Proposed siting Criteria of High Risk Industrial Facilities

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Abstract

This work deals with a description of the methodology for the definition of the design earthquake and associated topics for Nuclear Power Plants (NPPS) and applied it on high risk industrial facilities in Egypt.

New Probabilistic strong ground motion maps at Delta and Upper Egypt are derived by applying the "Cornell-McGuire" method to 27 earthquake source zones in the Nile Delta area and Upper Egypt. The design basis of earthquakes is estimated for Egypt.

A comparison of the results of design basis earthquakes (operation basis earthquakes and safe shutdown earthquakes) with equivalent estimates made in International atomic Energy Authority (IAEA), Italy, USSR, USA, Japan and Germany.

Introduction

The methodology for the definition of the design earthquake and associated topics for Nuclear Power Plants, is described in the IAEA Safety Guide 50 SG S1 Revision 1, (for which the Authors has worked for many years), and is briefly summarized by Serva (2004).

In selecting a site particular attention should be paid to two categories of earthquake-related features (Serva 2004):

Category (1): features that can have direct influence on the acceptability of the site

Category (2): features that can substantially influence the severity of the design basis earthquakes.

Category (1) features

It is active, capable faults at the site and/or potential for the occurrence of other unforeseeable geological hazards such as large landslides, liquefaction phenomena, karst collapses. If engineering solutions are not available or, if available, the cost of applying them is such that the project becomes economically infeasible, another site should be recommended. This is usually the case when a site is near one or more capable faults. In highly active areas, where both earthquakes and geological observations consistently reveal short earthquake recurrence intervals, periods of the order of tens of thousands of years may be appropriate for the assessment of capable faults. In less active areas, it is likely that much longer periods may be required. When faulting is known or suspected, investigations should include detailed geological geomorphological mapping, topographical analyses, geophysical (including geodesy, if necessary) surveys, trenching, boreholes, determining ages of faulted sediments or rocks, local seismological investigations and any other appropriate techniques, to ascertain when the last movement occurred.

Category (2) features

Category (2) features define the parameters of the ground motion of the design-basis earthquakes. To reach this goal, it is necessary to compile a specific and complete database for the construction of a seismotectonic model from which the potential earthquakes affecting the site can be derived. These earthquakes are then used to define the nature of earthquakes used as a basis for design of the facility. Thus, it is essential to obtain an integrated geological and seismological database. The elements of this database should be studied in greatest detail in the region close to the site where it will be more complete. In this connection, four scales of investigation are appropriate:

- Regional, near regional, the vicinity of the site, and the immediate area of the site. The main purpose of the regional studies is to provide knowledge of the tectonic framework of the region and its general geodynamic setting and to identify and characterize those seismological features that may influence the seismic hazard at the site. The main purpose of the near regional investigations is to characterize the more important seismological structures for the assessment of seismic hazards.
- Investigation of the site vicinity, as already mentioned, is designed to define in greater detail the history of faults with the special purpose of resolving the possibility of surface faulting at the site (fault capability) and identifying sources of potential instability (Class 1 features).
- Investigations at the site area should emphasize the definition of the physical properties of the foundation materials and the determination of their stability and response under dynamic earthquake.

Determination of the design basis ground motions

At least two levels (SL-1 and SL-2) of design basis ground motion are evaluated for each plant. The SL-2 level corresponds directly to ultimate safety requirements. This level of extreme ground motion will normally have a very low probability of being exceeded during the lifetime of the plant and represents the maximum level of ground motion to be used for design purposes. Its evaluation will be based on the seismotectonic model and a detailed knowledge of the geology and engineering parameters of the strata beneath the site area. The SL-1 level corresponds to a less severe but more likely earthquake load conditions with safety implications that differ from those of SL-2. In some IAEA Member States, licensing authorities require only one level, the SL-2, which corresponds to a level with a probability of 10-4 per year of being exceeded. In other Member States, SL-1 corresponds to a level with a probability of 10-2 per year of being exceeded. The assessment of appropriate ground motion levels for SL-2 and SL-1 may involve analyses based on deterministic and/or probabilistic considerations.

Result and Dissections

Using the source zones, recurrence models, attenuation model and the hazard model of Bender and Perkins (1987), the seismic hazard map for Delta and upper Egypt is produced.

The results obtained with the probabilistic are similar to those from deterministic by (El-Sayed et. al. 2001). The considerable difference in some area may be related to the following factors: the probabilistic methods are very sensitive to the completeness of the catalogues and use simple attenuation laws that oversimplify the wave propagation phenomena

The Safe Shutdown Earthquakes (SSE) within Egyptian territory can generate ground acceleration to 0.12 & 0.14 for Delta area and Aswan respectively. The (SSE) for Western desert, Mediterranean Sea Coast and Red Sea area, 0.08, 0.1 & 0.16g., respectively (El. Hfnawy et al. 2004). these values are extremely high for the area within a capable fault. Table 1 summarizes exclusion criteria and minimum seismic design for NPPs of some important Nations in nuclear industry. Data are taken from Serva, (1993). We can add Egypt to Serva table. The quick look of this table (Serva2004) indicates that exclusion criteria depend mainly on the availability of suitable sites in a country, sensitivity of the technical and scientific community to the earthquake risk phenomenon and design restrictions against seismic loads for nuclear power plant. For example the exclusion criterion of intensity IX or over (MSK) in the former USSR (in other words, nuclear power plants were not designed for a seismic input exceeding 0.2 g) is obviously linked to the large availability of sites and to design restriction type reactors for coping high seismic loads. The minimum ground motion used as the basis for design at the site may be based on a near field or far field earthquake (or both). In the case of the near field earthquake, this is considered the maximum value of the random (floating) event, which in Japan can be as high as M=6.5. In Japanese practice however, it is assumed that this earthquake is not associated with surface faulting if in the site are present unfaulted terrains not younger than Tertiary (Serva, 2000). In Egypt, The same assumption is not appropriate when the value reaches IX MSK because such earthquakes should always be associated with structures detectable by state-of-the-art methods of geology and geophysics

Table 2. Minimum requirements and exclusion criteria for NPP's , iting and design (Serva 1993 & and modified by adding Egypt).

Code	Exclusion criteria	Minimum requirements
IAEA	Presence of capable fault at the site	Minimum SL2=0.1 g anchored to a site specific response spectrum
Egypt	Presence of capable fault at the site	Minimum SL2=0.16 g anchored to a site specific response spectrum
Italy	Area of historically observed intensity equal to (X) MCS (MMI or MSK) or greater. Presence of Capable fault at the site.	Minimum SSE=0.18 g anchored to a wide band standard response spectrum
Former USSR	Sites having a potential for intensity IX MSK or greater. In other words: NPP cannot be designed for more than 0.2 g.	Bearing capacity of the foundation soil > 0.2 kg/cm2
USA		Minimum SSE=0.1 g anchored with a wide band response spectrum
Germany	Presence of capable fault at the site	Minimum peak ground acceleration =0.05g
Japan	Sites having capable faults or close to faults having Quaternary slip-rate higher than 1 mm/y.	Foundation must be on sediments not younger than Tertiary. S2 shall withstand a near field earthquake (minimum distance 10 km) having M = 6.5

Conclusion

The main purpose of the present work is to provide guidance on the determination of the design basis ground motions for nuclear power plant. It has been described and commented because it looks the more appropriate one for using in the seismic design of the industrial plants. This is because this approach gives to the specialist a global view of the problem, pushing him to judge the level of information that is sufficient for making a reliable assessment, of the plant he is dealing with, taking into account its position (hazard level at the site) and cost. In other words, the detail required on the database (quality, quantity and type of geological, geophysical, seismological and engineering data) should be strictly linked to the level of risk/environmental impact of the plant under analysis. However a requirement that should remain the same is the Quality Assurance of the whole process in terms of data and their treatment (Serva, 2000).

This study deals with two parts, the first is estimate the (SSE) for Delta and Upper Egypt, as well as the (SSE) which calculated by (El- Adham & El-Hemamy,2004 and Hefnawy, et.al, 2004) to estimate the minimum seismic design for NPPs. Therefore, two maps of seismic hazard at different return periods for a Delta and Upper Egypt were constructed. These maps with the other maps at Red Sea and El-Dabaa area (El-Hefnawy et. al 2004) were used as a general guideline to regional distribution of seismic hazard in terms of peak acceleration values over the general area. They can also be used to calculate the (SSE). A comparison of the results of design basis earthquakes (operation basis earthquakes and safe shutdown earthquakes) with equivalent estimates made in IAEA, Italy, USSR, USA, Japan and Germany.

The second parts, applied these estimation on high risk industrial zone in Egypt, It is evident that there are no plants having the same level of risk of a NPP. However an industrial area containing different type of plants including some dealing with very toxic substances (Table 2) in the Author opinion, should be treated only a little less than an NPP. For some aspects, also a single plant dealing with very toxic material located in an intensively populated (e.g. downtown) area and a significant dam should be treated in a similar way Serva (2000).

Table 2. Most hazardous industrial Plants (Serva, 2000)

For Man Large	*Large VLPG storage plants. Large Chlorine storages. Phosgene storages and process users.*
For Environment	Large diesel oil or fuel oil tank farms.

The quick look of the methodology one can say it should be similar to the NPPs when we are dealing with a system of plants for which an accident can cause relevant risks on man and/or natural environment in term of a real extend and level of contamination (Serva 2004). A similar concept is expressed also by Gurpinar, 1997. In such a case, as for the nuclear, we should define, as design earthquake SL2 (SL1 in Seava,s, (2000) opinion is not necessary), the maximum potential earthquake, i.e. the ten thousands years return period earthquake. The engineering treatment of this earthquake can be significantly different from one defined in the nuclear and this theme is not treated here. Category 1 features should be analyzed in same detail of the nuclear

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