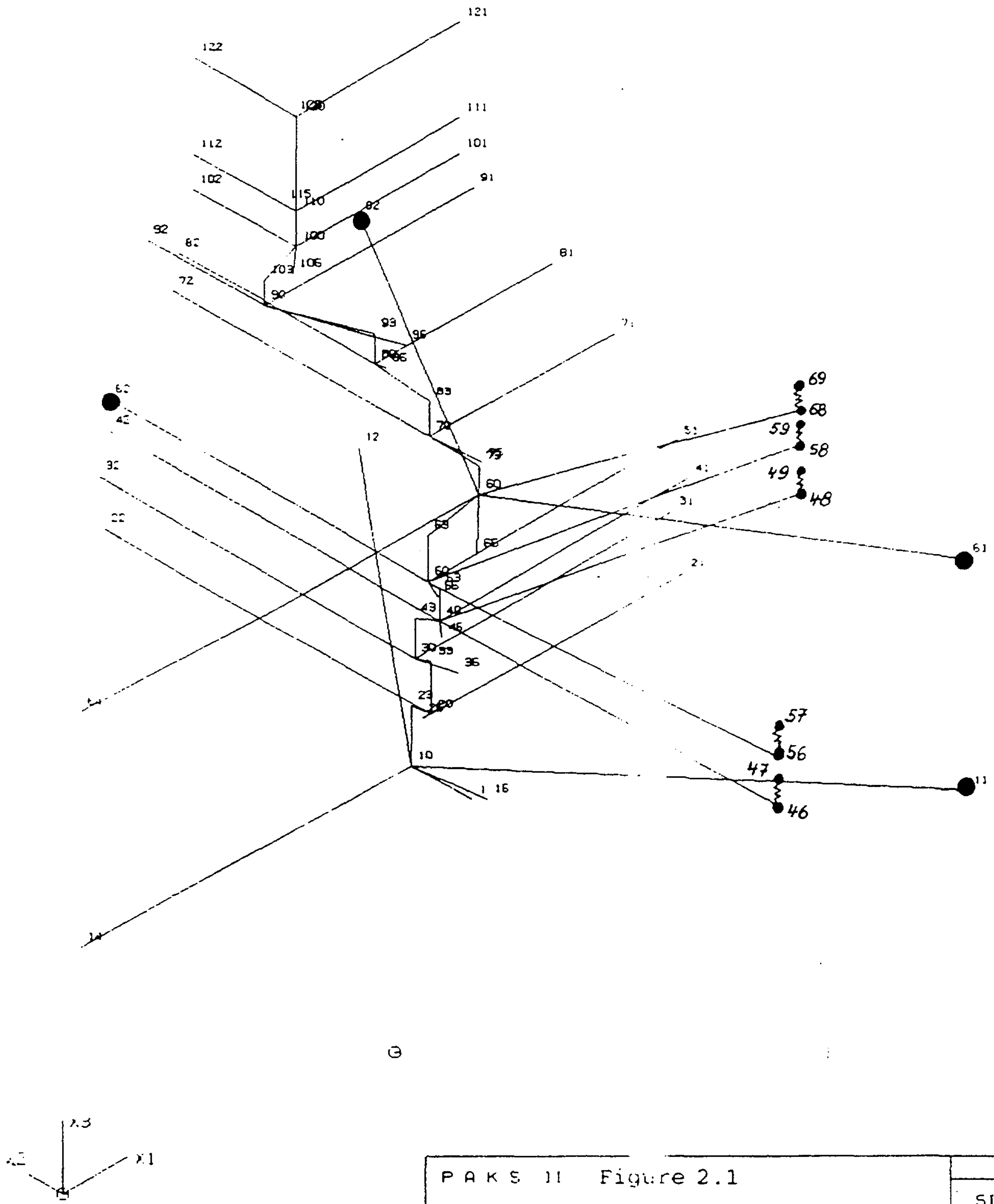


Fig. 6.



P A K S II Figure 2.1	6-SEP-91
	SIEMENS
PAKS II MAIL BUILDING BEAM MODEL V424/91/0043 POINTS NUMBERING	STRUDYN

STANDPKT.:(-1.00,-1.00,1.00)

Fig. 7.

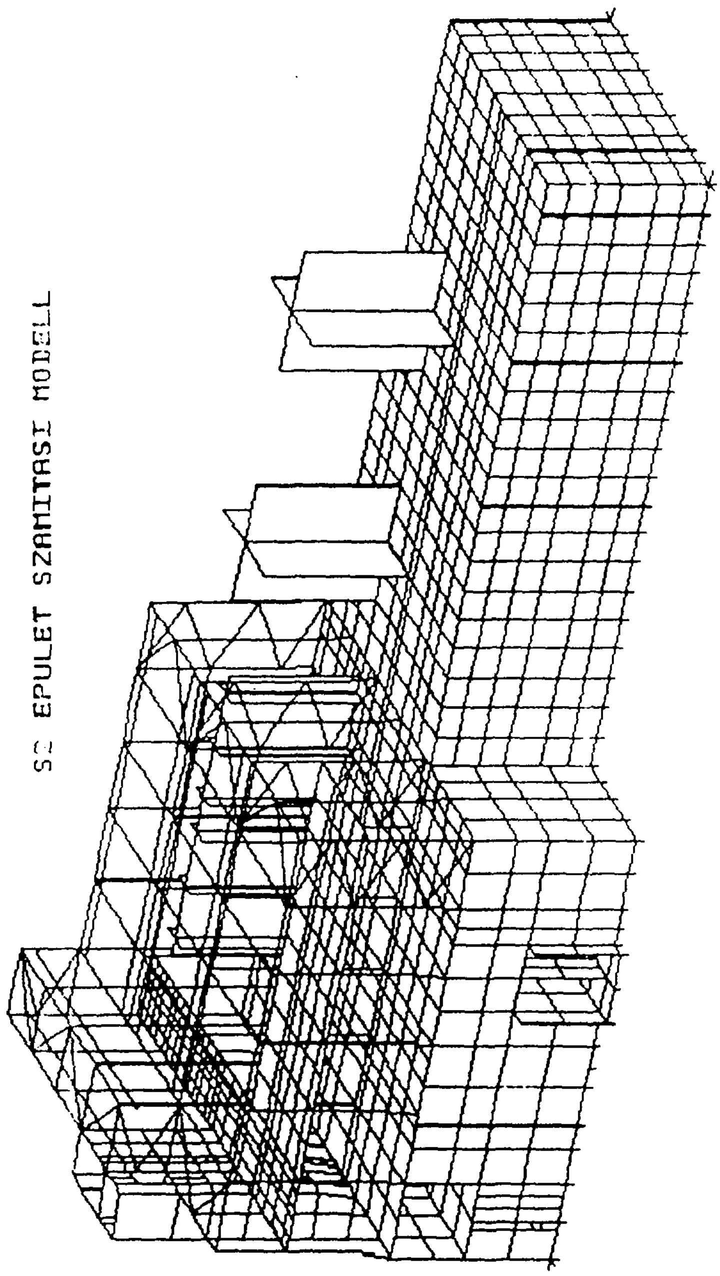


Fig. 8.

SEISMIC SAFETY PROGRAM

4.4. SEISMIC RESISTANCE ASSESSMENT FOR THE TECHNOLOGY

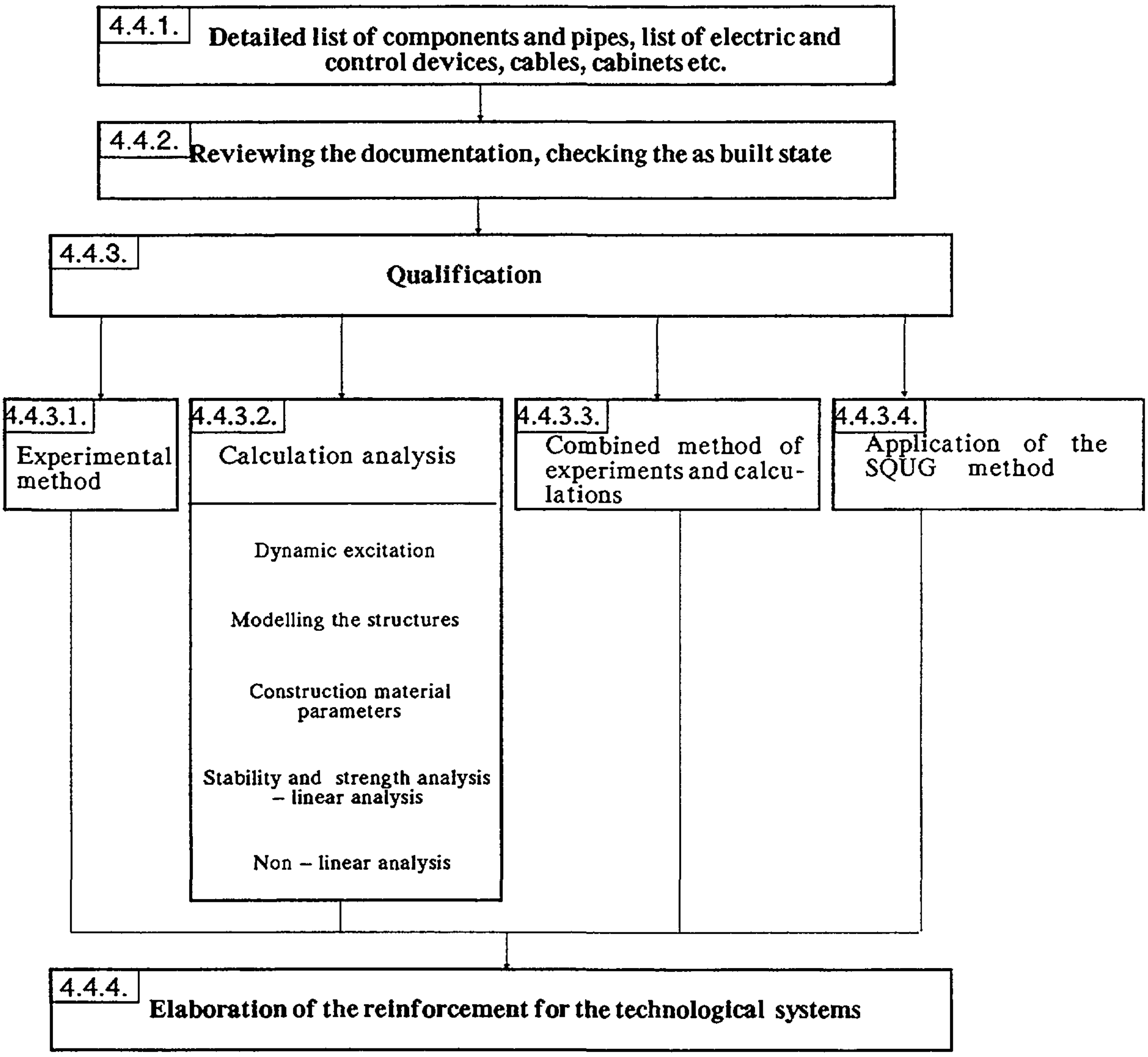


Fig. 9.

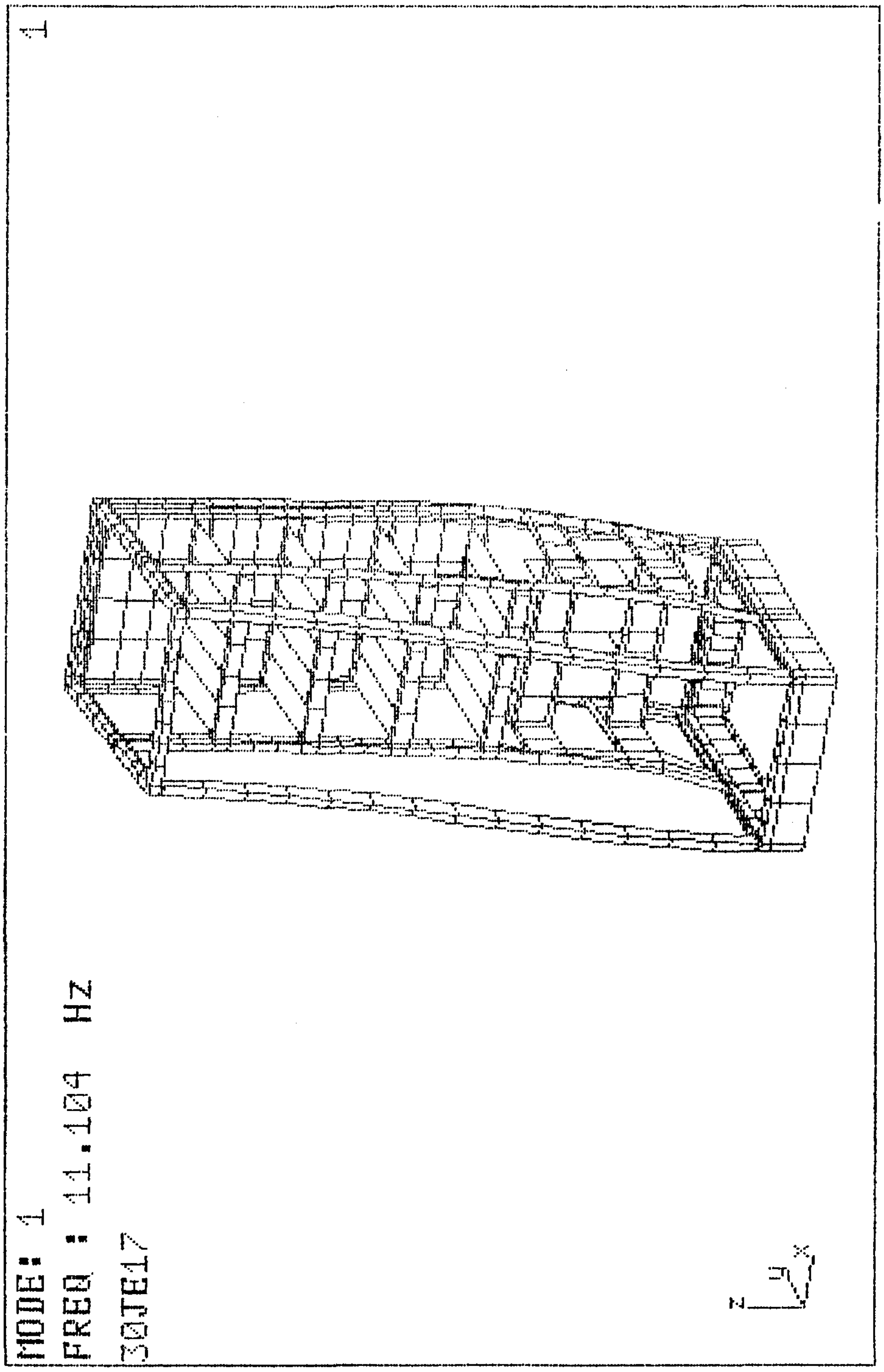


Fig. 10.

WORK	1992-93	1994-95	1996
ASSESMENT OF THE SEISMIC HAZARD FOR THE SITE (Official opinion of the Scientific Coordination Commitee)			
ESTABLISHMENT OF THE NEW CONCEPT OF SEISMIC SAFETY FOR THE POWER PLANT			
SEISMIC RESISTANCE ASSESSMENT FOR THE BUILDINGS – MODELLING, PRELIMINARY DINAMIC CALCULATIONS – FINAL EVALUATION – DESIGN OF (EVENTUEL) REINFORCEMENTS			
SEISMIC RESISTANCE ASSESSMENT FOR THE TECHNOLOGY *MECHANIC* – EVALUATION OF THE ACTUAL SEISMIC RESISTANCE – DEVELOPING THE TECHNICAL SOLUTIONS – DESIGNING THE REINFORCEMENTS *ELECTRIC* – CONCEPT AND LIST OF COMPONENTS – FINDING OUT THE ACTUAL SEISMIC RESISTANCE – DESIGNING THE MODIFICATIONS *CONTROL AND INSTRUMENTATION* INSTALLATION OF THE EARTHQUAKE PROTECTION SYSTEM – TEST RUN IN MANUAL MODE – INTEGRATION INTO THE REACTOR PROTECTION SYSTEM, AUTOMATIC MODE C&I ITEMS – CONCEPT AND LIST OF COMPONENTS – QUALIFICATION OF THE SYSTEMS AND COMPONENT – DESIGNING THE MODIFICATIONS			
REALIZATION			

Fig. 11.

PROPOSALS FOR COORDINATED ACTIVITY AND IAEA SUPPORT

— IAEA SUPPORT IN SEISMIC HAZARD RE-EVALUATION OF OPERATING VVER-440 SITES TO AVOID „POLITICAL" DISTURBANCES

— PSA FOR EARTHQUAKE - A COORDINATED RESEARCH PROGRAM - NEW SEISMIC SAFETY PHYLOSOPHY

— EVALUATION OF AS-BUILT SEISMIC SAFETY

- BEST ESTIMATE METHODS SUPPORTED BY EXPERIMENTS
- SPECIFIC ACCEPTANCE CRITERIA FOR VVER-440 v-213
- SQUG-LIKE DATA- AND KNOWLEDGE-BASE

COORDINATED RESEARCH PROGRAMMES

Fig. 12.