3.2. Evaluation on Building Damage

Basic Terminology:

Damage: Destruction, deformation and inclination of a building, which includes structural and non-structural elements, caused by an earthquake.

Damage index: Indices indicating degree of danger, class of damage for building as a whole, damage level for each building element.

Safety: Building conditions which ensure the safety of human life even at a possible severe earthquake.

Structural element: Building elements which compose the structural system to resist dead and live loads, and external loadings such as earthquake excitation.

Non-structural element: Building elements other than structural elements like exterior and interior wall, partition wall, ceiling, roof, and so on.

Retrofit: Strengthening the structural system of an existing building with poor aseismic capability to fit the requirement of current building code.

Purpose:

Methodology of an evaluation on building safety after earthquake or tsunami

Important Points:

Timing:

Timing	Evaluation Methodology	Example
Immediate	• First announcement of building damage	• Reports of eye witness & Feelings by local habitants • Broadcast
Within few days	• Quick inspection	• Evaluation into 3 ranks, inspected, limited entry and no entry
Within few weeks	• Damage Classification • Damage survey in a typical area • Damage overview in damaged area	• Seismic capacity assessment

Grade:

Grade	Methodology	Deals
Minimum Necessary	Reports of eye witness & Feelings by local habitants	Information to habitants
Better	Instant evaluation	Advice to habitants about Restoration
Best	Evaluation on building safety	Advice to habitants about Retrofitting Statistics of damages

3.2.1. First Announcement of Building Damage

Immediately after the earthquake occurrence, within a few hours, it is very important to know the general damage distribution and identify the most severely damaged areas where emergency rescue action is required. At this time, quick information transfer becomes important though reports of eye witness or findings by local habitants. Such information must be integrated for the effective rescue actions as well as building damage evaluation considering the determination of priority or order of various response actions, and appropriate emergency plan must be managed and operated.

Considering the shutdown of computer systems due to the break of electric power supply, the role of broadcast becomes important especially wireless network systems for the collection of damage information.

A survey shall be performed to roughly assess the disaster level of buildings within one or two days immediately after an earthquake. A small number of investigators will also visually inspect the appearance of buildings while taking into consideration the reports by residents.

3.2.2. Quick Inspection of Damaged Buildings[1]

This section mainly presents the method of quick inspection in Japan. The methods in the U.S. and Turkey are attached as Other Example 1 and 2, respectively, at the end of the section.

Damaged buildings shall be inspected between the third day and the seventh day after the earthquake, or for a longer period depending on the disaster level, to evaluate building safety against aftershocks by the visual inspection of their appearance and in the buildings' interiors by building structure engineers. The judgment result of this inspection shall be classified as "inspected", "limited entry", or "unsafe" and posted near the building entrance.

1) Purpose

The purpose of the quick inspection of damaged buildings is to judge the risk of collapse or tip-over of the buildings damaged by an earthquake or falling of building components due to aftershocks as soon as possible, and to provide information on the risk of using the buildings before they are restored for long-term use. This should help prevent secondary disasters that would endanger people in earthquake-stricken areas.

Explanation

(1) The primary responsibility to ensure the safety of a building rests with its owner, building manager, or occupant. The owner and relevant people have the responsibility to ensure the safety of the building damaged by an earthquake.

In case the damage by the earthquake is too large or there are a number of owners for a building, however, it is not always possible for the owners of the damaged building or relevant people to confirm the safety of the building by themselves. A large-scale earthquake normally has a number of aftershocks. Buildings damaged by an earthquake will be destroyed further by the intense vibration of aftershocks and might collapse, thereby subjecting a number of people to the threat of secondary disasters. Damaged buildings that would affect roads or adjacent houses in particular can hurt third parties.

Therefore, from the viewpoint of the safety of citizens after an earthquake, it is not desirable to entrust the entire responsibility for the safety of damaged buildings to the owners or relevant people without taking administrative action.

For this reason, the safety of damaged buildings shall be judged as part of emergency action by local governments immediately after an earthquake.

This post-earthquake, quick inspection of damaged buildings is an action by the Center for the Quick Inspection of Damaged Buildings, which is organized in the Disaster Response Headquarters to quickly investigate buildings and other structures and offer information from the professional viewpoint of architectural technology. This inspection does not assess the monetary loss due to the disaster or judge whether the damaged buildings can be used for a long period of time. The "criterion on the damage classification" [1)] will be applied to the judgement of whether the damaged buildings can be used for a long time or whether structural reinforcement is necessary for restoration.

(2) Aftershocks are usually smaller than that of the main shock; however, they are sometimes equal to or larger than the first earthquake. In addition, different earthquakes often occur at an equal to or larger scale than that of the first shock after a short interval in the same area, though they are not regarded as aftershocks from the viewpoint of seismology. Recent, well-known typical combinations of an earthquake and a subsequent earthquake that was larger in scale and damage are the Miyagi-ken-oki Earthquake in February 1978 (M6.7) and the earthquake at the same place in June 1978 (M7.4); and the Kagoshima-ken Nanseibu Earthquake in March 1997 (M6.2) and the earthquake (M6.3) occurred in Satsuma area, Kagoshima Prefecture, in May 1997.

However, for judging the risk level, this criterion assumes that aftershocks have smaller scales than that of the main shock. In case a building has been damaged further by aftershocks to require changes in the risk level judgement, quick inspection will be performed again.

(3) Buildings on a slope will collapse together with the ground if the slope collapses when water percolates downward through the ground at post-earthquake rains through fissures caused by the earthquake. An example is the case of the 1990 Philippine earthquake when a slope cracked by the earthquake later collapsed due to a post-earthquake rain and washed away a reinforced concrete building. This quick inspection will also pay attention to the risk of building collapse due to such non-aftershock phenomena.

These non-aftershock phenomena that cause building collapse include the effects of typhoons and strong winds and snow loads after snowfall on earthquake-stricken buildings. It is important to take into consideration the effects of strong winds and snowfall immediately after an earthquake, particularly on wooden buildings and steel structure buildings.

(4) To inspect facilities for the usability as a post-earthquake shelter, the safety against aftershocks shall be examined more carefully and minutely. It is important to inspect not only the safety of interior and exterior structures but also the safety and availability of gas

and electricity, the water supply and drainage, and telecommunication facilities.

This criterion is designed to quickly judge the risk level of damaged buildings by focusing on appearance inspection. The inspection and judgement manual focuses especially on the inspection and judgement of damaged buildings in general by volunteer inspectors.

Therefore, the inspection and judgement on shelter facilities may be made as a separate duty by the Disaster Response Headquarters in the earthquake-stricken area. For this reason, it may be required for small-scale local governments that do not have engineering staff to seek for the cooperation of inspectors to judge damaged buildings. In such a situation, it is desirable to carefully inspect the interior and exterior of damaged buildings in detail according to this criterion and the inspection and judgement manual.

2) Scope of Application

This criterion on quick inspection applies to wooden, steel, reinforced concrete and steel framed reinforced concrete buildings damaged by an earthquake. Because buildings are different in the construction method and height depending on the type of structures and subsequently in the earthquake damage features and risk level, this criterion on quick inspection is set for each type of structure.

Explanation

(1) This criterion on quick inspection applies to the judgement of the risk of collapse of earthquake-damaged buildings due to aftershocks and does not apply to that of buildings damaged by other causes. For example, because different typhoons and strong winds have different directions, pressures, and other characteristics, this criterion cannot directly be applied to the judgement of the risk level of the buildings damaged by a strong wind against the winds that follow in a later typhoon. In case an earthquake-damaged building is potentially subjected to strong winds, however, it is required to pay attention to their effect on the building.

(2) This criterion on quick inspection summarizes the methods to judge the risk of wooden, steel structure, reinforced concrete, and steel framed reinforced concrete buildings of ordinary construction due to an aftershock and other effects. However, there are some special-purpose buildings of special construction method that are different from the conventional methods. As such special buildings have little experiences with earthquake damage, there is little knowledge of the method to judge the risk level. Hence, this criterion does not make judgement on such buildings. Therefore, a special team should be organized, including design engineers of the building, to judge the risk level in case such buildings are

damaged in an earthquake. In addition, a separate inspection should be done for buildings that store dangerous materials; but such buildings are not covered by this criterion. In case this criterion is applied to such buildings as an emergence measure, the risk level should be judged while considering whether the buildings still have the capability to store dangerous materials.

For these reasons, this criterion does not apply to the buildings of non-conventional construction. More specifically, this criterion excludes high-rise buildings of ten stories or over, and buildings of long-span, space truss or suspension structure, and other special construction methods.

In regard to building construction, the scope of application differs for wooden, steel structure, reinforced concrete, and steel framed reinforced concrete buildings. Among concrete-based structures, this criterion may be applicable to precast concrete and reinforced concrete block buildings. In the case of precast structure, joints will more seriously be damaged than structural members. In such a situation, because the judgement based on the damage of joints is not prescribed, flexible actions are required to read joints in the inspection sheet, which will be presented later, as columns for inspection and judgement.

This criterion is not applicable to inspection of such buildings that are called the buildings of a prefabricated method, wooden frame construction, or traditional construction method for temples and shrines. If it is applied to such buildings, therefore, the spirit of the inspection should appropriately be observed.

To the buildings having some parts with tow or more of the following: reinforced concrete, steel framed reinforced concrete, some steel structure, and some wooden structure, it is possible to apply the criterion on quick inspection for each construction method that is presented below, and make comprehensive judgement based on the judgement on each construction method. In this case, different inspection methods will be used for the different construction methods.

3) Definition of Terms

In this criterion, terms are used according to the following definitions.

• Quick inspection: Quick inspection implies both temporary and emergency inspections on the assumption that there is an emergency that requires a number of judgements to be made during a short period of time immediately after an earthquake that has damaged buildings. The judgement is temporarily made according to this criterion and may be changed after the damage has been surveyed later by a detailed inspection with an ample period of time.

• Degree of danger: The degree of danger means the level of the danger that affects human life due to the destruction of building frames, and falling or tip-over of building components. There are three ranks of degree of danger, "unsafe", "limited entry", and "inspected", based on the damage levels of different parts of the object building.

The term "inspected" is used to mean "safety" in the inspection and judgement according to this criterion. However, the quick inspection of degree of danger based on an appearance survey in a limited scope does not mean that inspection and judgement have been made to the extent that the "safety" of the building is guaranteed. It is only to confirm that there are no "unsafe" or "limited entry" elements in the scope covered by the inspection. If the result of judgement is expressed as "safe," it would lead to the misunderstanding that the building can be used safely for a long period of time. For these reasons, the term "inspected" is used in the criterion.

• Class of damage: The class of damage means the level of earthquake-caused destruction or deformation of buildings or objects attached thereto. There are three ranks of damage level, A, B, and C, in an ascending order, for the quick inspection of damaged buildings.

• Damage level: The damage level means the level of destruction of members and parts of reinforced concrete and steel framed reinforced concrete buildings. The "criterion on damage classification" [2] defines five levels of destruction, I to V, in an ascending order according to the extent of damage. This criterion on quick inspection of damaged buildings is related to the damage levels III and over.

4) Method of Inspection

To inspect damaged buildings and judge the degree of danger, those who are qualified for quick inspection of damaged buildings visually inspect the appearance of buildings and their parts at the disaster site for settlement, inclination, and destruction.

Explanation

(1) Quick inspection of damaged buildings is performed according to the request by local governments by the inspecting building engineers (hereinafter referred to as "judges") who have been trained on the technique of the criterion of quick inspection of damaged buildings, and are registered at the prefectural governments. To ensure that judges correctly understand the criterion on quick inspection of damaged buildings and the inspection and judgement manual, and to ensure that damaged buildings are appropriately inspected and judged for their safety, judges are assumed to have expert knowledge equal to or at a higher level than that required for registered architects.

(2) Buildings are visually inspected in principle from outside by using simple instruments.

In the quick inspection of damaged buildings, judges can quit further inspection once the object building has been judged as "unsafe". However, even buildings that are judged as not damaged by an appearance inspection may have been seriously damaged on the inside structure to cause collapse. Therefore, it is desirable to confirm that there is no damage inside such apparently-intact buildings. In such a situation, it is also possible to inspect the inside based on in situ interviewing of the users or owner of the building.

(3) Simple instruments may be required to measure the settlement, inclination, or damage of buildings.

(4) Buildings are inspected by using a judgement and inspection sheet prepared for each structure type. However, there are buildings whose structural type cannot be judged from outside appearance. In particular, it is often difficult to distinguish between a wooden and a steel structure or between a reinforced concrete and a steel framed reinforced concrete structure. Even a building apparently of reinforced concrete structure can be regarded as a steel framed reinforced concrete building if it has eight stories or over. Judge whether a building is steel or reinforced concrete by touching it or knocking to hear the sound. It is often difficult to judge whether a building is of wooden or steel structure, unless the exterior finish has dropped to expose the inside. In such a situation, it is appropriate to regard it as a wooden building for inspection, because such buildings are often of wooden structure according to the past experience.

For buildings of mixed structures, select an appropriate inspection sheet after confirming the damage level and judging the main structure, and use other inspection sheets as necessity arises and record the condition of the building in the margin of the sheet.

(5) It is desirable to prepare a house map as shown in Fig.3.2.2-4 in order to identify the name and location of each building to be inspected.

5) Method of Judgement

Inspect the object building and judge the settlement, inclination, and damage of the structure according to the judgement criterion prescribed in the inspection sheet for quick inspection of damaged buildings, and judge the degree of danger of the building as follows based on the judgement result.

(1) Degree of danger of building

• Unsafe: Judge the building as "unsafe" if it has one or more C-ranked items with regard to settlement, inclination, or damage of building frames. Even though it has no rank C items, judge the building as "unsafe," if it is of steel structure and has four or more

B-ranked items, or if it is of reinforced concrete or steel framed reinforced concrete structure and has two or more rank B items.

• Limited entry: Judge the building as "limited entry," if it has one or more B-ranked items with regard to settlement, inclination, or damage of building frames.

• Inspected: Judge the building as "inspected" when it is not at the degree of danger of "unsafe" or "limited entry."

(2) Risk level of components to fall or to be tipped over

• Unsafe: Judge the object component as "unsafe," if it has one or more C-ranked inspection items with regard to the possibility to fall or to be tipped over.

• Limited entry: Judge the object component as "limited entry," if it has one or more B-ranked inspection items with regard to the possibility to fall or to be tipped over.

• Inspected: Judge the component as "inspected" when it is not at the risk level of "unsafe" or "limited entry".

Explanation

(1) The degree of danger of a damaged building is judged separately for the risk to human life due to the collapse and for that due to building components that fall during aftershocks or due to other causes. This is to express whether the building can be used based on the said two categories of danger by the method referred to in the next chapter. Even when there is no damage to the building or no risk of collapse, it shall be judges as unsafe if there are objects that would fall or be tipped over near the entrance of the building that would endanger the users, owner, or third parties. In this manner, the degree of danger due to the collapse of the building and that due to the objects that would fall or to tip-over shall be judged separately.

6) Action according to the judgement result

To notify the building owner, users, or third parties of the quick inspection result, judges shall post the specified sticker at the entrance of the building or other places where the sticker is easy to view. When it is possible, judges should explain the inspection result to the building owner and advise about the prevention of danger. Judges shall also post a sticker in the relevant place to notify the judgement result on the danger of objects that could fall.

Explanation

(1) Figs 3.2.2-1 to 3.2.2-3 show an example of the sticker for "unsafe", "limited entry", and "inspected", respectively.

(2) When the building has inclined to a large extent and has the possibility to fall over as a rigid body at an aftershock, it is required not only to post a sticker for danger at the building to arouse attention but also to indicate the danger to enter the area in which the building would fall upon. In the 1995 Great Hanshin earthquake, a building that inclined significantly (because it had broken columns on the first floor) totally collapsed during an aftershock and blocked nearby roads. In this case, the area crushed by the collapsed building was approximately equal to the height of the building.

(3) The area that will be affected by an object attached to a building when it falls or it is tipped over depends on its size and profile. As a guide, assume the dangerous area is the circle on the ground immediately below the object that has a radius equivalent to half the height where the object is installed. If there are canopies or screens on the route along which the object will fall, their effect shall additionally be considered, since the object will rebound at such obstacles.

(4) Inspectors shall explain the judgment result to the building users, describe the allowable area of entry, and give easy-to-understand precautions required for entering the building in the column for comments on the judgment sticker. Oral explanation may be enough or stickers can be omitted for some buildings.

Administrative action will be taken to prevent entry into buildings that would affect the safety of third parties.

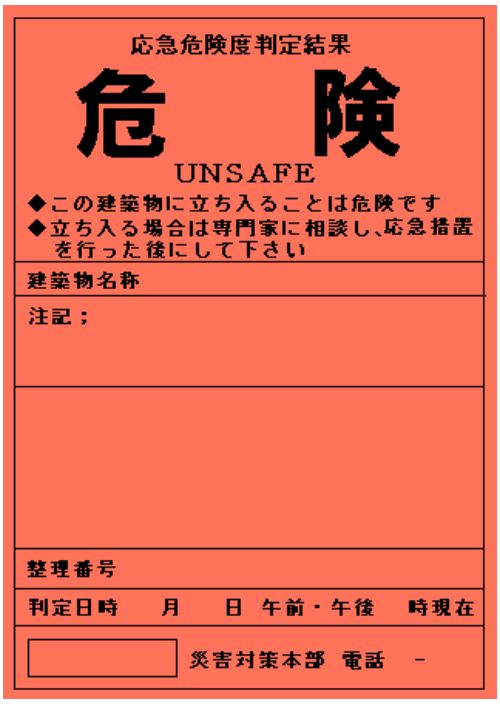


Fig. 3.2.2-1　Example of the sticker for “unsafe” (in red)

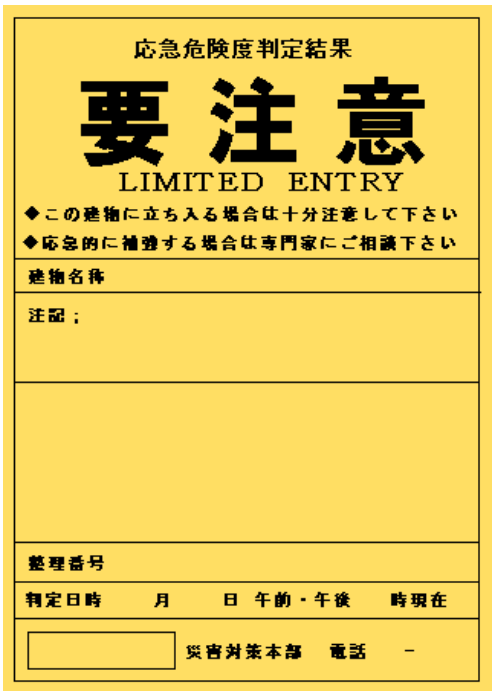


Fig. 3.2.2-2　Example of the sticker for “limited entry” (in yellow)

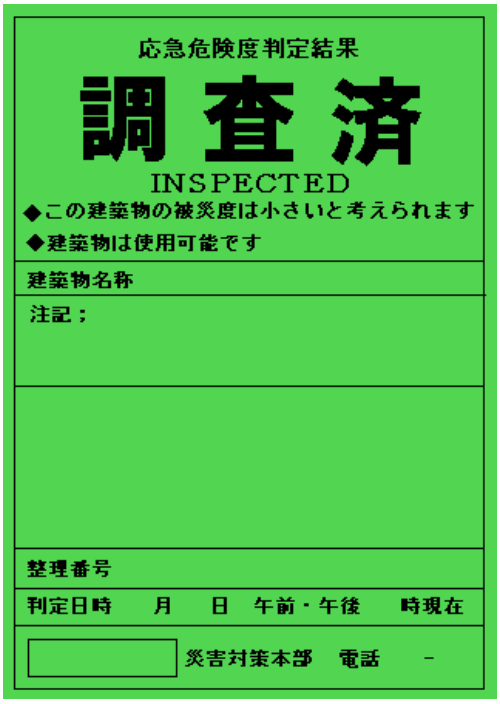


Fig. 3.2.2-3　Example of the sticker for "inspected" (in green)

7) Changing the judgment

The judgment can be changed for buildings for which quick inspection of damaged buildings was performed, when effective measures have been taken later to prevent collapse or other categories of danger, or when the damage conditions have been changed or inspected in detail to have the original judgment changed.

Explanation

(1) The primary purpose of the quick inspection of damaged buildings is to inspect damaged buildings, judge the degree of danger based on the quick inspection and judgment manual against the possibility of collapse or other categories of danger, and inform the building owner of the judgment result. This is to prevent secondary disasters that would affect human life and is not to judge whether the object building can be used for a long period. The judgment is not linked with the certificate for damage that is used to apply for subsidies for recovery from disaster. It is important to note that changing the judgment is an action to be taken only when the degree of danger that affects human life has changed.

The original judgment shall also be changed when the damage has intensified by aftershocks. When an aftershock at a comparatively large scale has occurred, quick inspection and degree of danger judgment shall be performed again for all buildings in the disaster area.

(2) When effective emergency reinforcement measures have been taken for a damaged building to lower the degree of danger, or objects that would fall have been removed, the degree of danger will be changed from "unsafe" to "limited entry", or from "limited entry" to "inspected" based on the result of the second inspection and judgment.

The emergency reinforcement measures shall be limited to those that ensure an effective result, such as replacing a damaged column with a reliable reinforcement structure that can sufficiently bear the vertical load that has been born by the column. Simple measures such as supporting a building that has inclined to a large degree with oblique beams will not constitute a reliable emergency reinforcement measure that allows changing the judgment result. Because there are few documents on emergency reinforcement technologies, this issue shall be investigated further. With regard to emergency reinforcement or subsequent judgment, appropriate measures shall be taken, including consultation with experts on the technology of buildings and structures.

(3) Since the quick inspection of damaged buildings is performed in a short period of time, it may be changed later based on a detailed inspection. There may be cases where the judgment shall be changed to "unsafe" after an interior inspection for buildings originally judged "limited entry" or "inspected" with a comment "according to an appearance

inspection", or to "limited entry" after a deliberate inspection for buildings originally judged as "unsafe" because it was originally a borderline call and thus labeled to ensure safety. However, a deliberate attitude is required in the latter case.

In the following pages, mono-color photos and full-color photos are presented. Generally, the mono-color photos are quoted from Reference [1]. And the full-color photos are produced by the members of Building Research Institute, Ministry of Construction, until 1995.

References

[1] "Quick inspection manual for damaged buildings", The Japan Building Disaster Prevention Association, Feb. 1998. (in Japanese)

[2] "Damage classification method for damaged buildings post-earthquake and seismic retrofit guideline", The Japan Building Disaster Prevention Association, Sept. 2001. (in Japanese)

[3] "Zenrin House Map ’94, Chuo-ku, Kobe City (east part) ", Zenrin Co., Ltd., Jan. 1994.

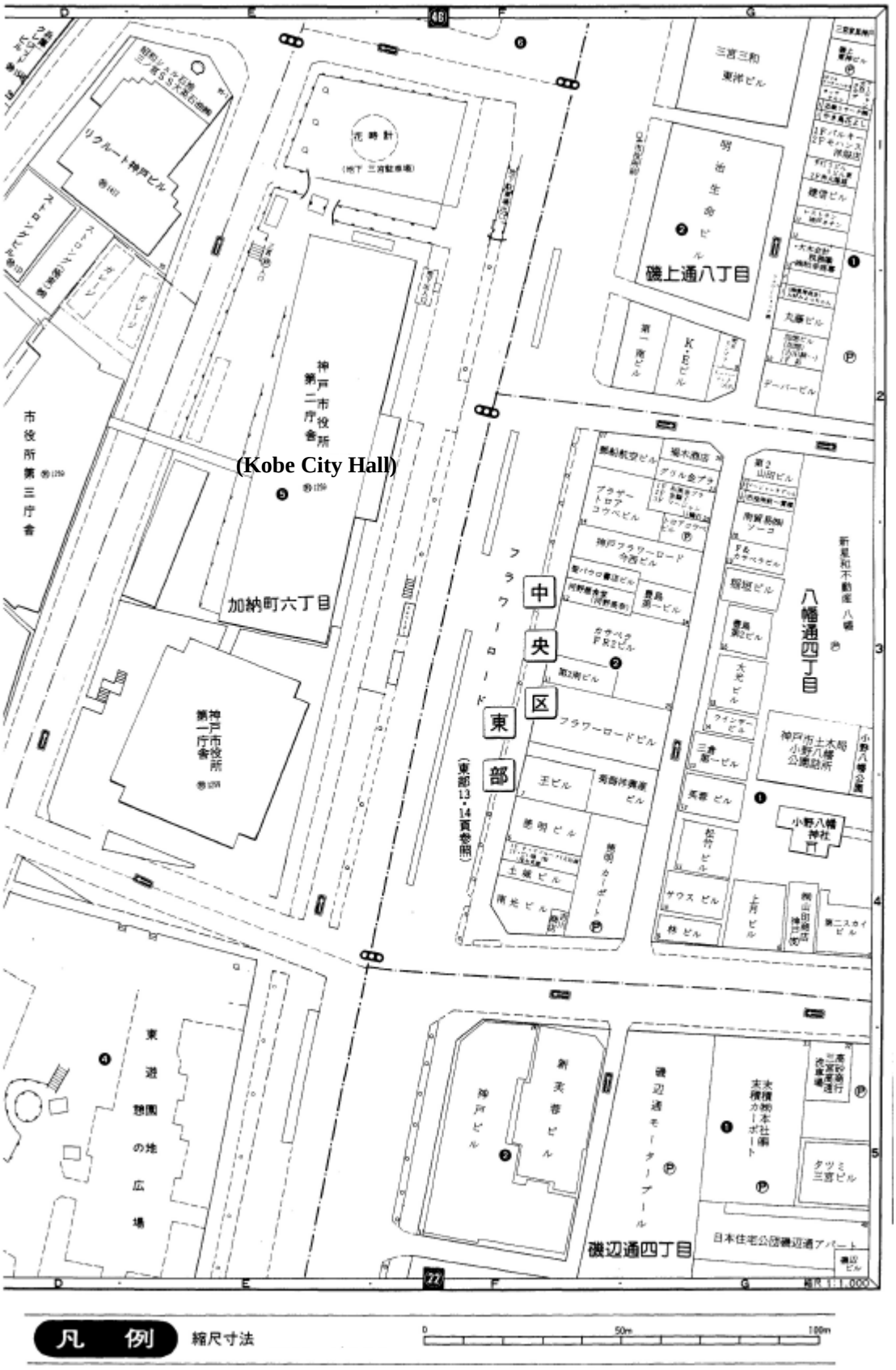


Fig.3.2.2-4 Example of House Map[3]

Kobe City Chuo-ward (East Part)

Total column should be filled in with figures

RC

Table 3.2.2-1 Quick Inspection Sheet for Reinforced Concrete Buildings and Steel Framed Reinforced Concrete Buildings[1]

Serial No.

Serial No. _____ Inspection date and hour _____ Time of Inspection _____
Name of the Inspector (county and prefecture / No.) _____ (_____/_____)
_____ (_____/_____)

Building No.

Outline of the building

1 Name of the building _____ 1.1 Building No. _____
2 Address of the building _____ 2.1 Serial No. in the residential district map ___
3 Use 1.Detached house 2.Tenement style 3.Apartment house 4.Dwelling house combined with other uses 5.Store 6.Office 7.Inn and Hotel 8.Public facilities such as a government building 9.Hospital and clinic 10.Day nursery 11.Factory 12.Warehouse 13.School 14.Gymnasium 15.Theater, amusement facilities 16.Others ( )
4 Type of Structure 1.Reinforced concrete 2.Pre-cast concrete 3.Concrete block 4.Steel framed reinforced concrete 5.Hybrid of ( ) and ( )
5 Number of stories Above ground _____ and underground _____
6 Size of the building Dimensions of the first floor [a]_____m × [b]_____m

Serial No. in the residential district map

3	
4	
Above ground	stories
Under-ground	stories
a	m
b	m

Inspection Inspection method:(1. Appearance inspection only 2. Appearance and internal visual inspection)

Inspection method

Inspection 1 The degree of danger judged at a glance (mark the appropriate items with a circle, judge the building to be dangerous, stop the inspection and skip to the comprehensive judgment).

1. Entire or partial collapse and fallen floors of the building	2. Significant destruction of the foundation and its significant displacement from the superstructure
3. Significant inclination of the building in whole or in part	4. Others ( )

1

Inspection 2 The degree of danger judged from the states of the adjacent buildings, the nearby ground, the building frames and other factors

		Rank A	Rank B	Rank C
Judgment (1)	①Whether there are members that suffered damage severer than damage level III	1. No	2. Yes	

Judgment (1) ①

Judgment (2)	②Presence of danger caused by destruction of the adjacent buildings and the nearby ground	1. No	2. Uncertain	3. Yes
	③Settlement of the entire building due to destruction of the ground	1. Less than 0.2 m	2. 0.2 m - 1.0 m	3. More than 1.0 m
	④Inclination of the entire building due to differential settlement	1. Less than 1/60	2. 1/60 - 1/30	3. More than 1/30
	Damage to columns [the floor (which suffered the most serious damage) through the inspecting for ⑤ and ⑥ below ( )] (if bearing wall structure is in use, the length of the wall is substituted for the number of columns)			
	⑤Number of columns that suffered damage level V ( ) / Number of columns inspected ( ) [Inspection rate (%)]	1. Less than 1 %	2. 1 %-10%	3. More than 10 %
	⑥Number of columns that suffered damage level IV ( ) / Number of columns inspected ( ) [Inspection rate (%)]	1. Less than 10 %	2. 10 %-20 %	3. More than 20 %
	Judgment (2)	1. Inspected (when all items are given Rank A)	2. Limited entry (when one of the items is given Rank B)	3. Unsafe (when one or more items are given Rank C, or when two or more items are given Rank B)

② ③ ④

The most seriously damaged floor

⑤ ⑥

Judgment (2)

Judgment of the degree of danger Judgment is determined by judgment (1) or judgment (2), whichever is greater	1. Inspected (internal visual inspection required)	2. Limited entry	3. Unsafe

Judgment

Inspection 3 The degree of danger caused by falling and shifting of objects

	Rank A	Rank B	Rank C
①Frame and glass of the window	1. Almost no damage	2. Deformation and cracks	3. Danger of falling
②Exterior finishing material (for wet construction)	1. Almost no damage	2. Partial cracking and crevices	3. Significant cracking and spalling
③Exterior finishing material (for dry construction)	1. Slight damage such as cracks in the joint	2. Crevices observed in the plate	3. Significant displacement of the joint and destruction of the plate
④Signboard and fitting	1. No tilt	2. A slight tilt	3. Danger of falling
⑤Exterior escape stair	1. No tilt	2. A slight tilt	3. A significant tilt
⑥Others ( )	1. Safe	2. Special attention required	3. Dangerous
Judgment of the degree of danger	1. Inspected (when all items are given Rank A)	2. Limited entry (when one or more item is given Rank B)	3. Unsafe (when one or more item is given Rank C)

① ② ③ ④ ⑤ ⑥

Judgment

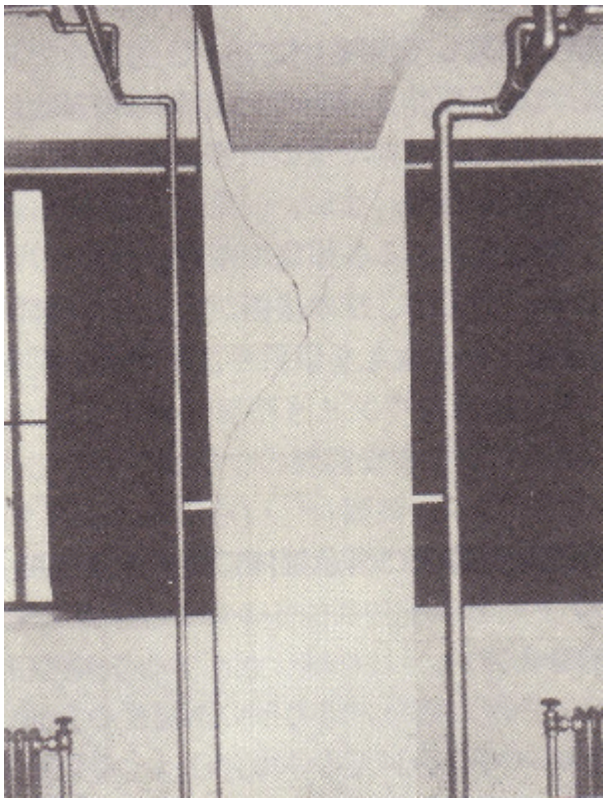
Comprehensive judgment (the building should be judged here to be dangerous if it was judged to be dangerous in Inspection 1; otherwise it should be judged according to the degree of danger in Inspection 2 or in Inspection 3, whichever is greater).

1. Inspected (green) 2. Limited entry (yellow) 3. Unsafe (red)

Comprehensive judgment

Comment (state whether danger is from the building frame, or from falling objects)

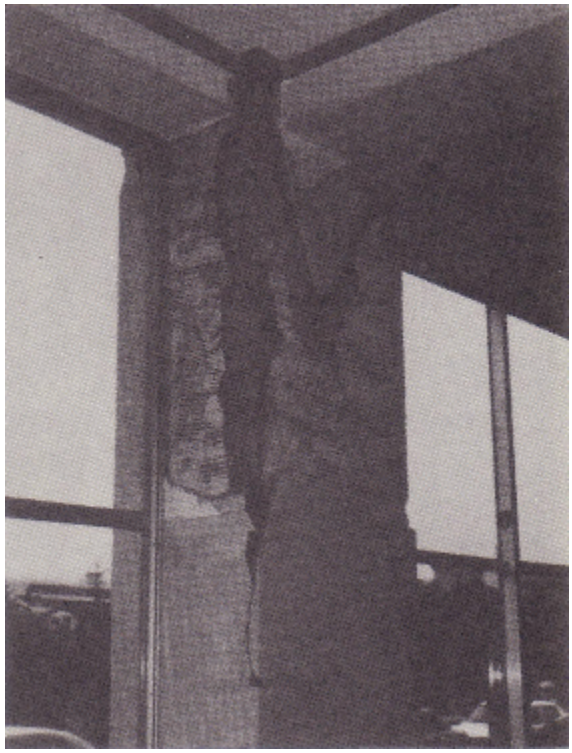
Note: comments should be the same as the notes written on stickers.



(a) About 2mm-wide X-shaped cracks on a column

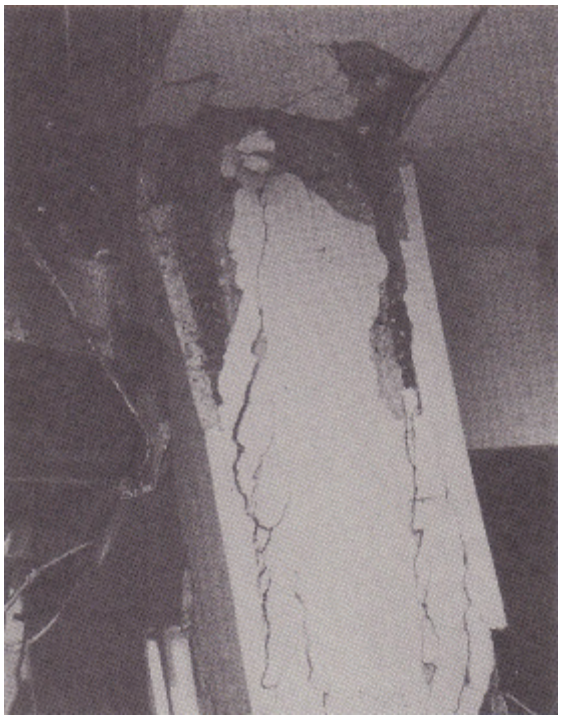
(b) Shear cracks on a short column at the left to right deformation is affected by the low wall on the right side

Photo 3.2.2-1 Example of damage level III



(c) A column that has not deformed with reinforcement bars exposed. Although a large volume of covering concrete has come off, the column concrete has not come off.

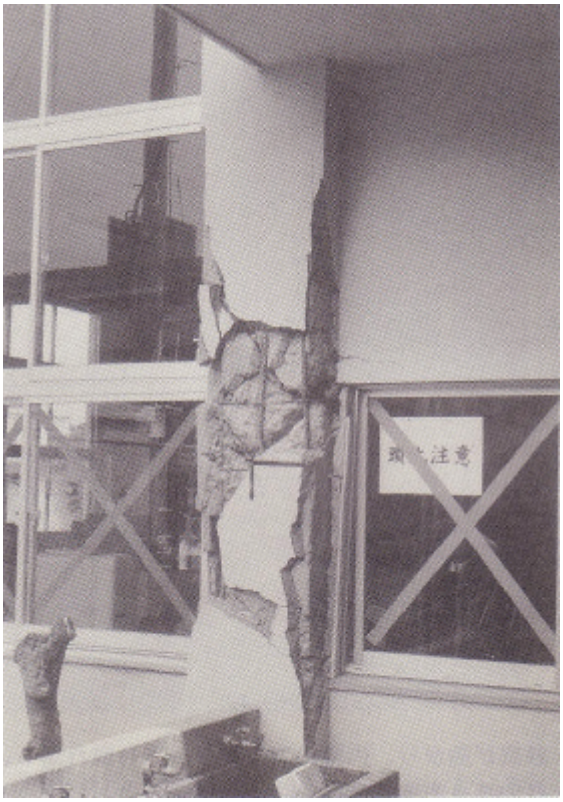
Photo 3.2.2-1 Example of damage level III (Cont.)



(a) The column capital concrete has come off and has exposed the vertical main reinforcement. It is exposed in a wide area with a large crack along the reinforcement that spread to the column center.

Photo 3.2.2-2 Example of damage level IV

(b) A large volume of concrete has come off and has exposed reinforcement bars in a wide area.



(c) A large volume of concrete has come off and has exposed reinforcement bars in a wide area. If the column has deformed in the vertical direction, the damage will be at the level V.

Photo 3.2.2-2 Example of damage level IV (Cont.)

(a) The reinforcement bars have bent and the concrete inside the column has collapsed. The column has deformed in the vertical direction.

(b) The column capital and base have fractured due to bending shear and have deformed the column in the vertical direction.

Photo 3.2.2-3 Example of damage level V

(c) See-through shear cracks on a wall; also the wall and column reinforcement bars are significantly bent.

Photo 3.2.2-3 Example of damage level V (Cont.)

Photo 3.2.2-4 Example of the sinking and tilt of an entire building.

Photo 3.2.2-5　Example of building tilting at 2 degrees or more

Example of the damage due to partial inclination that is caused by the fracture of first-floor columns

Photo 3.2.2-6　Example of the damage due to partial inclination

Example of the damage due to a large horizontal deformation caused by the damage of columns

Photo 3.2.2-7 Example of the damage due to partial inclination

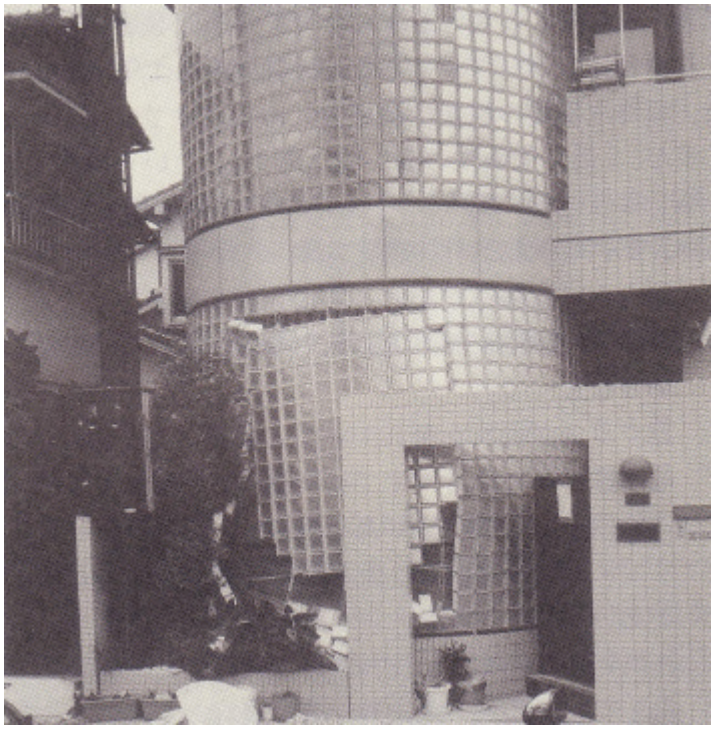


Photo 3.2.2-8 Example of a Rank C falling object

Table 3.2.2-2 Quick Inspection Sheet for Steel Buildings[1]

Total column should be filled in with figures

S

Serial No. _____ Inspection date and hour _____ Time of inspection _____
Name of the inspector (county and prefecture / No.) _____ (_____/_____)
_____ (_____/_____)

Serial No.

Building No.

Outline of the building

1 Name of the building _____ 1.1 Building No. _____
2 Address of the building _____ 2.1 Serial No. in the residential district map ___
3 Use 1.Detached house 2.Tenement style 3.Apartment house 4.Dwelling house combined with other uses 5.Store 6.Office 7.Inn and Hotel 8.Public facilities such as a government building 9.Hospital and clinic 10.Day nursery 11.Factory 12.Warehouse 13.School 14.Gymnasium 15.Theater, amusement facilities 16.Others ( )
4 Type of Structure 1.Rigid frame 2.Brace 3.Prefabrication 4.Others ( )
5 Number of stories Above ground _____ and underground _____
6 Size of the building Dimensions of the first floor ^{a}_____m×^{b}_____m

Serial No. in the residential district map

3

4

Above ground _____ stories

Under-ground _____ stories

a _____ m

b _____ m

Inspection Inspection method:(1. Appearance inspection only 2. Appearance and internal visual inspection)

Inspection method

Inspection 1 The degree of danger judged at a glance (mark the appropriate items with a circle, judge the building to be dangerous, stop the inspection and skip to the comprehensive judgment).

1. Entire or partial collapse and fallen floors of the building	2. Significant destruction of the foundation and its significant displacement from the superstructure
3. Significant inclination of the building in whole or in part	4. Others ( )

1

Inspection 2 The degree of danger judged from the states of the adjacent buildings, the nearby ground, the building frames and other factors

		Rank A	Rank B	Rank C	
①Presence of danger caused by destruction of the adjacent buildings and the nearby ground		1. No	2. Uncertain	3. Yes	①
②Inclination of the entire building due to differential settlement		1. Less than 1/300	2. 1/300 - 1/100	3. More than 1/100	②
③Inclination of the building in whole or in part					③
	When the number of floors above the floor where the inclination started is one or less	1. Less than 1/100	2. 1/100 - 1/30	3. More than 1/30	
	When the number of floors above the floor where the inclination started is two or more	1. Less than 1/200	2. 1/200 - 1/50	3. More than 1/50	
The most seriously damaged floor ( )	④Occurrence of buckling of member	1. No buckling	2. Local buckling	3. Overall buckling or significant local buckling	④
	⑤Rate of bracing rupture	1. Less than 20 %	2. 20 % - 50 %	3. More than 50 %	⑤
	⑥Rupture of the column-beam joint section and joint	1. No rupture	2. Partial rupture or cracks	3. Rupture of more than 20 %	⑥
	⑦Destruction of the column base	1. None	2. Partial	3. Significant	⑦
	⑧Occurrence of corrosion	1. Almost no corrosion	2. Significant corrosion in various places	3. Pores observed in various places	⑧
Judgment of the degree of danger		1. Inspected (when all items are given Rank A) (internal visual inspection required)	2. Limited entry (when three or less items are given Rank B)	3. Unsafe (when one or more items are given Rank C, or when four or more items are given Rank B)	Judgment

The most seriously damaged floor

Inspection 3 The degree of danger caused by falling and shifting of objects

	Rank A	Rank B	Rank C	
①Roofing material	1. Almost no damage	2. Significant displacement	3. Overall displacement and destruction	①
②Frame and glass of the window	1. Almost no damage	2. Deformation and cracks	3. Danger of falling	②
③Exterior finishing material (for wet construction)	1. Almost no damage	2. Partial cracking and crevices	3. Significant cracking and spalling	③
④Exterior finishing material (for dry construction)	1. Slight damage such as cracks in the joint	2. Crevices observed in the plate	3. Significant displacement of the joint and destruction of the plate	④
⑤Signboard and fitting	1. No tilt	2. A slight tilt	3. Danger of falling	⑤
⑥Exterior escape stair	1. No tilt	2. A slight tilt	3. A significant tilt	⑥
⑦Others ( )	1. Safe	2. Special attention required	3. Dangerous	⑦
Judgment of the degree of danger	1. Inspected (when all items are given Rank A)	2. Limited entry (when one or more items are given Rank B)	3. Unsafe (when one or more items are given Rank C)	Judgment

Comprehensive judgment (the building should be judged here to be dangerous if it was judged to be dangerous in Inspection 1; otherwise it should be judged according to the degree of danger in Inspection 2 or in Inspection 3, whichever is greater).

1. Inspected (green) **2. Limited entry (yellow)** **3. Unsafe (red)**

Comprehensive Judgment

Comment (state whether danger is from the building frame, or from falling objects)

Note: comments should be the same as the notes written on stickers.

Photo 3.2.2-9　Damage of the PC curtain wall of a 5-story, moment resisting frame structure office building

Photo 3.2.2-10　Yield and fracture of a beam end inside a 5-story, moment resisting frame structure office building

Photo 3.2.2-11　A building collapsed at low stories.

Photo 3.2.2-12　A building inclined to a large extent

Photo 3.2.2-13 Serious damage of piles

Photo 3.2.2-14 Danger of building site collapse

Photo 3.2.2-15 A building with the risk of collapse

Photo 3.2.2-16 Surrounding area of the building settled due to ground liquefaction

Photo 3.2.2-17　A building inclined due to the lateral flow of the ground (displacement of bulkhead)

Photo 3.2.2-18　A condominium inclined due to differential settlement

Photo 3.2.2-19 An inclined building

Photo 3.2.2-20 A building inclined at the 1st and 2nd floors only

Photo 3.2.2-21 A locally buckled column

Photo 3.2.2-22 A totally buckled column

Photo 3.2.2-23　Rupture of angle braces

Photo 3.2.2-24　Buckling of wide-flange-shaped braces

Photo 3.2.2-25 Rupture of a welded beam end

Photo 3.2.2-26 Rupture of a welded part between column and diaphragm

Photo 3.2.2-27　Displacement of a concrete column base of insufficient encasing height

Photo 3.2.2-28　Concrete below a column base plate that has lost its axial load supporting capacity.

Photo 3.2.2-29 Minor damage on an exposed column base

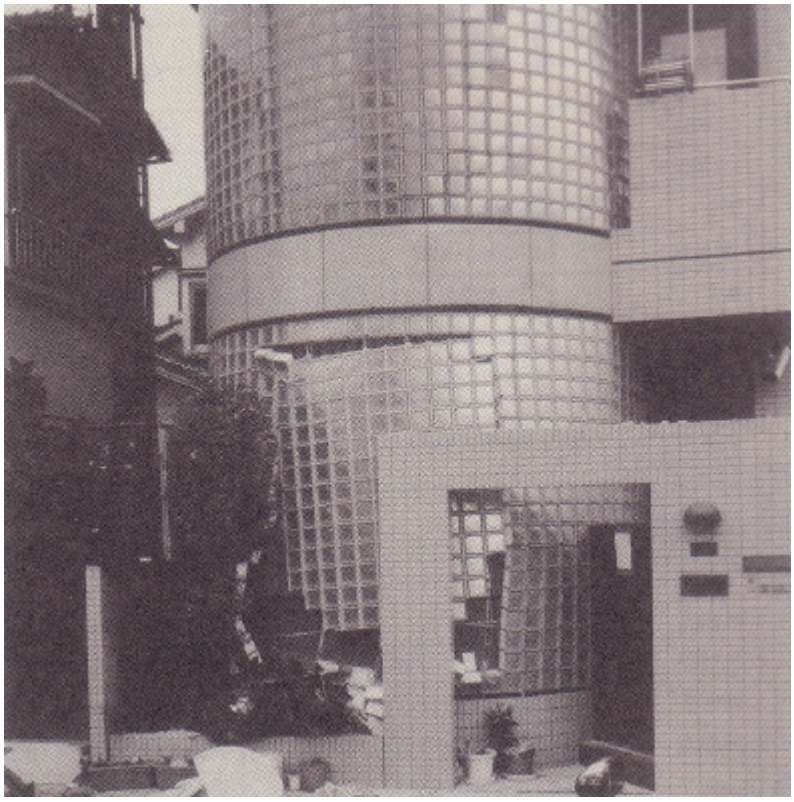


Photo 3.2.2-30 Example of Rank C falling object

Total column should be filled in with figures

W

Table 3.2.2-3 Quick Inspection Sheet for Wooden Buildings[1]

Serial No. _____ Inspection date and hour _____ Time of inspection _____

Name of the inspector (county and prefecture / No.) _____ (_____／_____)

_____ (_____／_____)

Serial No.

Building No.

Outline of the building

1 Name of the building _____ 1.1 Building No. _____

2 Address of the building _____ 2.1 Serial No. in the residential district map ____

3 Use 1.Detached house 2.Tenement style 3.Apartment house 4.Dwelling house combined with other uses 5.Store 6.Office 7.Inn and Hotel 8.Public facilities such as a government building 9.Hospital and clinic 10.Day nursery 11.Factory 12.Warehouse 13.School 14.Gymnasium 15.Theater, amusement facilities 16.Others ( )

4 Type of Structure 1.Conventional framework 2.Wood frame construction 3.Prefabrication 4.Others ( )

5 Number of stories 1.One-storied house 2.Two-storied house 3.Others ( )

6 Size of the building Dimensions of the first floor [a]_____m×[b]_____m

Serial No. in the residential district map

3

4

5

a m

b m

Inspection Inspection method:(1. Appearance inspection only 2. Appearance and internal visual inspection)

Inspection method

Inspection 1 The degree of danger judged at a glance (mark the appropriate items with a circle, judge the building to be dangerous, stop the inspection and skip to the comprehensive judgment).

1. Entire or partial collapse and fallen floors of the building	2. Significant destruction of the foundation and its significant displacement from the superstructure
3. Significant inclination of the building in whole or in part	4. Others ( )

1

Inspection 2 The degree of danger judged from the states of the adjacent buildings, the nearby ground, the building frames and other factors

	Rank A	Rank B	Rank C
① Presence of danger caused by destruction of the adjacent buildings and the nearby ground	1. No	2. Uncertain	3. Yes
② Inclination of the entire building due to differential settlement	1. None or slight	2. Significant falling in or rising up of the floor and the roof	3. Destruction of the roof truss and the settlement of the entire floor
③Damage to the base	1. None	2. Partial	3. Significant (with destruction)
④Tilt of the first floor of the building	1. Less than 1/60	2. 1/60 - 1/20	3. More than 1/20
⑤Damage to the walls	1. Slight cracks	2. Serious cracking and spalling	3. Danger of falling
⑥Corrosion and damage	1. Almost none	2. Partial chipping away of the section	3. Serious chipping away of the section
Judgment of the degree of danger	1. Inspected (when all items are given Rank A)	2. Limited entry (when one or more items are given Rank B)	3. Unsafe (when one or more items are given Rank C)

① ② ③ ④ ⑤ ⑥

Judgment

Inspection 3 The degree of danger caused by falling and shifting of objects

	Rank A	Rank B	Rank C
①Roofing tile	1. Almost no damage	2. Significant displacement	3. Overall displacement and destruction
② Frame and glass of the window	1. Almost no damage	2. Deformation and cracks	3. Danger of falling
③Exterior finishing material (for wet construction)	1. Almost no damage	2. Partial cracking and crevices	3. Significant cracking and spalling
④Exterior finishing material (for dry construction)	1. Slight damage such as cracks in the joint	2. Crevices observed in the plate	3. Significant displacement of the joint and destruction of the plate
⑤ Signboard and fitting	1. No tilt	2. A slight tilt	3. Danger of falling
⑥ Exterior escape stair	1. No tilt	2. A slight tilt	3. A significant tilt
⑦Others ( )	1. Safe	2. Special attention required	3. Dangerous
Judgment of the degree of danger	1. Inspected (when all items are given Rank A)	2. Limited entry (when one or more items are given Rank B)	3. Unsafe (when one or more items are given Rank C)

① ② ③ ④ ⑤ ⑥ ⑦

Judgment

Comprehensive judgment (the building should be judged here to be dangerous if it was judged to be dangerous in Inspection 1; otherwise it should be judged according to the degree of danger in Inspection 2 or in Inspection 3, whichever is greater).

1. Inspected (green) 2. Limited entry (yellow) 3. Unsafe (red)

Comprehensive Judgment

Comment (state whether danger is from the building frame, or from falling objects)

Note: comments should be the same as the notes written on stickers.

Photo 3.2.2-31 A scene of apparent unsafe

Photo 3.2.2-32 A scene of apparent unsafe

Photo 3.2.2-33 Differential settlement of a building (Rank A)

This mono-color photo is produced by BRI members.

Photo 3.2.2-34 Differential settlement of a building (Rank B)

Photo 3.2.2-35 Differential settlement of a building (Rank C)

This mono-color photo is produced by BRI members.

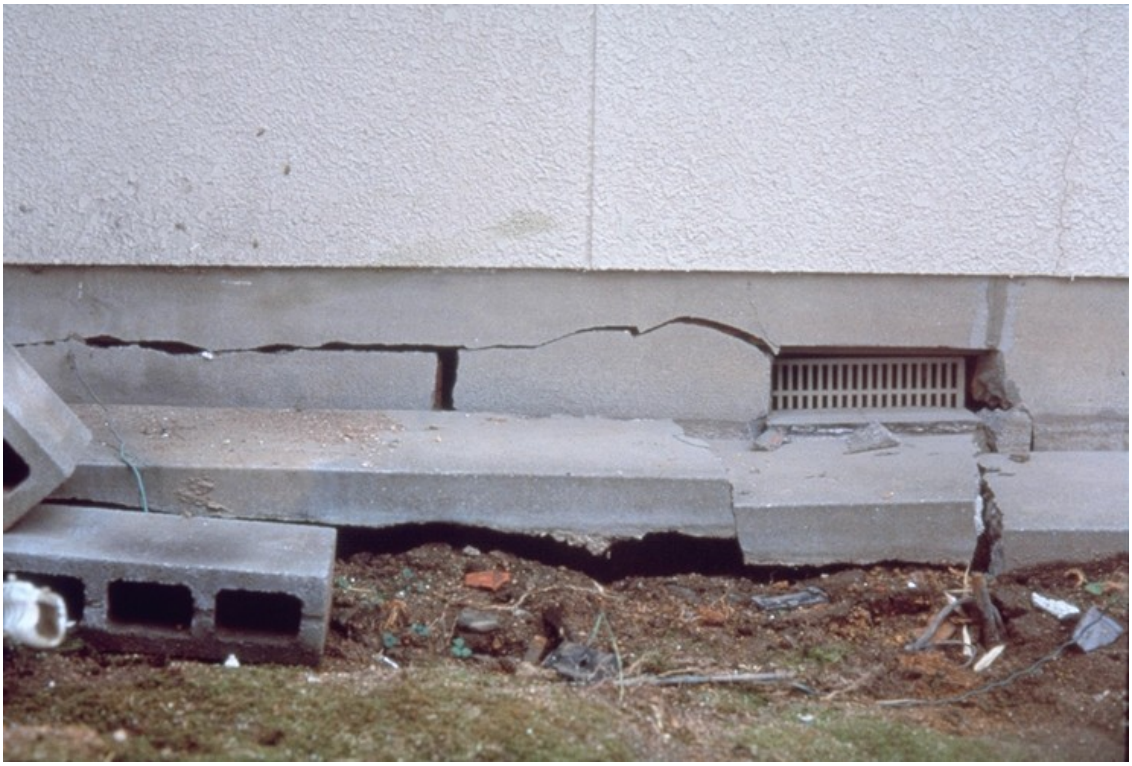


Photo 3.2.2-36 Damage on a foundation (Rank C)

Photo 3.2.2-37 Tilting of a building at the first floor (Rank B)

Photo 3.2.2-38 Tilting of a building at the first floor (Rank C)

Photo 3.2.2-39 Damage on a wall (exterior wall) (Rank B)

Photo 3.2.2-40 Damage on a wall (interior wall) (Rank B)

Photo 3.2.2-41 Damage on a wall (exterior wall) (Rank B)

Photo 3.2.2-42 Damage on a wall (exterior wall) (Rank B)

Photo 3.2.2-43 Damage on a wall (exterior wall) (Rank C)

Photo 3.2.2-44 Ant damage (Rank C)

Photo 3.2.2-45 Ant damage (Rank C)

Photo 3.2.2-46 An object that can fall (roof tile) (Rank C)

This mono-color photo is produced by BRI members.

Photo 3.2.2-47 An object that can fall (Rank B)

Photo 3.2.2-48 An object that can fall (Rank C)

Photo 3.2.2-49　An object that can overturn (block wall) (Rank C)

Other Example 1

[Rapid Evaluation Method in the United States][1]

1) Objective

The objective of Rapid Evaluation is to quickly, and with a minimum of manpower, inspect and evaluate buildings in the damaged area. Following a damaging earthquake, there is usually a scarcity of skilled manpower available to conduct building-by-building inspections. It has been the experience to date in California that most initial post event inspection are done by building inspectors from the local building department or from nearby communities. These individuals are employed by building departments to inspect construction, check plans, evaluate dangerous conditions, and perform similar tasks. As a rule, most building departments have many more building inspectors than structural plan checkers or structural engineers.

Rapid Evaluation is designed to utilize the talents and experience of building inspectors and other people with similar experience in construction. This does not, of course, preclude the possibility of using experienced structural engineers, architects, etc., to do initial evaluations.

Once all buildings in a given area have been inspected and those that are apparently safe or obviously unsafe have been posted, the remaining structures, the so-called gray-area buildings, are left for a Detailed Evaluation by a structural engineer. This approach conserves the generally limited structural engineering resources for those buildings that require more extensive visual examination and detailed knowledge of structural design to evaluate.

2) Qualifications of Damage Inspectors

The Rapid Evaluation method is designed for use by individuals with at least 5 years of experience in general building design, construction, or inspection. This includes building inspectors in particular as well as volunteer civil/structural engineers, architects, building contractors, and others who have been involved in the building design and construction process. While the procedures given in Section 3) are fairly general and the expertise of structural engineers is not

Table3.2.2-4 Basic Rapid Evaluation Criteria[1]

Condition	Posting
1. Building has collapsed, partially collapsed, or moved off its foundation	UNSAFE
2. Building or any story is significantly out of plumb	UNSAFE
3. Obvious severe damage to primary structural members, severe racking of walls, or other signs of severe distress present	UNSAFE
4. Obvious parapet, chimney or other falling hazard present	AREA UNSAFE
5. Large fissures in ground, massive ground movement, or slope displacement present	UNSAFE
6. Other hazard present (e.g., toxic spill, asbestos contamination, broken gas line, fallen power line)	UNSAFE or AREA UNSAFE

essential, it is desirable to use individuals familiar with the structural aspects of building construction. The damage inspectors need to have a basic familiarity with building construction so that structural damage or any unusual situations (e.g., cracks in the ground, falling hazards) can be readily recognized. Individuals with previous post earthquake building safety evaluation experience as well as those who have participated in special training programs will generally make excellent choices.

3) Rapid Evaluation Procedure and Criteria

This procedure begins with a reconnaissance of a damage area, or a suspected damage area. The general level of damage or lack of damage should be noted because this is often an important clue to the likelihood of finding damage and to its severity. When a building is selected for evaluation, Rapid Evaluation is done by first examining the outside of the structure. The inspector should walk around the entire structure, if this is possible. Ordinarily, only the exterior of the building is inspected at this time, unless there is a suspected or reported problem. This is done primarily to maximize the number of

inspections in the immediate post event period. If a building is clearly in an unsafe condition, it should not be entered.

Each building is evaluated using the six basic Rapid Evaluation criteria given in Table 3.2.2-4. These are used to rate the building's condition with respect to safety of occupants and the public.

The six criteria selected for the Rapid Evaluation process were chosen for being externally observable conditions or items of damage that, individually or collectively, are sufficient to warrant use of the Unsafe or, in the case of falling or other hazards, the Area Unsafe posting categories. Because the Rapid Evaluation process is designed to conserve anticipated limited manpower resources, the damage assessments are necessarily coarse. Inspectors are to look for readily observable, gross kinds of structural distress, such as partial collapse, leaning buildings, and partial chimney collapse. In addition, geotechnical conditions, such as slope movement, that threaten building safety are grounds for posting a structure Unsafe. A Rapid Evaluation form is given in the next page.

Buildings that are apparently safe are to be posted Inspected, and the Inspected placard is to be marked to indicate whether this inspection was "exterior" only or "exterior and interior". Generally, an initial Rapid Evaluation will be only of the exterior for reasons discussed above. If occupants report a problem, or if the building cannot be adequately viewed from the outside, or if a problem is suspected, the interior should also be inspected.

Unsafe buildings must be posted as soon as possible with the Unsafe placard and the occupants informed that they must leave the premises immediately. Placards must be placed at all entrances.

Because many structures will not fall easily into either the Inspected (i.e., apparently safe) or Unsafe classifications, the third posting classification, Limited Entry, will also have to be used. This is to be used when the level of safety concern is doubtful and the structure's condition is neither apparently safe nor obviously unsafe.

Table3.2.2-5 Rapid Evaluation Inspection Procedure[1]

1. Examine the entire outside of the structure.
2. Examine the ground in the general area of the structure for fissures, bulged ground, or signs of slope movement.
3. Ordinarily enter a building only when the structure cannot be viewed sufficiently from the outside or when there is suspected or reported problem such as gross nonstructural distress (e.g., fallen ceiling or badly damaged partitions visible from the outside). Do not enter obviously unsafe structures.
4. Evaluate the structure using the six criteria (Table 3.2.2-4), and complete the Rapid Evaluation form. Doubtful buildings should be slated for Detailed Evaluation. Make sure exitways are clear.
5. Post the structure according to the results of the evaluation. Use one of the three placards (Inspected, Limited Entry, or Unsafe). On the Inspected placard, indicate whether only the "exterior" or the "exterior and interior" was inspected by checking the appropriate box. Post every entrance to a building classified Limited Entry or Unsafe.
6. Explain the significance of Limited Entry or Unsafe postings to building occupants, and advise them to leave immediately. Areas designated Area Unsafe must also be evacuated.

Limited Entry placards are to be placed at each entrance, and the occupants informed of the significance of the damage. Generally, entry is permitted only for emergency purposes, and this will be indicated on the placard. A structure designated Limited Entry must be given a subsequent Detailed Evaluation, and this requirement is indicated by the damage inspector on the Rapid Evaluation form.

The entire Rapid Evaluation procedure is summarized on Table3.2.2-5.

References

[1] ATC20, Procedures for Post-earthquake Safety Evaluation of Buildings, Applied Technology Council, 1989.

[2] ATC20-1, Addendum to the ATC20 Post-Earthquake Building Safety Evaluation Procedure, Applied Technology Council, 1995.

Table 3.2.2-6

ATC-20 Rapid Evaluation Safety Assessment Form[1]

Block_____ Parcel No._____

BUILDING DESCRIPTION:

Name: _____

_____

Address: _____

_____

No. of stories: _____

Basement: Yes ☐ No ☐ Unknown ☐

Primary Occupancy: Dwelling ☐
Other Residential ☐ Commercial ☐ Office ☐
Industrial ☐ Public Assembly ☐ School ☐
Government ☐ Emer. Serv. ☐ Historic ☐
Other_____

OVERALL RATING: *(Check One)*

INSPECTED (Green) ☐
___ Exterior only
___ Exterior and Interior
LIMITED ENTRY (Yellow) ☐
UNSAFE (Red) ☐

INSPECTOR:

Inspector ID_____

Affiliation _____

INSPECTION DATE:

Mo/day/year_____

Time _____ am pm

Instructions: Review structure for the conditions listed below. A "yes" answer to 1, 2, 3, or 5 is grounds for posting entire structure UNSAFE. If more review is needed, post LIMITED ENTRY. A "yes" answer to 4 requires posting AREA UNSAFE and/or barricading around the hazard. Hazards such as a toxic spill or an asbestos release are covered by 6 and are to be posted and/or barricaded to indicate AREA UNSAFE.

Condition	*Yes*	*No*	*More Review Needed*
1. Collapse, partial collapse, or building off foundation	☐	☐	☐
2. Building or story noticeably leaning	☐	☐	☐
3. Severe racking of walls, obvious severe damage and distress	☐	☐	☐
4. Chimney, parapet or other falling hazard	☐	☐	☐
5. Severe ground or slope movement present	☐	☐	☐
6. Other hazard present	☐	☐	☐

Recommendations:

☐ No further action required
☐ Detailed Evaluation required (circle one) Structural Geotechnical Other_____
☐ Barricades needed in the following areas: _____
_____
☐ Other: _____

Posted at this Assessment: ☐ Yes ☐ No

Comments: _____
_____
_____
_____
_____
_____

Other Example 2

Damage classification forms[1] in Turkey are shown in the following pages. These forms were proposed by the Specialist Team of Japan International Cooperation Agency to Turkey government, at the time of the Izmit, Turkey Earthquake of August 17, 1999. Other forms proposed by the local government in Turkey were also used.

Reference

[1] Fumitoshi Kumazawa, Takashi Kaminosono, Yoshiaki Nakano; “Quick Inspection Procedure Applicable to RC Buildings in Turkey,” Proceedings of the Third Japan-Turkey Workshop on Earthquake Engineering, pp.400-402, 21-25 Feb. 2000.

[Quick Inspection Method in Turkey]

INSPECTION SHEET 1/3

Table 3.2.2-7

QUICK INSPECTION OF DAMAGED BUILDINGS (REINFORCED CONCRETE STRUCTURES) [1]

STEP 0 ID Code : _____ Number of Inspections : _____

Time and Date of Inspection : ____ : ____, 1999 / Mon._____ / Day_____

Name of Inspector(s) (Affiliation / ID Number)

_____ (_____ / _____)

_____ (_____ / _____)

DESCRIPTION OF INSPECTED BUILDING

1. Address : _____
2. Contact Person: _____ TEL: _____
3. Building Use : 1. Apartment House, 2. Individual House, 3. Residence with Commercial Use, 4. Office, 5. Others (_____)
4. Type of Partitioning Walls : [ ] Hollow Brick [ ] Solid Brick [ ] RC wall [ ] Other (_____)
5. Number of Stories: Basement _____ + Ground Story _____+ Upper Stories _____

STEP 5 **SUMMARY** ***(Complete the sheet on the following pages and then summarize results below.)***

OVERALL RATING:

[ ] INSPECTED	[ ] LIMITED ENTRY	[ ] UNSAFE
Original lateral resistance is not significantly degraded, and temporary use or occupancy is allowed.	Temporary use is not allowed unless retrofit to prevent damage progress, repair to remove life-threatening hazards and/or barricades around hazard striking area(s) are made. Detailed assessment may be needed.	Emergency retrofit to prevent sudden collapse is needed, but entry and temporary use are not allowed. Detailed assessment needed.

RECOMMENDATIONS:

[ ] Shoring / bracing / jacketing needed in the following area(s): _____

_____

[ ] Removal of falling and/or overturning hazard(s) needed in the following area(s): _____

_____

[ ] Barricade / off-limits needed in the following area(s): _____

_____

[ ] Other(s) (area(s):_____): _____

_____

COMMENTS:

_____

_____

_____

_____

Table 3.2.2-7 (Cont.)

INSPECTION SHEET 2/3

INSPECTIONS

STEP 1 **Inspection 1.** General Inspection of Entire Building

If a building is obviously unsafe due to following damage, mark the corresponding reason(s), identify the building "UNSAFE" and check as such in SUMMARY on the first page. (Inspections 2 and 3 can be skipped.)

[ ] Total or Partial Collapse	[ ] Extensive Damage to and/or Remarkable Offset of Superstructure from Foundation
[ ] Remarkable Inclination of Entire Building or Individual Story	[ ] Other(s) _____

STEP 2 **Inspection 2.** Hazard from Damage to Adjacent Buildings, Surrounding Ground and Structural Members

	A	B	C
a. Hazard Resulting from Damage to Adjacent Buildings or Surrounding Ground Failure	[ ] No	[ ] Uncertain	[ ] Yes
b. Settlement of Buildings due to Ground Failure	[ ] <0.2 m	[ ] 0.2-1.0m	[ ] >1.0 m
c. Inclination of Buildings due to Differential Settlement	[ ] < 1/60 rad.	[ ] 1/60-1/30 rad. (seemingly inclined)	[ ] > 1/30 rad. (easily noticeable)
d. Damage to Columns ***1. Inspect the most seriously damaged story, sketch building and count damaged columns as indicated at the bottom of this page, and then fill up the following d-1 and d-2.*** ***2. If no serious damage to a column but some to beams and/or beam-column joints is found above or below the column, take it into account of damage to the column.***			
d-1. Ratio of Damage IV or V [(1)/(3)x100] _____ %	[ ] < 1/100 (1 %)	[ ] 1/100 - 1/10 (1 % - 10 %)	[ ] > 1/10 (10 %)
d-2. Ratio of Damage III [(2)/(3)x100] _____ %	[ ] < 1/8 (12.5 %)	[ ] 1/8 - 1/4 (12.5% - 25%)	[ ] > 1/4 (25 %)

Structural Safety Judgement from a. to d.	[ ] INSPECTED* (only A)	[ ] LIMITED ENTRY (B ≥ 1 but C = 0)	[ ] UNSAFE (C ≥1 or B ≥ 2)

**** Either Interior Inspection or Interview needed as a general rule***

[SKETCH : *If a column shape is rectangular, sketch as such.*]	**Inspected story : _____**
	(1) Number of damage rank IV or V _____
	(2) Number of damage rank III _____
	(3) Number of inspected columns _____
	(4) Number of total columns _____
	(5) Inspected Ratio of columns [(3)/(4) x 100] ____ %
	1. Sketch building configuration and column location of the

Table 3.2.2-7 (Cont.)

INSPECTION SHEET 3/3

STEP 3

inspected story in the left box.
2. Find out columns with damage rank ≥ III and indicate them.

Inspection 3. Falling and/or Overturning Hazards

	A	B	C
e. Framed Nonstructural Wall [ ] Hollow Brick [ ] Solid Brick [ ] Concrete Block	[ ] No or slight damage	[ ] Cracks observed but no out-of-plane deformation	[ ] Extensive cracks penetrated, offset from boundary members or out-of-plane deformation
f. Unframed Nonstructural Wall [ ] Hollow Brick [ ] Solid Brick [ ] Concrete Block	[ ] No damage	[ ] Slight damage	[ ] Diagonal cracks observed
g. Wooden Roof	[ ] No damage [ ] Unknown	[ ] Some damage observed but no falling hazards present	[ ] Noticeable inclination, deformation or separation from top story
h. Stairways [ ] Interior [ ] Exterior	[ ] No or slight damage [ ] Unknown	[ ] Extensive cracks observed but stair rebars are anchored	[ ] Noticeable inclination / separation from connected members and rebar anchorage missing or uncertain
i. Window Frame and Windowpane	[ ] No or slight damage	[ ] Visible deformation and/or cracks	[ ] Likely to fall down
j. Finishings [ ] Plaster [ ] Mortar	[ ] No damage	[ ] Partial crack or separation	[ ] Remarkable crack and/or separation
k. Elevated Water Tank, Chimney, Signboard, Machinery etc.	[ ] No inclination [ ] Unknown	[ ] Slight inclination	[ ] Likely to fall down
l. Other Hazard(s) ( )	[ ] No damage	[ ] Damage observed	[ ] Life-threatening

STEP 4			
	Nonstructural Safety Judgement from e. to l.	[ ] INSPECTED* (Only A and/or B)	[ ] LIMITED ENTRY (C ≥ 1)

**** Either Interior Inspection or Interview needed as a general rule***

SUB-SUMMARY on Inspections 2 and 3

Inspected Areas	[ ] Exterior only	[ ] Exterior & Interior(or Interview)

1. Check one in Inspections 2 and 3, and then choose the highest rating among them as the OVERALL RATING.

	INSPECTED	LIMITED ENTRY	UNSAFE
Inspection 2 (Structural Safety)	[ ]	[ ]	[ ]
Inspection 3 (Nonstructural Safety)	[ ]	[ ]	---
OVERALL RATING *Check the highest rating among Inspections above.*	[ ]*	[ ]	[ ]

**** Either Interior Inspection or Interview is needed as a general rule.***

2. Following the above results, fill up SUMMARY on the first page. If B or C Rank for falling and/or overturning hazards (questions e. through l.) exists, describe your recommendations and comments in SUMMARY on the first page.

3.2.3. Damage Classification[1]

This section mainly presents the method of damage classification in Japan. The methods in the U.S. and Italy are attached as Other Example 1 and 2, respectively, at the end of the section.

To evaluate the safety of damaged buildings for permanent use, the class of damage shall be judged during a period from the 7th to 60th days, or for a longer period depending on the disaster level, after an earthquake has occurred. This involves doing a detailed survey to classifying the damage as slight damage, light damage, moderate damage, major damage and collapse. The survey is of the external appearance and inside of the object building and is done by building construction engineers according to the request of the building owner.

1) Definition and purpose of damage classification

The damage classification is for building construction engineers to enter the object building damaged by an earthquake to inspect its settlement, inclination, and damage of structure, classify the damage as one of the above five levels, and judge whether restoration work is necessary for continued use.

Immediately after an earthquake, building construction engineers do both of the following:

(1) Judge the danger of the object building to collapse or that of the objects attached thereto to fall down or overturn at aftershocks, post a sticker to indicate "unsafe", "limited entry", or "inspected", and provide the building owner and third party pedestrians with the information whether entry is allowed, in order to avoid danger as part of "quick inspection", and

(2) Assess the class of damage of the structure of the damaged building as a next step and judge whether restoration work is necessary for continued use based on the result of the " damage classification ".

The above steps are to expedite the restoration of damaged buildings and disaster area.

Major objects of the damage classification are the buildings judged as "unsafe" or "limited entry" due to structural damage by the quick inspection or those buildings judged as damaged equally or more seriously by other technological judgment. In addition, the degree of danger of the buildings judged as "inspected" is also judged in principle if the owner continues to use or permanently uses the building. This is because the result of the quick inspection, which is mainly based on an appearance inspection during a short period of time immediately after the earthquake, may change when the damage is

inspected more thoroughly at a later date.

In the damage classification, the earthquake-resistance capability remained with the object building or the residual aseismic performance ratio R (%) is assessed. R is an indication introduced into this criterion to express the ratio between the aseismic performance levels before and after the building is damaged; it is estimated based on the damage of the structure to judge whether restoration work is necessary for continued use. Because this requires expert knowledge of building structure, the class of damage is normally judged by building construction engineers (Class 1 registered architects, Class 2 registered architects, and registered architects for wooden buildings).

For each structural type, such as reinforced concrete, steel framed reinforced concrete, steel structure and wooden structures, a criterion on damage classification and guideline for restoration technology are prepared. Then, a procedure based on the class of damage of the building, the residual aseismic performance ratio R and the seismic intensity scale in the area is used to judge the necessity or degree of required restoration work. Inspectors use the announced seismic intensity scale or determine a scale when seismic intensity in the area concerned can be judged based on the actual ground conditions, disaster situation and the scale of seismic intensity in the neighboring areas. There are generally directions involved in the intensity of earthquake ground motion and structural characteristics (strength and toughness) of buildings. The ground motion sometimes works favorably on buildings to reduce damage depending on the combination of dominant directions. In such a case, therefore, it is important to carefully judge the necessity and degree of restoration work.

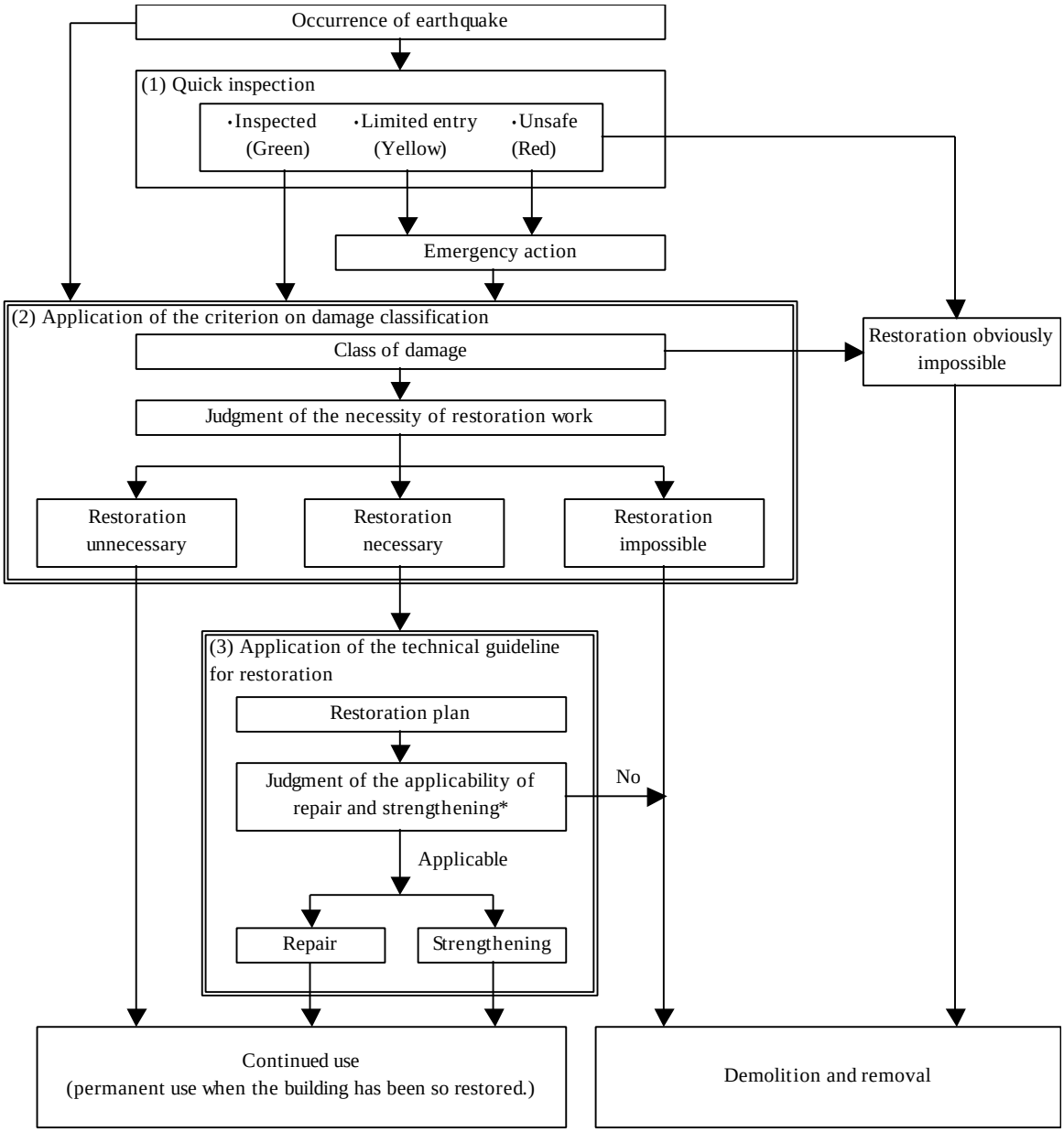
2) Significance and the procedure for restoration from disaster

To restore damaged buildings promptly, it is extremely important for construction engineers, facility owners, and building managers to thoroughly discuss restoration strategies in advance and prepare a restoration procedure. Fig. 3.2.3-1 shows an example of the procedure for restoration from disaster. As seen in the figure, there are normally several ordered stages in the restoration procedure.

(1) 1st stage (immediately after the occurrence of disaster): Quick inspection (survey of the safety against aftershocks)

(2) 2nd stage (after the confusion is calmed to some extent): Damage classification (survey of the class of damage and the necessity of restoration work)

(3) 3rd stage (during the stabilized period): Restoration plan and work



* The possibility of restoration shall be comprehensively judged from the technological viewpoint while taking into consideration economy and possibility of performing restoration work

Fig. 3.2.3-1 Example of a flow of restoration work from a disaster.[1]

As different aspects should be judged in different ways, the flow will become more complicated in actuality depending on the magnitude of disaster and structure type. It shall be noted that until the restoration of damaged buildings is completed, the aseismic performance available for permanent use is not guaranteed, and it is only a temporary measure to use the damaged buildings for the time being. Even if it is judged possible to repair a slightly damaged building for continued use, it shall be retrofited to ensure the

earthquake resistance stipulated in the law (hereinafter referred to as the "aseismic retrofitting expedition act").

The following are the definition of each item in the flow in Fig. 3.2.3-1 and items to be noted.

• Quick inspection: The quick inspection is to inspect the structure and building frames of the object building, its periphery and risky objects to fall or overturn, and judge whether the use of the building shall be limited to prevent secondary disasters due to aftershocks.

• Temporary measure: The temporary measure is to install temporary support members to prevent the collapse of buildings or prevent damage from propagating on buildings, members, and parts judged as "unsafe" (with a red sticker) or "limited entry" (with a yellow sticker) by the quick inspection or judged as equivalent with regard to the degree of danger by other technical standards. This also involves removing objects that could fall or overturn, take protective measures, and set entry prohibited areas.

• Restoration: Restoration is to recover or improve the structural performance, durability, and functions of buildings damaged by an earthquake, including the following repair and strengthening.

• Repair: Repair is to recover the structural performance of damaged buildings to the original level (before the disaster).

• Strengthening: Strengthening is to improve the structural performance above the original level (before the disaster).

• Continued use: Continued use is to use damaged buildings temporarily by applying repair, strengthening, and other measures for the period until permanent use is approved.

• Permanent use: Permanent use is to use damaged buildings for a long period of time after applying permanent restoration measures.

3) Scope of application and items to be noted

The criterion on damage classification and technical guideline for restoration are prepared for each structure type. However, there are buildings of special construction, which are different from the conventional construction method, that are built for special purposes after deliberate discussions. Because such special buildings have few experiences of earthquake damage and thus one has little knowledge of the method to judge the damage level, this criterion does not assume the judgment on such buildings. If such buildings have been damaged by an earthquake, a special team shall be organized including design engineers of the building, therefore, to judge the damage level. The following are structure types out of the scope of this criterion. See relevant provisions for more information on each

type.

- High-rise building
- Long-span structure
- Traditional construction for shrines and temples

The relevant criterion shall be applied to each part of buildings that have mixed structures, such as indoor gymnasiums whose substructure is composed of concrete and superstructure or roof is made of steel. A number of buildings at the 1995 Hyogo-ken Nanbu earthquake had damage to their joint between the above two parts. The damage caused the anchor bolts to slip off or the concrete to come off. The damage level at the joint and the method of restoration should be determined according to the criterion of damage classification and guideline for the restoration for steel structure buildings.

In addition, different earthquakes often occur in the same area with magnitudes equal to or a larger than that of the first earthquake that occurred a little earlier; however, they are not regarded as aftershocks in terms of seismology. Recent, well-known, typical combinations of an earthquake and a subsequent earthquake that was larger in scale and damage are the Miyagiken-oki Earthquake in February 1978 (M6.7) and the later earthquake at the same place in June 1978 (M7.4), and the Kagoshimaken-Hokuseibu Earthquake in March 1997 (M6.2) and the later Kagoshima Prefecture Satsuma area earthquake (M6.3) in May 1997. As referred to above, it shall be noted that the restoration of damaged buildings after an earthquake does not necessarily guarantee the aseismic performance for permanent use because it is only a temporary measure to use the damaged buildings for the time being. Even if it is possible to repair a slightly damaged building for use, it is requested to confirm that the restored building satisfies the aseismic performance stipulated in the Aseismic Retrofitting Expedition Act, and appropriately retrofit it to guarantee permanent use in case it does not.

In the following pages, mono-color photos and full-color photos are presented. Generally, the mono-color photos are quoted from Reference [1]. And the full-color photos are produced by the members of Building Research Institute, Ministry of Construction, until 1995.

References

[1] "Damage classification method for damaged buildings post-earthquake and seismic retrofit guideline", The Japan Building Disaster Prevention Association, Sept. 2001. (in Japanese)

Table 3.2.3-1 Investigation Sheet for Judging the Class of Damage to Reinforced Concrete Buildings and Steel Framed Reinforced Concrete Buildings[1]

Serial No.: _____ Inspection date and hour: _____
Time of inspection: _____ Inspector: _____
Inspector's position: _____

1. Outline of the building

1.1 Name of the building: _____
1.2 Address of the building: _____
1.3 Owner of the building: _____ Address for contact: _____
1.4 Person for contact: _____ Address for contact: _____
1.5 Use (Choice of multiple items allowed):
☐Office ☐Housing ☐Apartment ☐Store ☐Factory ☐Warehouse ☐School ☐Day nursery
☐Government building ☐Public hall ☐Gymnasium ☐Hospital ☐Others ( )
1.6 Type of structure: ☐Reinforced concrete ☐Pre-cast concrete ☐Concrete block
☐Steel framed reinforced concrete ☐Hybrid structure of ( ) and ( )
1.7 Structural form: ☐Rigid frame ☐Bearing wall ☐Others ( )
1.8 Structure of the foundation: ☐Spread foundation ☐Piling foundation (Type:)
1.9 Size of the building:( ) stories above and ( ) stories under the ground, penthouse (stories)
Dimensions of the first floor: about (m)×(m)
1.10 Geographical features of the site: ☐Flat ☐Slope ☐Plateau ☐Basin ☐Others ( )
1.11 Surrounding geographical features of the site: The site is (m) away from a precipice, (m) away from a river, the sea, a lake or a swamp (Note: no entry is needed when the distance to each feature is 50 m or more)
1.12 Exterior finish (Choice of multiple items allowed):
☐Fair-faced concrete ☐Mortar ☐Tile ☐Stone pitching ☐Curtain wall
☐PC plate ☐ALC plate ☐Block ☐Others ( )
1.13 Drawings and specifications Structural calculation sheet: ☐Retained ☐Not retained
Drawings for design presentation: ☐Retained ☐Not retained
Construction record: ☐Retained ☐Not retained
1.14 Construction date Year ( ) (☐1971 or earlier ☐1972 or later ☐unknown)

2. Class of damage

2.1 Judgment based on the collapse of the building and the falling in of its floors

Whether the collapse or the falling occurred:
☐Yes (Proceed to 2.3, omit calculation, and classify the damage to the superstructure as "collapse") ☐No (move to 2.2)

2.2 Judgment based on the settlement and the inclination of the foundation

Damage to the foundation
Whether the pile was damaged: ☐Yes ☐No ☐unknown Whether liquefaction of the ground occurred: ☐Yes ☐No ☐unknown

① Settlement of the foundation S =_____m

② Inclination of the foundation q_x =_____rad. q_y =_____rad. $q = \sqrt{{q_x}^2 + {q_y}^2}$ =_____rad.

(0.01 rad. = 0.573 degree, 1 degree = 0.01745 rad.)

Table 1
Class of damage to the building with the piling foundation

		Settlement of the foundation (m) 0	0.1	0.3	
Inclination of the foundation	1/300	No damage	Light damage	Moderate damage	※
	1/150	Light damage	Moderate damage	Moderate damage	Major damage
	1/75	Moderate damage	Moderate damage	Major damage	Major damage
		Major damage	Major damage	Major damage	Major damage

Table 2
Class of damage to the building with the spread foundation

		Settlement of the foundation (m) 0.05	0.1	0.3	
Inclination of the foundation	1/150	No damage	Light damage	※	※
	1/75	Light damage	Moderate damage	Moderate damage	※
	1/30	Moderate damage	Moderate damage	Major damage	Major damage
		Major damage	Major damage	Major damage	Major damage

※:Excluded from the assumption as it requires a detailed inspection.

Class of damage by the settlement and the inclination of the foundation
☐No damage ☐Light damage ☐Moderate damage ☐Major damage

2.3 Judgment based on the residual aseismic performance ratio R of the superstructure

① The most seriously damaged floor and the direction of the damage
Floor ( ) Direction: ☐Direction of the short side ☐Direction of the long side

② Necessity of zoning: ☐Unnecessary (judgment is made from the entire building)
☐Necessary (judgment is made from zone to zone with zones shown in a floor plan or the like)

Table 3.2.3-1 (Cont.)

③ The result of inspection of the damage level of structural members
*Enter the appropriate number of columns or walls in parentheses and total them.
With regard to the "wall with the double-side column", one span of the wall should be counted as one wall.

	Shearing column	Bending column	Wall with no column	Wall with the single-side column	Wall with the double-side column	Total	
Total of members	( ) +	( ) +	( ) +	( ) +	( ) =	( )	
Number of members inspected	( )① +	( )② +	( )③ +	( )④ +	( )⑤ =	( )	
	①×1 +	②×1 +	③×1 +	④×2 +	⑤×6 =	( )	$= A_{org}$
Damage level 0	( ) +	( ) +	( ) +	( )×2 +	( )×6 =	( )	$= A_0$
Damage level I	( )×0.95 +	( )×0.95 +	( )×0.95 +	( )×1.9 +	( )×5.7 =	( )	$= A_1$
Damage level II	( )×0.6 +	( )×0.75 +	( )×0.6 +	( )×1.2 +	( )×3.6 =	( )	$= A_2$
Damage level III	( )×0.3 +	( )×0.5 +	( )×0.3 +	( )×0.6 +	( )×1.8 =	( )	$= A_3$
Damage level IV	( )×0 +	( )×0.1 +	( )×0 +	( )×0 +	( )×0 =	( )	$= A_4$
Damage level V	( )×0 +	( )×0 +	( )×0 +	( )×0 +	( )×0 =	0	$= A_5$

$$\sum A_j = A_0 + A_1 + A_2 + A_3 + A_4 + A_5 = (\quad)$$

④ Residual aseismic performance ratio R

$$R = \frac{\sum A_j}{A_{org}} \times 100 = \frac{(\quad)}{(\quad)} \times 100 = (\quad)$$

Class of damage by the residual aseismic performance ratio R of the superstructure
☐No damage ($R = 100$) ☐Slight damage ($95 \le R < 100$) ☐Light damage ($80 \le R < 95$)
☐Moderate damage ($60 \le R < 80$) ☐Major damage ($R < 60$) ☐Collapse (R can be considered almost 0 because of the collapse of the building and the falling in of its floors)

3. Damage to other parts

Damage to accessory structures (when damaged, enter in the blanks the damage conditions, dangerous places and whether action should be taken)

☐Floor slab:	☐Not damaged	☐Damaged (_____)
☐Penthouse:	☐Not damaged	☐Damaged (_____)
☐Exterior escape stair:	☐Not damaged	☐Damaged (_____)
☐Roof-top chimney:	☐Not damaged	☐Damaged (_____)
☐Connecting corridor:	☐Not damaged	☐Damaged (_____)
☐Expansion joint:	☐Not damaged	☐Damaged (_____)
☐Others ( ):	☐Not damaged	☐Damaged (_____)

4. Judgment of the necessity of the restoration

Announced seismic intensity scale: ☐VI-plus or higher ☐VI-minus ☐V-plus ☐V-minus or lower (Detailed inspection required)

Table 3 Necessity to restore the foundation

Class of damage / Seismic intensity scale	Light damage	Moderate damage	Major damage
V-minus or lower	×	×	×
V-plus	△	×	×
VI-minus	○	△	×
VI-plus or higher	○	○	△

Table 4 Necessity to urgently restore the superstructure

Class of damage / Seismic intensity scale	Slight damage $95 \le R < 100$	Light damage $80 \le R < 95$	Moderate damage $60 \le R < 80$	Major damage or collapsed $R < 60$
V-minus or lower	×	×	×	×
V-plus	◎	△	△	△
VI-minus	◎	○(△)	△	△
VI-plus or higher	◎	◎(○)	○(△)	△

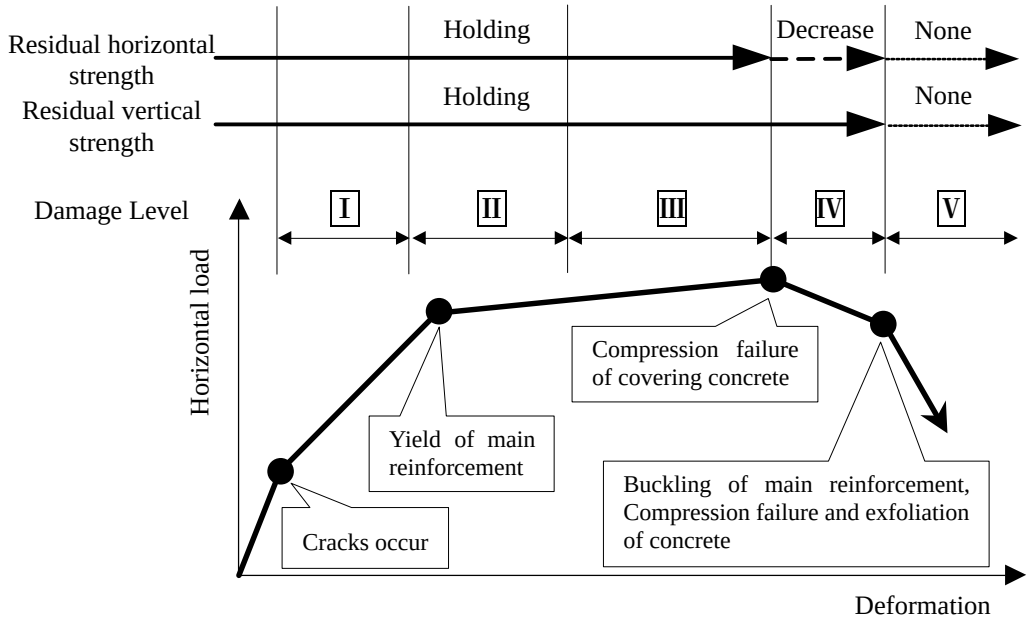
*( ) applies to the buildings constructed in 1971 or earlier

- **Class of damage to the foundation**: ☐No damage ☐Light damage ☐Moderate damage ☐Major Damage
- **Necessity to restore the foundation**:
  ☐Unnecessary (no damage) ☐Repair (○) ☐Repair (detailed inspection desirable) (△) ☐Detailed inspection (×)

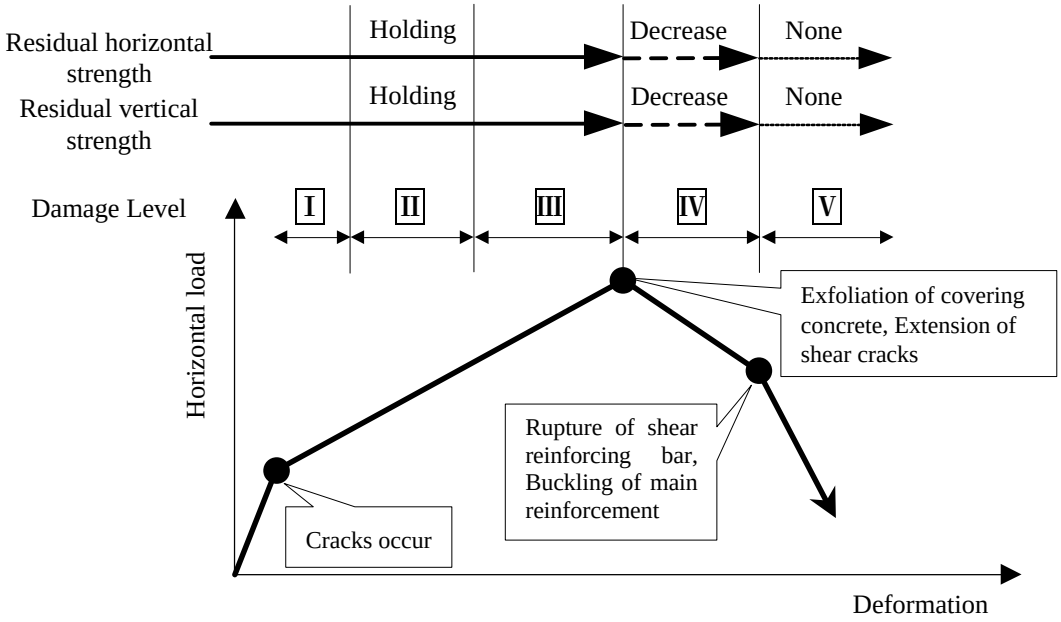
- **Class of damage to the superstructure**:
  ☐No damage ☐Slight damage ☐Light Damage ☐Moderate damage ☐Major damage ☐Collapse
- **Necessity to urgently restore the superstructure**:
  ☐Unnecessary (no damage) ☐Small repair (◎) ☐Emergency restoration(repair of the structure) (○) ☐Emergency measure or emergency restoration (△) ☐Detailed inspection (×) ☐Indisputably no possibility of emergency restoration (collapse)

Table 3.2.3-2 Criterion on the damage level [1]

Damage level of column and bearing wall	Description of damage
I	Cracks invisible from a remote distance (width 0.2 mm or less)
II	Cracks visible with the naked eye (width 0.2 to 1 mm)
III	Comparatively large cracks with small amounts of concrete coming off (width 1 to 2mm)
IV	Large cracks (wider than 2mm) in quantities with concrete came off to expose reinforcement in a wide area
V	Reinforcement bent and the inside concrete came off with the column (bearing wall) apparently deformed in the vertical and horizontal directions, and settled or inclined with reinforcement sometimes broken.



(a) Case of member with plastic deformation capability (Bending resisting member)



(b) Case of member which breaks in brittle fracture (Shear resisting member)

Fig.3.2.3-2 Concept of load-deformation relationship and damage level [1]

Photo 3.2.3-1 About 2-mm-wide X-shaped cracks on the column and large cracks on the covering concrete

Photo 3.2.3-2 Covering concrete has come off to a large extent, but the column structure concrete has not come off much. The reinforcement is slightly exposed without deformation.

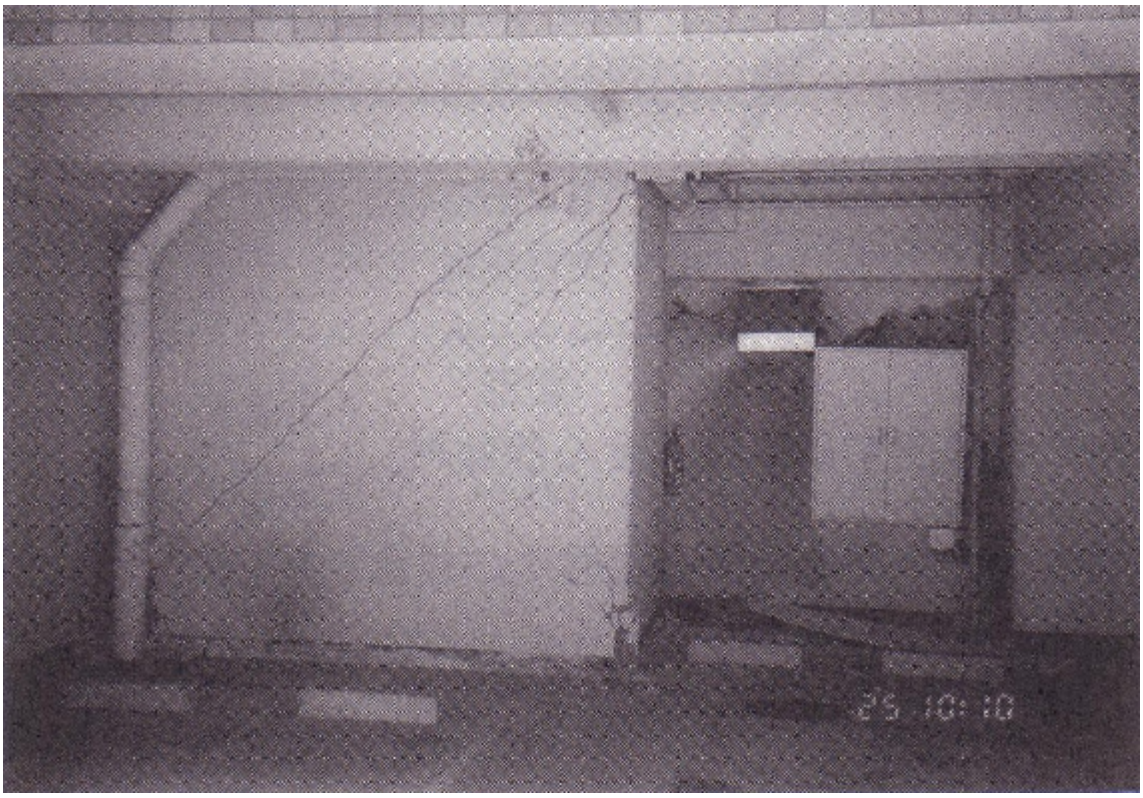


Photo 3.2.3-3 About 2-mm-wide diagonal cracks on the wall without concrete coming off or without compression failure.

Photo 3.2.3-4 Diagonal cracks on the wall and cracks at the joint between lower beam part and wall plate that is caused by sliding without deformation of vertical wall reinforcement.

Photo 3.2.3-5 Cracks wider than 2 mm on the column with concrete that came off to expose reinforcement, but without buckling or deformation

Photo 3.2.3-6 Concrete seriously came off to expose reinforcement to a large extent, but without buckling or deformation

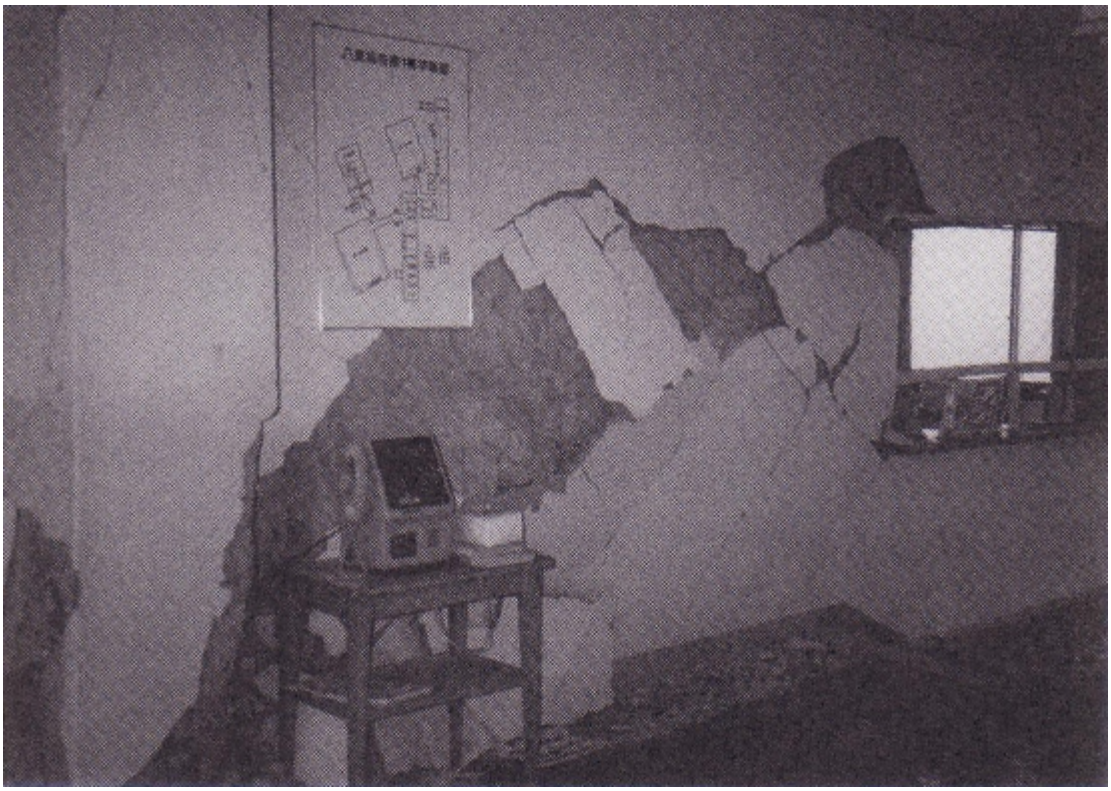


Photo 3.2.3-7 Covering concrete seriously came off and a number of diagonal cracks wider than 2 mm, but without buckling or deformation of reinforcement.

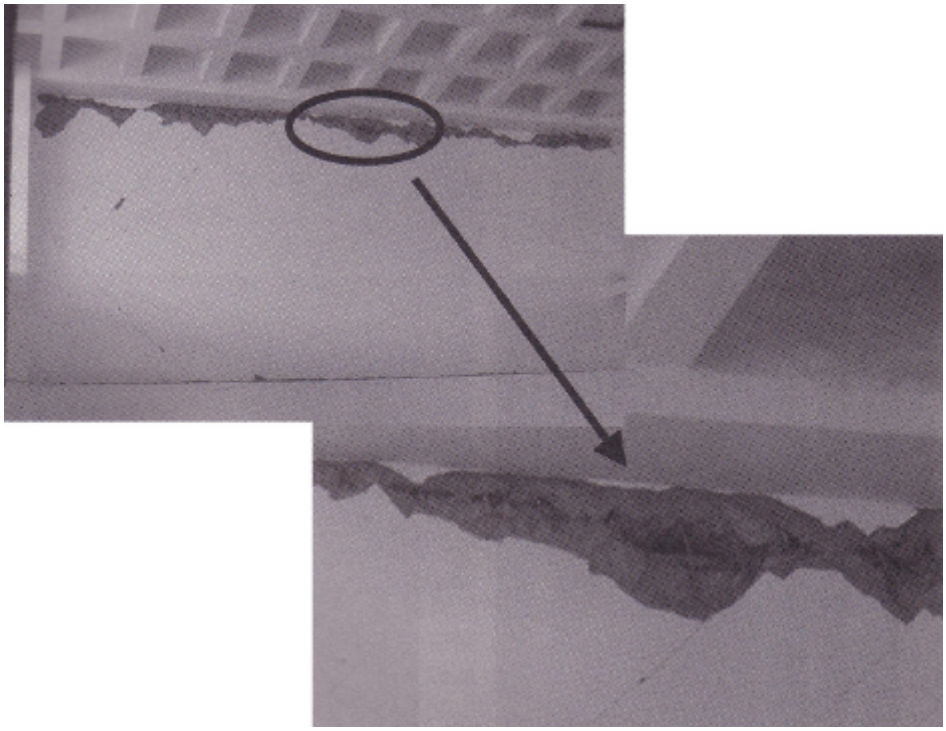


Photo 3.2.3-8 Diagonal cracks on the wall and cracks at the joint between lower column part and wall plate that was caused by sliding with local deformation of part of the vertical wall reinforcement.

Photo 3.2.3-9　A number of large diagonal cracks on the wall and column to expose reinforcement without buckling, break, or deformation in the vertical direction.

Photo 3.2.3-10　The main reinforcement buckled, hoop hock disconnected, and inside concrete that came off with apparent deformation into the vertical and horizontal directions.

Photo 3.2.3-11　Large see-through cracks on the wall with significantly-bent wall reinforcement.

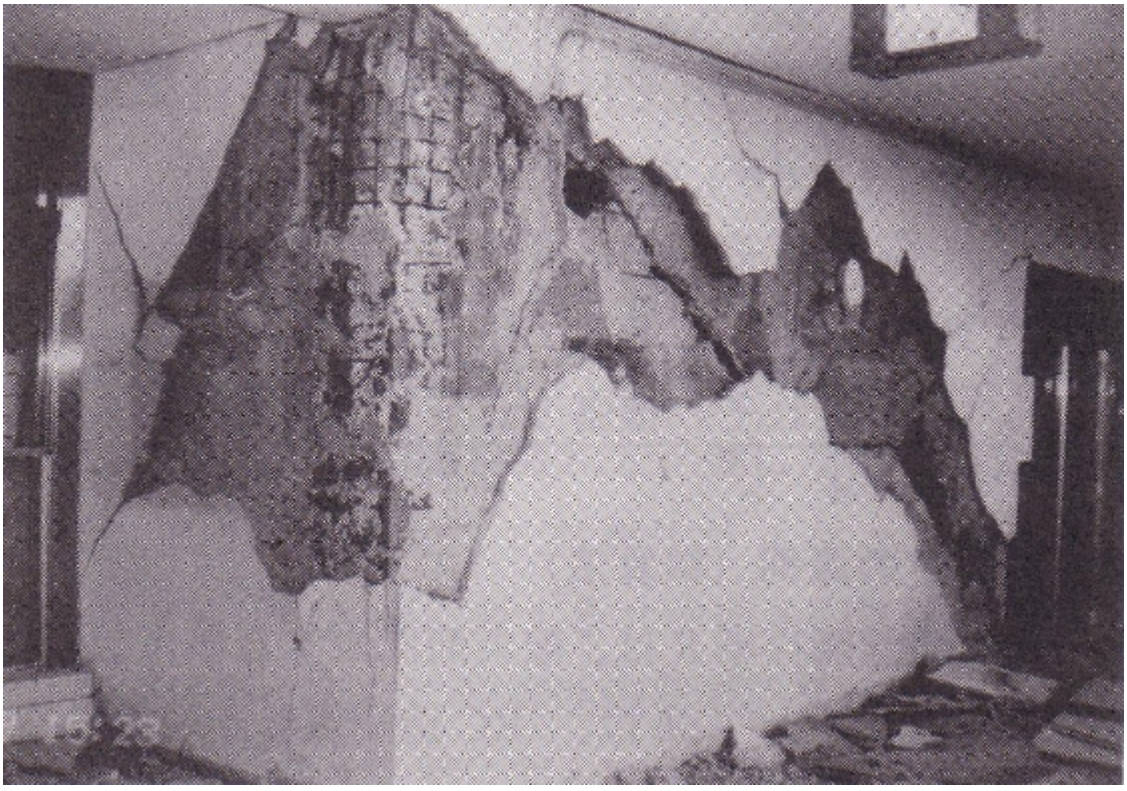


Photo 3.2.3-12　Large and oblique see-through diagonal cracks on the wall with concrete coming off.

Photo 3.2.3-13　The 1st floor columns broken to cause a story collapse and the 2nd story and above fallen down.

.Photo 3.2.3-14　The 1st floor columns broke thus significantly tilting the entire building

Photo 3.2.3-15 The three spans of the 1st floor on the right side have broken and caused a story collapse. On such a building, the damage should be judged separately for the three spans and the rest of the building.

Table 3.2.3-3 Investigation Sheet for Judging the Class of Damage to Steel Buildings[1]

Serial No.: _____ Inspection date and hour: _____
Time of inspection: _____ Inspector: _____
Inspector's position: _____

1. Outline of the Building

1.1 Name of the building: _____
1.2 Address of the building: _____
1.3 Owner of the building: _____ Address for contact: _____
1.4 Person for contact: _____ Address for contact: _____
1.5 Use (Choice of multiple items allowed):
☐Office ☐Housing ☐Apartment ☐Store ☐Factory ☐Warehouse ☐School ☐Day nursery
☐Government building ☐Public hall ☐Gymnasium ☐Hospital ☐Others ( )
1.6 Type of structure: ☐Steel ☐Hybrid structure of ( ) and ( )
1.7 Structural form: ☐Rigid frame ☐Brace ☐Truss ☐Others ( )
1.8 Structure of the foundation: ☐Spread foundation (individual footing, continuous footing, mat foundation)
☐Piling foundation (Type:)
1.9 Size of the building:( ) stories above and ( ) stories under the ground, penthouse (stories)
Dimensions of the first floor: about (m)×(m)
1.10 Geographical features of the site: ☐Flat ☐Slope ☐Plateau ☐Basin ☐Others ( )
1.11 Surrounding geographical features of the site: The site is (m) away from a precipice, (m) away from a river, the sea, a lake or a swamp (Note: no entry is needed when the distance to each feature is 50 m or more)
1.12 Exterior finish (Choice of multiple items allowed):
☐Fair-faced concrete ☐Mortar finishing on metal lath ☐Tile ☐Stone pitching
☐Curtain wall (metal, glass) ☐PC plate ☐ALC plate ☐Block ☐Others ( )
1.13 Drawings and specifications Structural calculation sheet: ☐Retained ☐Not retained
Drawings for design presentation: ☐Retained ☐Not retained
Construction record: ☐Retained ☐Not retained
1.14 Construction date Year ( ) ☐unknown

2. Inspection and evaluation (Check off the appropriate items)

2.1 Inspection of structural framework and damage classification

The most seriously damaged floor and the direction of the damage
Floor ( ) Direction: ☐Direction of the short side ☐Direction of the long side

Class of damage	Foundation	Structural form								
		(a) Rigid frame			(b) Brace			(c) Truss		
		X		Y	X		Y	X		Y
I s	☐ $1/300 < y \leq 1/150$	☐	$1/500^* < f \leq 1/150$	☐	☐	The compression brace is slightly buckled and deformed	☐	☐	The ceiling brace is partially buckled and deformed	☐
		☐	Members start to yield	☐						
		☐	Cracks occur in the column base concrete	☐	☐	Cracks occur in the column base concrete	☐	☐	Cracks occur in the column base concrete	☐
II s	☐ $1/150 < y \leq 1/100$	☐	$1/150 < f \leq 1/100$	☐	☐	The high strength bolt slips	☐	☐	The truss is slightly buckled and deformed outward	☐
		☐	The panel zone yields	☐						
		☐	The anchor bolt elongates	☐	☐	The anchor bolt elongates	☐	☐	The anchor bolt elongates	☐
					☐	The tension brace yields	☐			
III s	☐ $1/100 < y \leq 1/50$	☐	$1/100 < f \leq 1/50$	☐	☐	$f \leq 1/50$	☐	☐	The truss is significantly buckled and deformed outward	☐
		☐	Local buckling and deformation is slight	☐	☐	The brace rupture rate is 20% or less	☐			
					☐	The joint section ruptures	☐			
IV s	☐ $1/50 < y \leq 1/30$	☐	$1/50 < f \leq 1/30$	☐	☐	$1/50 < f \leq 1/30$	☐	☐	The buckling and deformation of diagonal and chord members are slight	☐
		☐	Local buckling and deformation is medium	☐	☐	The brace rupture rate is 20 to 50%	☐			
		☐	The joint section rupture rate is 20% or less	☐						
V s	☐ $1/30 < y$	☐	$1/30 < f$	☐	☐	$1/30 < f$	☐	☐	The buckling and deformation of diagonal and chord members are serious	☐
		☐	Local buckling and deformation is serious	☐	☐	The brace rupture rate is more than 50%	☐			
		☐	The joint section rupture rate is more than 20%	☐				☐	The joint section (including the anchor section) ruptures	☐
VI s		☐	Collapse	☐	☐	Collapse	☐	☐	Collapse	☐

Note 1: y is a residual deformation angle caused by the maximum relative settlement.
Note 2: f is a residual angle of inclination of the column (* For buildings with a roof truss, such as a gymnasium, the lower limit of this angle should be 1/300.)

Table 3.2.3-3 (Cont.)

The class of damage to structural framework (The highest and appropriate class of damage in each category of the foundation and the structural form in the above table)

X	☐ **I** s	☐ **II** s	☐ **III** s	☐ **IV** s	☐ **V** s	☐ **VI** s	☐No appropriate item (O_S)
Y	☐ **I** s	☐ **II** s	☐ **III** s	☐ **IV** s	☐ **V** s	☐ **VI** s	☐No appropriate item (O_S)

2.2 Inspection of finishing and non-structural members, and damage classification

Class of damage	Damaged part									Standard for estimating the maximum horizontal angle
	(a) Finished internal and external wall			(b) Ceiling			(c) Opening			
	X		Y				X		Y	
I w	☐	Slight cracks in the corner section	☐	☐	Displacement and separation of the ceiling member		☐	A little awkward opening-closing and slight cracks	☐	～1/150
II w	☐ ☐	Displacement of the joint Slight spalling	☐ ☐	☐	Partial spalling		☐ ☐	Destruction of many corner sections Difficulty in opening and closing	☐ ☐	1/150～1/50
III w	☐ ☐ ☐	Serious cracks over the entire surface Partial spalling Swelling out	☐ ☐ ☐	☐	Overall spalling		☐ ☐	Destruction of the majority of corner sections Impossibility in opening and closing	☐ ☐	1/50～1/30
IV w	☐	Serious spalling	☐	☐	Very serious overall spalling		☐	Significant destruction	☐	1/30～

The class of damage to finishing and non-structural members (The highest and appropriate class of damage in the above table)

X	☐ **I** w (including "no appropriate item")	☐ **II** w	☐ **III** w	☐ **IV** w
Y	☐ **I** w (including "no appropriate item")	☐ **II** w	☐ **III** w	☐ **IV** w

3. Comprehensive judgment (Check off the appropriate items)

Judge by the classes of damage to the structural framework, finishing, and non-structural members according to the table below.

	X	Y
Slight damage	☐	☐
Light damage	☐	☐
Moderate damage	☐	☐
Major damage	☐	☐
Collapse	☐	☐

Announced seismic intensity scale								
I	**II**	**III**	**IV**	V-minus	V-plus	VI-minus	VI-plus	**VII**

	Os	**I** s	**II** s	**III** s	**IV** s	**V** s	**VI** s
I w	Slight damage	Light damage		Moderate damage		Major damage	Collapse
II w							
III w							
IV w							

4. Other matters taken notice of

Photo 3.2.3-16 Damage of the PC curtain wall of a 5-story, moment resisting frame structure office building

Photo 3.2.3-17 Yield and fracture of a beam end inside a 5-story, moment resisting frame structure office building

Photo 3.2.3-18　A building collapsed at low stories.

Photo 3.2.3-19　A building inclined to a large extent

Photo 3.2.3-20 Serious damage of piles

Photo 3.2.3-21 Danger of building site collapse

Photo 3.2.3-22 A building with the risk of collapse

Photo 3.2.3-23 Surrounding area of the building settled due to ground liquefaction

Photo 3.2.3-24 A building inclined due to the lateral flow of the ground (displacement of bulkhead)

Photo 3.2.3-25 A condominium inclined due to differential settlement

Photo 3.2.3-26 An inclined building

Photo 3.2.3-27 A building inclined at the 1st and 2nd floors only

Photo 3.2.3-28 A locally buckled column

Photo 3.2.3-29 A totally buckled column

Photo 3.2.3-30　Rupture of angle braces

Photo 3.2.3-31　Buckling of wide-flange-shaped braces

Photo 3.2.3-32 Rupture of a welded beam end

Photo 3.2.3-33 Rupture of a welded part between column and diaphragm

Photo 3.2.3-34　Displacement of a concrete column base of insufficient encasing height

Photo 3.2.3-35　Concrete below a column base plate that has lost its axial load supporting capacity.

Photo 3.2.3-36　Minor damage on an exposed column base

Photo 3.2.3-37　Example of Rank C falling object

Table 3.2.3-4 Investigation Sheet for Judging the Class of Damage to Wooden Buildings[1]

Check List for Judging the Class of Damage (1)

Serial No.: _____ Inspection date and hour: _____
Time of inspection: _____ Inspector: _____
Inspector's position: _____

1. Outline of the building

1.1 Name of the building: _____
1.2 Address of the building: _____
1.3 Owner of the building: _____ Address for contact: _____
1.4 Person for contact: _____ Address for contact: _____
1.5 Use: ☐Housing ☐Apartment ☐Store ☐Dwelling house combined with a store ☐Office ☐School ☐Factory ☐Warehouse ☐Inn ☐Hospital ☐Barn ☐Others ( )
1.6 Construction date (Date of construction: _____ Date of extension / reconstruction: _____)
1.7 Size of the building: ☐One-storied house ☐Two-storied house ☐Others ( )
Area of the first floor: (m^2)
1.8 Use of metal
・Metal at framework joint (☐Used ☐Practically unused)
1.9 Survey of durability
・Construction method of external wall (☐Stud wall framing finished on both sides / ☐Column-exposed wall of Japanese traditional method)
・Stud wall framing finished on both sides (☐cement rendering ☐siding boards ☐wood siding)
・Deterioration of column-exposed wall (☐Termite damage and rot more than half on external columns and the ground sill / ☐Termite damage and rot locally on external columns and the ground sill / ☐No abnormality in particular)
・Highly durable specifications (☐High-durability specifications of Finance Corporation / ☐High-level specifications of Finance Corporation / ☐High-level specifications similar to the above / ☐Nothing in particular)
1.10 Construction method of the inside of the building
・Inside of the building (☐Stud wall framing finished on both sides ☐Column-exposed wall)

2. Inspection on damage conditions

2.1 Inspection for estimating the maximum relative story deformation angle

Building frame	Residual deformation				1/120 rad.	1/90 rad.	1/60 rad.	1/40 rad.
	Brace					Swelling out	Some of braces buckled	Multiple braces buckled
Exterior finishing material	External wall	Siding		Nails came loose	Corner sections of the opening had cracks	Cracks in the corner sections of the opening spread and part of the sections came loose	Corner sections of the opening had cracks that ran vertically	Corner sections of the opening had multiple cracks that ran vertically
		Cement rendering	Corner sections of the opening had cracks	Cracks in the corner sections of the opening spread	Other places than the corner sections of the opening also had cracks	Cracks in other places than the corner sections of the opening spread	General part of external wall had cracks	General part of external wall had multiple cracks
	Openings, etc.			Part of the sash gaskets came off	Sash gaskets came off	Sash crescents were damaged	Sash crescents and glass were broken	Multiple sash crescents and panes of glass were broken
Interior finishing material	Inner wall	Cloth finishing	Corner sections had wrinkles	Corner sections got torn and the middle section had wrinkles	Corner sections had tears that ran vertically and the middle section got torn	Tears in the middle section spread	Multiple joints of plaster boards got torn	The majority of joints of plaster boards got torn
		Column-exposed wall		Marks of displacement were left between columns and walls	Crevices were occurred between columns and walls	Crevices between columns and walls were 3-5 mm wide	Crevices between columns and walls were 5mm wide and more	Multiple crevices between columns and walls were 5mm wide and more
	Openings, etc.					Shoji screens got torn		

Table 3.2.3-4 (Cont.)

2.2 Inspection of each part

(1) Ground

●Ground
- ☐The ground has slight crack.
- ☐The ground has many cracks.
- ☐The ground has collapsed.

●Differential settlement
- ☐Differential settlement has occurred.

●Retaining wall
- ☐Retaining walls are damaged.

●Liquefaction
- ☐Liquefaction has occurred.

(2) Foundation

●Foundation
- ☐Damaged
- ☐Ruptured
- ☐Moved
- ☐Washed away
- ☐Overturned

●Outer foundation
- ☐The outer foundation has cracks 0.3mm wide and more and less than 200mm long in 2 to 5 places.
- ☐The outer foundation has suffered local destruction and spalling and falling off of finishing mortar.
- ☐The outer foundation has one or two cracks that are so serious that the foundation is isolated from the ground sill with the result that it is unable to support the superstructure on the sill.
- ☐The outer foundation is in no condition to support the superstructure.

●Anchor bolt
- ☐Some anchor bolts have come out.
- ☐Some anchor bolts or nuts are missing.

(3) Floor framing

●Level
- ☐The floor is slightly out of level.
- ☐The floor is significantly out of level.
- ☐All the floor boards are significantly out of level.

●Ground sill, floor post
- ☐The floor post has slipped somewhat from its footing.
- ☐The floor post has slipped a few centimeters off its footing.
- ☐The sill has slipped somewhat from the foundation.
- ☐The column has slipped somewhat from the sill.
- ☐The floor post has fallen off from its footing.
- ☐The sill has slipped significantly from the foundation.
- ☐The column has slipped significantly from the sill.
- ☐All sills, columns and floor posts have fallen off from their foundations or footings, and the majority of sleepers and floor joists have dropped down.
- ☐The rot of the ground sills and the floor posts has been noticed, and the termite damage to these features has been noticed.

●Floor boards
- ☐Slight displacement of the floor frame and the wall has been noticed.
- ☐The joint of the floorboards has a gap.
- ☐The floorboard is displaced.
- ☐The floorboard is broken.

●Bathtub and toilet
- ☐The bathtub and the toilet are displaced a few centimeters.
- ☐The bathtub and the toilet are significantly displaced.

(4) Framework

●Framework material
- ☐Cracks are observed in framework materials such as a column or a beam.

Table 3.2.3-4 (Cont.)

●Face plate of the bearing wall
□Destruction of the face plate is observed.

(6) Finishing material

●Cement rendering and other finish
□In the wall of cement rendering, tile or plaster finish, the periphery of the corner sections of the opening have slight crack.
□In the wall of cement rendering, tile, or plaster finish, the finishing material in many places has fallen off.
□In the wall of cement rendering, tile, or plaster finish, the major part of the finishing material has scaled off or fallen off.
□All the finishing material has fallen off.

●Boards
□Such boards as one made of sprayed a plywood sheet and a siding board have slight displacement in their joint sections.
□Part of the boards have cracks and displacement in their joint sections of the finished surface.
□The majority of the boards have significant displacement in their joint sections of the finished surface and in part of the joint sections of the nailed facing materials, and they have come loose in part of the nailed facing materials. And they have suffered destruction of the corner sections of the facing materials.
□Nails have come loose and some of them are missing in the majority of the boards.

●Fittings
□The aluminum sash refuses to open and close, its locking is broken, and its beads sealant strips have come off.
□There is a gap between the wooden sash and the wall.
□The pane of glass in the aluminum sash is broken.
□The aluminum sash has come off and is broken.
□The aluminum door is broken.
□The wooden sash is broken.
□The wooden fitting is broken.
□All fittings and sashes are broken.

●Inner wall
□There are gaps along the periphery of the inner wall.
□The plywood sheet of the inner wall is displaced.
□The plywood sheet of the inner wall has come off or come loose.
□The plywood sheet of the inner wall is broken with coming off or falling off.

●The tile and others on the external wall and in the bathroom and the toilet
□The joints of tiles on the external wall and in the bathroom and the toilet have cracks.
□Tiles on the external wall and in the bathroom and the toilet have come off.
□Wall cloth is torn.
□Tiles on the external wall and in the bathroom and the toilet have fallen off.
□The rot and termite damage of the external wall have been noticed.

(7) Roof

●Level
□The roof is out of level.

●Roof truss
□Part of the roof truss is broken.
□The roof truss has suffered serious destruction, and the majority of roofing materials are damaged.
□The rot of the backing of the roof and the small roof has been noticed.

●Roofing tile
□ Part of munegawara tiles (kanmurigawara and noshigawara tiles) are displaced and broken. Other tiles have suffered no breakage.
□Munegawara tiles are significantly displaced, broken, and have fallen off, but other tiles have suffered a little breakage.
□Munegawara tiles are overall displaced, broken, and have fallen off, and other tiles are also significantly displaced.
□Almost all tiles are displaced, broken, and have fallen off.

●Roofing material
□When a metal plate is used as the roofing material, such damage as coming off of plates is observed in their joint sections.

●Ridge
□Destruction of the ridge is observed.

Table 3.2.3-4 (Cont.)

Check List for Judging the Class of Damage (2) Serial No.: _____ Inspector: _____

3. Class of damage to buildings (Check off the appropriate items)

Part	Item of damage	Damage calculation formula and damage level					Class of damage
Foundation (outer foundation)	Rate of damage	Length of damaged foundation (_____ m (number)) / Length of outer foundation (_____ m (number)) ×100=(_____ %)					
		Less than 15% ☐ I	15～30% ☐ II	30～65% ☐ III	65～85% ☐ IV	85% or more ☐ V	
	Damage conditions	☐ I	☐ II	☐ III	☐ IV	☐ V	
Floor framing (floor framing of the first floor)	Rate of damage	Area of damaged floor (_____ m^2) / Area of the first floor (_____ m^2) ×100=(_____ %)					
		Less than 10% ☐ I	10～30% ☐ II	30～60% ☐ III	60～85% ☐ IV	85% or more ☐ V	
	Damage conditions	☐ I	☐ II	☐ III	☐ IV	☐ V	
Framework (columns on the first floor)	Rate of damage	Number of damaged columns (_____) / Number of columns on the first floor (_____) ×100=(_____ %)					
		Less than 10% ☐ I	10～30% ☐ II	30～60% ☐ III	60～85% ☐ IV	85% or more ☐ V	
	Damage conditions	☐ I	☐ II	☐ III	☐ IV	☐ V	
Bearing wall (bearing wall on the first floor)	Rate of damage	Length of damaged bearing wall (_____ m) / Length of bearing wall on the first floor (_____ m) ×100=(_____ %)					
		Less than 10% ☐ I	10～30% ☐ II	30～60% ☐ III	60～85% ☐ IV	85% or more ☐ V	
	Damage conditions	☐ I	☐ II	☐ III	☐ IV	☐ V	
Finishing material (Finished surface of the external wall)	Rate of damage	Area of damaged wall (_____ m^2) / Area of external wall (_____ m^2) ×100=(_____ %)					
		Less than 15% ☐ I	15～40% ☐ II	40～65% ☐ III	65～85% ☐ IV	85% or more ☐ V	
	Damage conditions	☐ I	☐ II	☐ III	☐ IV	☐ V	
Roof (Roof of Top floor)	Rate of damage	Area of damaged roof (_____ m^2) / Area of roof (_____ m^2) ×100=(_____ %)					
		Less than 15% ☐ I	15～40% ☐ II	40～65% ☐ III	65～85% ☐ IV	85% or more ☐ V	
	Damage conditions	☐ I	☐ II	☐ III	☐ IV	☐ V	
Comprehensive class of damage							

To classify the damage of each part as one of five classes (slight damage, light damage, moderate damage, major damage, and collapse), buildings will be surveyed from two viewpoints: the rate of damage and the damage conditions. When the levels determined by the rate of damage and the damage conditions are different, the higher level should be adopted for the pertinent part. The average of the

Table 3.2.3-4 (Cont.)

Announced seismic intensity scale								
Ⅰ	**Ⅱ**	**Ⅲ**	**Ⅳ**	V-minus	V-plus	VI -minus	VI- plus	**Ⅶ**

5. Judgment of the necessity of the restoration

The necessity of the restoration shall be judged according to the following Table.

Necessity of strengthening or other measures

Disaster level / Seismic intensity scale	Slight damage	Light damage	Moderate damage	Major damage / Collapse
V-minus or lower	△	×	×	×
V-plus	○	△	×	×
VI-minus	○	○	△	×
VI-plus or higher	○	○	○	△

○: Restoration by repair

△: Restoration by repair or strengthening (Detailed examinations are required based on the survey results related to restoration planning.)

×: Restoration by strengthening, or demolition (Detailed examinations are required based on the survey results related to restoration planning.)

Photo 3.2.3-38 Slight damage

Photo 3.2.3-39 Moderate damage

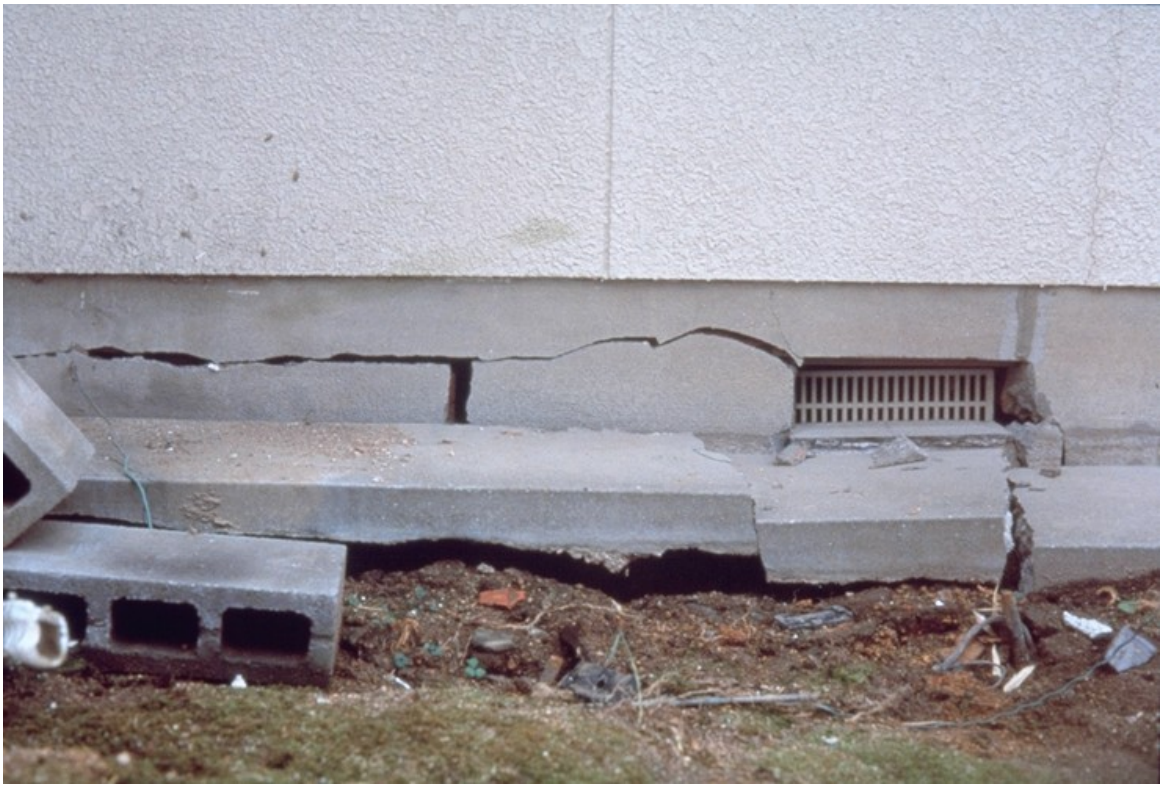


Photo 3.2.3-40 Major damage

Photo 3.2.3-41 Destruction

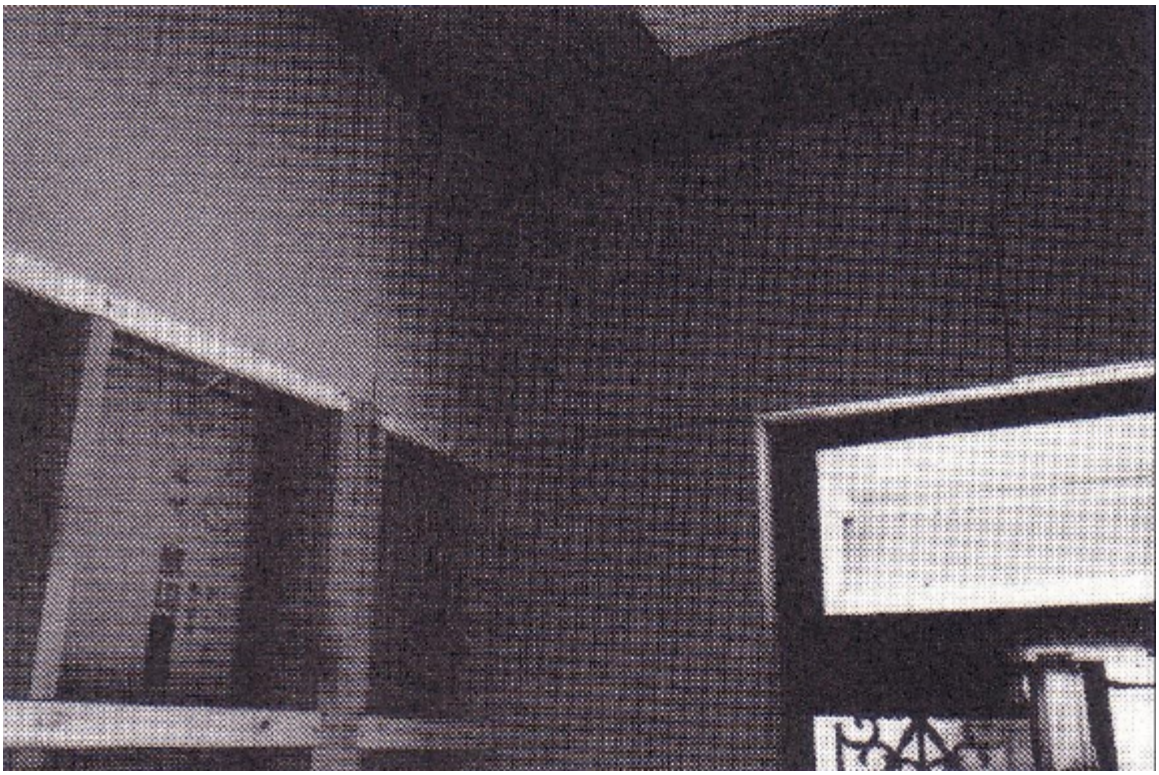


Photo 3.2.3-42 Light damage

Photo 3.2.3-43 Moderate damage

Photo 3.2.3-44　Major damage

Photo 3.2.3-45　Destruction

Photo 3.2.3-46 Moderate damage

Photo 3.2.3-47 Major damage

Photo 3.2.3-48 Destruction

Photo 3.2.3-49 Slight damage

This mono-color photo is produced by BRI members.

Photo 3.2.3-50 Light damage

Photo 3.2.3-51 Moderate damage

Photo 3.2.3-52 Major damage

Photo 3.2.3-53 Destruction

Photo 3.2.3-54　Slight damage

This mono-color photo is produced by BRI members.

Photo 3.2.3-55　Light damage

Photo 3.2.3-56 Moderate damage

Photo 3.2.3-57 Major damage

Photo 3.2.3-58　Destruction

Other Example 1

[Detailed Evaluation Method in the United States] [1]

This method is primarily used to evaluate the safety of buildings posted Limited Entry after a Rapid Evaluation. Normally this will be done by having engineers familiar with building design observe the damage and assess its impact on life safety. Ideally, this evaluation will be carried out by a team of at least two structural engineers, both of whom have experience in the seismic design of buildings similar to those being inspected. In the aftermath of a large quake, however, this ideal may be impossible, and alternative teams will probably have to be used. One such alternative is the use of a team consisting of one structural engineer and one building inspector.

The inspection team should closely examine the entire building, inside and out, particularly its structural system (i.e., whatever parts are exposed and viewable). Ordinarily, they will not perform destructive exploration such as removal of plaster or gypsum walls to view the structural system, although in many cases this may be required of the owner before a full assessment can be made.

The overall purpose of a Detailed Evaluation is to evaluate safety and recommend a posting classification. The Detailed Evaluation is intended to provide reasonable assurance that the structural system, as well as elements of the building that could cause falling hazards, are sufficiently safe before the building is put back into service. Considerable use of judgment by the inspection team will generally be required since it is very difficult, if not impossible, to develop damage evaluation procedures and guidelines that can be used without judgment.

References

[1] ATC20, Procedures for Post-earthquake Safety Evaluation of Buildings, Applied Technology Council, 1989.

[2] ATC20-1, Addendum to the ATC20 Post Earthquake Building Safety Evaluation Procedure, Applied Technology Council, 1995.

Table 3.2.3-5

ATC-20 Detailed Evaluation Safety Assessment Form[1]

Block_____ Parcel No._____

BUILDING DESCRIPTION:

Name: _____

_____

Address: _____

_____

No. of Stories: _____

Basement: Yes ☐ No ☐ Unknown ☐

Approximate Age: _____Years

Approximate Area:_____Square feet

Structural System:

Wood Frame ☐ Unreinforced Masonry ☐

Reinforced Masonry ☐ Tilt-up ☐

Concrete Frame ☐ Concrete Shear Wall ☐

Steel Frame ☐ Other _____

_____

Primary Occupancy:

Dwelling ☐ Other Residential ☐ Commercial ☐

Office ☐ Industrial ☐ Public Assembly ☐

School ☐ Government ☐ Emer. Serv. ☐

Historic ☐ Other _____

OVERALL RATING: *(Check One)*

INSPECTED (Green) ☐

LIMITED ENTRY (Yellow) ☐

UNSAFE (Red) ☐

INSPECTOR:

Inspector ID _____

Affiliation_____

INSPECTION DATE:

Mo/day/year _____

Time _____ am pm

Instructions: Complete building evaluation and checklist on next page and then summarize results below.

Posting:	*Existing*	*Recommended*
None	☐	
Inspected *(Green)*	☐	☐
Limited Entry *(Yellow)*	☐	☐
Unsafe *(Red)*	☐	☐

Posted at this Assessment:

☐ Yes ☐ No

Existing posting by:

_____

Recommendations:

☐ No further action required

☐ Engineering Evaluation required (circle one) Structural Geotechnical Other_____

☐ Barricades needed in the following areas: _____

_____

☐ Other *(falling hazard removal, shoring/bracing required, etc.):*_____

_____

Comments *(Why posted Unsafe, etc.):* _____

_____

_____

_____

_____

Sheet _____ *of* _____

Table 3.2.3-5 (Cont.)

ATC-20 Detailed Evaluation Safety Assessment Form (Continued)

Instructions: Examine the building to determine if any hazardous conditions exist. A "yes" answer in categories 1, 2, or 4 is grounds for posting building UNSAFE. If condition is suspected to be unsafe and more review is needed, check appropriate Unknown box(es) and post LIMITED ENTRY. A "yes" answer in category 3 requires posting and/or barricading to indicate AREA UNSAFE. Explain "Yes", "Unknown" findings and extent of damage under "Comments."

	Hazardous Condition Exists			
Condition	*Yes*	*No*	*Unknown*	*Comments*
1. *Structure Hazardous Overall*				
Collapse/partial collapse	☐	☐	☐	
Building or story leaning	☐	☐	☐	
Other_____	☐	☐	☐	
_____	☐	☐	☐	
2. *Hazardous Structural Elements*				
Foundations	☐	☐	☐	
Roof/floors (vertical loads)	☐	☐	☐	
Columns/pilasters/corbels	☐	☐	☐	
Diaphragms/horizontal bracing	☐	☐	☐	
Walls/vertical bracing	☐	☐	☐	
Moment frames	☐	☐	☐	
Precast connections	☐	☐	☐	
Other_____	☐	☐	☐	
_____	☐	☐	☐	
3. *Nonstructural Hazards*				
Parapets/ornamentation	☐	☐	☐	
Cladding/glazing	☐	☐	☐	
Ceilings/light fixtures	☐	☐	☐	
Interior walls/partitions	☐	☐	☐	
Elevators	☐	☐	☐	
Stairs/exits	☐	☐	☐	
Electric/gas	☐	☐	☐	
Other_____	☐	☐	☐	
_____	☐	☐	☐	
4. *Geotechnical Hazards*				
Slope failure/debris	☐	☐	☐	
Ground movement, fissures	☐	☐	☐	
Other_____	☐	☐	☐	
_____	☐	☐	☐	

SKETCH:

Sheet _____ of _____

Other Example 2

Damage classification forms in Italy[1] are shown in the following pages.

Reference

[1] Manuale per la Compilazione della Scheda di 1° Livello di Rilevamento Danno, Pronto Intervento e Agibilità per Edifici Ordinari Nell'emergenza Post-Sismica", Gruppo Nazionale per la Deifesa dai Terremoti, Nov.2000.

Table 3.2.3-6 [1]

SERVIZIO SISMICO NAZIONALE
Presidenza del Consiglio dei Ministri
DIPARTIMENTO DEI SERVIZI TECNICI NAZIONALI

Presidenza del Consiglio dei Ministri
DIPARTIMENTO NAZIONALE DELLA PROTEZIONE CIVILE

Consiglio Nazionale delle Ricerche
GRUPPO NAZIONALE PER LA DIFESA DAI TERREMOTI

1° LEVEL FORM FOR POST-EARTHQUAKE DAMAGE AND USABILITY ASSESSMENT AND EMERGENCY MEASURES IN RESIDENTIAL BUILDINGS

(AeDES 05/2000) Request code |__|__|__|__|__|__|__|__|__|__|

SECTION 1 Building identification

Province: _____

Municipality: _____

Locality: _____

Address

1 ○ Street
2 ○ Road
3 ○ Alley
4 ○ Square
5 ○ Other

Number |__|__|__|__|

INSPECTION DATA

Surveyor |__|__|__| day |__|__| month |__|__| year |__|__|

Form n. |__|__|__|__| Date |__|__| |__|__| |__|__|

Istat Reg.	Istat Prov.	Istat Municip.	Aggregate num.	Building num.
|__|__|__|	|__|__|__|	|__|__|__|	|__|__|__|__|	|__|__|__|

Ista Locality code |__|__|__|__| Tipo carta

Ista Census code |__|__|__| N° carta |__|__|__|__|

Land Register Foglio |__|__|__| Allegato |__|__|

Particelle |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|

Posizione edificio 1 ○ Isolated 2 ○ Internal 3 ○ End 4 ○ Corner

Building name or owner name |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|

Code Use S |__|__|

Sketch of structural aggregate and building location

SECTION 2 Building description

Metrical data

Total number of stories

○1 ○9
○2 ○10
○3 ○11
○4 ○12
○5 ○>12
○6
○7
○8

Average interstory height [m]

1 ○≤ 2.50
2 ○2.50÷3.50
3 ○3.50÷5.0
4 ○> 5.0

Undergr. stories

A ○0 C ○2
B ○1 D ○≥3

Average floor area [m^2]

A ○≤ 50	I ○400 ÷500
B ○50 ÷ 70	L ○500 ÷650
C ○70 ÷ 100	M ○650 ÷900
D ○100 ÷ 130	N ○900 ÷1200
E ○130 ÷ 170	O ○1200 ÷1600
F ○170 ÷ 230	P ○1600 ÷2200
G ○230 ÷ 300	Q ○2200 ÷3000
H ○300÷ 400	R ○ > 3000

Age

Costruction age and strengthening [max 2]

1 ❑ ≤ 1919
2 ❑ 19 ÷ 45
3 ❑ 46 ÷ 61
4 ❑ 62 ÷ 71
5 ❑ 72 ÷ 81
6 ❑ 82 ÷ 91
7 ❑ 92 ÷ 01
8 ❑ ≥ 2002

Use

Use

A ❑ Residential
B ❑ Production
C ❑ Business
D ❑ Offices
E ❑ Public
F ❑ Storage
G ❑ Strategic
H ❑ Turistic

Numb.of units in use |__|__|

Utilisation in percentage

A ○ > 65%
B ○ 30÷65%
C ○ < 30%
D ○ Non in use
E ○ In constr.
F ○ Unfinished
G ○ Abandon

Occupants

100	10	1
0	0	0
1	1	1
2	2	2
3	3	3
4	4	4
5	5	5
6	6	6
7	7	7
8	8	8
9	9	9

Ownership A ○ Public B ○ Private

Table 3.2.3-6 (Cont.)

Istat Province |__|__|__| Istat Mu iicip. |__|__|__| Surveyor N° |__|__| Form N° |__|__|__|__|__| Date |__|__| |__|__| |__|__|

SECTION 3 Building Type (multichoice; max 2.)

Horizontal Structures \ Vertical structures	Unknown	Masonry buildings: Irregular layout or bad quality (stones, pebble,..) — Without ties or tie beams	Masonry buildings: Irregular layout or bad quality (stones, pebble,..) — With ties or tie beams	Masonry buildings: Regular layout and good quality (Hwn stones, bricks,..) — Without ties or tie beams	Masonry buildings: Regular layout and good quality (Hwn stones, bricks,..) — With ties or tie beams	Isolated columns	Mixt	Strengthened
	A	B	C	D	E	F	G	H
1 Unknown	○	❒	❒	❒	❒	SI	❒	❒
2 Vaults without ties	❒	❒	❒	❒	❒	○	G1	H1
3 Vaults with ties	❒	❒	❒	❒	❒		❒	❒
4 Flexible floors	❒	❒	❒	❒	❒	NO	G2	H2
5 Semirigid floors	❒	❒	❒	❒	❒	○	❒	❒
6 Rigid floors	❒	❒	❒	❒	❒		G3	H3

R.c. or steel structures	
R.c. frames	❒
R.c. shear walls	❒
Steel frames	❒

REGULARITY	Irregular	Regular
	A	B
1 Plan and elevation	○	○
2 Cladding distribution	○	○

Roofs

1 ○ Heavy and thrusting
2 ○ Heavy and non thrusting
3 ○ Light and thrusting
4 ○ Light and non thrusting

SECTION 4 Damage to Structural Elements and existing emergency measures

Structural component - Pre-existing damage \ Damage level and extension	DAMAGE (1): D4-D5 Very Heavy > 2/3	D4-D5 Very Heavy 1/3 - 2/3	D4-D5 Very Heavy < 1/3	D2-D3 Severe > 2/3	D2-D3 Severe 1/3 - 2/3	D2-D3 Severe < 1/3	D1 Light > 2/3	D1 Light 1/3 - 2/3	D1 Light < 1/3	Null	EXISTING EMERGENCY MEASURES: None	Removal	Ties	Repair	Propping	Barrier or protection
	A	B	C	D	E	F	G	H	I	L	A	B	C	D	E	F
1 Vertical structures	❒	❒	❒	❒	❒	❒	❒	❒	❒	○	○	❒	❒	❒	❒	❒
2 Horizontal structures	❒	❒	❒	❒	❒	❒	❒	❒	❒	○	○	❒	❒	❒	❒	❒
3 Stairs	❒	❒	❒	❒	❒	❒	❒	❒	❒	○	○	❒	❒	❒	❒	❒
4 Roofs	❒	❒	❒	❒	❒	❒	❒	❒	❒	○	○	❒	❒	❒	❒	❒
5 Claddings and partitions	❒	❒	❒	❒	❒	❒	❒	❒	❒	○	○	❒		❒	❒	❒
6 Pre-existing damage	❒	❒	❒	❒	❒	❒	❒	❒	❒	○						

(1) - The damage extension must be filled only if the corresponding damage level is present in the building.

SECTION 5 Damage to Non-structural Elements and existing emergency measures

Damage	PRESENT	EXISTING EMERGENCY MEASURES: None	Removal	Propping	Repair	No entry	Barrier or protection
	A	B	C	D	E	F	G
1 Falling of plaster, coverings, false-ceilings	○	○	❒	❒	❒	❒	❒
2 Falling of tiles, chimneys...	○	○	❒	❒	❒	❒	❒
3 Falling of ledges, parapets, canopies	○	○	❒	❒	❒	❒	❒
4 Falling of other internal or external objects	○	○	❒	❒	❒	❒	❒
5 Damage to hydraulic or sewage plant	○	○			❒	❒	❒
6 Damage to electric or gas plant	○	○			❒	❒	❒

SECTION 6 Falling objects from other buildings and existing emergency measures

Cause	Risk on: Building	Risk on: Entry road	Risk on: Lateral roads	Existing emergency measures: No entry	Existing emergency measures: Barriers or passing protection
	A	B	C	D	E
1 Object falling from adjacent buildings	❒	❒	❒	❒	❒
2 Lifelines damage	❒	❒	❒	❒	❒

SECTION 7 Soil and Foundation

SITE MORPHOLOGY				DAMAGE (present or possible): ❒ Slopes ❒ Foundation Soil			
1 ○ Top	2 ○ High slope	3 ○ Mild slope	4 ○ Plain	A ○ Absent	B ○ Produced by eqk.	C ○ Worsened	D ○ Preexistent

Table 3.2.3-6 (Cont.)

Istat Province |__|__|__| Istat Mu nicip. |__|__|__| Surveyor N° |__|__| Form N° |__|__|__|__|__| Date |__|__|__|__|__|__|

SECTION 8 Usability assessment

Risk assessment

RISK	STRUCTUAL (Sect. 3 e 4)	NONSTRUCTURAL (Sect. 5)	EXTERNAL (sect. 6)	GEOTECHNICAL (sect. 7)
SMALL	❍	❍	❍	❍
SMALL AFTER MEASURES	❍	❍	❍	❍
HIGH	❍	❍	❍	❍

Building Classification

A	USABLE	❍
B	USABLE AFTER EMERGENCY MEASURES	❍
C	PARTIALLY UNUSABLE (1)	⊘
D	TEMPORARELY UNUABLE (to be re-inspected)	❍
E	UNUSABLE	❍
F	UNUSABLE DUE TO EXTERNAL RISK (1)	❍

(1) Restrictions on building use must be clearly reported in the notes when building is classified as B or C. Falling hazard when building is classified as F.

Inspection accuracy

1 ❍ From the outside only
2 ❍ Partial
3 ❍ Complete (> 2/3)
4 ❍ Not inspected: a ❍ Inspection refused b ❍ Ruins c ❍ Demolished
because of d ❍ Owner not present e ❍ Other .....

Suggested emergency measures, limited extension(*) or wide extension (**)

*	**	Suggested emergency measures	*	**	Suggested emergency measures
1 ❒	❒	Ties	7 ❒	❒	Removal of ledges, parapets, canopies
2 ❒	❒	Repair of light damage to partitions or claddings	8 ❒	❒	Removal of other kind of falling objects
3 ❒	❒	Repair of light damage to the roofs	9 ❒	❒	Barriers or passing protection
4 ❒	❒	Stair propping	10 ❒	❒	Repair of plants
5 ❒	❒	Removal of plaster, coverings or false ceilings	11 ❒	❒	
6 ❒	❒	Removal of tiles, chimneys	12 ❒	❒	

Unusable dwellings, families and people to be evacuated

Unusable dwellings |__|__| Families to be evacuated |__|__| People to be evacuated |__|__|__|

SECTION 9 Notes

On the damage, emergency measures, usability, etc.

Item	*Notes*

Signs of the surveyors

Table 3.2.3-6 (Cont.)

INSTRUCTION FOR THE FILLING OF THE FORM AeDES 05/2000

La scheda va compilata per un intero edificio intendendo per edificio una unità strutturale "cielo terra", individuabile per caratteristiche tipologiche e quindi distinguibile dagli edifici adiacenti per tali caratteristiche e anche per differenza di altezza e/o età di costruzione e/o piani sfalsati, etc.

La scheda è divisa in **9 sezioni**. Le informazioni sono generalmente definite annerendo le caselle corrispondenti; in alcune sezioni la presenza di caselle quadrate (❒) indicano la possibilità di multiscelta: in questi casi si possono fornire più indicazioni; le caselle tonde (❍) indicano la possibilità di una singola scelta. Dove sono presenti le caselle |__| si deve scrivere in stampatello appoggiando il testo a sinistra ed i numeri a destra.

Sezione 1 - Identificazione edificio.
Indicare i dati di localizzazione: Provincia, Comune e Frazione.
IDENTIFICATIVO SCHEDA: Il rilevatore riporta il proprio numero assegnato dal coordinamento centrale, un numero progressivo di scheda e la data del sopralluogo.
IDENTIFICATIVO EDIFICIO
L'organizzazione del rilevamento prevede un Coordinamento Tecnico e la collaborazione dell'ufficio tecnico comunale. Questo ha tra l'altro il compito di assistenza per l'espletamento del lavoro dei rilevatori e per l'individuazione degli edifici. L'edificio in generale non è pre-individuato ed è quindi compito del rilevatore il suo riconoscimento e la sua identificazione sulla cartografia riportata nello spazio della prima facciata. Il codice identificativo dell'edificio, costituito dall'insieme dei dati della prima riga nello spazio in grigio, viene poi assegnato, in modo univoco, presso il coordinamento comunale dove i rilevatori, dopo la visita comunicano l'esito del sopralluogo. La numerazione degli aggregati e degli edifici deve essere tenuta aggiornata in una cartografia generale presso il coordinamento comunale in modo che i rilevatori possano riferire le visite di sopralluogo, che sono richieste in genere su unità immobiliari, all'edificio che effettivamente le contiene. Per l'identificativo, il n° di carta, i dati Istat e i dati catastali è necessario quindi avvalersi della collaborazione del coordinamento comunale. Posizione edificio: se l'edificio non è isolato su tutti i lati, va indicata la sua posizione all'interno dell'aggregato (Interno, d'estremità, angolo). Denominazione edificio o proprietario: indicare la denominazione se edificio pubblico o il nome del condominio o di uno dei proprietari se privato (es. : Condominio Verde, Rossi Mario).

Sezione 2 - Descrizione edificio
N° piani totali con interrati: indicare il numero di piani complessivi dell'edificio dallo spiccato di fondazioni escluso quello di sottotetto se non utilizzato a mansarda. Computare interrati i piani mediamente interrati per più di metà della loro altezza. Altezza media di piano: indicare l'altezza che meglio approssima la media delle altezze di piano presenti. Superficie media di piano: va indicato l'intervallo che comprende la media delle superfici di tutti i piani. Età (2 opzioni): è possibile fornire 2 indicazioni: la prima è sempre l'età di costruzione, la seconda è l'eventuale anno in cui si sono effettuati eventuali interventi *sulle strutture*. Uso (multiscelta): indicare i tipi di uso compresenti nell'edificio. Utilizzazione: l'indicazione abbandonato si riferisce al caso di *non utilizzato in cattive condizioni*.

Sezione 3 - Tipologia (massimo 2 opzioni)
Per gli edifici in muratura si possono segnalare le due combinazioni: strutture orizzontali e verticali prevalenti o più vulnerabili; ad esempio: volte senza catene e muratura in pietrame al 1° livello (2B) e solai rigidi (in c.a.) e muratura in pietrame al 2° livello (6B). La muratura è distinta in due tipi in ragione della qualità (materiali, legante, realizzazione) e per ognuno è possibile segnalare anche la presenza di cordoli o catene se sono sufficientemente diffusi; è anche da rilevare l'eventuale presenza di pilastri isolati, siano essi in c.a., muratura, acciaio o legno e/o la presenza di situazioni miste di muratura e strutture intelaiate. Gli edifici si considerano con strutture intelaiate di c.a. o d'acciaio, se l'intera struttura portante è in c.a. o in acciaio. Situazioni miste (muratura-telai) o rinforzi vanno indicate, con modalità multiscelta, nelle colonne G ed H della parte "muratura".

G1 : c.a. (o altre strutture intelaiate) su muratura
G2 : muratura su c.a. (o altre strutture intelaiate)
G3 :Muratura mista a c.a. (o altre strutture intelaiate) in parallelo sugli stessi piani

H1: Muratura rinforzata con iniezioni o intonaci non armati
H2: Muratura armata o con intonaci armati
H3: Muratura con altri o non identificati rinforzi

Per le strutture intelaiate le tamponature sono irregolari quando presentano dissimmetrie in pianta e/o in elevazione o sono in pratica completamente assenti in un piano in almeno una direzione.

Sezione 4 - Danni ad ELEMENTI STRUTTURALI PRINCIPALI ...
I danni da riportare nella sezione 4 sono quelli 'apparenti', cioè quelli riscontrabili a vista. Nella tabella ogni riga è riferita ad un tipo di componente l'organismo strutturale, mentre le colonne sono differenziate in modo da consentire di rilevare i livelli di danno presenti sulla componente e le relative estensioni in percentuale rispetto alla sua totalità nell'edificio.
La definizione del livello di danno riscontrato è di particolare rilevanza, essa è basata sulla scala macrosismica europea EMS98, integrata con le definizioni puntuali utilizzate nelle schede di rilievo GNDT. In particolare si farà riferimento alla sommaria descrizione riportata di seguito, maggiori dettagli sono riportati nel manuale:
D1 danno leggero: è un danno che non cambia in modo significativo la resistenza della struttura e non pregiudica la sicurezza degli occupanti a causa di cadute di elementi non strutturali; il danno è leggero anche se queste ultime possono rapidamente essere scongiurate.
D2-D3 danno medio – grave: è un danno che potrebbe anche cambiare in modo significativo la resistenza della struttura senza che venga avvicinato palesemente il limite del crollo parziale di elementi strutturali principali.
D4-D5 danno gravissimo: è un danno che modifica in modo evidente la resistenza della struttura portandola vicino al limite del crollo parziale o totale di elementi strutturali principali. Stato descritto da danni superiori ai precedenti, incluso il collasso.

Provvedimenti di pronto intervento eseguiti: sono quelli che con tempi e mezzi limitati conseguono una eliminazione o riduzione accettabile del rischio; vanno indicati quelli già messi in atto.

Sezione 5 - Danni ad ELEMENTI NON STRUTTURALI...
Per gli elementi non strutturali va indicata la presenza del danno e gli eventuali provvedimenti già in atto, con modalità multiscelta.

Sezione 6 - Pericolo ESTERNO ed interventi di (p.i.) eseguiti
Indicare i pericoli indotti da costruzioni adiacenti e/o dal contesto e gli eventuali provvedimenti presi, con modalità multiscelta.

Sezione 7 - Terreno e fondazioni
Va individuata la morfologia del sito ed eventuali dissesti sul terreno e/o sulla fondazione, in atto o temibili.

Sezione 8 - Giudizio di AGIBILITÀ
Il rilevatore stabilisce le condizioni di rischio dell'edificio (tabella *valutazione del rischio*) sulla base delle informazioni raccolte, dell'ispezione visiva e delle proprie valutazioni, relativamente alle condizioni strutturali (Sezione 3 e 4 - Tipologia e danno), alle condizioni degli elementi non strutturali (Sezione 5), al pericolo derivante dalle altre costruzioni (Sezione 6) e alla situazione geotecnica (Sezione 7); . L'esito **B** va indicato quando la riduzione del rischio si può conseguire con il *pronto intervento (opere di consistenza limitata, di rapida e facile esecuzione che rendono agibile l'edificio)*. L'esito **D** solo in casi particolarmente problematici e soprattutto se si tratta di edifici pubblici la cui inagibilità compromette funzioni importanti.
Unità immobiliari inagibili, famiglie e persone evacuate: sono da indicare gli effetti del giudizio di inagibilità, qualora confermato dal Sindaco; vanno pertanto indicate anche le famiglie e persone da evacuare, oltre a quelle che abbiano già lasciato l'edificio.
Provvedimenti di pronto intervento: nel caso di esito B indicare i provvedimenti necessari per rendere agibile l'edificio.

Sezione 9 - Altre osservazioni
Accuratezza della visita: indicare con quale livello di accuratezza e completezza è stato possibile effettuare il sopralluogo .
Sul danno, sui provvedimenti di pronto intervento, l'agibilità o altro: riportare le annotazioni che si ritengono importanti per meglio precisare i vari aspetti del rilevamento. L'eventuale fotografia d'insieme dell'edificio deve essere spillata nel riquadro tratteggiato in chiaro e nel solo angolo in alto a destra.

3.2.4. Damage Survey in a Typical Area[1]

To promptly assess the cause of damage, buildings around the seismic center should be surveyed several weeks to several months after an earthquake has occurred.

The survey working groups of the Hyogo-ken Nanbu Earthquake, Architectural Institute of Japan, surveyed almost all buildings in Kobe and Ashiya cities as well as part of Nishinomiya city. Summarized below are the numbers of buildings in Chuo-ku pertinent to different survey items whose location can be identified on the map.

(1) Outline of the survey by the Hyogoken-Nanbu Earthquake Survey WG, Architectural Institute of Japan

At the beginning of February 1995, the members of Kinki Branch, Hyogo-ken Nanbu Earthquake Survey WG, Architectural Institute of Japan, surveyed the damaged buildings with respect to the purpose of use, structure type, number of stories above ground, and the class of damage.

(2) Summary of the survey results obtained by the Hyogo-ken Nanbu Earthquake Survey WG, Architectural Institute of Japan

In total, 9,321 buildings were surveyed. See Table 3.2.4-1 for their categories.

When the surveyed buildings are classified by the structure type, 3,953 are wooden, 2,276 are RC, 1,271 are S structure, and 119 are SRC structure. In terms of the number of stories, they include 2,935 two-story buildings, 1,045 three-story, 839 four-story, and 416 five-story buildings, which represent a wide range of building profiles. In terms of the class of damage, 458 buildings fell down or collapsed and 605 suffered a major damage. The buildings at these two disaster levels account for about 16% of the total. Six buildings were completely destroyed by fire.

Reference

[1] “A temporary survey report for building damages due to the 1995 Hyogo-ken Nanbu Earthquake”, Building Research Institute, Ministry of Construction, Aug. 1995. (in Japanese)

Table 3.2.4-1 Summary of the survey results by the Architectural Institute of Japan[1]

Total: 9,321 buildings

No.	Item	Category	Number of buildings
1.	Location	1 - Chuo-ku, Kobe city	9269
		2 - Unknown	52
		Total	9321
2.	Purpose of use	1 - Hotel	51
		2 - Office	1263
		3 - Apartment houses	4872
		4 - Store	1622
		5 - Factory	68
		6 - Warehouse	65
		School	74
		Hospital	78
		Government offices	37
		Parking lot	72
		Hall	6
		7 - Others	149
		8 - Multi-purpose	312
		99 - Unknown	652
		Total	9321
3.	Structure type	1 - Cast-in-place RC structure	2276
		2 - Precast RC structure	0
		3 - SRC structure	119
		4 - S structure	1271
		5 - Others	3953
		6 - Complex structure	55
		99 - Unknown	1647
		Total	9321
4.	Number of stories	1	235
		2	2935
		3	1045
		4	839
		5	416
		6	212
		7	150
		8	153
		9	96
		10 to 30	148
		Unknown	3092
		Total	9321
5.	Class of damage	1 - Falling or Collapse	458
		2 - Major damage	605
		3 - Moderate damage	1078
		4 - Light damage or less	6890
		5 - Burnt down	6
		6 - Partially burnt	0
		99 - Unknown	284
		Total	9321

3.2.5. Damage Overview in Damaged Areas[1]

To assess the cause of damage, buildings around the seismic center should be surveyed on and after to several months after an earthquake has occurred.

Using the data of the Quick Inspection of building damage, the macro analysis was performed to understand the outline and the tendency of damage.

1) Object building

Because of the main object building of the Quick Inspection was a condominium, "House" and "Condominium" occupy the majority of the usage of investigated buildings.

In assessment, buildings are classified into three groups, i.e. reinforced concrete (RC) structure, steel (S) structure and wood structure. RC structure also includes the steel framed reinforced concrete (SRC) structure. Each building was inspected by using the investigation sheet.

2) Assessment result "X"

The buildings are automatically classified into three categories; those are "Safe", "Damaged" and "Fatal" according to totalization of the description in investigation sheet. Since there were some incompleted sheets in which only a few items like address or building name were filled, automatic judgement was impossible for such buildings. Among of them, if there were no special description in the margin of the sheet, the building is assumed "Safe" and the rest are labeled "X". The real damage level of "X" buildings is decided later from special description and other source etc. However, in this report "X" remains "X" as it was firstly classified. It will be done after the Quick Inspection data used in the Geographic Information System (GIS) is fixed.

3) Lack of data

The investigation sheet of some "Safe" buildings was not made in Akashi-city and Amagasaki-city (a total number of such buildings is uncertain). It is understood that the data and the result of analysis about both cities are less reliable.

4) Suffering rate

The suffering rate R_S Shows the rate of unsafe buildings and is calculated from following expression.

$$R_S = \frac{N_F + N_D}{N}$$

N : total number of buildings
N_F : number of “Fatal” buildings
N_D : number of “Damaged” buildings

5) Assessment area

Following names are used to divide the Hyogo prefecture into the Mainland side and Awaji island.

Hyogo area 8 cities : Akashi, Kobe, Ashiya, Nishinomiya, Takarazuka, Itami, Amagasaki and Kawanishi on the Mainland.

Awaji area 7 towns : Awaji, Hokudan, Higashiura, Ichinomiya, Tsuna, Sumoto and Seidan on the Awaji island.

For each figures and tables in this report, the name of the cities and towns are arranged sequentially from west to east (Akashi to Kawanishi) in Hyogo area and north to south (Awaji to Seidan) in Awaji area according to the distance from the epicenter.

Reference

[1] “A Survey Report for Building Damages due to the 1995 Hyogo-ken Nanbu Earthquake”, Building Research Institute, Ministry of Construction, Japan, March 1996.

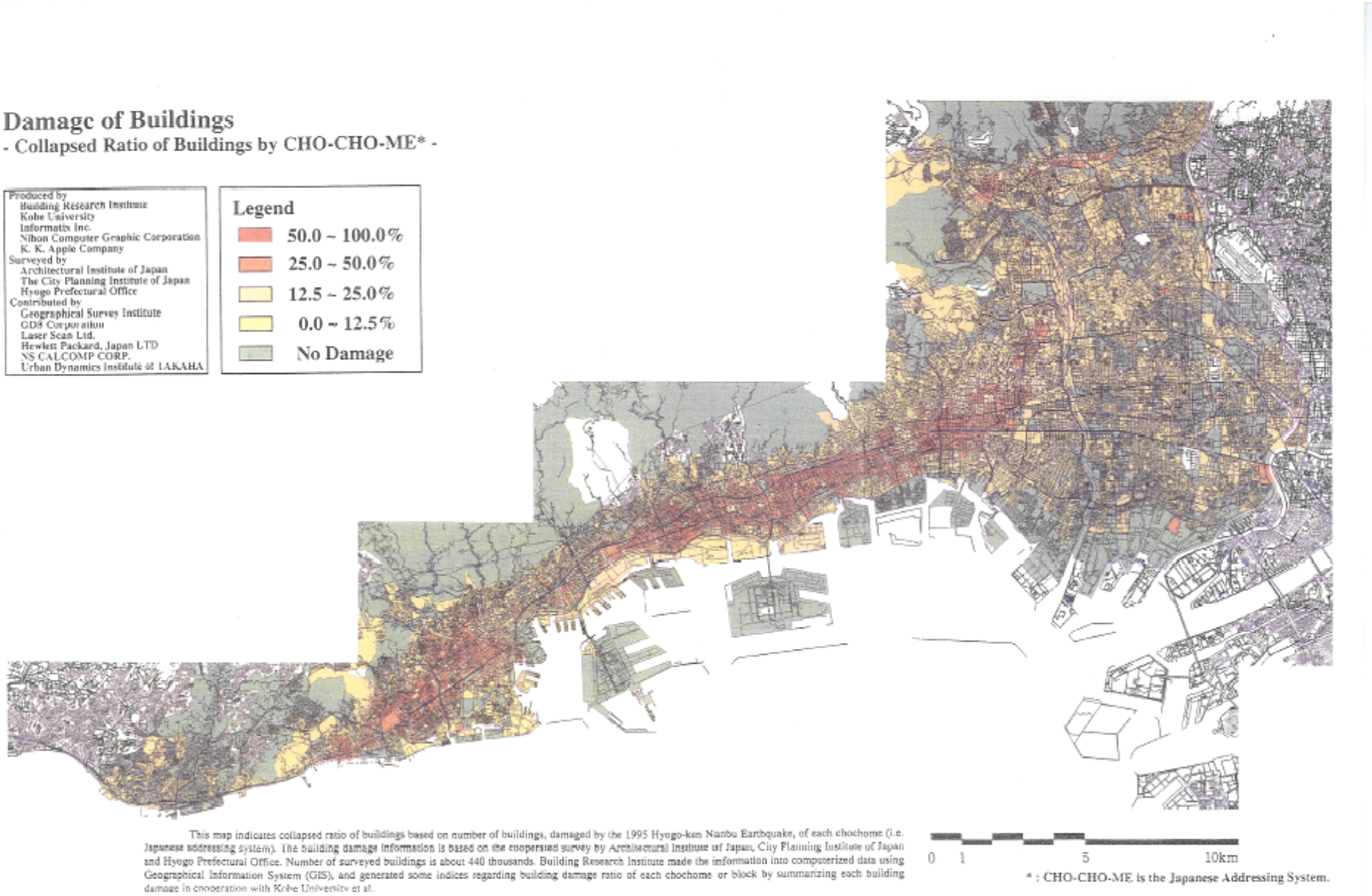


Fig. 3.2.5-1 Damage Overview in Damaged Area[1]