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Technical Problems Related to Post-Earthquake Field Emergency Assessment of Building Damage and Safety

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Abstract: When a strong earthquake occurs, buildings are often damaged in varying degrees. The safety assessment of earthquake-damaged buildings is an important part of post-earthquake emergency rescue work. The aim of safety assessment is to quickly and effectively assess the safety of damaged buildings and reduce the loss of life and property of people in disaster areas. In the past, the safety appraisal of earthquake site was carried out according to experts' experience, the appraisal results varied from person to person, and the appraisal efficiency was low. In this paper, the seismic safety and availability standards are established by summing up the rich experience of earthquakes in China, and the relationship between these standards and different damage states is proposed, the damage assessment of reinforced concrete and masonry structures is specified in detail. The damage states of different structural and non-structural components are quantified, and the previous seismic damage pictures are added. Then, according to the severity and quantity of earthquake damage, the safety evaluation rules of the whole building are established, and the earthquake damage of the whole building is evaluated. The results show that the safety evaluation results based on these rules are consistent with the actual situation. Therefore, the proposed method can be used for fast and effective security identification.

Keywords: Post-Earthquake Field, Emergency Assessment, Building Damage, Safety Assessment, Severity, Quantity

1. Introduction

Earthquakes are sudden natural disasters that endanger people's lives and property [1], are a threat to people and buildings [2]. They have repeatedly caused considerable losses and casualties in many parts around the world [3]. Earthquake-prone cities are exposed to important societal and financial losses [4]. After the occurrence of a disaster event, in particular in urban areas, rapid and accurate building damage and safety evaluation is critical [5]. In addition to the many other societal and economic issues following natural disasters, one critical need is the determination of building safety [6]. It is then of crucial importance, early in the aftermath of a major earthquake, to inspect the buildings and identify the damages they have suffered [7]. Based on previous experience [8-17], more technical problems are raised, which are related to the assessment of observed damage and its impact on the safety and availability of the buildings under inspection. It must be fully understood that such inspections are carried out in emergency situations, mainly to save human lives and protect property from aftershocks. In addition, it has to be recognized that the engineer-inspector has neither the time nor the tools commonly used in his profession to provide a definite answer to safety issues. On the contrary, he needs to make assessment in view of the observed damage, experience and relevant training, follow some regulations that depend on the type of building structure. The regulations are presented for reinforced concrete and masonry buildings, which are based on China's experience amassed over the past decades and previous work on this issue. A Seismic Damage Checklist has been compiled to guide engineers to inspect all elements affecting building safety in order to achieve a reliable assessment of unified application standards. The generic criterions are followed by detailed regulations based on quantitative description of damage in different components, accompanied by suitable sketches and photographs.

2. General Criterion for Safety and Damage

Earthquake represents one of the main causes of damage to constructions [18]. Post-earthquake field inspections and classification of building damage are essential first steps in recovery following a major earthquake [19]. According to classic practice around the world, a building attacked by destructive earthquakes is divided into one of two classifications: safe use and unsafe use. Green and red are used to mark building in each type of classifications. General safety and availability criterion with general description of related damages, available for any kind of building, can be seen in Table 1. According to the kind of building, the damage severity and quantity of various components and the importance of damaged components to the integrity and residual capacity of buildings are taken into account in the overall damage assessment of such classifications. For severity of damage, there is a 1-5 digital scale; For quantity of damage, there is a 1-4 digital scale. All the scales are described as follows: Damage severity: 1= Almost intact, 2= Slight, 3=Moderate, 4= Heavy, 5= Destroyed. Quantity of damage: 1= Individual, 2= A Few, 3= Portion, 4= Majority Generally, there are two types of observation operation: rapid and detailed inspections. If the two operations fail to get the final identification results, engineering inspection will be used. Rapid inspection is usually carried out only outside the building, not inside the building. It is based on the observed earthquake damage and does not consider the quantity. Therefore, it belongs to a relatively simple inspection. Detailed inspections generally require access to the interior of the building. It needs to consider the severity and quantity of seismic damage of each structural member at the same time. In both cases, the assessment is based on the general criteria given in this paper, taking into account the importance of damaged components for building safety (e.g. damage in slabs vs damage in walls). The criteria are applicable to reinforced concrete and masonry buildings which are the two most common structural types in China.

Form of Opinions on Building Safety Assessment in Post-earthquake Field

1.BUILDING LOCATION

NO: ______________________________ **Site:** ____________________________

2.DESCRIPTION OF THE BUILDING

Owner: ___________________________

Construction Area: _______________m^2, **Safety Building:** _______________m^2

House Use: _______________________ **Building Structure:** _______________

Storeys of Buildings: _______________ **Year Built:** ______________________

3. ANTI-SEISMIC CONDITION

Pre-earthquake Quality:____

Expect Earthquake Effect: (**Minor** **Large**) Earthquake Effect;

(Ⅵ Ⅶ Ⅷ Ⅸ) Intensity

Previous Seismic Fortification of Buildings: (**A. Seismic Fortification**

B. No Seismic Fortification)

Seismic Fortification: (Ⅵ Ⅶ Ⅷ Ⅸ) Intensity

4.OVERALL ASSESSMENT

Expert Conclusion: (**A B C D**) Safety Building

(**Whole Part**) Temporary Non-use of Building

5.COMMENTS

Suggestion: ____

Explanation: ____

Appraiser: ______________ **Unit:**_____________________________________

Date: ___________________

Notes: 1. Choose the right choice in parentheses and circle it. To cross out with oblique lines that do not belong to the conclusion of appraisal.

2. The choice of bold characters in earthquake action, seismic fortification and conclusion must be made.

3. Building Structure: Multi-storey masonry buildings, Multi-storey and high-rise reinforced concrete building, Brick House with Inner Frame and Bottom Frame, Single-storey reinforced concrete column factory building, Single-storey Brick-column factory buildings and open houses, Wood-structured houses, Earth stone Wall House

Figure 1. *Form of Opinions on Building Safety Assessment in Post-earthquake Field.*

Summary of Requirements for Assessment of Safety Buildings in Post-earthquake Field

<table>
<tr><th rowspan="2">Classification of Buildings</th><th rowspan="2">Earthquake Effect</th><th colspan="2">Seismic Fortification Criterion</th><th colspan="4">Seismic Damage Status of Buildings</th><th rowspan="2">Site, Foundation and Adjacent Building Impact</th></tr>
<tr><th>Grade</th><th>Intensity</th><th>Main structure</th><th>Non-structural element</th><th>Decoration</th><th>Damaged before the earthquake</th></tr>
<tr><td rowspan="2">A Safety Building</td><td>Minor Earthquake Effect</td><td>A, B</td><td>No requirement</td><td colspan="3" rowspan="2">No seismic damage, or individual damage points.
Does not affect bearing capacity.
Does not affect stability.</td><td rowspan="2">No extension</td><td rowspan="8">The surrounding site is stable, without the impact of landslides, bank collapses, liquefaction, floods and other hazards to the safety of buildings; the foundation is stable, without the impact of sliding, uneven settlement, bearing capacity decline and other causes of upper structure damage; not affected by adjacent building earthquake damage.</td></tr>
<tr><td>Large Earthquake Effect</td><td>A</td><td>Not less than the predicted intensity of large earthquake effect</td></tr>
<tr><td rowspan="2">B Safety Building</td><td>Minor Earthquake Effect</td><td>A, B</td><td>No requirement</td><td colspan="2" rowspan="2">No seismic damage, or individual damage points.
Does not affect bearing capacity.
Does not affect stability.</td><td rowspan="2">There may be earthquake damage, no sign of occurrence or recurrence of falling patches or blocks.</td><td rowspan="2">No obvious extension</td></tr>
<tr><td>Large Earthquake Effect</td><td>A</td><td>Not less than the predicted intensity of large earthquake effect</td></tr>
<tr><td rowspan="2">C Safety Building</td><td>Minor Earthquake Effect</td><td>A, B</td><td>No requirement</td><td rowspan="2">There is a small amount of slight earthquake damage, which does not affect the overall and local stability, and the bearing capacity can be slightly reduced.</td><td colspan="2" rowspan="2">There is earthquake damage. After taking emergency measures, there is no sign of dumping or falling.</td><td rowspan="4">Extensible without endangering overall and local safety</td></tr>
<tr><td>Large Earthquake Effect</td><td>A</td><td>Not less than the predicted intensity of large earthquake effect</td></tr>
<tr><td rowspan="2">D Safety Building</td><td>Minor Earthquake Effect</td><td>A, B</td><td>No requirement</td><td rowspan="2">Overall, there may be slight seismic damage, individual seismic damage may be more obvious, without affecting the overall and local stability, individual component bearing capacity may be reduced, the overall may be slightly reduced.</td><td colspan="2" rowspan="2">There may be earthquake damage or collapse. After taking emergency measures, there is no sign of collapse.</td></tr>
<tr><td>Large Earthquake Effect</td><td>A</td><td>Not less than the predicted intensity of large earthquake effect</td></tr>
</table>

Note: 1. Minor earthquake effect refers to the effects of earthquakes that are subjected to a second time with less intensity than the effects of previous earthquakes.
2. Large earthquake effect refers to earthquakes with the same or greater impact intensity as those of previous earthquakes.
3. Fortification level: Grade A refers to the requirement of fortification intensity to be constructed according to the requirement of fortification intensity or to meet the requirement of fortification intensity in the seismic appraisal standard.
Grade B refers to that without seismic fortification.

Figure 2. *Summary of Requirements for Assessment of Safety Buildings in Post-earthquake Field.*

Table 1. *Damage, availability and posting classification of buildings.*

Posting Classification	availability	Damage State
SAFE BUILDING (GREEN)	Usable	1-2=Almost intact - Slight
Earthquake-stricken buildings that can be safely used in expect earthquake effect. There are four types of safe buildings: A, B, C, D		
TEMPORARILY UNRESIDENTIAL BUILDING (RED)	Unusable	3-5=Moderate- Destroyed
Earthquake-stricken buildings may be damaged by earthquakes that endanger lives or cause heavy losses of property in expect earthquake effect. They cannot ensure the safety of use, or the aseismic capacity and safety of buildings affected by earthquakes cannot be evaluated at the earthquake site for a while.		

3. Opinion Form for Damage, Safety

A simple mean for performing good inspection and making certain evaluation of building safety is the opinion form in which engineers–inspectors can give good opinion about the damage and safety. The opinion form here is shown as Figure 1. At the same time, the following points should be kept in mind at all times:

1. Some information of the whole building subject to earthquake is only recorded in this form, but the specific component damage information is not recorded.
2. Some of the necessary information about the building is only included, which makes it simple and clear. At the same time, the form can provide people with the information they need.
3. This form is suitable for engineers or scholars with rich experience in safety assess. For those with less

experience, it may be necessary to develop more detailed forms. The Inspection Engineer will eventually give a comprehensive assessment based on the seismic damage status of structural and non-structural components.

4. According to different types of safe buildings, the requirements of various types of safe buildings (mainly for Multi-storey masonry buildings, Multi-storey and high-rise reinforced concrete building) are tabulated in the safety assess as shown in Figure 2.

There are five groups of information in the FORM. The five groups are separate parts of the form as follows:

3.1. Part 1 (Building Location)

The content of this part is basically completed during the rapid inspection. During the detailed inspection, the content only when there is no filling in or error filling in will be added.

1) *NO*. This is given by the appraiser according to the order of the house being appraised.
2) *Site*. This is usually provided by local government departments or housing owners. It shows the location of the building.

3.2. Part 2 (Description of the Building)

1) *Owner*. This can be done by asking local government departments, housing residents or neighbors.
2) *Construction Area*. This can be obtained by asking the local housing authority or the owner of the house.
3) *Safety Building*. This is usually filled in at the detailed inspection stage. It requires inspectors to enter the building for detailed inspection before it can be obtained.
4) *House Use*. This is easier for the inspector to judge. If there are buildings that are difficult to judge, it would be wise to consult the owner or occupant of the house.
5) *Building Structure*. This can be judged by consulting the housing administration or by following the instructions in the form.
6) *Storeys of Buildings*. This can be easily judged by the appearance of the building.
7) *Year Built*. As for the construction year, the appraiser can consult the housing management department or the owner. Otherwise the appraiser should make an estimate.

3.3. Part 3 (Anti-seismic Condition)

1) *Pre-earthquake Quality*. This mainly refers to the quality of the building before the earthquake. Generally, it is estimated in the detailed inspection.
2) *Expect Earthquake Effect*. The earthquake-stricken building may be affected again by the earthquake. At the same time, the magnitude of earthquake impact is predicted.
3) *Previous Seismic Fortification of Buildings*. This can be consulted with the local housing management department. Otherwise, only a rough estimate can be made.

3.4. Part 4 (Overall Assessment)

Expert Conclusion. This is done during the detailed inspection phase. The assessor will make a final assess of the damaged buildings. The earthquake damage assessment is based on Tables 2 and 3, related earthquake damage pictures (Figures 3-5) and a large number of earthquake damage assessment experience. The overall assessment of earthquake-damaged buildings should be completed by considering Tables 2 and 3, that combines the severity of component damage (the highest observed) with the estimation of its quantity (the number of components damaged at a particular level). In the whole process of identification, an important principle should be followed, the safety of the occupants is the most important, not the maintenance cost.

Table 2. *Typical damage severity for multi-storey masonry buildings.*

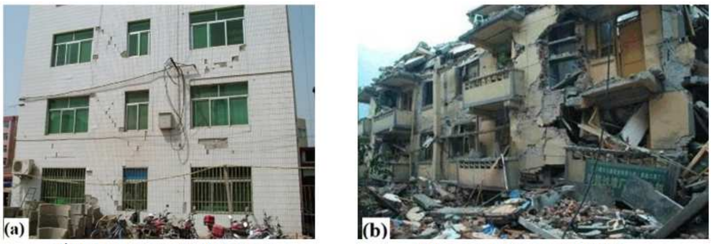
Damage severity	Damage description
1=Almost intact	1. The main load-bearing walls are basically intact; The roofs and floors are intact. 2. Minor damage of individual non-bearing components. 3. The structure has normal function and can continue to use without repair.
2= Slight	1. No damage or slight cracks (d≤1.5mm) in load-bearing walls; The roofs and floors are intact. 2. Portion of the non-bearing components are slightly damaged, or individual is obviously damaged. 3. The basic function of the structure is unaffected. It can be continued with minor or no repairs.
3= Moderate	1. Majority load-bearing walls have slight cracks (d≤1.5mm), portion of them have obvious cracks (1.5mm<d≤3.0mm), and individual of them have serious cracks (d>3.0mm). 2. Majority of the non-structural member are obviously damaged. 3. The basic function of the structure is affected to a certain extent, and it can be used after repairing.
4= Heavy	1. Majority load-bearing walls have obvious cracks (1.5mm<d≤3.0mm), portion have serious cracks (d>3.0mm). 2. Cracks in roofs and floors, partial collapse or serious deformation of sloping roofs, and serious damage to non-bearing components. 3. The basic function of the structure is seriously affected, and even portion of the function is lost, so it is difficult to repair or has no repair value.
5= Destroyed	1. Majority walls are severely damaged; Structures are on the verge of collapse or have collapsed. 2. Structural use function no longer exists, no possibility of repair.

Note: d-width of cracks.

Table 3. *Typical damage severity for multi-storey and high-rise reinforced concrete building.*

Damage severity	Damage description
1= Almost intact	1. Frame beams and columns are intact. 2. Minor damage of individual non-bearing components. 3. The structure has normal function and can continue to use without repair.
2= Slight	1. Minute cracks (Cracks that can be seen clearly by the naked eye caused by earthquakes) appear in individual frame beam and column members. 2. Portion of the non-bearing components are slightly damaged, or individual is obviously damaged. 3. The basic function of the structure is unaffected. It can be continued with minor or no repairs.
3= Moderate	1. Most frame beams and columns have slight cracks (d≤0.5mm), some have obvious cracks (0.5mm<d≤1.0mm), and individual have concrete peeling at the end of beams and columns. 2. Majority of the non-structural member are obviously damaged. 3. The basic function of the structure is affected to a certain extent, and it can be used after repairing.
4= Heavy	1. Frame beams and columns are severely damaged. Majority of the beams and columns are peeled off and the main bars are exposed. Individual of the main bars of columns are buckled under compression. 2. Non-bearing components are seriously damaged. 3. The basic function of the structure is seriously affected, and even portion of the function is lost, so it is difficult to repair or has no repair value.
5= Destroyed	1. Frame beams and columns are seriously damaged, and structures are on the verge of collapse or have collapsed. 2. Structural use function no longer exists, no possibility of repair.

Note: d-width of cracks.



Slight damage (GREEN) Heavy damage (RED)

Figure 3. *Seismic damage grade of masonry structure.*

Almost intact Slight Moderate Heavy

Figure 4. *Seismic damage grade of infilled wall.*

Figure 5. *Seismic damage grade of RC structural elements.*

3.5. Part 5 (Comments)

1) *Suggestion*. For buildings damaged by earthquakes, appraisers often give some suggestions. For example, these suggestions could include the rapid demolition of a whole dangerous building and the removal of local hazards (e.g. the demolition of a collapsed daughter's wall). In addition, whether public facilities can continue to be used safely or not, appraisers should also give corresponding suggestions. For the earthquake-damaged areas, warning signs should be set around dangerous buildings in a certain range.
2) *Explanation*. To some extent, the appraiser should explain the contents (mainly damage assessment) in the form.

4. Criterion for Damage and Safety Assessment

In the following sections, the criterion for evaluating the severity of damage associated with various types of failure of reinforced concrete and masonry buildings are given [20, 21]. It is noteworthy that the various damage descriptions in Tables 2 and 3 are descriptions of each damage level. The damage listed in the table sometimes exists or does not exist in actual earthquake damage. Therefore, the criteria in the table can only be used as an aid rather than an absolute judgement.

Damage severity of structural and non-structural components of various types of buildings (masonry and reinforced concrete structures) is determined according to the criteria in Tables 2 and 3, respectively.

Damage quantity refers to the number of components with specific damage severity of a component. If a component has different levels of damage severity (e.g. infilled walls with severity of 1-3), the most serious damage should be taken and the corresponding number of the severity should be recorded. Based on the comprehensive consideration of the severity and quantity of damage to each component, the overall seismic damage assessment of damaged buildings is carried out according to Tables 4 and 5.

The most important thing is that the inspector should first determine the type of structure (Section 2), then evaluate the "ultimate load" of each bearing member, and then judge the damaged member. Although it is basically impossible to automatically assess safety based on observed component damage, a lot of work has been done in order to make a more objective assessment in safety evaluation. The safety of the whole earthquake-stricken building is based on the observational damage of the damaged components (beams, columns, infilled walls, parapets, roofs) and their contribution to the seismic capacity of the earthquake-stricken building.

In summary, the steps for safety assessment of earthquake-stricken buildings are as follows:

1. Damage severity (1–5) and quantity (1–4) of each damaged component is determined on the basis of these (Tables 2, 3, Figures 3–5).
2. Damage to individual components is assessed in accordance with the criteria in Table 4, which evaluates damage to components in terms of severity and quantity of damage. For this purpose, the following letter symbols are used to represent each component group.

A: columns, beams, beam-column joints, shear wall, masonry wall, ring Beam and constructional column; B: Non-load-bearing wall; C: Floors and roofs; D: Non-structural components, ancillary buildings and ketches.

3. As shown in Table 5, the "overall safety assessment" of earthquake-stricken buildings (green or red; Part 4 of the Opinion Table) must take into account the "safety assessment classification" of individual components.

It can be seen that structural components (A), non-load-bearing wall (B), floors and roofs (C), non-structural components, ancillary buildings and ketches (D) are crucial to the overall safety assessment of earthquake-stricken buildings. Generally, the assessment of the safety of an entire earthquake-stricken building follows any of these classifications for partial damage assessment. Damage to minor components does not affect a building marked green, possibly limited or subject to interference.

It should be emphasized again that the rules and standards given in this paper should always be considered as a supplement rather than a substitute for safety assess.

Table 4. *Criterion for assessment of element damage.*

Damage types	Assessment	Damage severity	Damage quantity
A. Structural Components (columns, beams, beam-column joints, shear wall, masonry wall, ring Beam and constructional column)	Green	1, 2	1, 2
	Red	3, 4, 5	3, 4
B. Non-load-bearing wall	Green	1, 2	1, 2
	Red	3, 4, 5	3, 4
C. Floors and roofs	Green	1, 2	1, 2
	Red	3, 4, 5	3, 4
D. Non-structural components, ancillary buildings and ketches	Green	1, 2	1, 2
	Red	3, 4, 5	3, 4

Table 5. *Criterion for overall assessment.*

NO.	Seismic damage assessment of components	Overall assessment
1	A and B and C and D: Green	Green
2	A: Red, B and C and D: Green	Red
3	A and C: Green, B or D: Red	Green
4	C: Red, A and B and D: Green	Red
5	A and C: Red, B or D: Green	Red
6	A and B and C and D: Red	Red

5. Multi-storey Masonry Buildings

Masonry buildings can be built in a variety of materials (e.g. bricks, stones, concrete blocks) and ways (e.g. with or without ring beams or structural columns). From the economic point of view, low-cost construction is the most significant aspect that makes masonry structures reliable [22].

In Table 2, the damage grade of masonry buildings is related to the damage degree of load-bearing walls, roofs and floors, non-load-bearing walls, etc. At the same time, the pictures in Figure 3 will help evaluators evaluate effectively.

The criteria given are sufficient to cover all cases, but it is important to pay special attention to the tremendous changes in mechanical properties of load-bearing walls.

6. Multi-storey and High-Rise Reinforced Concrete Building

At present, the number of multi-storey and high-rise reinforced concrete buildings is the largest in China, especially in cities. They can be used for many purposes, such as residential buildings, office buildings, teaching buildings, etc. Concrete structures can be constructed in a variety of ways, such as cast-in-place or prefabricated, or they can be combined.

RC buildings are normally designed and analyzed as a bare frame without considering the contribution of the infill material to strength and stiffness [23]. Before the promulgation of building codes (especially in China before 1980), the quality of cast-in-place concrete buildings was often not effectively controlled, so they were vulnerable to strong earthquakes. In destructive earthquakes that have occurred, most of the collapsed multi-storey buildings belong to this category. At the same time, they have to bear the vast majority of human losses. Due to the lack of modern concepts (e.g. strong columns, weak beams, strong shear, weak bending, good ductility, etc.), they are often more vulnerable to strong earthquakes than modern new buildings (after formal design and construction). Old structures are often poorly designed, so long periods of strong earthquakes will damage the vertical bearing components, resulting in a rapid decline in strength and stiffness.

The partition wall is the wall that separates the interior space of the building, and it usually does not bear load. Now in the design of reinforced concrete buildings, partitions are usually brick walls or concrete block walls, which are input into the design model as line loads rather than solid elements. From the destructive earthquakes that have taken place in China, it can be seen that partition walls have played a very good role in the earthquake resistance of the whole building. They are often used as the first line of defense against earthquakes, so that some buildings with poor quality cannot collapse. Because the bricks used for filling walls tend to have high stiffness, they absorb most of the seismic energy in the early stage of the earthquake, which leads to more serious damage than other components. The damage increases the structural damping and reduces the seismic force transmitted to the concrete members. Therefore, as the first line of defense against earthquake of concrete structures, infilled walls provide effective protection for concrete bearing components. However, over-damaged filling walls pose a threat to the lives of people who want to use the building. Therefore, the life safety of building users should be considered as the main objective when building safety is affected by earthquakes. Of course, the damage of infilled walls should be assessed with reference to the corresponding criteria in Table 3. For example, if the damage of the infilled wall is very serious and the bearing parts are not visible, but the overall seismic capacity of the building is significantly reduced, then the building will often be labeled green restricted or red.

The integrity of precast concrete buildings is worse than that of cast-in-situ concrete buildings. The connection of each component of precast concrete buildings is generally weak, which is prone to damage in earthquake. Therefore, these connected areas should be checked first in seismic safety assessment.

In Table 3, the overall damage severity of reinforced concrete buildings is related to the damage types of each component. The corresponding photographs (Figures 4 and 5) in this paper are very useful for inspectors who are inexperienced in seismic safety assess.

7. Rules Applied to the ESESBD Program

The ESESBD is the abbreviation of earthquake safety evaluation system for building damage. Other countries around the world have also developed multiple security identification systems [24-31]. The system is based on the network platform, using modular design and layered architecture. At the same time, the system can quickly and accurately analyze the seismic damage information of buildings collected by appraisers. Through a lot of tests, it can be shown that the identification time of the system is short, and it has good accuracy and stability. The expert system will help appraisers record the damage of building components with a unified standard. At the same time, the system has set up some rules to help inspect whether the damage of building components recorded by appraisers at the earthquake site is consistent with the system standards. If the damage recorded by the appraiser is inconsistent with the standard of the system, the system will issue a warning message. The appraiser then needs to re-correct his or her records to conform to the system's standards. The criteria summarized in Tables 4 and 5 are applicable only to multi-storey reinforced concrete and multi-storey masonry buildings, and so far, all the experience of earthquake site safety assess in China has come from these buildings. Special attention should be paid to the fact that the severity of component failure is only considered in rapid inspection, while the severity and quantity of component failure are also considered in detailed inspection.

8. Conclusions

In the emergency period after strong earthquakes, it is a complex and difficult task to appraise the safety of earthquake-stricken buildings. Especially in emergencies, in a short period of time, a large number of aftershocks occur, so it will be more difficult to carry out safety assess. Based on the valuable experience of destructive earthquakes in China in the past decades, this paper quantifies the typical earthquake damage in multi-storey reinforced concrete and multi-storey masonry buildings. According to the damage severity and quantity of each component in the earthquake-stricken building, the damage is quantified. Through the quantification, the safety of buildings can be evaluated comprehensively. In addition, a large number of standards and rules have been established within the expert system. A more objective assessment will be obtained by recording the type of structure and the observed seismic damage of components. The application of the system described in this paper will benefit the work of assessors, greatly shorten the time of safety assess, help observers to grasp the main information, and finally give a more objective and unified safety assessment of earthquake-stricken buildings. Results obtained show that:

1. Based on decades of local (China) experience, damage, availability and posting classification of buildings have been proposed. At the same time, the damage of structural members is considered in terms of the severity and quantity of the damage.
2. According to seismic experience and national norms, Opinion form for damage and safety, summary of requirements for assessment of safety buildings, typical damage severity for masonry buildings and reinforced concrete buildings were set which help the appraiser to make a unified and effective assessment quickly.
3. Criterion for assessment of element damage and overall damage are designed which allow the appraiser to more accurately determine the overall damage of the building based on the damage of the component.

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