OPENING LECTURE

RECENT IAEA ACTIVITIES REGARDING WWER TYPE NPP SAFETY IN RELATION TO EXTERNAL EVENTS

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I.A.E.A.

SMiRT-12 CONFERENCE SEMINAR No. 16

UPGRADING OF EXISTING NPPs WITH 440 AND 1000 MW WWER TYPE PWRs FOR SEVERE EXTERNAL LOADING CONDITIONS
Abstract

This paper is the product of a meeting of a number of international specialists on the topic of seismic upgrading of nuclear facilities held at the IAEA in 1992. Its purpose is to provide guidance on the methodological aspects of a seismic upgrading program for a nuclear power plant.

An overview of a procedure which is recommended to assess and enhance the seismic capacity of existing VVER reactors is provided. Major focus of this procedure is to provide a cost-effective process which will allow to prioritize and implement needed modifications in a timely manner, using the realistic assessment of responses and capacities.

Major technical elements of this procedure are: (1) identification of the most critical systems, components and structures needed for safe shutdown and to maintain safe shutdown; (2) evaluation of as-built conditions through data gathering activity such as review of design drawings and construction specifications and detailed walkdown; (3) realistic assessment of plant response and capacity evaluations for developing acceptance criteria and designing cost-effective fixes, and (4) functional qualification of active mechanical and electrical components through use of generic test data applicable to all VVERs, plant-specific tests and earthquake experience data.

This procedure is sub-divided into three major categories: equipment, structures and distribution systems for prioritizing design and implementation of needed fixes. Some fixes, such as anchorage upgrade, are easily identifiable and could be designed for conservative seismic demand. This demand would be confirmed after a detailed plant response analysis is completed. Other fixes involving major structural elements or complex load paths would necessitate realistic response evaluations as well as capacity evaluation to design cost-effective fixes.

The paper provides several examples of the implementation of this methodology to nuclear power plants in Eastern Europe within the framework of IAEA projects.

Background

As the ratio of the number of operating nuclear power plants to those in the stages of siting and design has continually increased within the past fifteen years, the emphasis of nuclear safety related to external hazards has also shifted to existing facilities.

In this context, methods have evolved to re-evaluate seismic input parameters for existing sites as well as seismic capacities of structures, equipment and distribution systems of nuclear power plants with the purpose of seismic verification and possibly upgrading.
Methodology Outline

During the two preparatory meetings held in 1992, a flow chart was prepared describing an overall methodology for assessing and enhancing the seismic capacity of existing nuclear power plants. This flow chart is presented in Figure 1.

The aim of the assessment is to show that the plant can withstand a Level SL2 earthquake without giving rise to a Level V accident (on the INES Scale). This will be interpreted as ensuring that service condition D (as defined by ASME), or the equivalent, is not exceeded. If this is not possible, modifications will be identified that, when implemented, will prevent the occurrence of the Level V accident.

It should be noted that a Level V accident is defined as an "Accident with Off-site Risk".

As may be seen from Figure 1, after identification and classification of systems to be considered, the seismic input, soil data, acceptance criteria and loading combinations are established. Considerable effort and decision making is required to arrive at this point. In general, the seismic input is determined using the principles and methods established for new sites and plants. (See e.g. IAEA 50-SG-S1, Rev. 1, 1991). The only difference might be due to the "lifetime" of the plant, when the input is calculated on a probabilistic basis. This is generally shorter for existing plants (if life extension is not envisaged) and may lead to somewhat lower design values.

The major difference with the seismic design of a new plant would be related to acceptance criteria, which would make use of existing safety margins to the fullest extent possible.

Beyond the evaluation of the situation and setting up of criteria, the methodology is specific depending on the plant item in question, i.e. structures, distribution systems and equipment.

Special emphasis is given to the "easy fixes' resulting from the structural evaluation of distribution systems and equipment, which, when implemented may increase seismic safety most cost effectively.

This has been already observed in the seismic upgrading of the Kozloduy NPP, Units 1-2, for which the IAEA has provided continuous support through review services including the preparation of the Terms of Reference (TOR) for the seismic upgrading program\(^1\). The TOR specifies four phases for the seismic upgrading of the Kozloduy NPP, Units 1-2, each phase increasing the safety level by implementation of "easier" fixes and assessing the seismic capacity of more complex items systematically. This eventually leads to the attainment of the seismic safety goal within a specified time frame.

\(^1\) This program was funded by the European Community and executed by WANO.
The actual benchmarking of analysis and testing is mainly envisaged for structural systems in the beginning of the project. The method for the interaction of testing to analysis is presented in Figure 2.

It is planned to conduct full scale dynamic testing of the reactor structures of both the Kozloduy (Unit 5 or 6) and Paks (Unit 1, 2, 3 or 4) Nuclear Power Plants either in 1993 or 1994. Although some testing was already performed on these structures previously, it is envisaged to have a more systematic and integrated approach of testing for the benchmark study.

The partition of tasks to different participating institutes and a draft work plan/schedule for the CRP can be seen in Table 2 and Figure 3 respectively. These will be updated during the first coordination meeting in September 1993 to be held in Paks.

Concluding Remarks

The benchmark study under the IAEA Coordinated Research Program has drawn a great deal of interest from all concerned member states. It promises to serve as a forum for the exchange of ideas related to different analytical methods, codes, testing techniques and criteria all focused on the problem of assessment and enhancement of seismic capacity of existing nuclear power plants of the VVER type. It is expected that the results of the program will help in understanding the existing seismic safety level of these plants in terms of current international practice and provide guidance to the owners of these plants in improving this level.

References


Acknowledgements

The article comprises a synthesis of the conclusions of two meetings in 1992 held in Vienna by about thirty international specialists whose valuable contributions both to this paper and to the Coordinated Research Program are gratefully acknowledged.
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Table 1. Seismic Safety Review Services
Figure 1. Chart for the Assessment and Improvement of Seismic Capacity

CONSTRUCTIONS (BUDGET, SCHEDULE) ➔ OVERALL OBJECTIVE: SEISMIC QUALIFICATION OF WWER TYPE NPP's

SAFE SHUTDOWN ➔ SYSTEMS IDENTIFICATION, SYSTEMS CLASSIFICATION ➔ ACCIDENT MITIGATION
* EMERGENCY POWER
* EMERGENCY COOLING

ACCEPTANCE CRITERIA, LOAD COMBINATIONS ➔ EVALUATION OF THE AS-BUILT SITUATION: * DATA GATHERING
* DRAWINGS
* PLANT WALKDOWN

SAFE SHUTDOWN ➔ EVALUATION OF THE AS-BUILT SITUATION: * DATA GATHERING
* DRAWINGS
* PLANT WALKDOWN

SYSTEMS IDENTIFICATION, SYSTEMS CLASSIFICATION ➔ SEISMIC INPUT, SOIL DATA

EVALUATION OF THE AS-BUILT SITUATION: * DATA GATHERING
* DRAWINGS
* PLANT WALKDOWN

STRUCTURES ➔ DISTRIBUTION SYSTEMS (PIPING, CABLES, DUCTS, TRAYS) ➔ EQUIPMENT
IDENTIFY WEAK LINKS, MODELLING ASSUMPTIONS, AS-BUILT CONDITIONS

STRUCTURES ➔ DISTRIBUTION SYSTEMS (PIPING, CABLES, DUCTS, TRAYS) ➔ EQUIPMENT
IDENTIFY WEAK LINKS, MODELLING ASSUMPTIONS, AS-BUILT CONDITIONS

TEST ➔ RESPONSE ANALYSIS ➔ EASY FIXES

TEST ➔ RESPONSE ANALYSIS ➔ EASY FIXES

CAPACITY EVALUATION (DUCTILITY) ➔ LOAD PATH ANALYSIS, TESTING ➔ DESIGN

CAPACITY EVALUATION (DUCTILITY) ➔ LOAD PATH ANALYSIS, TESTING ➔ DESIGN

DESIGN ➔ IMPLEMENT

DESIGN ➔ IMPLEMENT

IMPLEMENT ➔ CHECK OF DEMAND

IMPLEMENT ➔ CHECK OF DEMAND

A. Gürpınar K08/6
Figure 2. Interaction of Analysis and Testing

**TESTING ACTIVITY**

- Data Collection and Checking of Drawings
- Preliminary Inspections
- Testing Plan for:
  - Structures
  - Materials
  - Mechanical Equipment
  - Distribution System
  - Electrical Equipment
- Testing Execution
- Analysis of Results
- Additional Testing

**ANALYTICAL ACTIVITY**

- Loads, Load Combinations
  - Acceptance Criteria
  - Site Related Parameters
- Elementary Routine Calculations
- Detailed Numerical Analysis and Numerical Models Validation
- Seismic Safety Assessment
Table 2 - Partition of Tasks for Participating Institutions

<table>
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CRP - Benchmark Study for Seismic Analysis/Testing of an Existing NPP

Task 1 - Systems Identification/Classification

<table>
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WESI (B) will coordinate this task

Task 2 - Design Regulations, Acceptance Criteria, Loading Combinations

AEP (RF) - Coordinator
Argonne (USA)
VNIIAM (RF)

Task 3 - Seismic Input, Soil Conditions

AEP (RF)
Argonne (USA)
K-NPP (BG) - Coordinator
P-NPP (H) - Coordinator
VNIIAM (RF)
WESI (B)

Task 4 - Standards, Criteria - Comparative Study

New - Old, USSR - West

AEP (RF)
Argonne (USA)
CKTI (RF)
EA (Sp.)
Ismes (I)
SA (Cz.) - Coordinator
Skoda (Cz.)
VNIIAM (RF)
Task 5 - Walkdown (Reconnaissance)

AEP (RF)
Argonne (USA)
CKTI (RF)
EA (Sp.)
EQE (BG)
Ismes (I)
K-NPP (BG) - Coordinator for Kozloduy Walkdown
P-NPP (H) - Coordinator for Paks Walkdown
Siemens (G)
SP (CH)
VNIIAM (RF)