Guidelines for Promotion of Earthquake-resistance School Building

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Preface

It is an important issue to enhance the earthquake resistance capacity of school facilities to ensure the safety of children and students and also to play a roll as an emergency evacuation site for the local population at the time of earthquake occurrence.

Concerning to the earthquake resistance of school facilities, Ministry of Education, Culture, Sports, Science and Technology has requested local governments as establishers of schools to introduce the importance coefficient, enhance the level of earthquake resistance design, and promptly promote the earthquake resistance of school facilities built before the enforcement of the New Earthquake-proof Standards (1981).

Survey carried out by the Fire Defense Agency and Cabinet Office from fiscal year 2001 to 2002 showed that earthquake resistance to public facilities including school facilities was not sufficiently developed. And also in the results of urgent survey on the earthquake resistance improvement situation carried out for facilities of public schools throughout the country by the Ministry of Education, Culture, Sports, Science and Technology in May 2002, it reported that “seismic diagnosis was carried out on only 30% of the buildings built under the Standards before 1981, and it was estimated that 40% of entire school buildings and facilities had some problems in their earthquake resistance capacity.”

Under these situations, “Survey and study on promotion of earthquake resistance to school facilities cooperators meeting” was established in October 2002, and discussion was held again about measures promptly taken by the local governments as establishers to promote earthquake resistance for entire school facilities under jurisdiction of the local governments based on the results of related survey and study up to then. The results were reported in “Promotion of Earthquake-resistance School Building” in April 2003.

Based on the report, this “Guidelines for Promotion of Earthquake-resistance School Building” describes basic concept on the earthquake resistance of the school facilities in Chapter 1, and in Chapter 2, methods to plot out the earthquake resistance promotion plan and the points to keep in mind together with methods to determine the urgency of earthquake resistance project from the results of the priority survey on the earthquake resistance and the diagnosis of earthquake resistance were proposed.

We request the establishers, with the help of this guideline to promote promptly and steadily the earthquake resistance of the school facilities under your jurisdiction.

Guidelines for Promotion of Earthquake-resistance School Building

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Chapter 1　Basic concept on the earthquake resistance of school facilities

1. Necessity of the earthquake resistance of school facilities

(1) Ensuring safety of children and students, and prompt resumption of educational activities

For the school facilities are places where many children and students study and live most part of their day, it is vital to maintain safe and healthy environment. The building and facilities of schools, therefore, must be maintained to keep enough capacity of the earthquake resistance, to make damages to the buildings and facilities minimal, to protect lives of children and students at the time of earthquake occurrence, and to resume the educational activities as soon as possible.

(2) Emergency evacuation sites for local population at times of disasters occurrence

The school facilities are public facilities one of the most familiar to the local people, and these are places to learn and enjoy companionship not only for children and students but also for local people. Furthermore, these play a vital role to be emergency evacuation sites for local population at the time of disasters such as earthquake. On this account, it is important to maintain necessary capacity sufficient to be evacuation sites for children and students, and also local people at the time of earthquake and after shocks.

(3) Establishment of the earthquake resistance capacity adequate for the school facilities

Taking the safety of children and students at the time of earthquake and capacity to be an emergency evacuation site immediately after the disaster into consideration, designing to ensure the sufficient earthquake resistance capacity by introducing the importance coefficient and designing extra earthquake load are important for enlargement and reconstruction as well as new construction of school facilities.

It is also important to estimate scale of earthquake motion in the area on interest taking active fault that causes inland earthquake and subductional-zone earthquake that affect large areas into consideration.

2. Basic policy on the promotion of the earthquake resistance for existing school facilities

(1) Priority measures of the earthquake resistance to school facilities in danger of collapsing or wrecking

To prevent human damages to children and students at the time of earthquake, based on the results of the prioritization of vulnerable building for seismic rehabilitation, seismic diagnosis or vulnerability assessment has to be promptly carried out. After having identified individual earthquake resistance capacity of the school facilities and taking estimated scale of earthquake motion in the area on interest into consideration, it is important to implement the earthquake resistance projects such as reconstruction or seismic reinforcement for the school facilities giving priority to danger of collapsing or wrecking.

(2) Prompt implementation of the seismic diagnosis adequate to characteristics of the school facilities

It is important to select the standards for the seismic diagnosis adequate for the characteristics of each school facility.

For most of the reinforced concrete school buildings are rigid frame structure, the second diagnosis described in "Standards for the seismic diagnosis on reinforce concrete buildings and the interpretation, 2001 revised edition" (Japan Architectural Disaster Prevention Association) is generally adequate to apply as the standards for school buildings. It can be thought, however, to estimate overall earthquake resistance capacity by applying the third diagnosis together, or assess the simplified earthquake resistance capacity by applying the first diagnosis according to the structural characteristics of buildings on interest.

"Standards for the earthquake resistance capacity diagnosis on gymnasiums" 1996, (Educational Facilities Department, Minister's Secretariat, Ministry of Education, Culture, Sports, Science and Technology) is adequate to apply as standards for seismic diagnosis of gymnasiums.

(3) Disclosure of results of the seismic diagnosis and the promotion program of earthquake resistance projects

To promote the earthquake resistance project on school facilities, importance and urgency of the project must be thoroughly understood by relevant parties in the administration such as departments and agencies of finance, construction, disaster prevention etc. (administrative department for school juridical organization, hereinafter same as above), and also by teachers and staff, parents and local population.

For this purpose, it is important that the local governments as establishers of schools have to disclose the results of the prioritization of vulnerable building for seismic rehabilitation projects and the seismic diagnosis, and in case the earthquake-resistance promotion planning is formulated, the contents and background of the program have to be disclosed to parties relevant to the schools, and build extensive consensus on the urgency of the earthquake resistance projects.

(4) Implementation of inspection and taking measures for the earthquake resistance on the non-structural members of school facilities

It is important that the local governments as establishers of schools, gaining cooperation from academic experts and engineers and using examples from "Survey and research on inspection of the earthquake resistance of the non-structural members of school facilities (report)", (Architectural Institute of Japan), carry out the earthquake resistance inspection on the so called non-structural members such as ceiling material in school buildings and gymnasiums, electric and machine facilities and apparatus, outer and inner walls, and take sufficient measures against the earthquake disaster.

(5) Promotion of improvement in quality and the earthquake resistance of school facilities

When the earthquake resistance of school facilities is promoted, it is desirable that the local governments as establishers of schools plan and work out the overall maintenance program after having sufficiently discussed the issue of improvement in quality of the school facilities based on the "Guideline for maintenance of school facilities."

(6) Prompt formulation of the earthquake-resistance promotion planning

The local governments as establisher of schools are required to take measures on the earthquake resistance such as the prioritization of vulnerable building for seismic rehabilitation projects, the seismic diagnosis, reconstruction, reinforcement for the earthquake resistance and so forth especially on the school facilities built before the enforcement of the New Earthquake-proof Standards in 1981.

For this purpose, after having sufficiently discussed items to keep in mind to formulate the earthquake-resistance promotion planning for existing school facilities described later in Chapter 2, it is important to formulate promptly the earthquake-resistance promotion planning containing urgency of individual project relevant to the earthquake resistance and its yearly plan, and systematically promote the earthquake resistance of school facilities.

Chapter 2 Formulation of the earthquake-resistance promotion planning for existing school facilities

1. Important point of view to formulate the earthquake-resistance promotion planning

(1) Establishment of organization for discussion

It is necessary to reach common understanding on importance and urgency of the earthquake resistance of school facilities within parties concerned to promote the program smoothly and promptly. In local governments, for example, it can be thought to establish a steering committee consisted of board of education and relevant departments and agencies of the administration such as finance, construction and disaster prevention, academic experts on architectural structure, designers, and teachers and staff of schools.

It is also effective to establish an experts group of architecture and structure specialists within the committee to maintain a system enable to plan and formulate specific matters for the earthquake-resistance promotion planning.

(2) Formulation of a rational earthquake-resistance promotion planning

A basic flow chart for the formulation of earthquake-resistance promotion planning is as shown in the reference material.

For the formulation of the earthquake-resistance promotion planning, a point of view to carry out earthquake resistance projects giving priority to buildings in higher danger of collapsing or wrecking is important to avoid human damages at the time of earthquake or after shock and to minimize damages to buildings and facilities.

It is also important to select a method for earthquake resistance reinforcement after having discussed and compared the costs and unit prices of the construction methods, and make effort to formulate a rational earthquake-resistance promotion planning.

(3) Setting a goal for the earthquake-resistance promotion planning

It is important to set a specific goal within a certain period when an earthquake-resistance promotion planning is formulated.

It is also important to set a yearly plan to attain the goal and to make effort to steadily promote the earthquake resistance of school facilities coordinating with maintenance programs for other public facilities.

2. Implementation of basic survey

(1) Implementation of actual condition survey on facilities

Basic information such as year of construction, building area, number of buildings, results of the seismic diagnosis and vulnerability assessment in case the diagnosis and survey have previously been done, with or without of earthquake resistance reinforcement, history affected by earthquake and fire and so forth are collected and identified on the school facilities concerned.

(2) Confirmation of design drawings and documents

Keeping of design drawings and documents (design and structure), structural calculation sheets, ground survey data and information, and so forth is confirmed on the each facility concerned. In case design drawing and documents are lost, site survey is carried out to prepare plans and framing elevations and other necessary drawings and documents. In case the design drawings and documents exist, the design drawings and documents are checked and confirmed with actual conditions of the buildings.

(3) Collection of data and information on the active fault and subductional-zone earthquake

Collection of data and information such as location of active fault, estimated forcal region of subductional-zone earthquake, expected scale of earthquake motion in the area on interest, results of survey on estimated damages by the earthquake motion and etc. is carried out on areas on interest and the surrounding.

It is also effective to utilize “Seismic Hazard Map in General View of the Whole Japan” and “Seismic Shaking Map for Specified Seismic Source Faults” prepared by The Headquarters for Earthquake Research Promotion.

(4) Confirmation on conditions of designated evacuation facilities

It has to be confirmed whether the school facilities concerned are designated or not as evacuation facilities at the time of disaster occurrence such as earthquake in the local disaster prevention program.

(5) Identification of merger and abolishment plan

Identification of merger and abolishment or diversion plans of schools concerned and local governments merger plans is important to discuss the earthquake-resistance promotion planning in mid and long term prospect.

3. Implementation and assessment of the prioritization of vulnerable building for seismic rehabilitation

(1) Purpose of the prioritization of vulnerable building for seismic rehabilitation

The main purpose to carry out the prioritization of vulnerable building for seismic rehabilitation is to know and discuss the priority that from which school facilities have to be started the seismic diagnosis or the vulnerability assessment by the local governments as establishers who have number of school facilities necessary to apply the earthquake resistance diagnoses or the vulnerability assessment.

(2) Points to keep in mind for the prioritization of vulnerable building for seismic rehabilitation

It can be thought that the prioritization of vulnerable building for seismic rehabilitation is omitted and the seismic diagnosis or vulnerability assessment is directly implemented if a small number of school facilities are concerned.

It can also be thought that main survey is omitted and the earthquake resistance capacity is identified by the first diagnosis for low-rise buildings with bearing wall structure. In this case, if the results of diagnosis are $Is \geq 0.9$, then, “Problems of the earthquake resistance are few”, but if $Is < 0.9$, then, proceeding to the second diagnosis, and urgency level of the earthquake resistance project is determined by the “4. Judgment of urgency on implementation of the seismic diagnosis and earthquake resistance project”.

Based on “Survey and research on the earthquake resistance capacity of school facilities (report)”(Architectural Institute of Japan) and applying the priority level Rp ① specified in “(3) ③ Method of assessment of prioritization of vulnerable building for seismic rehabilitation”, prompt implementation of the seismic diagnosis and adequate measures are needed for gymnasiums with light pre-cast concrete roof, which have been seriously damaged by the Kobe earthquake.

Applying the priority level Sp ① specified in the “(4) ③ Method of assessment of prioritization of vulnerable building for seismic rehabilitation”, prompt implementation of seismic diagnosis and adequate measures are needed for the structural steel framed gymnasium in which roof beams are not fixed to the supporting members (such as roller bearing) and no safety catcher is installed, and for buildings in which steel structures in girder direction are only non rigid joint structural frame without walls and framing braces.

Mean while, it is effective to discuss the priority level of the seismic diagnosis for various structural systems of school facilities such as wooden, concrete block, and structural steel concrete buildings other than reinforced concrete school buildings and structural steel framed gymnasiums gaining cooperation from academic experts and experts on each structural system of building.

(3) The prioritization of vulnerable building for seismic rehabilitation for reinforced concrete school buildings

① Method of implementation of the prioritization of vulnerable building for seismic rehabilitation

Reinforced concrete school buildings subject to the prioritization of vulnerable building for seismic rehabilitation are classified according to the construction year and number of stories into I to V specified in (i) below, then, correction items shown in (ii) below are discussed.

(i) Basic classification

Buildings on interest are classified into the following five categories according to the construction year and number of stories:

(Table 2.3.1) Classification by construction year and number of stories

Classification	Buildings fall under categories
I	Building built before 1971 and higher than 3 stories
Ⅱ	Building built before 1971 and 2 stories, or Building built after 1972 and higher than 4 stories
Ⅲ	Building built before 1971 and one story, or Building built after 1972 and 3 stories
Ⅳ	Building built after 1972 and 2 stories
V	Building built after 1972 and one story

Buildings having balanced Rahmen* structure are classified into I regardless the construction year and number of stories.

* A type of structure that decreasing quantity of steel reinforcement of columns by balancing cantilever protruded from column and inside moment when designing columns in beam direction of reinforced concrete school buildings. Beam direction is usually constructed in single span.

(ii) Correction items

Buildings subject to the survey are discussed on 5 items below and the results are classified into A, B and C.

Items c) and d) are determined from design drawings. If there are no drawings, the determination is done by site survey. In case floor plan of school buildings are not side corridor type, it is classified into B.

For 3 items b), c) and d), the lowest floor is surveyed. For buildings higher than 4 stories, the survey is carried out on the lowest floor and other floors except the highest and second highest floors, and the buildings are classified by the lowest evaluation of these floors.

a) Strength of concrete

Concrete strength test is carried out on member of frame of buildings on interest, and comparing to the design criteria strength in the original design, the results are classified as shown in the following table.

The strength test is carried out on three concrete cores collected from each floor and each construction period, and the strength test value is the smallest of average of results from the compressive strength test. For the method to collect the concrete cores, refer to 2.5.1 Survey on concrete material in the "Standards for the seismic diagnosis on reinforce concrete building, the interpretation, 2001 revised edition"

(Table 2.3.2) Classification by concrete strength

Classification	A	B	C
$\frac{\text{Strength test value}}{\text{Design criteria strength}}$	Over 1.25	Except A, and C	Below 1.0

If the strength tests value is lower than 13.5N/mm^2 (135kg/cm^2), or lower than 3/4 of the design criteria strength, survey on b) to e) is omitted and the priority level Rp in "③ Method of assessment of the prioritization of vulnerable building for seismic rehabilitation" is to be ①.

b) Aging

Aging conditions (corrosion of reinforcing steel, cracks etc.) of main members of structures such as columns and beams are surveyed and the results are classified as shown in the following table. The aging conditions are determined by visual check based on the "Illustration of simplified vulnerability assessment of public school buildings, 1. Reinforced concrete buildings, (2) State of preservation", and evaluated with b)-1 and b)-2 shown below.

(Table 2.3.3) Classification by ageing conditions

Classification	A	B	C
Conditions	Both corrosion of reinforcing steel and cracks are evaluation 1	Except A, and C	Both corrosion of reinforcing steel and cracks are evaluation 3

b-1) Reinforcing steel

Surveying on columns, beams and walls, and the lowest evaluation is adopted.

Evaluation	1	2	3
Conditions	No specific problem	Rust liquid is seen	Outcrop of reinforcing steels or expanded rusting is seen

b)-2 Cracks

Surveying on columns, beams and walls, and the lowest evaluation is adopted.

Evaluation	1	2	3
Conditions	Almost nil	Hair like cracks or cracks narrower than 1mm are seen	Cracks wider than 1mm are seen

c) Plan

Structural frames of buildings on interest are surveyed in the beam and girder directions, and according to the results, those are classified as shown in the table below.

For the structural frame in beam direction, with or without of single span structural frame (structural frame columns in beam direction are only two) is surveyed, while for the structural frame in girder direction, length of each span is surveyed, and according to the results, those are classified as shown in the table below.

(Table 2.3.4) Classification by number of span in beam direction and length of span in girder direction

Classification	A	B	C
Number of span in beam direction	No single span structural frame	Except A, and C	A half or more have single span structural frame
	And also		And also
Length of span in girder direction	All of span length is less than 4.5m		A half or more have span length over 6m

d) Position of quake resisting walls

Position of quake resisting walls are surveyed, and classified with the results as shown in the table below.

For the structural frame with missing wall in lower level*, buildings higher than three stories are surveyed, and for two stories buildings, make them as nil.

For interval of walls in beam direction, intervals of quake resisting walls positioned in the beam direction are surveyed. For with or without of gable walls, with or without of quake resisting walls at both side of gables are surveyed.

* Structural frame with missing wall in lower level refers to a condition that quake resisting walls exist over two or more floors but not in the immediate lower floor.

(Table 2.3.5) Classification by with or without of structural frame with missing wall in lower level, and classification by intervals of walls in beam direction and with or without of gable walls

Classification	A	B	C
Structural frame with missing wall in lower level	Nil	Except A, and C	Existing
	And also		And also
Intervals of walls in beam direction and with or without of gable walls	Less than 9m and also with gable walls in both side		More than 12m or no gable walls**

** When the gable wall exists only at one side, it is classified as no gable wall.

e) Expected seismic intensity

Expected seismic intensity of areas where the buildings on interest located are surveyed and classified with the results as shown in the table below. If the expected seismic intensity is not established, the classification is to be B.

(Table 2.3.6) Classification by expected seismic intensity

Classification	A	B	C
Expected Seismic intensity	Seismic intensity less than V^+	Seismic intensity VI^-	Seismic intensity more than VI^+

② Summary of the prioritization of vulnerable building for seismic rehabilitation

Results of the prioritization of vulnerable building for seismic rehabilitation are summarized in the summary table below.

(Table 2.3.7) Summary table of prioritization of vulnerable building for seismic rehabilitation

Classification		Evaluation items	Evaluation levels
Basic classification		Construction year ( ), Number of floors ( )	Ⅰ Ⅱ Ⅲ Ⅳ Ⅴ
Correction items	Strength of concrete	Design criteria strength ( ), Strength test value ( )	A B C
	Aging	Corrosion of reinforcing steel ( ), Cracks ( )	A B C
	Plan	Number of span in beam direction ( ), Length of span in girder direction ( )	A B C
	Position of quake resisting walls	Structural frame with missing wall in lower level ( ), Intervals of walls in beam direction ( ), With or without of gable walls ( )	A B C
	Expected seismic intensity	Expected seismic intensity ( )	A B C

③ Assessment method of the prioritization of vulnerable building for seismic rehabilitation

Priority level of Rp of the seismic diagnosis or vulnerability assessment of building on interest is determined by correcting priority (A is correction to lower the priority and C is correction to raise the priority) based on and according to the summary table of the prioritization of vulnerable building for seismic rehabilitation and assessment flowchart shown below.

Priority level Rp for the gymnasiums with light pre-cast concrete ceiling is to be ①.

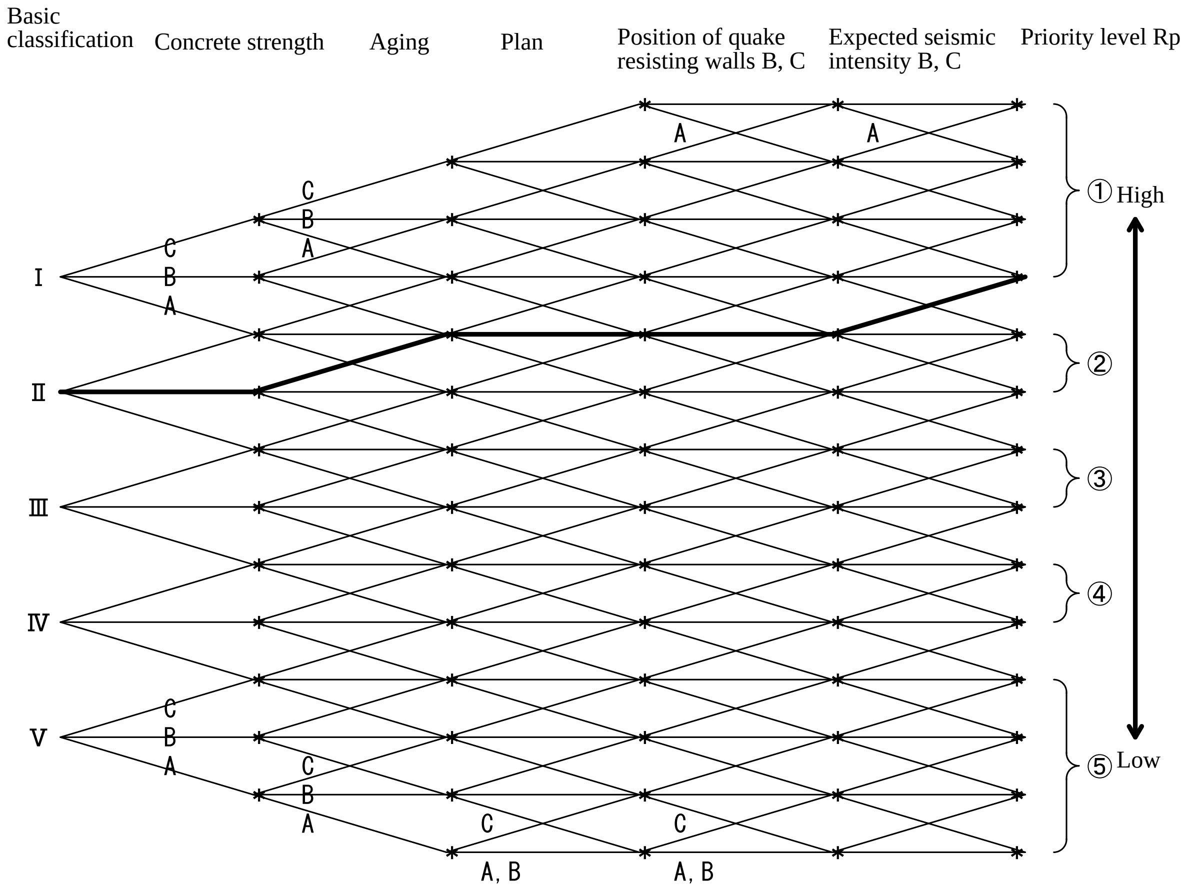

Figure 2.3.1 Assessment flowchart of priority by correction items

Annotation 1: The bold line in the chart above is a building in the basic classification II, and shows the priority correction when its classification of correction items are, for example, B for the concrete strength, C for the aging, B for the plan, B for the position of quake resisting walls and C for expected seismic intensity. The priority of the seismic diagnosis or vulnerability assessment is ① (top priority).

Annotation 2: When number of floors is subject to be surveyed, priority for each floor is surveyed, and the highest level of priority is adopted as the final result.

(4) The prioritization of vulnerable building for seismic rehabilitation of structural steel framed gymnasiums

① Implementation method of the prioritization of vulnerable building for seismic rehabilitation

For the structural steel framed gymnasiums subject to the prioritization of vulnerable building for seismic rehabilitation, items a) to g) shown below are discussed.

For items b) to f), major members of frames (referred to columns, girders, wall braces and eaves beams, hereinafter same as above) are evaluated by visual check and recorded in photographs, if necessary. Areas subjects to the visual check are preferable to be as wide as practically possible.

a) Earthquake resistance capacity of steel framing brace - I_{SB}

i) Calculation method

When girder direction earthquake resistance element of building on interest is the steel framing brace, the $I_{SB,}$ the earthquake resistance capacity of the steel framing brace is calculated by the following expression. And when girder direction earthquake resistance element is not the steel framing brace (reinforced concrete wall etc.), the classification is to be A.

$$I_{SB} = Cyi \times 1.3/AiFesi$$

Where Cyi is estimated value of yield layer shear modulus of the steel framing brace as follows:

Without structural calculation data: Cyi = 0.25

With structural calculation data: Cyi = 0.22 × (f / σ) min

(f / σ) min is ratio of allowable unit stress for temporary loading to the unit stress of action at earthquake for the members of brace (allowable), and obtained from the structural calculation data. If the calculation was done on number of braces, adopt the smallest value.

Ai is considered as equivalent to Ai specified in Article 88 of Enforcement Regulations of the Building Standard Law, and Fesi is considered as equivalent to Fesi specified in Paragraph 4 of Article 82 of the same Regulations. If the case falls under the category shown below, the values can be used.

Structural steel framed and one-story:		AiFesi = 1.0
Structural steel framed and two-story:	The second floor	AiFesi = 1.4
	The first floor	AiFesi = 1.0
RS or combined structures*and two-story:		AiFesi = 2.0

* The RS refers to a structure of reinforced concrete or structural steel concrete up to gallery and the superstructure is structural steel framed. The combined structure refers to a structure that a structural steel framed gymnasium is put on a reinforced concrete structure.

ii) Evaluation levels

According to the value of I_{SB} calculated by the method shown in i) above, the classification is done as shown in the Table below.

(Table 2.3.8) Classification by I_{SB} values

Classification	A	B	C
I_{SB} value	More than 0.7	More than 0.3 and less than 0.7	Less than 0.3

b) Corrosion of structural steel - F

i) Calculation Method

For the major members of frame and exposed type column bases, evaluation is done according to levels shown in the table below and the average value of F is calculated.

If the exposed type column bases are not used (including the column bases are unable to identify), the classification is done by the major members of frame only. Conditions of the corrosion of structural steel are determined by the visual check referring to 3.2.4 Corrosion of structural steel in the “Methods of measurement for vulnerability of existing structural steel framed school buildings (revised edition)”

$$F = 0.5\ (f_{frame} + f_{column\ base})$$

Where f_{frame} is conditions of corrosion on the major members of frame and $f_{column\ base}$ is conditions of corrosion on the exposed type column base. The classification is as shown in the following table. If the exposed type column bases are not used (including the column bases are unable to identify), $F = f_{frame}$

Classification of corrosion	
Nil	1.0
Finishing rust	0.8
Partial rust	0.6
Fracturing rust	0.3

ii) Evaluation levels

The levels are classified into categories shown in the table below with F value calculated by method described in i).

(Table 2.3.9) Classification by corrosion of structural steel

Classification	A	B	C
F value	More than 0.8	More than 0.6 and less than 0.	Less than 0.6

c) Conditions of buckling - N

i) Calculation method

For the major members of frame, buckling is classified into local and total buckling and evaluated by the categories shown in the table below and the multiplied value N is calculated. Conditions of buckling are determined by the visual check referring to 3.2.5 Conditions of buckling in the "Methods of measurement for vulnerability of existing structural steel framed school buildings (revised edition)."

$$N = n_{local} \times n_{total}$$

The n local is the local buckling of major members of frame, and the n total is the total buckling of the major members of frame. The conditions are as shown in the table below.

Classification of conditions of buckling	
Nil	1.0
Slight buckling	0.8
Definite buckling	0.6

ii) Evaluation levels

The classification is done as shown in the table below with N value calculated in i).

(Table 2.3.10) Classification by conditions of buckling

Classification	A	B	C
N value	More than 0.7	More than 0.5 and less than 0.7	Less than 0.5

d) Conditions of welding - M

i) Calculation method

Conditions of welded seams between columns and beams of the major Rahmen frame are surveyed and M is calculated by the expression below. Conditions of welding are determined by the visual check referring to 3.2.8 Welding method in the "Methods of measurement for vulnerability of existing structural steel framed school buildings (revised edition)."

$$M = \min (m_0, m_1, m_2, m_3 \ldots, m_n)$$

m_n is welding conditions of the welded seams between columns and beams of the major Rahmen frame. The lowest m in the surveyed portion is to be M.

Classification of welding conditions	
Nothing peculiar	1.0
Deformed*	0.7
Damaged**	0.4

* If it is suspected that edge of flange is not full melting welding, even the weld bead is regular in shape, the condition is classified as deformed.

** In cases of "the edge of flange is not full melting welding is suspected, and deformed weld bead, undercut, overlap and unfinished craters etc. are seen", and "diaphragm is lacked at the position of flange, or columns covered by steel sheets and H section became section and existence of diaphragm is suspected" these are classified as damaged.

ii) Evaluation levels

The classification as shown in the table below is done by M value calculated in i) above.

(Table 2.3.11) Classification by conditions of welding

Classification	A	B	C
M value	1.0	0.7	0.4

e) Safety of structure

Three items shown below are surveyed on major members of frame, and classified as shown in the table below. If any one of the items is applicable, the classification is to be C.

(Table 2.3.12) Classification by danger in major members of frame

Classification	A	C
Existence or not existence of danger	Not recognized	Recognized

Items to be checked on danger	
a	Important and dangerous differences between design drawings and specifications and actual conditions regarding the major members of frame and their joints (lack of the members, differences in sectional sizes and number of bolts etc.)
b	Notable deformation and damages other than the rust and buckling, sectional fractures, cracks in structural steels regarding the major members of frame and their joints
c	Partial removal of framing braces on the frame in girder direction

f) Safety on falling objects

Structural members with danger of collapsing and falling shown as example in the table below are surveyed in the gymnasium on interest and classified as shown in the table below. If any one of the portions is identified as object having danger of collapsing or falling, the classification is to be C.

(Table 2.3.13) Classification by existence of danger of collapsing or falling object

Classification	A	C
Existence or not existence of danger	Not recognized	Recognized

Examples of portions having danger of collapsing or falling	
a	Concrete block walls [collapsing to outside of wall surface]
b	Braces on roof surface, or components of roof (beams) [falling by break at joints]
c	Fixed portions of structural steels buried in the concrete (column base, fixed portions of beams) [falling of piece of concrete by damages]
d	Finishing material of wall, pendants, ceiling material [falling down]
e	Supports to floor framing (post) [shifting, collapsing]

g) Expected seismic intensity

Expected seismic intensity of areas where the buildings on interest located are surveyed and classified with the results as shown in the table below. If the expected seismic intensity is not established, the classification is to be B.

(Table 2.3.14) Classification by expected seismic intensity

Classification	A	B	C
Expected seismic intensity	Seismic intensity less than V^+	Seismic intensity VI^-	Seismic intensity more than VI^+

② Summary of the prioritization of vulnerable building for seismic rehabilitation

Results of the prioritization of vulnerable building for seismic rehabilitation are summarized in the table below.

(Table 2.3.15) Summary table of the prioritization of vulnerable building for seismic rehabilitation

Classification	Evaluation items	Evaluation levels
Earthquake resistance capacity of structural steel framing brace	I_{SB} = ( )	A B C
Corrosion of structural steel	F = ( )	A B C
Conditions of buckling	N = ( )	A B C
Conditions of welding	M = ( )	A B C
Safety of structure	( )	A C
Safety of falling objects	( )	A C
Expected seismic intensity	( )	A B C

③ Assessment method of the prioritization of vulnerable building for seismic rehabilitation

A priority index (P) is calculated with the expression below based on the summary table of the prioritization of vulnerable building for seismic rehabilitation, and a priority level (Sp) of the seismic diagnosis or the vulnerability assessment is determined for the building on interest.

For buildings in which roof beams are not fixed to the supporting members (such as roller bearing) and no safety catcher is installed, and for buildings in which steel structures in girder direction are only non rigid joint structural frame without walls and framing braces, the priority level Sp is to be ①.

In case safety level is C for the f) Safety of falling objects in the ① Implementation method of the prioritization of vulnerable building for seismic rehabilitation described above, detailed survey on the portion and adequate measures are promptly needed regardless of its priority level.

Priority index P = (Number of level B) + 5 × (Number of level C)

(Table 2.3.16) Table of priority assessment on structural steel framed gymnasium

Value of priority index P	Priority level Sp	
21~35	①	High
16~20	②	↑
11~15	③	↕
6~10	④	↓
0~5ke	⑤	Low

4. Determination of urgency on Implementation of the seismic diagnosis and the earthquake resistance projects

(1) The implementation method of the seismic diagnosis based on results of the prioritization of vulnerable building for seismic rehabilitation

Implementation of the seismic diagnosis or vulnerability assessment is needed for buildings to which higher priority levels are determined by the prioritization of vulnerable building for seismic rehabilitation described in the 3 of Chapter 2. If reconstruction of the buildings on interest is taken into consideration, the vulnerability assessment is thought first to start.

Priority levels based on the results of the prioritization of vulnerable building for seismic rehabilitation are determined for each reinforced concrete school building and structural steel framed gymnasium. Giving priority to which buildings or gymnasium is determined by organization or expert meeting to discuss the earthquake resistance of school facilities after making a comprehensive evaluation of contents of results from the prioritization of vulnerable building for seismic rehabilitation for each building and necessity of the buildings on interest.

Assessment of earthquake resistance capacity and priority of reinforcement for gymnasiums with light pre-cast concrete roof are determined based on the “Survey and research on earthquake resistance capacity of educational facilities (report)” (Architectural Institute of Japan).

Levels of urgency of structural steel framed gymnasiums in which roof beams are not fixed to the supporting members (such as roller bearing) and no safety catcher is installed are determined by the “(2) Method of determination of urgency on the earthquake resistance projects based on the seismic diagnosis” after urgently taking necessary measures to prevent falling.

Mean while, it is important to implement promptly the seismic diagnosis or the vulnerability assessment for buildings other than reinforced concrete school buildings such as wooden, concrete block and structural steel concrete buildings, and to take adequate measures for the earthquake resistance under the cooperation of academic experts and other experts specialized in the structural systems on interest.

(2) Method of determination of urgency on the earthquake resistance projects based on the seismic diagnosis

The urgency of the earthquake resistance projects such as reconstruction or earthquake resistance reinforcement are determined by the method shown below based on Seismic Index of Structure (Is) and index on horizontal load-carrying capacity (q or $C_{TU}S_D$) calculated from results of the seismic diagnosis.

① Determination of urgency of earthquake resistance for reinforced concrete school buildings by results of the seismic diagnosis

Based on the results of the seismic diagnosis, it is determined that the lower the buildings' earthquake resistance capacity, the higher the urgency for the earthquake resistance project such as reconstruction or earthquake resistance reinforcement. The earthquake resistance capacity is basically determined by the Seismic Index of Structure (Is), and corrected by value of the horizontal load-carrying capacity* (q or $C_{TU}S_D$).

Although the urgency determination by Seismic Index of Structure (Is) is done by using the smallest value in the each direction (beam and girder directions) as the representing value, distribution of Is and $C_{TU}S_D$ values, allowable in other direction, other combination of indexes of strength and ductility etc. are also taken into consideration as elements of correction.

According to these principles, examples of classification and correction of the urgency levels are shown below.

* Value calculated by strength index corresponding to the largest F value by which Is value is calculated, is adopted as the horizontal load-carrying capacity (q or $C_{TU}S_D$). To determine as safe (the Is value is more than 0.7), it is notified that the Is value has to be calculated in a range of more than 1.0 of q value ($C_{TU}S_D$ value is more than 0.3).

(i) Example of classification of the urgency levels

An example of determination on classification of urgency level that one level is corrected when the urgency level is classified by Is value 0.1 and q value is more than 1.5 ($C_{TU}S_D$ value is more than 0.45) is shown below. When the q value is in a range between 1.0 and 1.5 ($C_{TU}S_D$ value is between 0.3 and 0.45), it is linearly interpolated by combination of the Is value and the q value ($C_{TU}S_D$ value)

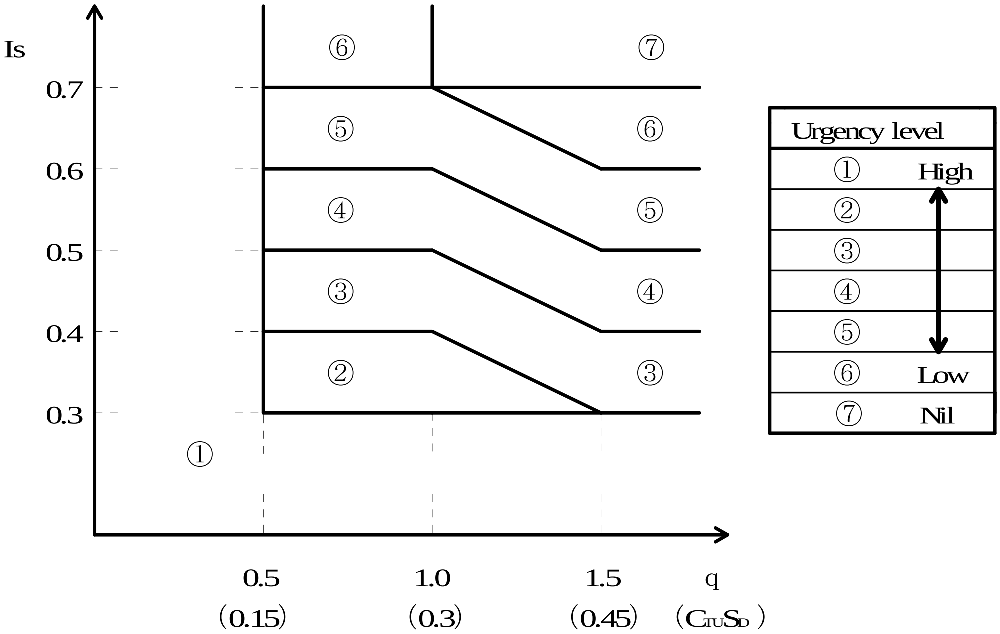

Figure 2.4.1 Urgency level determination chart (reinforced concrete school building)

(ii) Example of correction to the urgency level

In the following cases, for example, applying the correction to the urgency levels can be thought.

(a) In case value of the concrete strength test is less than 13.5N/mm^2 (135kg/cm^2) and also less than 3/4 of the design criteria strength, the urgency level is to be ①.

(b) In case the earthquake resistance capacity is lower than earthquake resistance index such as the structural frame with missing wall in lower level exists and becomes the second structure element* by ratio of axial tension to strength, a few earthquake resisting walls exist in beam direction and earthquake resistance capacity is low in both the directions, S_D index of horizontal rigidity is at the lowest level and so forth, the urgency may be raised one level.

* This refers to a condition of members that there are no other members as substitute to support the axial strength if the members on interest are damaged.

(c) In case the earthquake resistance index is determined slightly lower such as earthquake resistance index is determined by considering partial and extremely fragile members, or walls in beam direction are sufficiently located and the earthquake resistance index is determined by F=1.0 (shear columns) in spite of the long columns, the urgency may be lowered one level.

(d) If the expected seismic intensity in areas where buildings on interest are located is estimated more than VI+, the urgency may be raised one level**.

** If the expected seismic intensity is estimated VII, it is recommendable to raise the urgency another one level. Areas where their seismic intensity are possible to be VII are neighboring areas to fault line, the distance from the confirmed fault trace is less than 5km, areas covered by thick sedimentary layers corresponding to the third category ground of the Standard Building Law, and areas where their seismic intensity are supposed to be magnified by effects of geographic features such as cliffs and margin of basin.

In the determination of urgency levels, area coefficient Z, necessary to calculate q value may be value that specified by the Standard Building Law or value determined in the each region. However, area coefficient Z is to be 1.0 if the expected seismic intensity has been established taking the areas' seismic activity into consideration, because the seismic activity has been already considered when the estimated earthquake motion has been established.

(e) When the q value is 0.5 ($C_{TU}S_D$ value is 0.15) and large Is value is calculated due to the large F value, the urgency is classified as level ①. Therefore, after having calculated again the Is value with q value in a range of more than 0.5 ($C_{TU}S_D$ value is 0.15), and new level of the urgency has to be determined.

(f) If the urgency level differs in the second and third diagnoses, principally the classification of the second diagnosis is adopted. However, the urgency level may be corrected taking results of the third diagnosis into consideration.

② Determination of urgency of earthquake resistance for structural steel framed gymnasiums by results of the seismic diagnosis

Based on the results of the seismic diagnosis, it is determined that the lower the buildings' earthquake resistance capacity, the higher the urgency for the earthquake resistance project such as reconstruction or earthquake resistance reinforcement. The earthquake resistance capacity is basically determined by the Seismic Index of Structure (Is) and index on the horizontal load-carrying capacity (q).

The urgency levels are determined by combination of calculated Is value and q value. When the combination of Is value and q value are found for each floor and several urgency levels are obtained, the highest level of urgency has to be adopted.

(i) Example of classification of the urgency levels

An example of determination on classification of urgency level when the urgency level is classified using the Is value 0.1 and q value 0.5 is shown below.

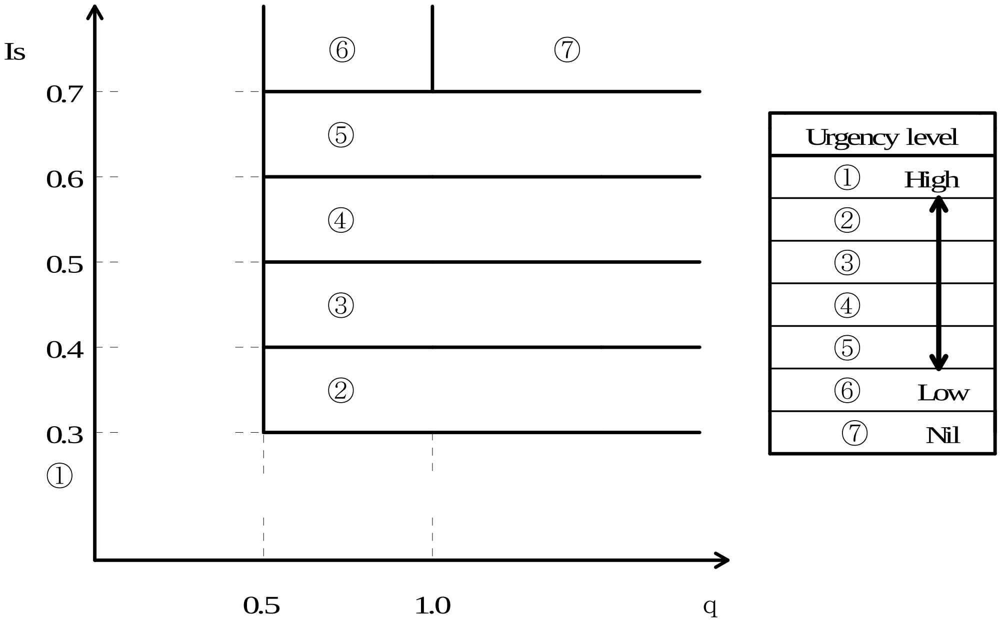

Figure 2.4.2 Urgency level determination chart (structural steel framed gymnasium)

(ii) Example of correction to the urgency level

In the following cases, for example, correction of urgency levels may be thought.

(a) For buildings in which level C is found in the evaluation items except in the item of expected seismic intensity in the prioritization of vulnerable building for seismic rehabilitation, and the conditions are not exactly reflected to calculation of Is and q values, the urgency level may be raised according to the actual condition of the danger.

(b) When the expected seismic intensity in areas where buildings on interest are located is estimated more than VI^+, the urgency may be raised one level. In this case, area coefficient Z to be used for calculation of Is and q values is to be 1.0*.

* In case the expected seismic intensity is estimated as VII, it is desirable to raise the urgency another one level. Areas where their seismic intensity are possible to be VII are neighboring areas to fault line the distance from the confirmed fault

trace is less than 5km, areas covered by thick sedimentary layers corresponding to the third category ground of the Standard Building Law, and areas where their seismic intensity are supposed to be magnified by effects of geographic features such as cliffs and margin of basin.

In the determination of urgency levels, area coefficient Z, necessary to calculate q value may be value that specified by the Standard Building Law or value determined in the each region. However, area coefficient Z is to be 1.0 if the expected seismic intensity has been established taking the areas' seismic activity into consideration, because the seismic activity has been already considered when the estimated earthquake motion has been established.

(3) Points to keep in mind to select reconstruction or earthquake resistance reinforcement

The earthquake resistance projects are reconstruction or earthquake resistance reinforcement. The local governments as establishers have to decide to select which method to employ after having considered the earthquake resistance capacity and durable period of each building, needs of parties concerned for the building on interest, costs necessary for the projects and so forth. However, it is recommendable to select the reconstruction for cases such as the earthquake resistance capacity is notably low (the urgency level ①, (Is < 0.3 or q < 0.5)), the concrete strength is remarkably low (the concrete strength test value is less than 13.5 N/mm^2 ($135kg/cm^2$) and also less than 3/4 of design criteria strength), large number of reinforcement members are needed, or the construction is extremely difficult, the educational function is notably affected by the earthquake resistance reinforcement. It is also taken notice that replacement or new installment of framing braces can improve the earthquake resistance capacity for the structural steel framed gymnasiums even if their urgency are level ① (Is < 0.3 or q < 0.5).

For the implementation of earthquake resistance reinforcement, the legality to the Standard Building Law, Fire Defense Law and other law and regulations in force, merger and abolishment or diversion plans of school buildings on interest, historical importance of the buildings on interest, the mergers of municipality concerning the establishers and so forth are points of concern to be carefully discussed.

Also for the existing school facilities, improvement of functions to deal with contemporary issues of the school facilities such as improvement of educational environment, quality of information environment, reduction of environmental load corresponding to the recycling-oriented society, etc. are strongly required. It is important to implement the earthquake resistance projects as a part of macro-scale renovation projects and at the same time to promote the enhancement of qualities mentioned above.

5. Formulation of yearly plan on the earthquake resistance projects

(1) Decision of priority

Priority of earthquake resistance projects on the school facilities concerned is discussed in the investigative organization concerning the earthquake resistance of school facilities and its experts meeting. Basically, priorities of the earthquake resistance projects are given to the school facilities with high urgency level and are in danger of collapsing or being badly damaged. At the same time, overall discussion regarding contents of results of the seismic diagnosis for each building and preparation for issues to enhance quality of the school facilities etc. is important.

The urgency levels based on results of the seismic diagnosis are different for the reinforced concrete school buildings, structural steel framed gymnasiums and gymnasium with light pre-cast concrete roof. It is important that priorities for these facilities are decided by the investigative organization concerning the earthquake resistance of school facilities and its experts meeting after the overall discussion regarding contents of results of the seismic diagnosis for each building and needs to the buildings on interest.

(2) Calculation of expected quantity of project

It is important that the local governments as establishers estimate the necessary project areas and costs to implement the earthquake resistance of school facilities concerned and identify the total quantity of the project.

(3) Establishment of project period

It is important that the local governments as establishers, taking actual conditions of the areas and the financial situations into consideration, establish the adequate periods of the projects to complete the earthquake resistance projects of the school facilities concerned smoothly and promptly.

(4) Points to keep in mind for the formulation of yearly plan

It is important for the formulation of yearly plan to consider points such as ensuring the consistency to development projects other than the earthquake resistance, considering durable period of each school facilities, establishing adequate unit prices for earthquake resistance reinforcement, giving the earthquake resistance project a position to the master plan and local disaster prevention programs formulated by the local government on interest, and the yearly plan is disclosed to parties concerned immediately after being formulated.

6. Implementation of earthquake resistance project

(1) Selection of adequate construction method for seismic reinforcement

For the seismic reinforcement plan of school facilities, it is important to maintain sufficient earthquake resistance capacity in the design of the seismic reinforcement by introducing the importance coefficient and adding extra magnitude of earthquake to the design criteria taking the scale of earthquake motion in the area on interest into consideration and to ensure the safety of children and students, and to maintain the function to play a role as an emergency evacuation site.

There are various construction methods for the seismic reinforcement. Considering the costs of reinforcement, selection adequate to the characteristics and actual conditions of the buildings is important. For the school facilities, the “Manual of seismic reinforcement of school facilities (for RC school building) revised edition 2003” and “Manual of seismic reinforcement of school facilities (for Structural steel framed gymnasium) revised edition 2003”, revised in March 2003 by the Ministry of Education, Culture, Sports, Science and Technology describe specific methods to select construction methods for the seismic reinforcement and technical items to be noted. These are recommendable to be used for reference.

When the seismic reinforcement and quality enhancement of the school facilities is simultaneously implemented, the “Survey and research on earthquake resistance improvement of school facilities (report)”, (Architectural Institute of Japan) describe basic way of thinking and specific techniques. This is recommendable to be used for reference.

(2) Methods of earthquake resistance improvement of non-structure members

The local governments as establisher are required to be routinely careful to maintain the school facilities, and adequately carry out inspection, repair and regular maintenance of facilities and equipment. Especially, for ceiling material, various equipment and apparatus, installed machines and other non-structure members, it is important to identify members doubted their earthquake resistance capacity, to formulate earthquake resistance improvement plan for them, and to take emergency measures until the improvement is done. For this purpose, “Survey and research on earthquake resistance inspection of non-structure members of school facilities (report)”, (Architectural Institute of Japan) is recommendable to be used for reference.

(3) Adoption of emergency reinforcement

When the prioritization of vulnerable building for seismic rehabilitation or the seismic diagnosis shows the earthquake resistance capacity of the building on interest is quite low, and a period to start implementation of the earthquake resistance project is rather long, the emergency reinforcement has to be carried out to ensure the safety of children and students.

For the specific methods of the emergency reinforcement, the “Manual of emergency restoration of school facilities” compiled by the then Ministry of Education in March, 1999 is recommendable for reference.

Reference   Flowchart of formulation of the earthquake-resistance promotion planning for existing school facilities

Annotation: This flowchart shows an example of general flow of formulation of the earthquake-resistance promotion planning