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Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities

September 19, 2006.

Nuclear Safety Commission

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Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities

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1. Introduction

This guide is provided to show the basis of the judgment for adequacy of the seismic design policy in the standpoints to ensure seismic safety at the Safety Review related to the application for the establishment license (includes the application of alteration of an establishment license) of the individual light water power reactor.

The former 'Regulatory Guide for Reviewing Seismic Design of Nuclear Power Reactor Facilities (decided by the Nuclear Safety Commission "NSC" on 20 July 1981 and revised on 29 March 2001, hereinafter referred to as "Former Guide") ' was the guide which was revised based on the state of arts of evaluating methods of static seismic force etc. by the NSC in July 1981, which had been provided in September 1978 by the Atomic Energy Commission. And it was partially revised in March 2001.

This time, overall revision of Former Guide has been conducted by reflecting accumulated new seismological and earthquake engineering knowledge and remarkable improvement and development of seismic design technology of nuclear power reactor facilities.

Incidentally, this guide shall be revised to reflect the coming new knowledge and experiences suitably according to accumulation of new findings.

2. Scope of Application

This guide shall be applied to the nuclear power reactor facilities (hereinafter referred to as "Facilities").

Nevertheless, basic concept of this guide could be referred to other type nuclear reactor facilities as well as other nuclear related facilities.

Incidentally, if some part of application contents could not comply with this guide, it would not be excluded if it reflected technological improvements or developments and seismic safety could be ensured farther than satisfying this guide.

3. Basic Policy

A part of Facilities designated as important ones from the seismic design points shall be designed to bear seismic force exerted from earthquake ground motion and to maintain their safety function, which could be postulated appropriately to occur but very scarcely in the operational period of Facilities from the seismological and earthquake engineering standpoints such as geological features, geological structure, seismicity, etc. in the vicinity of the proposed site.

Moreover, any Facilities shall be designed to bear the design seismic force sufficiently which is assumed appropriately for every classification in the seismic design from the standpoint of radiological effects to the environment which could be caused by earthquake.

Besides, buildings and structures shall be settled on the grounds which have sufficient supporting capacity.

(Commentary)

I. Regarding Basic Policy

(1) Regarding determination of earthquake ground motion in the seismic design

In the seismic design, it shall be based on the principle that ' the ground motion which could be postulated appropriately to occur but very scarcely in the operational period of Facilities and are feared affecting severely to Facilities' shall be determined adequately, and that, on the premise of this ground motion, the seismic design shall be conducted not to give any risk of serious radiological exposure to the public in the vicinity of Facilities from the external disturbance initiated by an earthquake.

This policy is equal to the ' basic policy' in Former Guide which is required to the seismic design with the provision of ' nuclear power reactor facilities shall maintain seismic integrity against any postulated seismic force assumed so sufficiently that no earthquake would induce significant accidents'.

(2) Regarding existence of "Residual Risk"

From the seismological standpoint, the possibility of occurrence of stronger earthquake ground motion which exceeds one determined on the above-mentioned (1) can not be denied. This means, in determination of seismic design earthquake ground motion, the existence of "Residual Risk"(defined as such a risk that, by extension of the effect of the ground motion which exceeds the determined design ground motion of Facilities, impairing events would occur to Facilities and the event in which massive radioactive materials diffuse from Facilities would break out, or the result of these events would cause radiological exposure hazards to the public in the vicinity of Facilities).

Therefore, at the design of Facilities, appropriate attention should be paid to possibility of occurrence of the exceeding ground motion to the determined one and, recognizing the existence of this "Residual Risk", every effort should be made to minimize it as low as practically possible not only in the stage of design basis but also in the following stages.

4. Classification of Importance in Seismic Design

Importance in seismic design of Facilities shall be classified into the followings from the standpoints of the possible impact of radiation to the environment caused by earthquake corresponding to the categories of Facilities.

(1) Classification on Function

S Class :

Facilities containing radioactive materials by themselves or related directly to Facilities containing radioactive materials, whose loss of function might lead to the diffusion of radioactive materials to the environment, Facilities required to prevent the occurrence of those events and Facilities required to mitigate the consequences resulting from the diffusion of radioactive materials in the occurrences of those accidents, and also whose influences are very significant,

B Class :

Facilities of the same functional categories as above S Class, however whose influences are relatively small,

C Class :

Facilities except for S or B Class, and ones required to ensure equal safety as general industrial facilities.

(2) Facilities of Classes

Facilities of Classes are shown as follows by the above classification of the importance in the seismic design,

1) S Class Facilities :

i) Equipment/piping system composing of the 'reactor coolant pressure boundary' (the definition is the same that is described in other Regulatory Guide for Reviewing Safety Design of Light Water Nuclear Power Reactor Facilities),

ii) Spent fuel storage pool,

iii) Facilities to add the negative reactivity rapidly to shutdown the reactor and Facilities to preserve the shutdown mode of the reactor,

iv) Facilities to remove the decay heat from the reactor core after reactor shutdown,

v) Facilities to remove the decay heat from the reactor core after the failure accident of reactor coolant pressure boundary,

vi) Facilities to prevent the propagation of radioactive materials directly as the pressure barrier at the failure accident of reactor coolant pressure boundary,

vii) Facilities, except for those in the category vi) above, to mitigate the diffusion of radioactive materials to the environment at the accident which involves the release of radioactive materials.

2) B Class Facilities :

i) Facilities connected directly to reactor coolant pressure boundary and containing radioactive materials by themselves or have possibility to contain radioactive materials,

ii) Facilities containing radioactive materials. Except for those whose effect of radiological exposure to the public due to their break is smaller enough to compare with annual exposure limit at the outside of the peripheral observation area, because of its small inventory of containing radioactive materials or of the difference of the type of storage system,

iii) Facilities related to the radioactive materials except radioactive wastes and have possibility to give excessive radiological exposure to the public and the operational personnel from their break,

iv) Facilities to cool the spent fuels,

v) Facilities except for those of S Class, to mitigate diffusion of radioactive materials to the environment at an accident which involves the release of radioactive materials.

(3) C Class Facilities :

Those Facilities not belong to above S or B Class.

5. Determination of Design Basis Earthquake Ground Motion

The ground motion to be established as the basis of the seismic design of the Facilities shall be determined adequately as the ground motion to be postulated to occur but very scarcely in the operational period of Facilities from the seismological and earthquake engineering point of view relating to geology, geological structure, seismicity, etc. in the vicinity of the proposed site, and to be feared making a serious impact to Facilities. (Hereinafter this ground motion is referred to as "Design Basis Earthquake Ground Motion Ss" or "DBGM Ss".)

DBGM Ss shall be determined on the following principles.

(1) DBGM Ss shall be determined as following two types of earthquake ground motions in horizontal direction and vertical direction on the free surface of the base stratum at the proposed site, relating to (2)"Site specific earthquakes ground motion whose source to be identified with the proposed site" and (3) "Earthquake ground motion whose source not to be identified" mentioned below.

(2) Site specific earthquakes ground motion whose source to be identified with the proposed site shall be determined on the following principles.

1) Taking account of the characteristics of active faults and the situation of earthquake occurrences in the past and at present in the vicinity of the proposed site, and classifying the earthquakes by the pattern of earthquake occurrence etc. plural number of earthquakes which are feared making severe impact to the proposed site shall be selected (hereinafter referred to as "Investigation Earthquakes").

2) Following items shall be taken into account concerning the 'characteristics of the active faults around the proposed site' in above-mentioned 1).

i) The active faults considered in the seismic design shall be identified as the one of which activities since the late Pleistocene epoch can not be denied. Incidentally, judgment of the faults can depended upon whether the displacement and deformation by the faults exist or not in the stratum or on the geomorphic surface formed during the last interglacial period.

ii) The active faults shall be investigated sufficiently by integrating geomorphological, geological and geophysical methods, etc. to make clear the location, shape, activity of the active faults, etc. according to the distance from the proposed site.

3) For any Investigation Earthquakes selected in above-mentioned 1), following evaluations of earthquake ground motion both i) with response spectra and ii) by the method with fault models shall be conducted, and DBGM Ss shall be determined from respective Investigation Earthquakes.

Incidentally, in evaluating the earthquake ground motion various characteristics (include the regional peculiarity) according to the pattern of earthquake occurrences, seismic wave propagation channel, etc. shall be taken into account sufficiently.

i) Evaluation of earthquake ground motion with response spectra

For respective Investigation Earthquakes, response spectra shall be appraised by applying appropriate methods and the design response spectra shall be evaluated on these spectra, and earthquake ground motions shall be evaluated in considering the earthquake ground motion characteristics such as duration time, time depending change of amplitude-enveloping curve suitably.

ii) Evaluation of earthquake ground motion by the method with fault model
For respective Investigation Earthquakes, earthquake ground motions shall be evaluated by settling the seismic source characteristics parameters with appropriate methods.

4) Uncertainty (dispersion) concerned with the evaluation process of the DBGM Ss in above-mentioned 3) shall be considered by applying the appropriate methods.

(3) Earthquake ground motion whose source not to be identified shall be determined on the following principle.

Design Earthquake Ground Motions shall be determined by collecting the observation records near the source which are obtained from past earthquakes inside the inland earth's crust, of which the source can not be related directly to any active faults, settling the response spectra based on those records by taking account of the ground material characteristics of the proposed site, and adding consideration of the earthquake ground motion characteristics such as the duration time, time dependent change of amplitude-enveloping curve, etc. suitably to these results.

(Commentary)

II. Regarding to determination of DBGM Ss.

(1) Regarding the characteristics of DBGM Ss.

In Former Guide, regarding design basis earthquake ground motion two categories of "Earthquake Ground Motion S1" and "Earthquake Ground Motion S2" were required to be determined, however in this revision both these motions were integrated, and enhancement of selection of Investigation Earthquakes, evaluation of ground motion etc. were strived for DBGM Ss.

This DBGM Ss is the premise ground motion of the seismic design to ensure seismic safety of Facilities and, in determining it , it's adequacy should be checked sufficiently according to the latest knowledge in the specific examination.

(2) The interpretation of the terminology regarding determination of DBGM Ss are as follows.

1) 'Free surface of the base stratum' is defined as the free surface settled hypothetically without any surface layer or structure and as the surface of base stratum postulated to be nearly flat with considerable expanse and without eminent unevenness to plan out design basis earthquake ground Motion.
'Base stratum' mentioned here is defined as a solid foundation of which sear wave velocity Vs exceeds 700m/s, and which has not been weathered

significantly.

2) 'Active faults' are defined as faults which moved repeatedly in recent geological age and have also possibility to move in the future.

(3) Regarding the principle of determination DBGM Ss

1) In selecting Investigation Earthquakes, the characteristics of active faults and the situation of earthquake occurrence in the past and at present should be investigated carefully, and furthermore existing research results concerned with distribution of middle, small and fine size of earthquakes in the vicinity of the proposed site, stress field, pattern of earthquake occurrence (including shape, movement and mutual interaction of the plate) shall be examined comprehensively.

2) Investigation Earthquakes shall be selected depending on the classification considering the pattern of earthquake occurrence etc. as follows.

i) Inside Inland Earth's Crust Earthquake

'Inside inland earth's crust earthquake' is defined as the earthquake which occurs in the upper crust earthquake generation layer and includes one which occurs in the rather offshore coast.

ii) Inter-plates Earthquake

'Inter-plates earthquake' is defined as one which occurs in the interfacial plane of two mutually contacting plates.

iii) Inside Oceanic Plate Earthquake

'Inside oceanic plate earthquake' is defined as one which occurs inside a subducting (subducted) oceanic plate, and is classified into two types,

'Inside subducting oceanic plate earthquake' which occurs near the axis of sea trench or in it's rather offshore area, and 'Inside subducted oceanic plate earthquake (Inside slab earthquake) 'which occurs in the land side area from the vicinity of the axis of sea trench.

3) The evaluation method using fault model should be regarded as important in the case of earthquake whose source is near the proposed site and process of its failure could be supposed to make large impact to evaluation of the ground motion.

4) In consideration of 'uncertainty (dispersion) concerned with the determination process of DBGM Ss', appropriate method should be applied considering the cause of uncertainty (dispersion) and it's extent which are supposed to make large impact directly to plan out DBGM Ss.

5) The principle of determination of 'Earthquake ground motion whose source not to be identified' is implied that, if the detailed investigation would be conducted sufficiently considering the situation etc. in the vicinity of the proposed site, it could not be asserted to evaluate all earthquakes inside inland earth's crust in advance which could have still the possibility to occur near the proposed site, therefore this earthquake should be considered commonly in all applications in spite of the results of the detailed investigation around the proposed site.

The validity of DBGM Ss determined by materializing this principle should be confirmed specifically in checking on the latest information at the time of each application. Incidentally, on that occasion, probabilistic evaluation could be referred as the needs arise regarding the ground motion near the source generated from the source fault which does not indicate any clear trace on the ground surface.

6) Regarding 'Site specific earthquakes ground motion whose source to be identified with the proposed site' and 'Earthquake ground motion whose source not to be identified', the exceedance probability of respective earthquakes should be referred in each safety examination from the standpoint that it is desirable to grasp that the response spectra of each seismic ground motion planed out correspond to what extent of the exceedance probability.

7) In the case that the necessary investigation and evaluation are implemented in selection of Investigation Earthquakes and determination of DBGM Ss, existing materials etc. should be referred in considering the accuracy of them sufficiently. If different result would be obtained compared with the existing evaluation results, its reason should be shown clear.

8) Regarding the ground which supports the structures of Facilities and Facilities themselves, if the peculiar frequency characteristics could be found in the seismic response, it should be reflected to determination of DBGM Ss as the needs arise.

(4) Regarding evaluation of the faults which assumed as the source of earthquake

1) As investigation of the active faults is the basis of the evaluation concerning the faults which is assumed as the source of earthquake, appropriate investigation should be implemented combining adequately the survey of existing materials, tectonic geomorphologic examination, the earth's surface geological feature examination, geophysical examination, etc. according to the distance from the proposed site. Especially in the area near the proposed site, precise and detailed investigation should be applied. Incidentally extent of the area near the proposed site should be decided suitably considering the relation etc. with DBGM Ss determined as 'Earthquake ground motion whose source not to be identified'.

2) Regarding active folds, active flexures, etc. these should also be the object of investigation in above-mentioned 1) as well as the active faults and should be considered in the evaluation of the faults assumed to be the source in accordance with their dispositions.

3) The dispositions of the faults should be evaluated appropriately grasping the under ground structure etc. depending on the regional situation. Incidentally, the special consideration should be required if the earthquake should be assumed from the dispositions of faults in the area where the faults are indistinct.

4) In the case, the scale of earthquake shall be postulated from the length of the fault etc. by applying the empirical formula, the scale should be evaluated adequately considering the special features etc. of the empirical formula.

5) Uncertainty shall be considered appropriately in assumption of the characteristics of the source, in the case that sufficient information could not be obtained to settle the source characteristics parameter including the shape evaluation of the fault to be assumed as the source even by implementing investigation of the active faults.

6. Principle of Seismic Design

(1) Primal Policy

Facilities shall be designed to fulfill the following primal policies of the seismic design for respective categories of Class.

1) Respective Facilities of S Class shall maintain their safety functions under the seismic force caused by DBGM Ss. And also shall bear the larger seismic force loading of those caused by "Elastically Dynamic Design Earthquake Ground Motion Sd" or the static seismic force shown below.
   (Hereinafter Elastically Dynamic Design Earthquake Ground Motion Sd is referred to as "EDGM Sd".)
2) Respective Facilities of B Class shall bear the static seismic force shown below. And, as for the Facilities those are feared of resonating with earthquake, the influence shall be evaluated.
3) Respective Facilities of C Class shall bear the static seismic force shown below.
4) In respective items shown above, the integrity of upper Class Facilities shall not be impaired by the damage of the lower Class Facilities.

(2) Computation Method for Seismic Force

The seismic force for seismic design of Facilities shall be obtained by using the methods shown below.

1) Seismic forces caused by DBGM Ss

Seismic force caused by DBGM Ss shall be computed by applying DBGM Ss in combining horizontal seismic force with the vertical seismic force appropriately.

2) Seismic forces caused by EDGM Sd

EDGM Sd shall be established based on DBGM Ss with the technological judgments. And the seismic forces caused by EDGM Sd shall be also evaluated in combining horizontal seismic forces with the vertical seismic force appropriately.

3) Static seismic force

Evaluation of the Static seismic force shall be based on the followings.

i) Buildings and structures

Horizontal seismic force shall be evaluated by multiplying the seismic story shear coefficient Ci by the coefficient corresponding to the importance classification of the facilities as shown below, and multiplying the weight at the above height of the story concerned.

S Class	3.0
B Class	1.5
C Class	1.0

Here, Ci of the seismic story shear coefficient shall be obtained in putting the standard shear coefficient Co to be 0.2, considering the vibration characteristics of the buildings and structures, categories of the ground, etc.

As for the facilities of S Class, both horizontal and vertical seismic forces shall be combined simultaneously in the most adverse fashion. The vertical seismic force shall be evaluated with the vertical seismic intensity which is obtained by putting the seismic intensity 0.3 as a standard, and by considering the vibration characteristics of buildings and structures, categories of the ground, etc. However the vertical seismic coefficient shall be constant in the height direction.

ii) Components and piping system

The seismic force of respective Classes shall be evaluated with the seismic intensities which are obtained by multiplying the seismic story shear coefficient Ci in above-mentioned i) by the coefficient corresponding to the importance classification of the Facilities as the horizontal seismic intensity, and by increasing the horizontal seismic intensity concerned and the vertical seismic intensity in above-mentioned i) by 20% respectively.

Incidentally, horizontal seismic force shall be combined with the vertical seismic force simultaneously in the most adverse fashion. However, vertical seismic forces shall be assumed to be constant in the height direction.

(Commentary)

III. Regarding the Design Principle

(1) Regarding the necessity of establishment of EDGM Sd

In Former Guide, the design basis earthquake ground motion should have been determined classified as two categories of Earthquake Ground Motion S1 and Earthquake Ground Motion S2 corresponding to the seismic importance classification of the buildings, structures, components and piping system, however in this revision, the determination of DBGM Ss shall only be required. In the seismic design concept to ensure seismic safety of Facilities, it is the basic principle that the safety functions of the seismically important Facilities shall be maintained under the seismic forces by this DBGM Ss.

In addition to confirm maintenance of seismic safety functions of the Facilities under this DBGM Ss with higher precision, establishment of EDGM Sd, which is closely related with DBGM Ss from technical standpoint, is also required to be prescribed.

(2) Regarding establishment of EDGM Sd

The concept of 'to bear the seismic force' which prescribed in the Article 6. in this Guide means that Facilities as a whole are designed in the elastic range on the whole to a certain seismic force.

In this case, design in the elastic range means to retain the stress of respective parts of the Facilities under the allowable limits by implementing stress analysis supposing the facilities as the elastic body.

Incidentally, the allowable limits shown here, does not require strict elastic limits and requires the situation that the Facilities as a whole should retain in elastic range on the whole even though the case in which the Facilities partially exceeds the elastic range could be accepted.

Although respective S Class Facilities are required 'to bear the seismic force' by EDEGM Sd, this EDGM Sd is established based on the technological judgment.

The elastic limits condition is the condition that the impact which the Earthquake Ground Motion makes to the Facilities and the situation of the Facilities can be evaluated clearly, and that it makes a grasp of maintenance of seismic safety functions as a whole of the Facilities under the seismic force by DBGM Ss more reliable by confirming that the Facilities as a whole retains in elastic limits condition on the whole under the seismic force by EDEGM Sd.

Namely EDEGM Sd assumes a part of the roles which the Design Earthquake Ground Motion S1 of Former Guide used to be attained in the seismic design.

EDGM Sd should be established by multiplying DBGM Ss by coefficients obtained on the technological judgment in considering the ratio of input seismic loads for the safety functional limits and the elastic limits for the respective Facilities and their composing elements. Here, in evaluating the coefficient, the exceedance probability which is referred in the determination of DBGM Ss would be consulted.

The concrete established value and reason of establishment of EDGM Sd should be made clear sufficiently in respective specific application.

Incidentally, the ratio of EDGM Sd and DBGM Ss (Sd/Ss) should be expected larger than a certain extent in considering the characteristics required to EDGM Sd, and should be obtained not to be less than 0.5 as an aimed value.

In addition, EDGM Sd would be established specifically to respective elements which compose the Facilities depending on the difference of their characteristics to be considered in seismic design.

Incidentally, regarding to B Class Facilities, 'as for Facilities that are feared resonating with seismic force loading, the influence shall be evaluated', the earthquake ground motion applied to this evaluation would be established with multiplying EDGM Sd by 0.5.

(3) Regarding the evaluation of the seismic force by DBGM Ss and EDGM Sd

In case that the seismic force by DBGM Ss and EDGM Sd are evaluated based the seismic response analysis, the appropriate analytical methods should be selected and suitable analytical consideration should be settled based on the sufficient investigation in considering to the applicable range of response analysis methods, applicable limits, etc.

Incidentally, in the case 'free surface of the base stratum' is very deep compared with the ground level on which Facilities would be settled, amplification characteristics of the ground motion on the ground level above free surface of the base stratum should be investigated sufficiently and be reflected to the evaluation of the seismic response as the needs arise.

(4) Regarding Static seismic force

Evaluation of the static seismic force should be depended upon 1) and 2) shown below.

In addition, regarding to the buildings and structures, the adequate safety margin of retained horizontal strength of buildings and structures concerned should be checked to maintain the retained horizontal strength required relating to the importance of Facilities, and the evaluation of retained horizontal strength required should be complied to the 3) shown below.

1) Horizontal seismic force

i) The datum plane for evaluation of horizontal seismic force should be the ground surface in principle. However, if it is needed to consider the characteristics such as the constitution of the building and the structures and the relation to the surrounding ground around Facilities, the datum plane should be provided appropriately and be reflected to the evaluation.

ii) Horizontal seismic force applied to aboveground part from the datum plane should be obtained to be the total of the seismic forces acted on the part concerned in accordance with the height of the building and the structure and be calculated with the following formula,

$Qi = n \cdot Ci \cdot Wi$

where,

Qi : Horizontal seismic force acting on the part in question,

n : Coefficient in accordance with importance classification of facilities (Earthquake-proof S Class 3.0, Earthquake-proof B Class 1.5, Earthquake-proof C Class 1.0).

Ci :Seismic story shear coefficient, it depends on the following formula,

$Ci = Z \cdot Rt \cdot Ai \cdot Co$

where,

Z : Zoning factor (to be 1.0, the regional difference is not considered),

Rt: A value representing vibration characteristics of building to be obtained by the appropriate calculation methods specified in standards and criteria which are assumed to be adequate for safety. Here, 'the appropriate calculation methods in standards and criteria which are assumed to be adequate for safety' corresponds to the Building Standard Law etc.

However, if the value which expresses the vibration characteristics and is evaluated considering the structural characteristics of buildings and structures, and the response characteristics and situation of the ground in the seismic condition would be confirmed to fall short of the value calculated by the methods in the Building Standard Law etc. it could be reduced to the evaluated value by this method (but equal to or not less than 0.7).

Ai: A value representing a vertical distribution of seismic story shear coefficient according to the vibration characteristics of building, to be calculated by the appropriate methods specified in standards, criteria and the other appropriate methods as is like Rt,

Co: Standard shear coefficient (to be 0.2),

Wi : Total of fixed loads and live loads supported by the part in question.

iii) Horizontal seismic force which acts on the parts of the buildings and structures under the datum plane should be evaluated by following formula,

$Pk = n \cdot k \cdot Wk$

where,

Pk : Horizontal seismic force acting on the part in question.

n : Coefficient in accordance with importance Classification of Facilities (Earthquake-proof S Class 3.0, Earthquake-proof B Class 1.5, Earthquake-proof C Class 1.0).

k : Horizontal seismic coefficient by the following formula,

$$k \geqq 0.1 \cdot \left[1 - \frac{H}{40}\right] \cdot Z$$

where,

H : Depth of each under part from the datum plane;
20 (m) at depths of >20 m,

Z : Zoning factor (to be 1.0, the regional difference is not considered),

Wk : Summation of dead loads and live loads of the part concerned.

Incidentally, in the case if the value would be calculated in evaluating the vibration characteristics suitably by considering the structural characteristics of buildings and structures, and the response characteristics and situation of the ground in the seismic condition, it would be the value calculated by this method.

2) Vertical seismic force

The vertical seismic force in the evaluation of the static force to Earthquake-proof S Class Facilities should be evaluated with the vertical seismic intensity by the following formula,

$$Cv = Rv \cdot 0.3$$

where,

Cv : Vertical seismic intensity,

Rv : A value representing the vertical vibration characteristics of the building , to be 1.0. However, based on special investigation or study, if it would be confirmed to fall short of 1.0, it would be reduced to be the value based on the results of investigation or study (but equal to or not less than 0.7).

3) Retained horizontal strength required

Retained horizontal strength required should be evaluated specified in the method in standards and criteria which are accepted to be adequate for safety.

Here, the standards and criteria which are accepted to be adequate for safety corresponds to the Building Standard Law etc.

Incidentally, in evaluation of retained horizontal strength required, the coefficient regarding the importance classification of the facilities which is multiplied by the seismic story shear coefficient should be settled to be 1.0 in all the case of Earthquake-proof S, B, C Class and standard shear force coefficient Co which is used in this case should be provided to 1.0.

7. Load Combination and Allowable Limit

The basic concept about combination of loads and allowable limits which shall be considered in assessing adequacy of design principle regarding seismic safety is as follows.

(1) Buildings and Structures

1) Earthquake-proof S Class Buildings and Structures

i) Combination with DBGM Ss and allowable limit

Regarding the combination of normal loads and operating loads with the seismic forces caused by DBGM Ss, the buildings and structures concerned shall have sufficient margin of deformation acceptability (deformation at ultimate strength)as a whole, and adequate safety margin compared to the ultimate strength of buildings and structures.

ii) Combination with EDGM Sd and allowable limit

Regarding resulted stress in combining the normal loads and operating loads imposed with the seismic loads caused by EDGM Sd or Static seismic force, allowable unit stress specified in standards and criteria assumed to be adequate for safety shall be established as the allowable limits.

2) Earthquake-proof B, C Class Buildings and Structures

Regarding resulted stress in combining the normal loads and operating loads imposed with Static seismic forces, allowable unit stress in above-mentioned 1) ii) shall be established as the allowable limits.

(2) Components and Piping System

1) Earthquake-proof S Class Components and Piping System

i) Combination with DBGM Ss and allowable limits

The functions of Facilities shall not be affected by the occurrence of excessive deformations, crack and failure, even if the most part of structures would reach yield condition and the plastic deformation would occur, with respective resultant stress due to combined respective loads which occur in the normal operating condition, unusual transient condition in operation and accident condition with the seismic loads caused by DBGM Ss.

As for the active components etc., acceleration limit etc. for retaining of function shall be established as the allowable limit, which is confirmed by the verification test etc. regarding the response acceleration caused by the DBGM Ss.

ii) Combination of EDGM Sd with allowable limits

The yield stress or the stress with equivalent safety to this shall be established as allowable limits to respective resultant loads due to combined loads at normal operating condition, unusual transient condition in operation and accident condition imposed with the seismic loads caused by EDGM Sd or Static seismic force.

2) Earthquake-proof B, C Class Components and Piping System

The yield stress or the stress with equivalent safety to this shall be established as allowable limits to respective resultant loads due to combined loads in normal operating condition and unusual transient condition in operation imposed with the seismic loads caused by Static seismic force.

(Commentary)

IV. Regarding Load Combination and Allowable Limit

The interpretation of the combination of loads and allowable limits should be based on the followings.

(1) Regarding 'respective loads which occur in unusual transient operation and accident', if the load acted on by the events which are feared being caused by the earthquake and the loads, even if which are not feared being caused by the earthquake but being caused by the events which continue in long term if they would occur once, should be considered to be combined with the seismic load.

However, even if the load is 'a load which occurs in accident', considering the relation between occurrence probability of this accidental event and the duration time, and the exceedance probability of the earthquake, the load caused by this event needs not be considered to be combined with the seismic loads if the probability that the both of them occur simultaneously is extremely small.

(2) Regarding the allowable limits for combination of buildings and structures with EDGM Sd etc. though it was required to be established as the 'allowable unit stress specified in standards and criteria assumed to be adequate for safety', this standards and criteria correspond concretely to the Building Standard Law etc.

(3)'Ultimate strength' in the terms regarding combination of the buildings and structures with DBGM Ss means the bounding maximum bearing load in reaching the condition, which is considered as the ultimate condition of the structures, where deformation and strain of the structure would increase remarkably by adding the load to the structure gradually.

(4) Regarding the allowable limit of components and piping system, though the basic principle requires to maintain the resulted stress under the ' yield stress or equivalent safety situation', this situation corresponds concretely to the situation specified in the 'Technical Standards on Structures etc. of Nuclear Power Generation Facilities etc.' which is prescribed in the Electricity Utilities ' Industry Law.

8. Consideration of the accompanying events of earthquake

Facilities shall be designed regarding the accompanying events of earthquake with sufficient consideration to the following terms.

(1) Safety functions of Facilities shall not be significantly affected by the collapses of the inclined planes around Facilities which could be postulated in the seismic events.

(2) Safety functions of Facilities shall not be significantly affected by the tsunami which could be postulated appropriately to attack but very scarcely in the operational period of Facilities.