Current status of NPP development & research programs in China

Rong PAN
Department of Plant siting & civil Engineering Nuclear & Radiation Safety Centre, MEP, China
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2. Current status of NPP development in China
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PART ONE

General Situation of Nuclear Safety Regulation
General Situation of Nuclear Safety Regulation

The Regulatory Authority

- MEP (NNSA) is the regulatory department of Central Gov.
- MEP (NNSA) is responsible for nuclear safety and radiation safety supervision, and radioactive environment management.
- NSC is the technical support for NNSA.
Main Tasks

- Safety Review & Inspection
- Information services
- Technical consultation
- Science Research on Nuclear & radiation safety
- Regulation policy & Codes Research
- Event Emergency Response & assessment

Nuclear & Radiation Safety
Nuclear Safety Regulation Hierarchy

1. **LAW**
   - 1 law

2. **DECREES**
   - 7 decrees

3. **DEPARTMENT RULES**
   - 30 department rules

4. **GUIDES**
   - 89 guides
• China has established its regulations concerning nuclear and radiation safety largely by adopting and adapting IAEA safety standards.

• China is committed to improve its regulatory system on the nuclear and radiation safety by reflecting domestic experiences combined with the latest international practices.
PART TWO

Current status of NPP development in China
Current status of NPP development in China

Totally 56 NPP units in 13 sites
32 units are in operation
24 units are under construction
19 Research Reactors

Appropriate Development Period: Sea shore project expansion+ several new projects (1994-2005)

Fast development period: amount of reprint projects+ Imported 3rd generation projects (2005- 2011)

Post Fukushima period: Independent design 3rd generation units + imported 3rd generation projects (2011~)
## Development Process of the Construction of Chinese NPPs

<table>
<thead>
<tr>
<th>Periods</th>
<th>Sites</th>
<th>DBE</th>
<th>Field condition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial Construction Period:</strong> Qinshan + Daya BAY NPP (1985-1994)</td>
<td>Qinshan NPP</td>
<td>0.15g</td>
<td>Hard rock foundation</td>
</tr>
<tr>
<td></td>
<td>Daya Bay NPP</td>
<td>0.20g</td>
<td>Hard rock foundation</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fast development period:</strong> amount of reprint projects + Input 3rd generation projects (2005-2011)</td>
<td>Fangjiashan NPP</td>
<td>0.15g</td>
<td>Hard rock foundation</td>
</tr>
<tr>
<td></td>
<td>Changjiang NPP</td>
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<tr>
<td></td>
<td>Ningde NPP</td>
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<td></td>
<td>Sanmen NPP</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Shidaowan HTR-PM NPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fangchenggang NPP</td>
<td>0.15g</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fuqing NPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hongyanhe NPP</td>
<td>0.19g</td>
<td></td>
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<tr>
<td></td>
<td>Yangjiang NPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Haiyang NPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Taishan NPP</td>
<td>0.20g</td>
<td></td>
</tr>
</tbody>
</table>
# Development Process of the Construction of Chinese NPPs

<table>
<thead>
<tr>
<th>Approved sites</th>
<th>DBE</th>
<th>Field condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xudapu NPP</td>
<td>0.15g</td>
<td>Hard rock foundation</td>
</tr>
<tr>
<td>Shidaowan NPP</td>
<td>0.19g</td>
<td></td>
</tr>
<tr>
<td>Lufeng NPP</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Potential sites</th>
<th>DBE</th>
<th>Field condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cangzhou Site</td>
<td>0.27g</td>
<td>Soil site foundation</td>
</tr>
<tr>
<td>Zhangzhou site</td>
<td>0.30g</td>
<td>Hard rock foundation</td>
</tr>
</tbody>
</table>

Post Fukushima period: Independent 3rd generation units (HL1000) + import 3rd generation projects + (2011~)
Safety improvements after Fukushima

- Comprehensive safety inspection and evaluation to nuclear installation national wide
- Issued *Generic Technical Requirements on Improvement Actions of Nuclear Power Plants After Fukushima Nuclear Accident*
- Experience feedback from the Fukushima Accident
- Optimized organizational structure, improved the regulatory standards, put forward new nuclear safety requirements, etc.
PART THREE

Resent research programs of NPP site & structure safety in China
NPPs and Potential tsunami sources along Chinese Coast
NPPs and Potential tsunami sources along Chinese Coast

\[ f(x | \mu, \sigma) = \frac{1}{\sqrt{2\pi} \sigma} \exp\left(-\frac{(\log x - \mu)^2}{2\sigma^2}\right) \]

\[ P(H \geq h) = 1 - \prod_{n}^{N} (1 - P_n(H \geq h)) \]
NPPs and Potential tsunami sources along Chinese Coast
Hybrid Simulation to Assess Performance of Seismic Isolation in Nuclear Power Plants

Computational Models

1-bearing equivalent model
5-bearing equivalent model
486-bearing model
Hybrid Simulation to Assess Performance of Seismic Isolation in Nuclear Power Plants

Seismic input motions

Two ground motions: provided by IAEA
- NRC RG 1.60 (IMPERIAL VALLEY)
- EUR (LOMA PRIETA)

Another two ground motions: with characteristics of long period and long duration
- NGA 1200 (CHICHI)
- XIAN (WENCHUAN)
Hybrid Simulation to Assess Performance of Seismic Isolation in Nuclear Power Plants

Peak acceleration of structures
Taking the results of top node as example under the input of DBE-RG 1.60

<table>
<thead>
<tr>
<th>Direction</th>
<th>1-bearing</th>
<th>5-bearing</th>
<th>486-bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td>X direction--DBE-RG 1.60</td>
<td>0.674</td>
<td>0.613</td>
<td>0.652</td>
</tr>
<tr>
<td>Y direction--DBE-RG 1.60</td>
<td>0.694</td>
<td>0.629</td>
<td>0.325</td>
</tr>
<tr>
<td>Vertical direction--DBE-RG 1.60</td>
<td>0.985</td>
<td>1.137</td>
<td>1.059</td>
</tr>
</tbody>
</table>

Divided by 150mm

Divided by 210mm

Divided by 1333.5mm
CAP1400 Nuclear island building seismic response tests & analysis
## Capacity of Shaking Table

<table>
<thead>
<tr>
<th>Dimension of shaking table</th>
<th>6×6m</th>
<th>Maximum eccentric moment</th>
<th>60kN.m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum load</strong></td>
<td>60T~80T</td>
<td>Maximum torsion angle</td>
<td>±3 degrees</td>
</tr>
<tr>
<td><strong>Maximum displacement</strong></td>
<td>±15cm and ±25cm for two horizontal directions; ±25cm for vertical direction</td>
<td>Working Frequency content</td>
<td>0.1~50HZ</td>
</tr>
<tr>
<td><strong>Maximum velocity</strong></td>
<td>±100cm/s, and ±125cm/s for two horizontal directions; ±80cm/s for vertical direction</td>
<td>Control mode</td>
<td>Digital control</td>
</tr>
<tr>
<td><strong>Maximum acceleration</strong></td>
<td>±1.5g and ±1.0g for two horizontal directions; ±0.8g for vertical direction.</td>
<td>Degree of vibration</td>
<td>Six degrees</td>
</tr>
<tr>
<td><strong>Maximum moment</strong></td>
<td>180t.m</td>
<td>Input signal</td>
<td>Seismic wave; random wave; harmonic wave.</td>
</tr>
<tr>
<td><strong>Maximum eccentricity</strong></td>
<td>100cm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
HTR-PM nuclear island building seismic response tests & analysis
PART FOUR

Undergoing research programs
Undergoing research programs

- CAP1400 Nuclear island building simplified analysis
- CAP1400 Nuclear island building SSI seismic response analysis
- NNSA capacity building
Modeling

- Tank
- Containment
- Internal structure
- Foundation
- Other NI structures

CAP1400 NI Building finite element
CAP1400 Nuclear island building SSI seismic response analysis

Input response spectrum

Site field material

Input time history

SSI

FRS

RG1.60 (HOR) Damping
- 2%
- 5%
- 7%

Acceleration (G)

Frequency (Hz)

Depth (m)

Shear modulus (GPa)

Acceleration (g)

Period (s)
Capacity Building of NNSA

Construction of the R&D Base

The construction of R&D Base, for the 1st stage
92,957 m² building
145,000 m² land
Investment 750 M RMB (120 M USD)
Thank you for your time