International Experts’ Meeting on Protection against Extreme Earthquake and Tsunami in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant

“TiPEEZ System” for Information management against earthquake, tsunami and nuclear disaster, considering nuclear communication

TiPEEZ : Protection of NPPs against Tsunamis and Post Earthquake considerations in the External Zone

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I. Lesson learned from Fukushima Accident
II. Background of TiPEEZ
III. Outline of TiPEEZ and Its Application
IV. Communication based on Nuclear Risk Information produced by TiPEEZ
V. Recognition of Total Comprehensive Technology
VI. Summary
I. Lesson learned from Fukushima Accident

■ The Tohoku Earthquake (Mw9.0) occurred at 14:46 on March 11, 2011.
■ Strong ground motion was observed at the Fukushima Dai-ichi NPP (F1-NPP) and reactors were shut down.
■ F1-NPP was attacked by tsunami about 46 minutes after EQ. and Various equipment of the water intake system and emergency diesel generators were flooded.
■ In this situation, station blackout occurred took place.
■ As a consequence, functions of reactor cooling system was lost, core damage occurred and radioactive materials were released to the off-site area.
■ Many residents around F1-NPP were evacuated.
■ In the evacuation, nuclear risk communication was not enough.
JNES was identified important issues based on lessons learned from F1-NPP accident as follows.

(1) Risk Evaluation against External Hazard
1) Gigantic main earthquake and tsunami, gigantic aftershock, triggered earthquake and earth crust submerge
2) Multi hazard (combination of seismic hazard and tsunami hazard)
3) Level 1-3 risk evaluation at multi units/sites against multi hazard
4) Core damage during short time by functional failure of support systems (seawater supply, power supply and signal systems)
5) Common cause failure of multi structures and components
6) Dependency among neighboring units
7) Isolation technology as countermeasure against external hazard

(2) Nuclear Disaster and Warning System against External Hazard
8) Combined emergency of both natural disaster and nuclear accident

(3) Nuclear Risk Communication regarding External Events
9) Nuclear risk communication with citizens and experts

(4) Total comprehensive Technology against External Events
10) Total comprehensive technologies (hazards, fragility, core damage, radiation expose, disaster prevention and risk communication)
Example of Dose Distribution

Cumulative dose of Cs-137 (Bq/m²) at 29th April 2011

- 3,000,000 - 14,700,000
- 1,000,000 - 3,000,000
- 600,000 - 1,000,000
- 300,000 - 600,000
- < 300,000

N/A Surveys Area
Fukushima Dai-ichi NPP

Damage of Unit 3 and Unit 4 of Fukushima Dai-ichi NPP

EPZ (10 km radius)
Evacuation Zone
Emergency evacuation preparation zone
(1) Current situations of resident evacuation in Fukushima NPP accident

The number of evacuating people from areas targeting evacuation, to the extent of 7 cities and towns: About 87,000

<table>
<thead>
<tr>
<th>Classification</th>
<th>Evacuation range (radius)</th>
<th>Announcement Date and Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evacuation directive</td>
<td>2km</td>
<td>19:03 Mar 11</td>
</tr>
<tr>
<td></td>
<td>3km</td>
<td>21:23 Mar 11</td>
</tr>
<tr>
<td></td>
<td>10km</td>
<td>5:44 Mar 12</td>
</tr>
<tr>
<td></td>
<td>20km</td>
<td>18:25 Mar 12</td>
</tr>
<tr>
<td>Stay indoor directive</td>
<td>30km</td>
<td>11:06 Mar 15</td>
</tr>
</tbody>
</table>

(2) Issues of resident evacuation

- The large area evacuation beyond borders of cities and towns had difficult response within those municipality’s administrative duties.
- The patients in a grave condition and residents in a senior people’s home had the difficulties on prompt evacuation because of having risks on moving to the shelters.
- The victims faced the difficulties on their life after evacuation while they did not have any things because of no information from the local municipalities concerning possibility of long period evacuation and preparatory subject to be needed.
- The shelters were prepared in the highly radioactive areas because of no information from the national government concerning the situation of radioactive extent.
Tsunami EBP Project: 2007.4-2010.3, Triggered by Sumatra tsunami (2004) Implementation Items:
- Act.1; Disaster Mitigation of NPP and External Zone based on TiPEEZ
- Act.2; Diffusion of Tsunami Analysis Code for Tsunami Hazard at NPP

Tsunami EBP Countries: IAEA Member States, especially Asian Regions

- Provision and operations support of TiPEEZ
- Provision and practical work support of Tsunami Analysis Codes

Legend symbol:
- Red: Participants of item 1
- Blue: Participants of item 2

Activity 1: TiPEEZ
- Tsunami inundation
- Radiation dose estimation

Activity 2: Tsunami analysis training

Tsunami disaster of Sumatra earthquake (2004.12)
Ⅲ. Outline of TiPEEZ and Its Application

Concept and Function of TiPEEZ

TiPEEZ is the system for disaster prevention /evacuation and information transmission based on risk management by seismic and tsunami PRAs targeting both of plant on site and off site. Main functions are as follows.

1. both functions used in ordinary terms and in emergency,
2. function supporting in spatial, in not depending on main frame computer (backup function),
3. Temporal-Spatial Function that deals with simultaneously information of related special location and information of related time process,
4. Seismic/tsunami hazards, fragilities and accident sequences evaluation,
5. Dose distribution evaluation based on the monitoring data, and
6. Automatic evacuation root evaluation.
Procedure of Seismic PRA (1/3)

(1) Seismic Hazard Evaluation
- Earthquake data
- Active fault data
- EQ occurrence and propagation model
- Hazard curve

(2) Fragility Evaluation
- Response analysis
- Structure analysis
- Shaking test data
- Capacity
- Fragility curves
- Ground motion acc.

(3) System Analysis
- Analysis of Scenario
- System analysis
- Accident sequence freq.

Level 1 PSA
Level 2 PSA (FP release rate)
Level 3 PSA (Individual risk)
(1) Collection of information related to Tsunami and Setting of accident scenario

(2) Tsunami Hazard Evaluation
- Tsunami Source Modeling
- Tsunami Analysis
- Tsunami hazard curve

(3) Tsunami Fragility Evaluation
- Tsunami inundation evaluation
- Capacity (height) of SSCs
- Function Failure Probability evaluation

(4) Accident Sequence Evaluation
- Accident sequence modeling (Event Tree, Fault Tree)
- Occurrence Frequency of accident
Illustration of Evacuation Evaluation by TiPEEZ (3/3)

On-site
- Dose distribution evaluation based on the monitoring data

Off-site
- Hazard evaluation
  - d) Seismic intensity
  - e) Tsunami inundation
- Fragility evaluation
  - f) Bridge damage
  - g) Steep slope damage

Gantt Chart of evacuation transportation plan

Evaluation of evacuation root
- Select of vehicle
  - Green line: Available route
  - Red line: Instructed route

Local government, citizen, etc.

The outputs of TiPEEZ system are announced to several organizations and citizen immediately. The efficient communication is significant at that time.
Transfer of TiPEEZ to Member States

<table>
<thead>
<tr>
<th>MS</th>
<th>Organizations</th>
<th>Reference NPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>NPCIL, AERB</td>
<td>Kudankulam</td>
</tr>
<tr>
<td>Korea</td>
<td>KHNP, KINS</td>
<td>Ulchin</td>
</tr>
</tbody>
</table>

Co-operative Work Process

- Technology transfer for autonomous customizations in MS

- Installation of TiPEEZ system (India/Korea)
- Programming the earthquake damage estimation code (India)
- Preparation of basic data (India/Korea)
- Table-top exercise (Feb, 2010, India)
- Site unique modification: - plant safety design/ - emergency response plan

Support by JNES

- TiPEEZ system software
- Basic topo. data making of sites
- Damage estimation methodology
- Software guidance
- Preparation of table-top exercise

It showed usability of TiPEEZ through exercise at India on 2010.
Many experts in relation to NPPs had their minds that objectives of risk communication is to give reflection into other person’s idea or to provide enlightenment and persuasion.

After Chernobyl Accident in 1986, the missing social trust to experts had resulted into the loss of meaning of objective identification guided to the enlightenment and persuasion.

After that, it had been made social decision making by involved citizens so that the solutions could be found out on carrying out collaborative workings of citizens and experts.

Emphasizing a tempting resource only without discussing risk potentiality in use of nuclear energy is not guided to sufficient trust in the nation.

It is needed to tackle actively for discussion with citizens as well as facing directly nuclear risks, or specifically significant issue is risk communication for establishing the trust.

It is consistent that specific scientific explanations are required on nuclear risks.
Roles of Seismic Engineering on Nuclear Risk Communication (2/4)

TiPEEZ evaluates various nuclear risk information (NRI). Roles of seismic engineering on nuclear risk communication based on NRI are as follows.

1) to attempt to produce the trust,
2) to identify and offer effective NRI so that NRI are implemented in collaborative workings with experts of nuclear system experts,
3) to process and compile NRI as highly clarity information,
4) to make a mutual information exchange scheme in order to send and receive them to society or citizens, and
5) to explain carefully the engineering meanings about seismic and tsunami hazards evaluation in consideration of uncertainty of natural phenomena, and fragility.

Considerable Terms on Nuclear Risk Communication (3/4)

1) Risk communication is not established by only numerical output of NRI.
2) It is important to issue processes leading to the output so that terms of evaluation, modeling, data, and evaluation results are demonstrated specifically, and clarity and explanation are secured.
3) It is highly significant to conduct efficient discussions on a mutual communication between citizens and experts so that it is used the effective human interface technology.
4) It is also important that communications among experts are unskillful, even if not focusing the communication between citizens and experts.
Examples of Communication between Citizens and Experts (4/4)

A research on nuclear risk communication which JNES & Niigata Institute of Technology (NIIT) is organizing in cooperation with the citizens of Kashiwazaki and Kariwa, the local medias, the local municipalities, and besides contacting with the IAEA, is ongoing as an execution instance of collaborative workings with citizens and experts.

1st Kashiwazaki International Symposium on Seismic Safety of Nuclear Installations (24-26 Nov. 2010, NIIT, Japan)

- **Symposium**: 4 sessions & 2 workshops
  - **Session A**: Earthquake & Ground Motion
  - **Session B**: Tsunami
  - **Session C**: Seismic Safety Margin & Risk
  - **Session D**: Information Dissemination System (Risk communication)

- **W.S.1**: "Seismic Observation in Deep Boreholes and their Applications"
- **W.S.2**: "Seismic Isolation of Nuclear Facilities"

- **Total attendance**: 568 persons including 69 overseas from 28 countries
It is inevitable for us to start out by “agreeing that the citizens are currently disagreeing”.

It is highly significant for us to “reach reasonable disagreement by overcoming unproductive confrontation”.

Agreement contents in WS
V. Recognition of Total Comprehensive Technology

Comprehensive technologies by looking over throughout hazard, fragility, core damage, radiation expose, disaster prevention and risk communication, and the plant life period every stage.

- It is needed a perspective that evaluates in the comprehensive technologies by looking over throughout seismic and tsunami hazards, fragility of soil, buildings, and components, core damage, fission product behavior, radiation expose, disaster prevention and risk communication.

- It is also needed a perspective that looks over the plant life period every stage.
VI. Summary

(1) Current Realization of Residents Evacuation and Nuclear Risk Communication on Fukushima Accidents

- It had not effective evacuations for the residents because of insufficient information related nuclear risks on F1-NPP accident.
- As a part of IAEA tsunami EBP, TiPEEZ was developed and applied to India NPP before F1-NPP accident.
- It is needed a perspective that evaluates in the comprehensive technologies by looking over throughout hazard, fragility, FP behavior, radiation expose, disaster prevention and nuclear risk communication.

(2) Proposals in the immediate term

- Lessons learned from the Fukushima Accidents, related resident evacuation and nuclear risk communication are analyzed, then significant factors are identified and reflected in the TiPEEZ functions.
- The TiPEEZ are applied in resident evacuation exercises, then its functions are confirmed as well as made refinement.
- The outcomes of the implementation above are going to result into fruitful international cooperation by reflected to the IAEA EBP activities.