Nuclear Safety Standards Committee
46th Meeting, 26 – 28 November, 2018

Agenda item 2.8

SEISMIC HAZARDS IN SITE EVALUATION FOR NUCLEAR INSTALLATIONS

Draft Safety Guide DS507

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Background

- SSG-9 (2010) respected the lessons learned from Kashiwazaki Kariwa NPP during the 2007 Niigata-ken Chuetsu Oki, Japan earthquake.
- The 2011 Tohoku earthquake and tsunami occurred in Japan on March 11. The Fukushima Daiichi Accident* highlighted again issues of seismic hazards in site evaluation.
- This guide is consistent with the Safety Requirements for Site Evaluation of Nuclear Installations (NS-R-3 Full-revision in progress, as DS484⇒SSR-1)

Status of the Document

New Safety Guide timely, to keep up with the pace of scientific and technological progress, which is evolving quickly in response to new observed data

- Nov. 1-3, 2017: DPP of the DS507 has been approved 42 CSS,
- Jan. 29-31, 2018: CS for draft (Participants: Argentina, France, Italy, Japan, Russia, Switzerland, Turkey, USA)
- Aug. 23, 2018: NS-CC approved to post in WASSC/NUSSC
- Nov. 19, 2018: WASSC approved submission to MS for comments
Scope

- All nuclear installations
- Pre-operational / operational / temporary or permanent shutdown stages
- Vibratory ground motions and permanent ground displacement
- The site selection and/or site evaluation stages
Comments and Resolutions

• Received 60 comments from: France, Germany, India, Japan, Republic of Korea, Pakistan and USA.

• All comments were addressed. More than 70% comments were accepted or accepted with modification.
Action Requested

Approval for submission to MS comments
Thank you!
## Comments and Resolutions

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Further Comment from Japan on Capable Fault
Para 7.10 (arrived on 22 Nov.)

Add footnote:

*It is observed that some member states have abundant experience and successful practices of fault survey, ground motion observation/evaluation and seismic design. These member states may have their specific siting criteria under their regulatory framework and appropriate engineering measures to be employed for this issue.*
Further Comment from Japan on Capable Fault
Para 7.10

Reason:
To state that those member states with abundant experience and successful practices for fault survey, ground motion observation/evaluation and seismic design may have their specific criteria.

It is also understanding that para. 7.10. means “in case that a capable fault in site vicinity, the site should be unsuitable without exception”. However, it depends on their engineering level and seismic measures member states can be developed to determine how far the faults with potential for seismogenic fault displacement phenomena exist in the site. There are no inconsistent with SSR-1 para. 5.4.

Finally, the value of distance 5 km from capable fault seems to be misinterpreted as international standards in this issue.
Reason of rejection by IAEA:

- Fault survey methods are discussed in section 3
- Vibratory ground motion is discussed in section 5
- Seismic design is discussed in DS490

But not in this para. It appears to make an artificial divide between different member states that is not justified, and it is not clear how this would avoid confusion of the other member states.

Capable faulting influences fault displacement hazard, which involves a very large degree of uncertainty, and for which there is no practical engineering solution. The footnote emphasized that an approach to determine how far faults with potential for seismogenic displacement extend into the site can be developed. Once developed, it could be introduced as good practice in a SR or TD. This para is intending to provide guidance to all MSs and cannot provide guidance where a mature methodology does not exist.
Basis of 5 km

**NS-G-3.3**, Pa3.14: Site vicinity studies should cover a geographical area **typically 5 km** in radius. In addition to providing a yet more detailed database for this smaller area, the objective of these investigations is to define in greater detail the neotectonic history of faults, especially for determining the potential for surface faulting at the site (fault capability), and to identify conditions of potential geological instability of the site area.

**SSG-9**, Pa3.16: Site vicinity studies should cover a geographical area **typically not less than 5 km** in radius. In addition to providing a yet more detailed database for this smaller area, the objective of these investigations is to define in greater detail the neotectonic history of the faults, especially for determining the potential for and rate of fault displacement at the site (fault capability), and to identify conditions of potential geological instability of the site area.
**Basis 5 km**

**SSG-35, PaA.12:** An in-depth investigation should be made of the capable faults within the area of the site vicinity (5 km radius) that combines the survey of existing reference materials, tectonic geomorphological investigation, investigation of surface geological features, and geophysical and other investigations.

**DS507, Pa3.26:** Site vicinity studies should cover a geographical area sufficient to encompass all faults and other seismotectonic features requiring detailed geophysical investigation; this is typically not less than 5 km in radius from the border of the nuclear installation site area. For new nuclear installation sites for which the exact layout of the buildings and structures have not been defined, the 5 km radius area should be defined from the border of the prospective selected site area. (based on comment from India)
Pa1.9 The methodologies recommended for nuclear power plants are applicable to other nuclear installations by means of a graded approach, whereby these recommendations can be customized to suit the needs of nuclear installations of different types in accordance with the potential radiological consequences of their failure when subjected to seismic loads. The recommended approach is to start with attributes relating to nuclear power plants and to modify the application of the recommendations until they are commensurate with installations with which lesser radiological consequences are associated. If no grading is performed, the recommendations relating to nuclear power plants should be applied to other types of nuclear installations. Also, the level of detail and the effort devoted to evaluating the seismic hazards at existing installation sites should be commensurate with a number of factors, e.g. the level of radiological hazard and the time remaining until it is remediated, the severity of the regional seismicity where the site is located, etc. For sites at which nuclear installations of different types are collocated, particular consideration should be given to using a graded approach. (Based on comment from USA)
Recommendation to NUSSC

- At present time - no known way of ensuring site safety for capable fault displacement for new site.
- DS507 provides guidance based on current accepted technical practice.
  - Therefore a new site should be considered unsuitable when reliable evidence shows the existence of a capable fault that has the potential to affect the safety of the site.
- Safety Requirement in DS484/SSR-1 allows MS to develop methodology to demonstrate site safety for capable fault displacement.
- If MS wants to take advantage of this – MS (or site operator) should develop methodology first.
- DS507 should not be changed in response to the MS(Japan) comment at this time.
Thank you again!
Comment from Japan on Capable Fault Para 7.10

Reason for rejection:
It is understanding that this para is intended to give a general recommendation, which are faced to dramatically different tectonic settings as well as very different practices in fault survey and seismic design. Our proposal is to add a footnote in this para to state that those member states with abundant experience and successful practices for fault survey, ground motion observation/evaluation and seismic design may have their specific criteria.

It is also understanding that para. 7.10. means “in case that a capable fault in site vicinity (as site vicinity means “within 5 km radius” stated in SSG-35), the site should be unsuitable without exception”. However, it depends on their engineering level and seismic measures member states can be developed to determine how far the faults with potential for seismogenic fault displacement phenomena exist in the site. There are no inconsistent with SSR-1 para. 5.4.

Finally, the value of distance 5 km from capable fault seems to be misinterpreted as international standards in this issue.
If during the selection and evaluation stages of a new site for a nuclear installation, reliable evidence is collected demonstrating the existence within the site vicinity and site areas of a capable fault with potential for seismogenic (i.e. primary) fault displacement phenomena, the feasibility of design, construction and safe operation of nuclear installations at this site should be evaluated. If its effects cannot be compensated by design/engineering protective measures, this issue should be treated as an exclusionary attribute* and an alternative site should be considered.

*Ref: para. 3.8 of IAEA Safety Standards Series No. SSG-35, Site Survey and Site Selection for Nuclear Installations
Reason for rejection

- This document is not the safety requirements (SR – DS484) but a safety guide providing an interpretation of these requirements. Every MS shall follow the SR, therefore the last sentence of para. 5.4 in DS484 has a broader scope than provided in this guidance. This SG at para. 7.10 is a more restricted interpretation than the SR, because this is providing a preferred interpretation in line with current accepted international practice. Therefore, this SG does not consider the potential for capable faults as anything but an exclusionary attribute.

- In this Para, fault displacement hazard is discussed, but the MS(Japan) discusses vibratory ground motion hazards only.

- It is noted that uncertainty in the location of capable faults is high, and primary faults within the site vicinity may influence the potential for displacement on secondary faults within the site area, and therefore directly under the NPP.
A proposed new site shall be considered unsuitable when reliable evidence shows the existence of a capable fault that has the potential to affect the safety of the nuclear installation and which cannot be compensated for by means of a combination of measures for site protection and design features of the nuclear installation. If a capable fault is identified in the site vicinity of an existing nuclear installation, the site shall be deemed unsuitable if the nuclear installation safety cannot be demonstrated.
Recommendation to NUSSC

• At present time - no known way of ensuring site safety for capable fault displacement.
• DS507 provides guidance based on current accepted technical practice.
  – Therefore a new site should be considered unsuitable when reliable evidence shows the existence of a capable fault that has the potential to affect the safety of the site.
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FIG. 5. Seismic landscape of the 1915 Fucino Italy Earthquake. (IAEA TecDoc-1769)

Surface rupture location is quite uncertain.
Capable Faults

Exclusion

Discretion

Site vicinity
~5km

Site area
~1km

Primary

secondary

Primary

secondary
Can we predict fault geometry?

→ No

2009 Prediction (National Hazard Map) 2016 Kumamoto Japan earthquake
Can we survive fault displacement?

No

Waterfall made by the fault displacement during 1999 Chi-chi earthquake
Old
If during the selection and evaluation stages of a proposed new site for a nuclear installation, reliable evidence is collected demonstrating the existence within the site vicinity and site areas of a capable fault with potential for seismogenic (i.e. primary) fault displacement phenomena, this issue should be treated as an exclusionary attribute and an alternative site should be considered.

New
During the selection and evaluation stages of a proposed new site for a nuclear installation, if reliable evidence is collected demonstrating the existence of a capable fault with potential for seismogenic (i.e. primary) fault displacement within the site vicinity, or within the site area, this issue should be treated as an exclusionary attribute and an alternative site should be considered.
During the selection and evaluation stages of a proposed new site for a nuclear installation, if reliable evidence is collected demonstrating the existence of a capable fault with potential for seismogenic (i.e. primary) fault displacement within the site vicinity but without any feasible way of compensating for such displacement, or within the site area in any case, this issue should be treated as an exclusionary attribute (see para. 3.8 of IAEA Safety Standards Series No. SSG-35, Site Survey and Site Selection for Nuclear Installations [9]) and an alternative site should be considered.

In an exceptional case, where it is necessary for the site to be considered, in order to comply with Requirement 15 and para. 5.4 of DS484, site safety must still be demonstrated. To do this:

a) It should be demonstrated that there is negligible potential for capable faults in the site vicinity to influence secondary faults in the site area. Or, if this is not possible;

b) It should be demonstrated that a feasible engineering solution is available to compensate for potential fault displacement in the site area.

It should be noted that although a) and b) are identified as possible ways of justifying site safety if there is the potential for capable faulting in the site vicinity, neither option is considered credible with the current state of both technology and reliable site specific database.
Can we predict fault geometry?

→ No

2009 Prediction (National Hazard Map)


2016 Kumamoto Japan earthquake
Fig. 12: Diagram illustrating the relationship between surficial seismogenic activity and the magnitude of surface slips. The figure shows a progression from small to large magnitude slips, with corresponding surface breaks and seismic zones.

- **Surficial Seismogenic Activity**: The surface is divided into sections that represent different magnitudes of seismic activity.
- **Surface Breaks**: Large slips are represented by shaded areas on the surface, indicating significant movement.
- **Seismogenic Zone**: The zone extends from the surface to a depth, indicating the depth of seismic activity.

The diagram highlights the importance of understanding the relationship between magnitude and surface activity for safety and risk assessment in seismic zones.
Proposed Structure

1. INTRODUCTION
2. GENERAL RECOMMENDATIONS
3. DATABASE OF INFORMATION AND INVESTIGATIONS
4. CONSTRUCTION OF SEISMIC SOURCE MODELS
5. VIBRATORY GROUND MOTION ESTIMATION METHODS
6. VIBRATORY GROUND MOTION SEISMIC HAZARD ANALYSIS
7. EVALUATION OF THE POTENTIAL FOR FAULT DISPLACEMENT AT THE SITE
8. PARAMETERS FROM THE VIBRATORY GROUND MOTION ANALYSIS, FAULT DISPLACEMENT AND OTHER ASSOCIATED SEISMIC HAZARDS
9. EVALUATION OF SEISMIC HAZARDS FOR NUCLEAR INSTALLATIONS OTHER THAN NUCLEAR POWER PLANTS
10. PROJECT MANAGEMENT SYSTEM
REFERENCES
ANNEX-TYPICAL OUTPUT OF PROBABILISTIC SEISMIC HAZARD ANALYSES
Scope

- **Interface with other documents:**
  - Site Evaluation for Nuclear Installations - Safety Requirements, NS-R-3 Rev. 1 (2016)
  - Site Evaluation for Nuclear Installations – Specific Safety Requirements (DS484→ SSR-1)