Emergency Assessment System of Damaged Buildings

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Foreword

The United Nations Centre for Regional Development (UNCRD) since 1985 has been focusing its efforts on the importance of regional development planning for disaster prevention in developing countries towards increasing the capability of these countries to plan for future disasters. With regards to activities for disaster mitigation, UNCRD has held seven international meetings under the title of International Research and Training Seminar on Regional Development Planning for Disaster Prevention, since 1987. These meetings were held with the participation of invited experts and/or researchers from all over the world, where issues on disaster management in developing countries were emphasized as having vital significance in the coming century. Before the first year of the International Decade for Natural Disaster Reduction (IDNDR), UNCRD has organized the above research and training seminar annually as one of its concrete programmes contributing to the IDNDR. As themes of the above seven seminars, UNCRD has chosen various topics focusing on disaster prevention in metropolises highly vulnerable to damage in the event of emergency situations. For this 8th Seminar, UNCRD has chosen the topic "Emergency Assessment System of Damaged Buildings". This system has been established since the late 1980s and has been used for the first time during the aftermath of the Loma Prieta Earthquake in the U.S. in 1989.

In the early morning of 17 January 1995, a day after this seminar was held, a large earthquake struck the Hanshin District of Japan. This disaster caused more than 5,000 deaths and injuries to more than 35,000 people. It also caused massive infrastructure damages, including the collapse of 90,000 buildings and the moderate damage to 72,000 houses. Due to this earthquake, we saw for the first time a large-scale application of the emergency assessment system of damaged buildings in Japan. This disaster also made many people realize the importance of this damage assessment system towards the assurance of safety after an earthquake. However, it is still an unfortunate fact that in most developing countries, this system is still not in place. This seminar therefore intends to transfer experiences from developed countries to developing countries concerning the Emergency Assessment System of Damaged Buildings.

Believing that the knowledge gained through this seminar will be significant for disaster management activities, in particular, in the field of emergency assessment system of damaged buildings, UNCRD hereby publishes the report and summary of the proceedings of the seminar. The seminar's success was largely due to the active participation of experts, academicians, administrators, and numerous other individuals from all over the world. Our heartfelt thanks are ex-tended to those who contributed to the preparation of the seminar as well as during its entire conduct. Deepest appreciation to the paper writers, all participants of the seminar, for their sincerest collaboration and hard work in making this seminar a resounding success.

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I. Morning Session

Loma Prieta Earthquake Response: A First Application of Standardized Building Evaluation

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1.0 Introduction

The October, 1989 Loma Prieta earthquake struck the San Francisco Bay area at a force of approximately 7.1 Richter. Although minor earthquakes are not unusual in this seismically active area, the extensive structural damage and loss of 63 lives in this moderate earthquake was hardly routine. Because of a profusion of media in San Francisco for the World Series Baseball games, damage resulting from this earthquake at once became the focus of public attention worldwide. Volunteer inspectors, engineers and researchers from around the country and many from other countries rushed to San Francisco to help assist, evaluate, and learn the lessons of the Loma Prieta earthquake.

The earthquake response by the City of San Francisco encompassed many areas, including response and fire suppression, inspection and repair of roads, bridges, utilities, water and waste water systems, and, of course, building inspection. For many local governmental agencies including the City of San Francisco, the Loma Prieta earthquake was the first test of various new emergency earthquake response programs including the first use of the now ubiquitous ATC-20 building damage assessment program.

All over the Bay area residents were impacted by building damage or fears of impending building damage. Residences, schools, shops and offices were subject to concern about user safety. The Department of Public Works immediately implemented the newly developed ATC-20 program of building damage assessment to determine the actual scope of building damage and to identify those buildings which actually posed hazards to the public, with the immediate goal of restoring habitable buildings to service as quickly as possible. This paper is an overview of the use of such a building damage assessment system, including positive effects and shortcomings. It is evaluation that we can determine the value of wider application of such standardized systems of damage assessment programs.

2.0 Overview of The Damage Assessment Program

The post-earthquake damage assessment program used by the City of San Francisco is entitled ATC-20 *Procedures for Post-earthquake Safety Evaluation of Buildings* [1], and sets forth a standardized procedure for damage assessment and data collection. The Applied Technology Council, ATC is a non-profit corporation which identifies structural engineering research issues and, through a combination of public and private funding, commissions and publishes work focusing on the f current engineering knowledge. State and Federal agencies jointly awarded a con-for the development of ATC-20, with engineering research and report preparation subcontracted to R.P. Gallagher Associates of San Francisco. Mr. Gallagher, a prominent structural engineer and current president of the Structural Engineers' Association of Northern California,
presented the first training seminar based on ATC-20 at a seminar in September, 1989 in San Francisco, just weeks before the Loma Prieta earthquake. With this information fresh in mind, San Francisco Building Inspection managers were able to implement a consistent building assessment and data collection program, which continued for over ten months.

The building damage assessment process using the ATC-20 program categorizes buildings into three classifications, UNSAFE, LIMITED ENTRY (now called RESTRICTED USE), and INSPECTED. In the Loma Prieta event, UNSAFE signified a building, which could not be or occupied due to damage or potential serious hazards. LIMITED ENTRY designated a building in which certain portions were off-limits for entry or use, or which otherwise had limits imp the use of the building. INSPECTED indicated that no significant hazards were found, although hidden damage might be present and non-structural repairs might be required. The City Francisco added a fourth category, SECURED, to indicate those buildings which did no threat to the public or adjoining buildings but which could not be occupied until repairs had been made or structural threats from hazardous adjoining buildings could be mitigated. Many UNSAFE buildings were reclassified to SECURED after shoring and security were provided to stabilize and protect the structures.

Building assessments were typically done in the field by a team of two inspector guidelines provided in the *ATC-20-1 Field Manual: Post-earthquake Safety Evaluations of Buildings* [2]. While teamwork provided obvious safety benefits, it also allowed the application of complementary skills, and it provided adequate manpower for taking the time necessary to speak with building residents, owners and neighbors about the actual impacts of building posting.

The ATC-20 program was the "rapid evaluation" component of a larger building assessment program. Buildings identified as damaged in the rapid response program became subject to detailed analysis, as needed, through either the ATC-20 “Detailed Evaluation” process, using more complete inspection criteria, or through detailed damage review and structure analysis typically undertaken by an engineer hired by the building owner in response to the City's posted San Francisco officials choose to omit the ATC-20 "Detailed Evaluation" phase and go from Rapid Evaluation to engineering review. That program decision was based on limited manpower available and a desire to reduce redundant inspections.

Data collected through the building classification effort provided essential information has been utilized in many ways beyond the simple tracking of individual building damage.

3.0. Retrospective View Of Standardized Damage Assessment Program In The Loma Prieta Earthquake

Benefits Of Standardized Evaluation. The value of standardized building inspection response has become increasingly clear over the five-year retrospective period since the Loma Prieta earthquake. Among the many benefits were the ability to rapidly initiate and implement an inspection program; the ability to utilize the many volunteer inspectors from around the State of California who had been trained or could be quickly trained in the standard inspection procedures; the consistent and uniform application of inspection standards which forestalled complaints of incorrect assessment; the creation of a database for tracking building repair, building re-inspection for research. As noted below, public confidence was substantially increased by the application of standardized emergency procedures.

Problems Related To Program Implementation. The first full-scale application of the ATC-20 program proved that this was an excellent technical program, which fulfilled its goals. The related policy and procedural issues, which went far beyond the scope of technical building assessment, were left to the local jurisdiction. It was these issues which often posed the greatest problems.

One of the most difficult problems to address in the heat of the emergency was related to the repair and upgrade standards for damaged buildings, and the establishment of standards of “acceptable risk” in buildings, issues still under review. Engineers and inspectors had to make difficult decisions when weighing potential damage from future aftershocks or future earthquakes against the need to have the public reoccupy slightly damaged, but potentially hazardous, buildings such as brick buildings. The mistaken public views that buildings, which “meet code” were “earthquake safe” was severely shaken, by widespread building damage in what, to the public, were non-hazardous buildings. In fact, most code provisions are intended to assure a reasonable measure of life safety and to prevent catastrophic collapse of structures, not to allow buildings to survive an earthquake in an undamaged, operational condition. This was shocking to many San Franciscans who had a different understanding of the codes.

Inspectors and engineers trained to deal with materials and structures were often challenged to deal with the human side of the emergency response and recovery. These technical professionals generally blossomed in these new roles, but it became clear that in a more severe catastrophe inspectors should have, as part of their training, special focus on the psychological aspects of stress and trauma. The most significant questions raised by the public related not to structural damage but to the human implications of the postings. Inspectors were asked questions such as “When can I reoccupy my building?” "Can I enter the building to get my personnel possessions?" and "How soon does my landlord have to fix my building?" The public demanded that the inspectors perform not just engineering functions but social and management functions as well, advising owners and residents of policies and procedures, listening to their concerns, and inspecting even non-structural damage to assuage individual's fears. San Francisco found that responding to policy questions and public fears was at least as important as the technical inspection itself.

Policies detailing building re-classification procedures were not in place at the time of the Loma Prieta earthquake and had to be developed during the hectic post-earthquake period. At that time, private engineers were given broad latitude to independently evaluate and post buildings, changing previous inspectors' classifications by simply posting a copy of their letter of evaluation the building and notifying the City. Other methods of reclassification included completion of repair work or requesting another City inspector confirm the classification. Inconsistencies in classification when multiple inspections were done at one building location became a significant problem. Many of these problems have now been addressed through published policies, better internal organization and preparation. Using the ATC-20 standardized inspection program such policies were relatively easy to integrate into the inspection procedures.

At this time, as California enters what some seismologists believe to be a seismically active period, the cadre of volunteer inspectors is much more experienced and the cities much more prepared than just five years ago.

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Public Response. Public response to the standardized damage assessment program was one initial confusion followed by acceptance and reliance. The key initial obstacle to initial public acceptance was related to lack of communication between the government and the public regarding the meaning of the classifications, the scope of inspections (most inspections were cursory and rapid), and the implications of the posting of a building. These Issues and other specific problems, such as providing information in various languages to respond to San Francisco's diverse population, were ultimately resolved through posted notices and printed information in newspapers.

Many private lawsuits in which the City has had to provide certified records and testify regarding the post-earthquake inspection program have supported the public's confidence in a standardized, uniform, unbiased program of emergency inspection. These legal and court reviews have upheld the validity of rapid building evaluation as a basis for governmental decision making. The qualifications of inspectors and the rights of owners to be notified and to attend hearings about proposed government actions regarding their properties are issues, which are consistently raised, in these various legal proceedings.

One of the greatest concerns of the public related to demolition of buildings. Affected property owners and tenants were relieved to find that the City supported a policy of providing security in areas of damaged buildings and, unless buildings represented imminent hazards, allowed even severely damaged buildings to be left standing in a secured condition until ail parties could review repair and salvage options. This demolition program became codified as part of San Francisco's building damage assessment program.

In America's litigious society, the success of this post-earthquake program and these policies in the eyes of the public can be measured by the absence of lawsuits filed against the City after the Loma Prieta earthquake. Public confidence in building inspection was never higher than in the immediate post-earthquake period, in large part due to the credibility developed through the application of a consistent and well-structured building inspection program.

Uses Of Building Damage Data. In the weeks and years following the Loma Prieta earthquake, the data collected as pert of the post-earthquake inspection program has been used in innumerable valuable ways. Essential data on the most severely damaged buildings was immediately compiled into a publication made available for public information and for use as an emergency management information base [3]. As a research database alone, the standardized evaluation program could be considered to be a success. Data has been used to analyze susceptibility to damage of various building types, particularly unreinforced brick buildings, and to develop and support codes and laws related to building upgrades. Data was used to identify hazardous soil areas and hazardous micro-zones of other types. The overall recovery process could be tracked through updated reports based on damage assessment surveys.

Future emergency shelter and housing needs have been projected from the number of units in UNSAFE, SECURED, and LIMITED ENTRY buildings. Legislative support for various inspection programs could be substantiated through the analysis of damaged building data collected as part of the standard program. Federal, State and local funding for repairs and hazard mitigation relied in large measure on the accurate and reliable records of both individual buildings and the composite picture painted by the overall data. Private parties, such as insurance companies and attorneys, still reference the damage survey forms as authoritative documentation of damage immediately following the Loma Prieta earthquake. Areas of damage were mapped building-by-building and subsequently coordinated with municipal utilities to form part of a meaningful geo-based data system, helpful in planning repairs and upgrades.

The City of San Francisco actively supported, and continues to support, research into the science and engineering of earthquake hazards, both geo-technical and structural. The database complied from Loma Prieta has provided research information for serious research investigations, including topics such as building pounding against other buildings and parapet safety performance in upgraded buildings. In all of these and in many other ways the data collected has been of far greater overall benefit than the simple sum of its parts. If for no other reason than the long-term benefits, a uniform damage assessment program is a worthwhile undertaking.

Many thoughtful comments related to the lessons learned in the Loma Prieta earthquake have been shared in a series of post-event conferences, some of which have focused on building evaluation issues [4]. These conferences, like the ATC-20 program itself, are oriented to technology transfer from research and technology to practical application.

4.0. Challenges And Recommendations

The value of a standardized building evaluation program in an urban area is, in large measure, related to the commitment of government agencies to implementing the program. Commitment is shown in assigning top management personnel to the task, in consistency and care with which data is collected and the database is constructed, and in the open provision of information for management and research purposes. Clear, consistent public policies related to building damage must be developed as a critical part of the evaluation program and must become part of inspectors' training. To expand the value of data and make the investment of time and energy more valuable, corollary data needs to be gathered, including ground motion data, building motion data from accelerometers and other recording devices, information on human movement and relocation, related utility and essential service damage, and other cross-disciplinary information. The integration of various government agencies and private groups into the post-earthquake evaluation and management plan is an inherent benefit to developing such a program.

An obvious prerequisite to implementation of damage assessment programs is the availability of trained technical personnel who are not required for more urgent needs, such as urban search and rescue, and who are not, themselves, victims of the crisis. Also required is a survey program with categories conforming to the local building stock. Reasonable, socially acceptable policies need to be developed and effectively communicated to allow the public to feel that the program has meaning and benefit to them, and that earthquake risks, preparedness, and active hazard mitigation issues are understood [5]. Maintaining a continuing level of public involvement in hazards which occur on a geologic time scale is itself a significant challenge. "Wake-up calls" such as the moderate Loma Prieta earthquake do much to help prepare for the serious earthquakes to come.

Many jurisdictions do not have the staff or expertise for post-earthquake planning or implementation in light of other more pressing priorities. Urban post-earthquake assessment and response program development would seem to require that a larger governmental jurisdiction, such as a state or national office, coordinate the development and implementation of such a program. The actual data analysis might also best be coordinated through such a central agency. Often at a state or national level, as well, are the regulations, which allow entry by inspectors into damaged building m the post-earthquake period and the codes which govern building construction and repair.

There may be no better way to understand the value and operation of an effective post-earthquake building evaluation program than to actively participate in a post-earthquake building evaluation program or to review the activities of such a program. Researchers and government officials from all countries are invited to review San Francisco's program when they are in the San Francisco Bay area.

5.0. References

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Safety Assessment Of Damaged Buildings

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1.0. Introduction

As with any program, the assessment of damaged buildings must have a goal. In this case we simply trying to identify damaged buildings. We are attempting to evaluate their safety for long term occupancy. Therefore, the goal is simply to get as many people as possible back into their buildings as quickly as possible. When accomplished, this goal assists the government greatly in its recovery and reconstruction efforts. The faster we can get peoples lives back to some semblance of normalcy, the faster the economic base of the city can return and the faster they enter the period. Furthermore, the faster people can return to their homes, the less the financial or maintaining shelters and the less the emotional strain on the people.

In order to accomplish this goal in California, the Office of Emergency Services (OES) - in conjunction with the Office of Statewide Health Planning and Development (OSHPD) and the Emergency Management Agency (FEMA) - contracted with the Applied Technology Council (ATC) to develop criteria for assessing buildings. These criteria are intended to provide consistency in the evaluation and posting of buildings. In addition, OES has completed and implemented a program, which provides local government with Safety Assessment Volunteers to assist in the completion of the safety assessment process in a timely manner.

One of the first questions that we must look at is "What qualifications are necessary for an individual to assess the safety of buildings?" Based on discussions with building officials, professional engineers, architects, and inspectors, the consensus is that the individual must have:

- *General knowledge of construction.* The evaluator must be able to look at any particular framing system and be able to rapidly identify the system, know how that system works, and what corresponding load path would be.

- *Professional experience*. The evaluator must have some level of practical experience working with the various framing systems. This experience may come from designing and detailing the systems, reviewing the designs and details prepared by others, or inspecting the actual construction of the systems.

- *Judgment.* Above all else, evaluators must be able to look at a damaged or potentially damaged system and, based on their experience and knowledge, make a judgment on the ability of that system to withstand another event of approximately equal magnitude.

In addition having a goal in order to expedite the process, having a well thought out and planned approach will also expedite the process. Part of this plan is to establish appropriate priorities for the particular community impacted. Within California we have established general priorities which are then refined and reorganized depending on the area impacted and the particular needs of the community.

For buildings and structures, we recommend the following priorities:

- *Essential Services Facilities*. Those facilities that must remain operational after a disaster, such as police and fire stations, communications centers, and hospitals.

- *Commercial, industrial and office buildings*. These buildings represent the economic base of the community. The faster we can get the economy moving, the faster the jurisdiction can recover.

- *High-density residential structures*. These are typically hotels and motels, which can be used for long-term sheltering of victims.

- *Single family and low-density residential units*.

For lifeline systems and facilities, the recommended priorities are:

- *Airports, Highways and Bridges*. These systems must be opened as soon as possible in order to expedite the movement of resources.

- *Reservoirs, water treatment plants, and sewage treatment facilities*. These facilities affect a large segment of the population.

- *Pipelines and other utilities*. In cases where domestic and fire water lines are damaged, these facilities may have a higher priority than reservoirs and treatment facilities.

- *Dams*. In California there is a state agency with responsibility for dams. Therefore, local government needs only consider very small dams, possibly located on private property, and used for irrigation.

2.0. Placards Used to Denote Condition for Occupancy

The ATC-20 procedures are based on a three-placard system using color to denote at a distance condition. These placards are intended to tell the owner and/or tenants what the condition of the building is in relation to continued occupancy. The selection of the appropriate placard is determined by performing an evaluation of the building with re-occupying the building as the main criterion. The level of evaluation performed at this time is not sufficient, in most cases, to determine how to repair the observed damage or whether it is economically feasible to repair it. The evaluation is only sufficient to determine whether or not the building can be occupied.

The GREEN placard is what is used to denote a relatively safe structure. This placard is entitled INSPECTED - LAWFUL OCCUPANCY PERMITTED. The criteria for a structure to be posted GREEN are 1) No apparent hazard found; 2) Repairs may be required; 3) Lateral load capacity and/or vertical load capacity has not been significantly decreased. When these conditions exist, then lawful occupancy is permitted.

The YELLOW placard is used to denote those structures which have been damaged yet access to the building is possible with caution and is titled RESTRICTED USE. This placard identifies those structures which can not be full occupied without repairs as well as those that can not be occupied but are relatively safe enough to allow access for possession retrieval. With this placard on the continued used of the building are noted on the placard. These restrictions could free access to retrieve possessions, merchandise, and business records, to long-term of all but one part of a structure. The criteria for a structure to be posted YELLOW is: l) the building is damaged but may or may not be habitable, 2) there is a falling hazard present in part structure, 3) there is damage to the lateral force and/or vertical load resisting systems, however, they are still able to resist loads. When these conditions exist, occupancy is permitted in accordance with noted restrictions.

The final placard is the RED placard, which is used to denote a building or structure, which represents a significant threat to the safety of occupants. Obviously, this placard is titled UNSAFE. However, we also recognize that there has not been sufficient evaluation performed in order to determine if repair is economically feasible. We know that most UNSAFE buildings can be repaired. The decision is often one of economics. In other words, is it more economical to repair or replace. This is a decision that must be made by the owner. Therefore, to make it clear to everyone, have added THIS IS NOT A DEMOLITION ORDER so the owner knows they must make decisions regarding what will happen to the building. The criteria for a structure to be posted RED is: 1) there is extreme hazard and that the building may collapse, 2) there is imminent danger of collapse from an aftershock, 3) there is a significant decrease in lateral and/or vertical load capacity. When these conditions exist, the building is unsafe for occupancy or entry except by authorities.

3.0. Types of Evaluations Performed to Determine Condition for Occupancy

As with the placard system, the evaluation approach also has three levels. Each level of evaluation is intended to develop more detailed information regarding the condition of a building. The rapid and detailed evaluations are intended to be performed by the local government while the engineering evaluation is performed by an engineer or architect retained by the owner of the building.

Ideally, the process begins with the rapid evaluation. This is where buildings are rapidly inspected, spending approximately 10 to 20 minutes per building. The intent of this level of evaluation is to quickly post the obviously safe or unsafe structures. Usually, there is no need to enter the buildings to conduct these evaluations. Some of the buildings, which are posted YELLOW or RED, where done so because the evaluators had questions regarding the condition of the building which could only be answered through a more detailed evaluation. On the evaluation form a notation is made that the building requires a detailed evaluation with an indication of the expertise that is required. In most cases this notation covers geo-technical or structural expertise. However, we can ask for any type of expertise. In many cases, we might ask for hazardous materials expertise if we suspect the presence of asbestos or other toxic material.

The rapid evaluation procedure consists of:

- Examining the structure from the outside by thoroughly looking at each wall of the building from the ground to the roof.

- Examining the ground around the building and over the full site, looking for evidence of surface rupture, liquefaction, subsidence, or landslide potential. When performing this part of the evaluation, remember that geological conditions can extend over several sites and not be visible on all the sites. Consequently, you will need to look at adjacent sites as you evaluate the building.

- Entering the building only if there are known conditions inside the building, which might change your recommendations relating to the condition of the building. Another possible reason to enter a building during a rapid evaluation is to evaluate the condition of access if the building has been deemed UNSAFE.

- Evaluate the structure using the rapid evaluation form. Based on the information included on the form and discussion with the rest of the team, recommend an appropriate posting. If the team were in doubt about the overall condition, they would consider a RESTRICTED USE placard allowing access only for the purpose of removing possessions. They would make sure a request for a detailed evaluation is made.

- Post the structure. A placard should be placed at each entrance to the building. The placard should include the date and time of the posting and all appropriate notations. Each placard should be filled out in ink with the same information.

- Explain posting to occupants. If the building is occupied at the time of the evaluation, meaning of the placard should be carefully explained to the occupants. If the recommendation is for UNSAFE, the team needs to make sure that the occupants understand that they need to evacuate the building. If the recommendation is for RESTRICTED USE, the team needs to make sure the occupants understand the restrictions that are being placed on continued occupancy. Furthermore, make sure that the restrictions are clearly noted on the placard.

The second level of evaluation is the detailed evaluation. This is where buildings are inspected more thoroughly, with more investigation into the framing systems. Detailed evaluations can take anywhere from one to four hours. This type of evaluation is a thorough visual examination of the damaged building, inside and out. It is usually performed on those buildings for which there is some question regarding the structural condition. In most cases, the building will have been posted with a RESTRICTED USE or UNSAFE placard during the rapid evaluation. The procedure for performing the detailed evaluation consists of the steps listed below.

Survey the building exterior:

- Determine structural system to the extent possible from the exterior. This is usually fairly easy for shear-wall type buildings but becomes more difficult with the more sophisticated framing systems. Determining the framing system at this point gives you a hint as to the types of damage that you might expect to find.

- Examine exterior for damage. Examine the walls for damage spending extra time at areas of vertical discontinuity and plan irregularities. Look also for racking of exterior walls, glass frames and other such areas that will indicate excessive drift. Also make sure you look for all types of falling hazards before you enter the building. Also look for new damage to foundations if exposed.

Examine the site for geo-technical hazards:

- Look around the site for fissures, bulged ground, and vertical ground movement.

- In hillside areas, look for evidence of landslide displacement either at the top or the bottom of the slope.

- Remember that geotechnical hazards can extend over multiple sites and be visible on one site but not visible on the adjacent site. Make sure that you look at the adjacent sites.

Inspect structural system from inside building:

- Do not enter obviously unsafe buildings. This is basic common-sense safety. If the building has lot been posted, post it at this time and complete your evaluation form.

- Do not perform destructive investigation. For this level of evaluation the teams are not authorized to perform destructive investigation. The evaluation is being performed under the responsibility of the jurisdiction not the owner. If the structural elements are covered, look for evidence of damage by the condition of the covering material. If you can not make a reasonable determination, note on the evaluation form that an engineering evaluation should be performed.

- Identify and examine the lateral force and vertical load systems. You are specifically looking to see if the capacity of either or both systems has been significantly decreased. Look for conditions where columns or framing connections have failed. Also look for evidence that the walls or supporting members are pulling away from the framing. You are also looking to see if the ground motion caused any residual drift. If residual drift is found, evaluate the P-delta effects from the basic gravity loads.

- Inspect basements for differential settlement, fractured components, bulges, or cracks in the walls that might indicate damage to the foundation system.

- Examine every floor including roof and penthouse(s). Move systematically through the building. Make sure that each floor is adequately investigated before proceeding to the next.

Inspect for nonstructural hazards:

- Look for damage to nonstructural systems such as ceiling systems, partitions, finishes, corridors, and stairways. Damage to these systems can indicate how the structural frame responded to the ground motion.

- Look for damage to equipment and equipment supports, particularly to the air-handling equipment and the fire-suppression and -detection systems. Teams should get as much information as possible regarding the condition of the fire-suppression and -detection equipment. This will play a large role in determining if the building can be reoccupied.

Inspect for other hazards

- Spills or leaks in stored chemicals pr other hazardous materials. Know the occupancy of the building being investigated. If the occupancy is one where chemicals are used, there is a higher potential for a spill. Older building most likely contain some amount of asbestos. This is does not mean that because the building is old it should be posted unsafe because of possible asbestos contamination. If during the investigation breaks in pipe insulation or other indications that asbestos may be in the air are found, they should be reported and building posted accordingly.

Complete forms and post buildings:

- Explain significance of placard to occupants if the building is occupied during your investigation. Using your experience and best judgment, recommend the placard that best represents the condition of the building.

The final level of evaluation is the engineering evaluation. This is the final and most comprehensive of the three levels. The engineering evaluation is performed by a professional engineer or architect retained by the building owner. This evaluation can take anywhere from one to seven days and will not only identify the damage but will determine the cause of the damage. The purpose of this evaluation is to determine the amount of damage and the cause of the damage then from that information develop the appropriate repair program. This repair program is then submitted to the building department to make sure it complies with the jurisdiction's repair criteria. Once the jurisdiction agrees with the proposal, a building permit is issued and the repair work proceeds.

4.0. Criteria Used to Determine Appropriate Posting

As stated in the beginning of this paper, judgment is one of the qualifications for an individual to perform safety assessments. In this section we will look at some of the basic criteria or conditions which would lead to a building being posted UNSAFE. Even though these criteria are obvious, one must use judgment to determine if the actual conditions preclude the owner and/or tenant from access to retrieve their possessions.

- Building has collapsed, partially collapsed, or moved off its foundation. UNSAFE
- Building or any story is significantly out-of-plumb. UNSAFE
- Severe damage to primary structural members UNSAFE
  - Columns noticeably out of plumb.
  - Buckled or failed columns.
  - Roof or floor framing separation from walls or other vertical support.
  - Bearing wall, pilaster, or corbel cracking which jeopardizes vertical support.
  - Broken, leaning, or seriously degraded moment frames.
  - Severely cracked shear walls.
  - Broken or buckled frame bracing.
  - Broken or seriously damaged diaphragms or horizontal bracing.
  - Multistory frame building with residual drift.
- Obvious parapet, chimney, or other falling hazard present. AREA UNSAFE

In this case judgment must be used when posting the building. The AREA UNSAFE placard should be posted near the falling hazard. However, if the hazard affects only a small portion of the total structure, consideration should be given to using the RESTRICTED USE placard in conjunction with the AREA UNSAFE. In the case of a commercial structure, teams could consider restrict-ing the use to employees only until a more detailed evaluation can be performed to see if other measures such as barricading can be easily taken in order to allow access to the general public.

- Large fissures in ground, massive ground movement, or slope displacement present UNSAFE
  - Base of building pulled apart or differentially settled, fractured foundations, walls, floors or roof.
  - Building in zone of faulting.
  - Suspected major slope movement

- Building in danger of being impacted by sliding or falling landslide debris from upslope.

- Other hazards present (e.g., toxic spill, asbestos contamination, broken gas line, fallen power line) UNSAFE

5.0. Condition of Access for Possession Retrieval

In the early hours after a damaging earthquake, the owners and/or tenants of buildings will want free access to their building to retrieve personal possessions, merchandise and business records. Therefore, early questions to be answered include, who can have access, when, and for how long. The rapid and detailed evaluations are aimed at long term occupancy of the structure, not short-term occupancy for possession retrieval.

Access to UNSAFE structures is a local policy issue that must be addressed by the jurisdiction. However, the evaluation process can provide the jurisdiction with key information to assist them in determining these policies. Though this specific information is not contained on the evaluation forms, the information can be provided on separate pieces of paper attached to the evaluation forms.

The process for evaluating access is similar to the process used by the detailed evaluation. Once the team has determined that a building is UNSAFE, they should perform an investigation of the access to that building. Basically, the team looks at exits, corridors, and stairs.

When investigating exits the team will:

- Verify operation of the doors.
- Identify falling hazards.
- Verify condition of pathway to and from the exit doors.

When investigating the corridors the team will:

- Identify falling hazards.
- Verify operation of the doors into other rooms.
- Note the Level of illumination.

When investigating stairways the team will:

- Determine if stairs are free of debris or obstacles.
- Determine structural condition of the stairs.
- Determine structural condition of landings.

Based on this information, the jurisdiction can determine if access will be allowed and whether or not any hazard mitigation will be required before access is allowed to the owner or tenant.

6.0. Personal Liability Issues with Responders

Within California our volunteers are extremely concerned with the personal liability they are exposed to when performing safety assessment. Approximately, half our resource pool comes from private industry where they do not have the same liability protections as government employees. This issue has been addressed in 3 ways such that these responders can not be held personal]y liable for the decisions they make.

Based on a determination from the state's Attorney General, OES registers all our private industry volunteers as Disaster Service Workers. In essence, these volunteers become non-paid employees of the state and are then provided the same liability protection as any other state employee. They can not be held personally liable for any of their recommendations. This protection is provided whether or not the receiving jurisdiction deputizes the volunteers.

After the Loma Prieta Earthquake, many architects volunteered their services to the City of Oakland to assist in the safety assessment of buildings. These individuals were not a part of the Safety Assessment Volunteer program, and, as such, they had not been registered as Disaster Service Workers. Concerned about future liability, they got legislation passed in 1990, which modified the state's Business and Professions Code to provide protection for professionally licensed architects and registered engineers. The American Institute of Architects is now a part of the Safety Assessment Volunteer Program. However, the changes to the Business and Professions Code remain in place. The stipulations are:

- evaluations must be performed within the first 30 days after the earthquakes;
- services must have been requested by a public official public safety officer, or city or county building inspector acting in an official capacity;
- no fee is paid or taken.

The final level of protection comes when the jurisdiction that is using the services of the volunteers deputizes them as Deputy Building Inspectors. When deputized, the Safety Assessment Volunteers become official representatives of that jurisdiction and are afforded the same protection as any employee of that jurisdiction. Again, volunteers can not be held personally liable. A second reason for deputizing js so volunteers can post official jurisdiction placards. These are placards that have been formally adopted by the jurisdiction and are enforceable by law. In order to post these placards, one must be an authorized representative of the jurisdiction.

7.0. Results of the Northridge Earthquake Response, January 17, 1994

At 4:31 AM PST on January 17, 1994 the costliest disaster in the history of the United States occurred. The magnitude 6.7 (M_m=6.7, M_s=6.8) earthquake resulted in widespread damage to Ventura, Los Angeles, and Orange Counties. During the 25 to 30 seconds of ground shaking there was approximately 10 seconds of strong shaking. Ground accelerations were measured well in excess of 1.0 g in both the vertical and horizontal directions at numerous locations within the San Fernando Valley and surrounding areas. The quake, the largest magnitude earthquake in the United States to be have an epicenter in a densely populated urban area, caused 57 deaths and 9,158 injuries of which 1,241 required hospitalization. By mid-morning local emergencies had been proclaimed by the three counties as well as by numerous cities within those counties, the Governor of the state of California proclaimed a state of emergency, and by 5:00 PM PST, the President of the President of the States had declared a major disaster within the three counties.

The safety assessment response began mid-morning of January 17 and lasted approximately two weeks. During this two-week period, OES provided assistance to seven local government jurisdictions and one state agency. This assistance consisted of approximately 600 volunteers from our Safety Assessment Volunteer Program and 280 representatives from the U.S. Army Corps of Engineers. In excess of 67,000 buildings were inspected and posted within the three counties during this two week period.

The following is a summary of the jurisdictions who requested assistance and the assignments that were made to support them.

TABLE NO. I - ASSIGNMENTS BY JURISDICTION

Jurisdiction	Assignments Made												
	1/17	1/18	1/19	1/20	1/21[1]	1/22	1/23	1/24	1/25	1/26	1/27	1/28	1/29
City of Fillmore	4	14	14	10	10			**N**		8	8	8	
City of Simi Valley		20	54	54	34			**O**					
City of Santa Clarita	10	10	10						20	20	20	20	20
City of Santa Monica	12	12	18	6	6			**R**	10	10	10	10	10
City of Culver							6	**E**					
City of Los Angeles		55	55	55	100	100	160	**P**	130	240	282	296	298
County of Los Angeles								**O**	11	6	4		
Div. of State Architect								**R**	4	2	2	2	
Totals	**26**	**111**	**151**	**125**	**150**	**100**	**166**	**T**	**175**	**286**	**326**	**336**	**328**

[1] Oak Grove Base Camp opened

8.0. Statistics Regarding the Response

Even though the use of Safety Assessment Volunteers was terminated on January 30, 1994, the City of Los Angeles continued to perform safety assessments. Their staff was augmented by engineers from the U.S. Army Corps of Engineers well into May. Finally, by July all safety assessment work had been completed and information provided to the Office of Emergency Services by the various jurisdictions within the three counties. Table No. 2, on the following page, represents the overall results of the Northridge earthquake safety assessment process broken down by occupancy. It should be noted that this table does not include the results of the evaluations of public schools. The Division of the State Architect, the state agency responsible for public schools, is compiling this information.

Information in the area sheltering as a result of vacated dwelling units was provided the Governor of California in the report ***Northridge Earthquake - January 17, 1994 - Interim Report***.

According to this report, immediately afier the quake more than 14,000 persons were either in shelters or camping in parks. Sixty-six temporary shelters were opened with the last shelter closing on February 21, five weeks after the quake. Even though formal shelters had been opened, many people were fearful of re-entering any type of building and elected to remain in the parks. At the peak of the operations, over 20,000 people where sheltered in the parks in large tents.

Looking at the results of the Northridge earthquake safety assessment response, and realizing that more than 50% of the buildings inspected were done in the first two weeks, points out the vital need of the program. Whether or not the goal of the safety assessment process was specifically met is hard to say. Realizing that the vast majority of buildings inspected in the first two weeks were found to be safe enough for long tenn occupancy (76%) shows that we certainly tried to get as many people as possible back into their buildings as fast as possible.

TABLE NO. 2 - SAFETY ASSESSMENT

OCCUPANCY	RED UNSAFE	YELLOW LIMITED ENTRY	GREEN INSPECTED	UNKNOWN	TOTAL FOR OCCUPANCY
Residential (Dwelling) % of Occupancy Total	2109 2%	9204 9%	80867 83%	5032 5%	**97212** **85.3%**
Other Residential % of Occupancy Total	9 2%	24 5%	304 59%	177 34%	**514** **0.5%**
Commercial % of Occupancy Total	583 8%	1267 17%	5436 72%	242 3%	**7528** **6.6%**
Industrial % of Occupancy Total	54% 2%	173 6%	759 27%	1878 66%	**2864** **2.5%**
Office % of Occupancy Total	4 4%	9 8%	90 80%	9 8%	**112** **0.1%**
Assembly % of Occupancy Total	3 10%	6 20%	16 53%	5 17%	**30**
Emergency Services % of Occupancy Total	1 4%	1 4%	14 54%	10 38%	**26**
Governmental/Public % of Occupancy Total	0 0%	6 8%	34 47%	32 44%	**72**
Worship % of Occupancy Total	7 8%	8 9%	67 74%	8 9%	**90**
Mixed Use % of Occupancy Total	10 15%	20 31%	31 48%	4 6%	**65**
Other % of Occupancy Total	218 4%	765 14%	2693 50%	1726 32%	**5402** **4.7%**
TOTAL % of Overall Total	2998 3%	11483 10%	90311 79%	9123 8%	**113915**
*** New RESTRICTED USE category was not used except in some mobile home parks where OES provided placards for the evaluation teams.**					

9.0. Conclusion

The procedures outlined in this paper have now been tested during response to four earthquakes in California within the last 5 years. The procedures have accomplished the desired results. The consistency of evaluations has improved with each event and more and more people are trained in the procedures. We can now highly recommend that these procedures, or similar procedures, are

Ready for application on a worldwide basis. Through the continued use of these procedures we can rapidly determine which buildings can be re-occupied on a long-term basis thereby reducing the impacts of the disaster by reducing the sheltering needs. This, in turn, allows the area to move faster into the recovery operations.

Assessment Criteria Of Seismo-Damaged Buildings In China

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Abstract

Investigations into seismo-damaged buildings have been developed in China and the assessment criteria of seismo-damaged buildings have been set up. This paper describes the main contents. of the Criteria, including the classification of the degrees of damage for different buildings, the principle of emergency repairs and risk elimination, and the estimation of direct economic loss and others.

1.0. Background

A strong earthquake is a test of the aseismatic behaviors of buildings, structures, engineering facilities and equipment. Although jt js impossible to observe the damaging process in a structure during an earthquake, the final damages are very clear. The investigations into seismo-induced damage caused by destructive earthquake are of vital importance to the summing up our aseismatic experience, analyzing aseismatic behaviors of structures and developing aseismatic techniques. Ever since the earthquake which hit the Xingtai Area of Hebei Province in 1966 the investigations into seismo-damage caused by strong earthquakes have been made in China with great progress.

These developments include the following:

1. Development from a system of describing damage phenomenon in a simple way into a system of summarizing damage regularities, analyzing damage mechanisms of typical buildings, including structural seismic simulation development;
2. From damage investigations of single buildings to those of multi disciplinary systems;
3. Started to pay attention on the damages to non-structural elements and the effects of city planning on damages;
4. Investigating the economic loss and the social influence caused by earthquake.

There are wide variety of houses and buildings in China. In previous damage investigations, engineers obtained different assessment results on the identification of damage degrees, and the economic loss in particular, which brought about a lot of confusion and disrupted rescue work. In order to set up a unified criteria and rules by which the degrees of damage to structures can be identified, direct economic loss estimated, emergency repair, risk elimination and building retrofit-ting performed the Assessment Criteria of Seismo-Damaged Buildings in China and Working Regulations of Seismo-Damage Investigations were compiled and promulgated in July 1990.

In the course of compiling the Criteria, an earthquake measuring 5.1 in the Richter scale hit the area of Jiangsu Province in February 1990. The Criteria being compiled was then used to assess the building damages and to estimate economic loss. A satisfactory assessment result was obtained, which provided a foundation for the promulgation of the Criteria. Since then the statistics of seismo-damages and the estimations of direct economic loss in investigations for some earthquakes are getting closer to reality which are helpful to the smooth progress of rescue work and to the task of building retrofitting.

2.0. The Basic Method To Identify The Degrees Of Seismo-Damaged Buildings

Of the different structures in China, multi-storeyed masonry structures comprise a high proportion of the total. Recently, reinforced concrete frame-structure buildings and prefabricated single-storeyed reinforced concrete column-factory buildings have been increasing in numbers gradually. In some regions there are structures such as; a) factory buildings with single-storeyed brick columns; b) houses with reinforced concrete lowest storey and masonry superstructures; and c) houses with masonry exterior structures and reinforced concrete frame interior structures. In the countryside there still exist many dwellings with load-bearing timber or brick columns, clay block walls or brick hollow walls, which were not designed by professional designers. These various buildings, subjected to a same earthquake, suffered varying degrees of damage. To identify seismo-damage degrees of buildings it is needed to notice the unification of common and unique features.

The basic methods taken in China are:

** Analyze different influencing factors and find out common regularities*

To coordinate the identification of damage degrees of different types of buildings the following factors have been taken into account:

1. To identify the degrees of damage for different types of buildings structural features such as force suffered characteristics, weak and frail positions, major and secondary elements should be considered. There are some detail identification rules which can be used to coordinate between each other and show differences among them.
2. Load-bearing and non load-bearing elements are distinguished. The damage degrees of load-bearing elements ale mainly referred to determining the damage degrees of a whole building.
3. In identifying the damage degrees of a whole building three kinds of quantity concepts in a broad sense with fuzzy implication are introduced:
   In a general sense, "a few" means less than 5 per cent,
   "partial" not more than 30 per cent,
   "majority " more than 50 per cent
4. In identifying the aftermath of seismo-damage, whether the building is still usable or not, how difficult the repair work is and how much the direct economic loss is should be fully considered.
5. If there were some damages in buildings caused by other reasons before the earthquake it is necessary to distinguish them from seismo-damages in the assessments.

* Take the usefulness of a building as an essential point and put forward the common classification of assessing the aseismatic behaviors of buildings after earthquake.

Usually a major destructive earthquake would accompany a series of strong earthquakes.

Assessing the aseismatic behaviors of buildings after the first earthquake is of significance to the rescue work. Taking usefulness symbols of measuring damage degrees of buildings and assessing their aseismatic behaviors, and considering the above-mentioned five factors, five classes indicating damage degrees or aseismatic behaviors have been identified for a variety of buildings after an earthquake:

Class A Perfect and basically perfect

There is no damage to load-bearing elements and slight damages to a few non toad-bearing elements. Different damages appear in auxiliary elements. The building is still usable without any repairs.

Class B Slightly damaged

There are tiny cracks in a few load-bearing elements, but obvious damage to a few non load-bearing elements. Different damages occur to auxiliary elements. The building is still usable without repairs or with a few repairs.

Class C Moderately damaged

There are small cracks in the majority of load-bearing elements but some cracks are very obvious. There are serious damages to a few non load-bearing elements. The building needs repairing and will be usable properly after taking safety measures.

Class D Severely damaged

There are severe damages to the majority of load-bearing elements or partial load-bearing elements collapse. Risk elimination is urgent. The building needs complete repairs and some parts should be demolished.

Class E Collapse

The Majority of load-bearing elements collapse and the building should be demolished.

In order for engineers to master the Assessment Criteria without any difficulty the main points of damage investigations have been indicated for various buildings. For instance, load-bearing walls and roofs are the main investigation points for multi-storeyed brick structure buildings; frame columns for multi-storeyed frame structures and paying some attention to frame beams and filling walls at the same time; roofs, columns and connections for prefabricated single-storeyed industrial buildings with reinforced concrete columns; brick columns and roofs for single-storeyed industrial buildings with brick columns; Load-bearing brick walls, frame columns and connections for buildings with reinforced concrete lowest storey frame and masonry superstructures or those with load-bearing structures composed of exterior masonry structures and interior reinforced concrete frame; timber or brick columns, Ioad-bearing walls and roofs for dwelling houses which were not designed by professional designers.

** Detailed classification rules about aseismatic behaviors of buildings after earthquake*

By taking multi-storeyed masonry and reinforced concrete frame-structure buildings as examples, the detailed classification rules about aseismatic behaviors of different type of buildings are described as follows:

Class A "The building is still usable without any repairs" means that for multi-storeyed masonry structure buildings there are no damages to load-bearing walls or there are very few tiny cracks in them, no damage to roofs, but different damages to auxiliary elements such as small chimneys on roofs, parapets and decorative elements; for multi-storeyed reinforced concrete frame structure buildings there are no damage to frame beams and columns, but some cracks in a few connections of filling walls and columns.

Class B "The building is usable without repairs or with few repairs" means that for multi-storeyed structure buildings there are tiny cracks partial load-bearing walls; no damage or very small damages to roofs; obvious cracks in the small structures over roofs and staircases; severely damages to a few non-load-bearing elements; big cracks or collapse in auxiliary elements or collapse. For multi-storeyed reinforced concrete frame-structure buildings there are slight cracks in a few frame columns and beams; obvious cracks iu partial of walls; severe damage to the small structures over roofs.

Class C "The building will be usable after repair and can be properly used after taking safety measures" means that for multi-storeyed masonry structure buildings there are serious cracks or collapse in a few load-bearing walls, obvious cracks in partial walls; a few roof elements collapse; serious cracks in a few non-load-bearing elements or parts of them loosened. For multi storey reinforced concrete frame structure buildings there are slight cracks in partial frame columns or obvious cracks in a few columns; serious cracks in a few walls or parts of them loosened.

Class D "Risk elimination is urgent. The building needs complete repair and some parts should be demolished" means that for multi-storeyed masonry structure buildings there are obvious cracks in the majority of load-bearing walls and serious cracks in partial walls, parts of them loosened or collapsed; partial floors and roofs collapse; the whole non-load-bearing wall collapse. For multi-storeyed reinforced concrete frame structure buildings in partial frame columns main reinforcing bars buckled, concrete loosened; partial storey collapse.

Class E "The building can 't be repaired and needs to be demolished and rebuilt" means that for both multi-storeyed masonry and reinforced concrete frame structure buildings the building ruins are less than 50 per cent.

3.0. Method Of Estimating Direct Economic Loss Of Seismo-Damaged Bui]dings

The analysis on economic loss of seismo-damaged buildings covers wide aspects related to many influential factors. In China it's rather late to start the study on this subject. Therefore in the Assessment Criteria only direct economic loss of seismo-damaged buildings is mentioned. According to the damage degrees of buildings the direct economic loss is calculated on the basis of the present construction cost in which the reduction due to the age of the building taken into account.

** The estimation of direct economic loss for a single building*

The estimation of direct economic loss for one building is made by considering the degrees; of damage and different percentage of present construction cost:

Class A	take 0-2%	perfect take 0%	average	take about 1%
Class B	2-10%		average	6%
Class C	10-30%		average	20%
Class D	30-70%		average	50%
Class E	70-100%		average	85%

Considering the ages of buildings reduction is given to present construction cost.

The reduction factors (Φ) are as follows:

Buildings of 1-10 years old	Φ = 0.9-1.0
10-25	Φ = 0.7-0.9
25-50	Φ = 0.5-0.7
50-over	Φ = 0.2-0.5
Shabby and dangerous buildings	Φ = 0.2

** Essential estimation of direct economic loss for all seismo-damaged buildings*

The overall estimation of direct economic loss for all seismo-damaged buildings can be made by selecting a certain numbers of representative buildings, referring to the estimated direct economic loss of a single building and using the method of analog analysis. The essential estimation of direct economic loss of each type of seismo-damaged buildings is expressed as:

$$LOSS = \Phi(0.01A_1 +0.06A_2.0.2A_3+0.5A_4+0.85A_5)\ COST$$

where:

LOSS = Direct economic loss
COST = Construction cost of average unit area for same type of buildings
Φ = Average reduction factor due to building ages
A1-A5 = Construction areas of buildings, of which the aseismatic behaviors (or damage degrees) are respectively from Class A to Class E

In a certain region (a town, a habitat micro-zone, a township or a village) the essential estimation of direct economic loss of seismo-damaged buildings is the sum of the losses for all types of seismo-damaged buildings in that region.

4.0. Concluding remarks

Since its promulgation, the Criteria has been put into effect separately in some places such as Inner Mongolia, Xingjiang and Fujian. Following the Criteria, the seismo-damage statistics and the direct economic loss estimation have been highly recognized by the local administrative departments and disaster-affected people. The Criteria has become an important technical and economic rule for rescue work and the task of building retrofitting.

1. It is reasonable to take the usefulness of post-earthquake buildings as a symbol of measuring damages, to consider different types of. structural characteristics, to distinguish damaged proportion in major elements, secondary elements and different positions, and to classify aseismatic behaviors or damage degrees of buildings.
2. If the aseismatic behaviors or seismo-damage degrees of buildings are Class A or Class B, the people living inside don't need to be evacuated or be moved to temporary shelters. This in effect reduces the problems and secondary damages caused b), improper temporary construction facilities.
3. The estimation of direct economic loss, according to damaged degrees and based on the present

construction cost in which the reduction due to building ages is considered. This can be taken as a guide by which the building retrofitting cost can be determined.

Except the Assessment Criteria for a variety of seismo-damaged buildings mentioned above in the paper, a similar criteria is being compiled at present in China for other structures such as warehouses, silos, tower supports, tanks, corridors, chimneys water tanks and others. It is believed that with the implementation of the Assessment Criteria for each type of seismo-damaged buildings the damage statistics of engineering structures and the estimation of direct economic loss will be closer to reality, which will be helpful to the smooth progress of rescue work and building retrofitting projects.

Discussions of the Morning Session

The seminar was chaired by Professor Tsuneo Okada from the Institute of Industrial Science University of Tokyo, Japan.

In the morning session, the following three papers were presented for discussions:

1. “Loma Prieta Earthquake Response: A First Application of Standardized Building Evaluation” by Laurence Kornfield;
2. "Safety Assessment of Damaged Buildings" by Richard Ranous; and
3. “Assessment Criteria of Seismo-Damaged Buildings in China” by Zhang Weiyue.

After the opening address by Dr. Hideki Kaji, Director of UNCRD, and the keynote speech Yujiro Ogawa, Disaster Management Planner of UNCRD, the session moved on to the technical presentations by the resource persons.

Chairman Okada began the session by stating that one of the speakers. Mr. Ranous, could not to the seminar due to flooding emergencies in California. The chairman also noted that the St part of the Mr. Ranous' presentation was similar to those of Mr. Komfield's presentation but latter part was regarding an application to the Northridge earthquake. Because of this, the chair asked Mr. Kornfield to expand his presentation to include the latter part of Mr. Ranous' presentation and also for Dr. Ogawa to make a brief discussion on the Northridge earthquake.

After the presentations, the chairman opened the floor for questions to the speakers. The first question was from a JICA participant from Venezuela. The participant asked whether in the determination after the inspection of a building, how does the system manage the repair of these buildings? Specifically, how does the government control such repair?

Mr. Komfield responded by saying that it differs depending on each case. Usually the cost is high and the people cannot find enough financing to repair damaged buildings. For cases where there is immediate hazard of collapse, the city will usually share with cost of temporary stabilization or repair. The owners are usually given the responsibility to figure out how to repair their buildings within a reasonable length of time, after which if there is no action, then the city of San Francisco takes action. California has laws to give cities power to declare buildings unsafe then help in the repair of the damage, but in the case of an earthquake where there will be many damaged buildings, it would be too costly for the city to administer and repair such damages. In such cases where the city pays for the repair of a damaged building, the owner of the building must pay the city back after some time, however this system produces several difficulties because of the required extra staff for the collection of money later on. At present the state has passed a law for upgrading brick buildings for retrofitting masonry. To force the owner to repair the building, there is now a system called "Receivership" where the owner must fix the building within a fixed time period (say 6 months) beyond which time, if there js no action then a private person receives the building under his authority. This person can do what he wants with the building, either repair or sell after which he must return the proceeds to the owner. This has been an effective program because it takes the City out of the middle. There is one technical problem however, and this is on the case of outstanding loans on the building. Usually the receiver must borrow money from banks to repair such buildings, but presently there is no law, which stipulates that these loans must be first in line, so the state law must be amended to assure this. The city of San Francisco has a policy not to demolish buildings if it not an immediate hazard. If it is a hazard, measures that are usually taken instead of demolishing includes shoring, and fencing off and then discussion with the owner which could take months, even years. In other cities, there have been long legal battles due to demolition of buildings.

The chairman said that he thinks that a very important problem regarding this topic is in the implementation.

A participant from Bulgaria asked the following question: Mr. Kornfield has said that ATC requires inspector's judgment. I would like to ask; a) how many of the city staff were trained before the Loma Prieta earthquake and what is the situation now, b) do you require special training for your staff, and c) are there any training programs for preparation of inspectors in your city?

Mr. Kornfield responded by saying that during the Loma Prieta earthquake, only a few staff members were trained because the earthquake occurred after a few weeks of the publication of ATC-20 methodology so there was need for hurried training for the city staff immediately after the earthquake. There were members of the engineering community who volunteered from other states and who already received training about ATC-20. However, it was the first application of the methodology so that most people did not have a clear understanding of it. Most of the training were conducted on auditoriums. When there were special problems, regarding unreinforced buildings for example, specialists would arrive and give lectures on these topics. During that time there were a lot of problems and the city had a difficult time coping with the inspections. Now, we have gone through four iteration of the inspection training and the pool of inspectors is large, many of which have had experiences in the inspection, making the demand for training much lower. As for the City of San Francisco, it has embarked on a program to train and certify inspectors, but the question now is who can do these inspections. I have been to court many times to testify regarding building damages, and many times the question was who was the inspector and was this inspector qualified? From experience, persons who does not have a background either as a licensed engineer or architect or a building inspector becomes very difficult to justify the deputization as in the case of building contractors and housing inspectors. Right now there is a big push in Califomia, throughout San Francisco, to do more training on a regular basis every few years to consider the long-term issue.

Director Kaji asked two questions to Professor Zhang. The first was with regard to the computation of economic loss for damaged buildings. In the classifications, Class E is stated to be estimated to give 85% loss. This seems strange because this building has already been demolished, so the loss should be 100%. The second question is with regard to the computation table for loss. I think that this table is useful for places where the building are very homogeneously constructed so basically the estimation would be made building by building. If the type of building or the damages to these buildings are different, I wonder if this king of formulations for the computation for economic loss would still be applicable in a wide area?

Professor Zhang responded by saying that because of the limited time, he was not able to state in detail his presentation. As for Class E, there is no direct explanation but a comparison to the present construction cost is much higher. If the building belongs to another class, then the percentage could be different. It is fuzzy especially when it comes to the age of the building. As for the computation formula, the cost beyond per unit area is A_1 to A_5 for the building area, thus we can use the formula to finally get the direct economic loss.

Engineer Sarausad asked Professor Zhang regarding pages 5 and 6 of the presented paper. Buildings which are 1-10 years old has a value of 0.9 to 10 while those of 50 years and over have a value of 0.2. The usual responsibility for engineers is 15 to 25 years. If the design is a mistake and building collapses, then the designer would be responsible. In economics, the return of investment for buildings is about 10 to 15 years. In the paper 1'vhich will be presented this afternoon, the age of the building will also be tackled contrary to a change per factor. I think that in the use of the formula, legal considerations should also be considered.

Professor Zhang responded by saying that the values presented were decided according to the discussions of experts in China. These are not too accurate and are rough and are not in too much detail.

Professor Sazanami of Ritsumeikan University directed a question to Mr. Kornfield. In a related issue Mr. Kornfield mentioned something about receivership. It is difficult to ask private persons to repair damaged buildings, so the question is will this system work or not? Will earthquake insurance or this kind of system would be the correct financial solution for the repair and reconstruction of damaged buildings. Also, what is the current earthquake insurance practice in the USA?

Mr. Kornfield stated that he is not an expert in insurance, but that a few years ago, the State of California passed a law requiring insurance for buildings across the state but it was overturned. Insurance is a reasonable way to deal with earthquake damage and many people have earthquake insurance. I myself have insurance. However, people like to gamble that there would be no earthquake. Some people win if they sold their property before the earthquake, but some lose. The problem with insurance is that it pays only every 500 years, whereas for those with no insurance, they can spend the money instead. Because of this, I believe that if you don't have insurance, then there should be no sympathy. It is your choice, so you should take your losses.

Presently, there is no such system for mandatory earthquake insurance across the USA. The rates would be difficult to set for the designated areas. The government should help those who want to insure like giving loans or through help by FEMA. My conclusion is "have insurance".

The chairman asked Mr. Kornfield if there was a limit to the amount of insurance payments for earthquake damage to houses in America.

Mr. Kornfield responded by saying that in some cases the deductible amount is about 20% or that it is not available in some areas. This is not true, earthquake insurance is always available and at a reasonable price.

Chairman Okada stated that in Japan, the upper limit is something like 5 million yen per house causing an impossibility to rebuild.

Mr. Kornfield answered that in America, there is no such upper limit of payments. An example is the City hall where repairs went up to 105 million dollars. Contractors carry insurance for the l05 million. There is available insurance but it is expensive.

Dr. Ogawa posed a question to Professor Zhang. In your paper on page 6, you have applied the estimation to Mongolia. My question is who did the inspections in these areas? Also, is there any assessment system in China and is this system carried out by staff only of the state? How do you apply this system to other places?

Professor Zhang responded by saying that in some places in Mongolia the system for assessing direct economic loss has been used in four cases. In each of these cases, the government's Ministry of Construction asked the Academy of Building Research to help local governments to assess the economic losses. Through the basis of the results of these activities, we have compiled the criteria for the estimation of direct economic losses for damaged buildings.

Director Kaji ads that regarding earthquake insurance, in the aftermath of the Nihon-Kai Chubu Earthquake in 1983, in order to recover after the earthquake, they have over-estimated the damages. There are usually some limitations and to get help over the same level, they have to over-estimate. On the other hand, insurers underestimate the damages by contacting directly the residents. There seems to be a problem with regard to the standards of the setting insurance estimates

Mr. Kornfield responded by saying that there seems to be this phenomenon but by just a little bit. Inspectors have tried unsuccessfully to assess the actual cost. Records were valuable during the assessment process later. However, there was no way to get an accurate estimate of costs. In Japan, insurance companies do their part in the assessment after an earthquake.

Chairman Okada responded that the insurance companies have their own assessment guide' lines. Many academic people were involved in the creation of such guidelines and that their assessment were not so different from those of the government's.

Director Kaji adds that there was such a big difference in 1983.

The chairman adds that at that time, no guidelines were set yet. The guidelines were set at around 1984.

Engr. Sarausad stated that after the 1990 Luzon earthquake, there were many estimates of the damages. In the Association of Structural Engineers of the Philippines (ASEP), they were asked to estimate the costs. After 3 to 4 years the appropriate data used was the replacement cost data. This was so because all costs were documented in the government, of course after factoring out inflation. As for private buildings having problems, the solution would be to replace the system completely with insurance in part or in full. As for the government, there is no problem with this regard but in practice, data of replacement and requisitions are not complete for private buildings. However, I think that these ideas are feasibly applicable.

Mr. Murakami asked Mr. Kornfield the following. I agree with the concept of the state municipalities using volunteers to assess damage to building after an earthquake, however, in case these inspectors are injured, who pays for their treatment?

Mr. Kornfield responds by saying that in standard inspection, there is still no state laws which apply thus there is no state standard. This makes cities not forced to follow any standards. However, standards are adopted for the sake of public safety, and because with such concrete data, it becomes easier to get aid from the federal or state governments.

Mr. Ranous paper states a recent law, which gives coverage by the state. San Francisco has added in its charter that in case of emergency, actions done for the city is covered by city insurance. There are some problems with volunteers wherein they have to go to courts to get aid. lp some cases these volunteers must be protected from demands for inspectors to return for an explanation about their inspection when inspectors are from out of state.

II. Afternoon Session

Emergency Assessment of Damaged Buildings In the Philippines: Its Necessity and Possible Parameters

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Abstract

The Philippines is prone to natural disasters like earthquakes, strong typhoons and floods. While earthquake resistant design regulations are continuously updated, fast, simple, and systematic emergency assessment of damaged buildings is deemed necessary to reduce "secondary" disasters, and to address the question whether such structures call be habitable again or be subjected to detailed assessment prior to be declared habitable again.

Taking into consideration the total information of the kind of buildings in the country, the parameters for emergency assessment of damaged buildings should include seismological and geotechnical information of the site where the building is located, together with the structural configuration and properties of the building itself.

1.0 Introduction

Due to its particular location along the circum-Pacific region, the Philippines is prone to natural disasters like earthquakes, strong typhoons and floods. Consequentially, because of earthquakes and strong typhoons, tsunamis (or tidal wave) and storm surges are felt, respectively, in numerous islands comprising the archipelago. Put in a different way, the Philippines including a, its capital, is so located in this part of the globe where flooding, earthquake hazards, typhoon hazards, volcanic hazards, are a constant threat, Punongbayan, R.S. [1993].

As evidenced during the July 16, 1990 Northern Luzon Earthquake, JICA [1990], scores of deaths, injuries, and infrastructure damage were caused due to ground rupture, landslides, and ground action. In the recent November 15, 1994 Mindoro Earthquake, a tsunami or tidal wave was reported to have exacted heavy human casualties and caused damages to houses along the shoreline minutes after the occurrence of the earthquake.

The combined statistics of the damaged and/or collapsed houses and medium to high-rise buildings in the Philippines totals 88,009 units covering the period of 1968-1990 and would show destructive earthquakes caused the partial destruction of the houses (70.2%), the total destruction of houses (29.2%), and the collapse or damage to medium or high-rise buildings to a smaller percentage (0.6%) only, Sarausad [199.3].

2.0. The Necessity Of Emergency Assessment Of Damaged Buildings.

The current source of earthquake design regulations in the country is the National Structural Code of the Philippines Volume I: Buildings, Towers and Other Vertical Structures, Fourth Edition which is also a referral code relating to structural concerns of the National Building Code Philippines, ASEP [1992].

While earthquake resistant design regulations in the Philippines are regularly being updated since 1972 to cope up with earthquake disasters, Sarausad [1992] an emergency assessment of damaged buildings immediately after the occurrence of a natural disaster is seen imperative.

Evaluation, without uniform parameters, could sometimes be based on personal perceptions, which could vary from one evaluator to another. This observation is confirmed by the author based on actual experiences in the earthquake rehabilitation program of damaged infrastructures caused by the July 16, 1990 Northern Luzon Earthquake.

Considering the heavy tolls in human lives and properties during the occurrence of natural disasters in the country especially earthquake and flood, an emergency assessment of damaged buildings is deemed necessary due to the following:

2.1. *Emergency Assessment as a Data Base*

An emergency assessment would generate a simplified "data base" of damaged buildings affected by earthquake or flood. This "data base" is important and could serve as a "starting point" for a comprehensive conceptualization and planning of an infrastructure rehabilitation that might become necessary.

2.2. *Emergency Assessment Would Prevent "Secondary" Disasters*

A fast and expeditiously-conducted emergency assessment would prevent "secondary" disasters like deaths and injuries due to the continued usage of structurally unsafe buildings habituated by occupants even in the absence of an assessment of the building's stability and safety.

2.3. *Emergency Assessment as a Rational "Starting Point"*

A standardized emergency assessment could be a start for a rational and uniform evaluation of damaged buildings especially if the data gathered are substantially complete.

2.4. *Emergency Assessment Can Facilitate Decision Making*

An emergency assessment could be used to declare a building habitable (if without damage) or to require detailed structural assessment of an affected building (if damage is deemed substantial).

3.0. Possible Parameters Of Emergency Assessment Of Damaged Buildings.

Any assessment of structures, including emergency assessment of damaged buildings, should be guided by the total information of buildings existing in the country. In the Philippines, as per NSO [1991], the total number of buildings was recorded at 4,301,901 units as of 1989. The "typical" building is a single house edifice predominantly used as a residential unit. It has a floor area between 20-49 sq.m. and has 1-2 floors. It is mostly private-owned. See Figs. 1-4. The single house structures are mostly made of wooden outer walls followed very closely by concrete, brick or stone wall materials. They have either a galvanized iron (G.I.) or an aluminum roof. At the time of the survey in 1989, these single houses were in good condition, needing minimal or no repair. They are aged between 10 to 20 years. See Figs. 5 - 8.

Emergency assessment as the word connotes is a rapid evaluation, at the soonest possible time, of the structural capacity of the remaining building after it had been subjected to a strong earthquake, typhoon, or severe flooding.

Notwithstanding the fact that detailed evaluation of existing structures is expected to be based on evaluation criteria or parameters before an earthquake, an emergency assessment of damaged building should be implementable even by non-technical personnel at the shortest possible time. These parameters could very well involve earthquake effects, ground shaking effects on structure, and structural factors affecting damage, IAEE [1986].

While expected to be effected within days preferably not exceeding a period of one week, its usefulness rest on the speed of its application, on it being useful as a reference data if the building has no structural damage, or on its relevance as a starting point for a detailed evaluation if the building has extensive structural damage. If a structure has an extensive structural damage, a detailed evaluation as to its safety, stability and adequacy shall have be implemented which could last in a period ranging from one week up to say six months.

Based on the perceptions as to what had happened during the July 16, 1990 Northern Luzon Earthquake, the possible parameters of emergency assessment of damaged buildings should consider the following matters:

3.1. *Fast Assessment*

Assessment should be done fast and its occupant together with the local government agency be informed right away as soon as practicable so that a decision can be made as to whether a damaged building can be immediately rehabilitated or not.

3.2. *Systematic Procedure Using Standard Form*

To standardize the decision-making and facilitate safety monitoring later on, the assessment should be done systematically utilizing previously agreed standard forms. Any decision to allowable immediate habitation of a building or not should be made only after the corresponding forms are filled-up.

3.3. *Simple Forms*

Since copies of the building plans and similar records may not be readily available in the field, answers to the questionnaires in the assessment form should be made simple and answerable by the person doing the evaluation.

3.4. *"User Friendly" Questionnaires*

Assessment form and questionnaires should be "user-friendly" preferably written using the national language and English.

3.5. *Safety First During Field Inspection*

Before entering any damaged building during the conduct of the emergency assessment, "loose" or heavily damaged structural or non-structural elements should be removed first.

3.6. *Simply Engineering Analytical Tools*

Rigid body kinematics and strength of materials concepts should be enough to determine and visualize the remaining strength or stability of the damaged building.

3.7. *Minimum Structural Integrity*

Structural integrity and stability of damaged buildings should still be adequate even if the "loose" structural and non-structural elements are removed.

3.8. *Structures with Doubtful Safety Should be Subjected to a more Detailed Assessment*

When in doubt of the structural adequacy and safety of the damaged building, occupancy should not be allowed pending the completion of a more rigorous and detailed assessment of the damaged building.

3.9. *Collapsed Buildings Should be Immediately Declared "Non-Habitable"*

Buildings that have collapsed should be declared "non-habitable" and immediately scheduled for demolition.

3.10. *Buildings with No Structural Damage Can Be Declared "Habitable"*

Buildings that do not have appreciable cracks and/or damage structural elements can be declared as "habitable" and can be occupied.

3.11. *Buildings with Structural Damage Be Rehabilitated First Prior to Occupancy*

Buildings with any or all of the following damage should be repaired or rehabilitated prior to its being declared as habitable:

- A primary column at a particular level has more than one crack within its height.
- A primary beam at a particular level has more than one crack within its span.
- A beam-column joint failure occurs at a particular level.
- A shear wall at a particular level is cracked traversing from one part of the wall to another.
- At a particular level, a primary lateral resisting element like a diagonal bracing or a knee brace is sheared or cut-off
- The damaged building has a permanent drift of 0.005/Rw.
- The damaged building has a permanent tilt of 50.
- The damaged building has permanently sunk by 50 mm.
- The damaged building has a relative settlement of 25 mm.
- If damaged structural elements are removed or deemed useless, the remaining building geometry is unstable or will become a vertical cantilever and not a frame.

Considering all of these, a proforma evaluation sheet is produced and shown in subsequent pages. The parameters, point systems, structure rating system enumerated in the proforma evaluation sheet are indicative values only at the present time. Over a period of time as local experience is enhanced, these parameters and point systems could improve to come up with a more accurate scenario.

4.0. Acknowledgment

I would like to extend my appreciation to Mr. Yujiro Ogawa, Disaster Management Planner, United Nations Centre for Regional Development and Dr, Raymundo S. Punongbayan, Director, Philippine Institute of Volcanology and Seismology (PHIVOLCS) for inviting me to serve as a resource person and deliver this paper during the 8th International Research and Training Seminar on Emergency Assessment System of Damaged Buildings this 16 January 1995 here in Osaka, Japan.

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Figures 1-4

Figures 5-8

Emergency Assessment of Damaged Buildings

Proforma Evaluation Sheet

A Location of Building

No. __________, Street ______________________, Municipality _______________
City ________________________________, Province ______________

B Evaluation (*)

1. Earthquake Effects

Is the building damaged by:

a. ground shaking

- Intensity 4 _5 points
- Intensity 5 _4 points
- Intensity 6 _3 points
- Intensity 7 _2 points

b. Ground failure?

- Fault zone movement / displacement _2 points
- Landslides _2 points
- Ground Settlement _2 points
- Soil liquefaction _2 points
- Ground fissures _2 points
- None _4 points

c. Tsunamis or tidal waves

- Yes _2 points
- No _4 points

d. Fire induced by earthquake?

- Less than 1 hour for wooden structure _6 points
- More than one hour for wooden structure _3 points
- Less than 2 hours for RC/CHB structure _6 points
- More than 2 hours for RC/CHB structure _3 points
- Not applicable because there was no fire _6 points

2. Ground Shaking Effect on Structures

a. Seismic load

Is the building mostly composed of:

- Light flexible materials, like wood, plywood, “sawali”, “nipa”,? _4 points
- Brittle and heavy CHB _2points
- Rigid and heavy R.C.? _2 points
- Flexible and light cladding of steel or asbestos? _4 points
- Brittle but light glass? _3 points

b. Factors Affecting Seismic Load

Is the building located in site with a:

- Seismic factor, Z?
  - * Z = 0.20 _6 points
  - * Z = 0.40 _3 points
- Importance Factor, I?
  - * I = 1.25, Essential Facilities _3 points
  - * I = 1.25, Hazardous Facilities _3 points
  - * I = 1.00, Special Occupancy Structures _6 points
  - * I = 1.00, Standard Occupancy Structures _6 points

(*) The parameters and point systems enumerated are for indicative use only at the present time

- Lateral Load Resisting System Factor. Rw of the remaining structure?
    - * Rw= 4, 5, 6 (rigid) _2 points
    - * Rw= 7. 8, 9 (moderately rigid) _4 points
    - * Rw= 10, 11, 12 (flexible) _6 points

3. Effect of Site Conditions on Building Damage

a. Location of the damaged building from an "active" fault line
- Within 5 meters or within a distance of the "greater" building plan dimension. _2 points
- Beyond 5 meters or the "greater" building plan dimension _3 points
- Not Known _4 points

b Location of the damaged building from a "suspected' or "inactive" fault line
- Within 5 meters or within a distance of the "greater" building plan dimension _4 points
- Beyond 5 meters or the "greater" building plan dimension _6 points
- Not known _8 points

c Location of the damaged building from a "liquefied" area
- Within 5 meters or within a distance of the "greater" building plan dimension _2 points
- Beyond 5 meters or the "greater" building plan dimension _3 points
- Not known _4 points

d Location of the damaged building from a sandv coastline, bodies of water. or similaT "[liquefaction-prone" area.
- Within 5 meters or within a distance of the "greater" building plan dimension _4 points
- Beyond 5 meters or the "greater" building plan dimension _6 points
- Not known _8 points

e Ground slope terrain where the damaged building is founded
- Slope less than 15º _8 points
- Slope 15º to 45º _6 points
- Slope greater than 15º _4 points

4. Number of storeys of the damaged building

a. One-storey _10 points
b. Two-storey _7 points
c. More than two storeys (No. of floors =____) _5 points

5. Overall Building Stability

a. Drift
* Does the building have a permanent drift?
- Yes _2 points
- No _10 points

b. Tilt
* Does the building have a permanent tilt?
- Yes _2 points
- No _10 points

c. Settlement

* Does the building have a permanent settlement?

- Yes _2 points
- No _10 points

6. Building Integrity

a. Primary Column

* At a particular level, does a primary column have more than one crack within its height?

- Yes _2 points
- No _10 points
- Not applicable because there is no column _ 8 points

b. Primary beam

* At a particular level, does a primary beam have more than one crack within its span?

- Yes _2 points
- No _10 points
- Not applicable because there is no beam _8 points

c. Beam-column joint

* At a particular level, does the building have a beam-column joint failure?

- Yes _2 points
- No _10 points

d. Shear wall and/or bearing wall

* At a particular level, does a shear wall and/or bearing wall have a crack traversing from one part of the wall to another?

- Yes _2 points
- No _10 points
- Not applicable because there is no shear wall and/or bearing wall _8 points

e. Primary lateral resisting element like diagonal bracing or a knee brace

* At a particular level, is the primary lateral resisting element sheared or cut-off?

- Yes _2 points
- No _10 points
- Not applicable because there is no primary lateral resisting element _8 points

7. If all the damaged and "loose" structural elements are removed, would the remaining structural resisting elements be:

a. Incomplete? _4 points
b. Basically complete? _7 points
c. Complete and basically undamaged? _10 points
d. Shear wall? _10 points
e. Dual system? _10 points

8. Possible failure Mechanism of Remaining Structure

a. Free standing or cantilevered _4 points
b. Single-framed structure _7 points
c. Multiple-framed structure _10 points
d. Wall enclosure without roof _4 points
e. Roof on two walls _7 points
f. Roof on three to four wall enclosure _10 points

g. Roofs and floors basically complete
h. Long building with roof trusses
i. Shear walls with openings

9. Age of the structure
a. Less than 15 years
b. Between 15 and 25 years
c. More than 25 years

10. Ownership of the structure
a. Private-owned
b. Government-owned
c. Company-owned

11. Intended usage of the remaining structure

a. Home dwelling
b. Office and public dwelling
c. Hospital, military, and similar vital facilities

C. Conclusion: (* *)

Structure's Rating	Recommendation
Structure with a rating of 60 and below	- To be abandoned or should be completely rebuilt. - Occupancy of the damaged building is not allowed
Structure with a rating between 60 and 80	- Can be strengthened or rehabilitated - Occupancy of the damaged is allowed only after the conduct of detailed assessment of the building and/or strengthening or rehabilitation is already effected
Structure with a rating greater than 80	- Basically needs minor repair or none at all - Occupancy of the building can be effected once “loose” non-structural elements, if any shall have been secured or repair have been already implemented

(**) The structure rating system are for indicative use only at the present time.

Issues to be Solved in the Establishment of Institution of Assessing the Safety of Damaged Buildings in Japan

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1.0. Introduction

Japan is an earthquake prone country. Therefore it is an important policy issue to keep buildings safe from earthquakes and to protect the lives and properties of the citizens.

To solve this issue, it is necessary to take pre-earthquake countermeasures and post-earthquake countermeasures effectively. At present, there are less post-earthquake countermeasures as compared with pre-earthquake countermeasures and there are some important issues to be solved. In this paper, the issues in the establishment of an institution of assessing the safety of damaged buildings in Japan is described.

2.0. Pre Earthquake Countermeasures for Buildings

2.1. Newly Constructed Buildings

Buildings are required to be safe for seismic load and other loads by the Building Code. To confirm the building securely, structural analysis is required for a certain scale of buildings.

Structural regulations was established in the Building Code when the law was enacted in 1950. Through experiences of Tokachi-Oki Earthquake and the advancement of Response Analysis Technology, the renewal of the previous structural calculation method became necessary. The idea of having the design seismic load which will depend on the Eigenvalue of the buildings and on the introduction of "ductility" in the design criteria are currently proposed through the Ministry of Construction's project "Development of New Seismic Design Method" carried out from 1972 to 1977. In June 1978, the Miyagiken-Oki Earthquake occurred and buildings using pilot is, the buildings of the center of gravity being remarkable partial, and the walls of blocks suffered many damages. In this earthquake, it showed the adequacy of the new Seismic Design Method. Also, based on the opinion of different consultants the Structure Calculation Regulation was extensively revised after 30 years and was carried out from June 1981.

The baslc idea of this revision is: (1) to allow no major damage during an intermediate earthquake (Intensity 5; Japan Meteorological Agency) and (2) to allow no collapse in an expected big earthquake, for example the Great Kanto earthquake (Intensity 7; JMA).

2.2. Existing Buildings (Assessing and Restoring)

Buildings constructed after 1981 have already used the above basis, but buildings constructed 6iefore 1981 may not have sufficient seismic resistance in comparison to the present Building Code's requirements such as extremely less share-walls and irregular column layout shapes. In comparison with law provisions which lays down the minimum acceptable level, we are able to check whether or not the building reaches the minimum seismic capability level. It is difficult to check how strong the seismic capability is for each building because seismic capability is decided by the complex combination of many factors. Therefore the methodology of assessing and improving the seismic capability of existing buildings is developed for RC structures, steel frame structures, wooden buildings and steel frame RC structures as "Seismic Assessment Criteria and Restoration Design Guideline".

The abstract for RC structures is as follows:

In seismic assessment, a seismic safety index is calculated and scored according to the type of structure and shape of the building. There are three levels of assessment. The first level of assessment is a simplified method and seismic strength is calculated by wall, column section, floor size and building weight ignoring the ductility of the building. This method is used for the selection of week buildings among many buildings. From the 2nd level to the 3rd level of assessment, the accuracy of the assessment increases accordingly with the addition of calculation factors. The programs for computer analysis have already been developed.

In these assessments, the structural seismic capability indexes are calculated from the seismic capability index, ground motion index, shape index and age index in each beam and girder (x, y) directions in each floor. Seismic strengths are decided by the structural seismic capability index. Reinforcements of seismic capability are the increase of seismic capability by increasing walls and reinforcing columns and beams.

3. Damage Assessment System in Post Earthquake

3.1. Restoration Technology Manual

"Restoration Technology Manual of Buildings" was developed in five years from 1981 as a part of the "Development of Restoration Technology of Damaged Buildings by Earthquake" carried out by the Ministry of Construction. This Manual was composed of damage assessment techniques, restoration techniques in proportion to damage form and the degree and synthetic technique on deciding how to repair damaged building which are needed during damage restoration after an earthquake.

The technology of the restoration of damaged building by an earthquake consists of the following two parts:

(A) Damage Assessment Technology

(a) Emergency Assessment

Emergency Assessment is to assess the risk of collapse of the whole or part of buildings by aftershocks or other forces and to judge risk of usage of buildings. The purpose of this assessment is to prevent a secondary disaster. Immediately after the earthquake, an emergency assessment will be done by Structural Engineers to observe the outline of buildings, sinking and leaning of buildings, damages of structural elements and risk of collapse. Results of the assessment are categorized into: "Danger", "Caution" and "Safe". "Danger" prohibits persons from entering the building “Caution” asks persons to pay attention.

(b) Damage Assessment

Damage Assessment is to investigate damage of buildings and divide them into damage extents and also to judge the necessity of restorations. It contributes to the quick restoration of a damaged building. Structural Engineers investigate the leaning of buildings and damages of structural elements from both inside and outside of buildings. Results of the assessment are categorized in to five levels "little damage", "slightly damaged", "half damaged", "seriously damaged" and "collapsed". The judgments of the necessity of restorations are divided into three categories, namely, "restoration", "restoration or reinforcement (detailed investigation needed)", "reinforcement or demolition (detailed investigation needed)" by damage extents and the intensity.

(B) Restoration Planning Technology

Restoration Planning Technology is the technology, based on the assessment, concerned with the investigation, design and selection of the restoration method to restore or reinforce the damaged buildings.

General procedures to judge the necessity of restoration is as follow:

(a) Assess Specific Condition

Assess existence of some special condition different from the general structural evaluation or economic evaluation (such as restoration required without economic rationality or demolition is scheduled even if restoration is easy).

(b) Economic Evaluation (1)

Evaluate value of the property and degree of wear and tear.

(c) Damage Evaluation (1)

Roughly estimate the damage and judge necessity of detailed investigation or necessity of restoration when damage is small.

(d) Damage Evaluation

Investigate in detail and set up the restoration plan. The restoration plan in this step should be detailed enough to calculate the value of property after the restoration and cost of restoration in the following economic evaluation (2).

(e) Economic Evaluation (2)

Calculate the value of property after being restored. The criterion of this evaluation is that value of property after restoration exceeds the value of property before it suffered damage and the cost of restoration.

(f) Restoration Plan

Restoration Plan should satisfy economic rationality.

(g) Economic Evaluation (3)

Calculate the value of the property and restoration cost as much as possible based on the restoration plan and evaluate the rationality of restoration. The restoration plan itself may be revised according to the economic evaluation. Restoration will begin when the rationality of restoration is recognized through these steps.

3. 2. Examples of Emergency Assessment in Japan

The Ministry of Construction did the an emergency assessment after the Kushiro-Oki Earthquake of 15 January 1993. The following is a summary of the assessment:

Kushiro-Oki Earthquake
Date: 1993.1.15 20:06
Magnitude: 7.8
Intensity: Six at Kushiro City (Hokhaido)
Five at Obihiro, Hiroo, Urakawa (Hokkaido) at Hachinohe (Aomori Prefecture)
Damage: Dead 2
Collapsed Houses: 53

Assessment
Date: 8th to 10th of February 1993
Place: Kushiro City
Engineers: two persons from Ministry of Construction,
15 Persons from Hokkaido government
Equipment: Plumb Clinometer (to measure Pillar Inclination),
Crack Measure (to measure Crack Width),
Measurement (to measure Foundatiori Inclination),
Convex, Light, Calculator, Camera and so on
Assessed buildings:
Buildings assessed were heavily damaged or public buildings that were already assessed by the Kushiro City Building Inspection officers. They selected them based on the information sent into the Disaster Countermeasures Headquarters after an investigation.
Result of Assessment:
Some were assessed as "Danger" and "Limited Use". For these buildings, residents of these buildings were already evacuated or had plans of restorations or restriction such as limited entry was taken.

3.3. Operation of Emergency Assessment System in Shizuoka Prefecture and Kanagawa Prefecture

Emergency Assessment Systems were established and the training of Assessment Engineers started in cooperation with municipalities since 1991 in Shizuoka Prefecture and since 1992 in Kanagawa Prefecture. In both local governments, Authorized Architects who put-in practice of design and construction management, are required to register as Assessment Engineers. Simulation training for both prefecture as well as lectures were introduced for improvement of skills of assessment.

(a) Shikuzuoka Prefecture

The qualification of an Assessment Engineer is those architects of 1st, 2nd and Wooden Structures who took the training course and is authorized by the Governor of Shizuoka Prefecture. The training ourses were held 35 times from 1991 to 1993. By the end of 1993 there were 4,660 registed Assessment Engineers.

(b) Kanagawa Prefecture

The qualification of an Assessment Engineer is those architects of 1st, 2nd and Wooden Structures. Special Building Inspectors or the person designated by the Governor of Kanagawa Prefecture who took the training course and is authorized by the Governor of Kanagawa Prefecture. The training courses were held 20 times every year since 1992. 3,167 have registered as Assessment Engineers by the end of 1993.

3.4. Liaison Council for Post Earthquake Countermeasures for Buildings

Ministry of Construction Established the Liaison Council for Post Earthquake Countermeasures for Buildings as of 20 of July 1993. The following is a summary of Council's activities:

(a) Purpose

The liaison council works for the arrangement of emergency assessment systems for confirming the safety of damaged buildings by large scale earthquake and the communication among the building inspection officers in the Government and in large scale earthquake-prone Local Governments. Post-earthquake countermeasures for buildings are conducted smoothly.

(b) Tasks

This council plays followmg parts

- Communication and arrangement concerning Emergency Assessment System
- Communication and arrangement concerning mutual supports over the boundary of prefectures
- Communication and arrangement concerning other than above.

(c) Organization

Members are: Building Disaster Prevention Section, Housing Bureau. Ministry of Construction; Prefectures of Ibaraki, Saitama, Chiba, Tokyo, Kanagawa, Yamanashi, Nagano, Gifu, Shizuoka and Aichi; and the Foundation of Japan Construction Disaster Mitigation Association.

(d) Proposal

The way to request and to dispatch of Assessment Engineers are under discussions. The following proposal is raised at present.

In principle a City/Town/Village should undertake the assessment work. Therefore the respective municipality should calculate the number of assessment engineers based on the number of buildings needed to be assessed and provide the training courses and register them.

Figure 1. Example

Buildings where safety assessment is needed urgently, provided by liaison council.
Buildings where safety assessment is needed urgently, provided by local government.
Buildings not included in the above categories.

However, earthquake has the misfortune to occur larger than supposed and before completing the training and registration of enough number of Assessment Engineers. Also, for some reason during an earthquake there is still an insufficient number of registered Assessment Engineers. Then the municipality will demand to send Assessment Engineers from other municipalities.

If the municipality which is in need of Assessment Engineers demands Assessment Engineers from other municipalities then the demand should go through the prefecture level. Accordingly, Prefectural governments must be aware of the exact number of registered Assessment Engineers in each municipality.

Figure 2. Example.

(1) City A struck by earthquake requests to receive Assessment Engineers (AEs) lacking enough personnel, to assess the safety of damaged buildings.
(2) Based on the "Plan for mutual Support of Assessment Engineers" established in advance, Prefecture D sounds out to City B to send AES
(3) City B informally appreciates to send AES for Prefecture D.
(4) Prefecture D asks to to send AES to City A.
(5) City B discusses the destination of AEs with City A.
(6) City B consents with Prefecture D to send AEs.
(7) Prefecture D communicates with City A that City B will send AEs.
(8) City B sends AES to City A.

3.5. Issues

(a) Generalization of System

When a large-scale earthquake produces a lack of Assessment Engineers, the Local Government must demand to send them others. If the contents of the training courses and the tools and materials used in the assessment are different in each municipality, it becomes difficult for the Assessment Engineers who are dispatched to assess damaged buildings quickly and precisely. So there is a need to standardize such system.

(b) Status and Compensation

It is often difficult when no one but the public officials knows the knowledge of assessment of damaged buildings. Most Assessment Engineers are civil architects. The law establishing their competence and responsibility is limited and the institution of accident insurance for incidents in assessing damaged buildings is not yet in place.

(c) Information Exchange

It is not clearly how to contact Assessment Engineers when information does not go through after an earthquake occurring.

(d) Payment

There is no idea that bears the necessary expenses to assess damaged buildings

4.0. Conclusions

A large-scale earthquake occurring in a developing country causes innumerable death due to collapsed buildings. The Japanese Government usually sends study groups to developing countries, which suffered heavy damage due to a large-scale earthquake. They grasp damage circumstances on the spot and support emergency techniques to prevent more casualties due to aftershocks. Through the request of the Japan International Cooperation Agency to establish permanent techniques in preventing earthquake disaster, we send professionals for earthquake disaster prevention to developing countries and make architects in developing countries study and train about earthquake disaster prevention. These are useful in the improvement of our earthquake disaster prevention technique.

However, the Emergency Assessment System of damaged buildings after earthquake in Japan is still incomplete as stated above. Presently, some issues to be solved are in institution and application of assessing the safety of damaged buildings. The possibility of large-scale earthquake occurrence at the Southern part of the Kanto district and Tokai district is strong. Therefore we must solve these issues and establish Emergency Assessment System in haste.

Post-Earthquake Inspection and Evaluation of Earthquake Damage in Buildings for Countermeasure

Masaya Murakami
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Abstract

This paper describes firstly the circumstances of development of the post-earthquake inspection and evaluation of earthquake damage in buildings for countermeasure in Japan and its concept and procedure. Secondly it introduces the self-evaluation safety assessment form in the safety inspection plan, which has been prepared by the Shizuoka Prefecture. Finally it comments on the technique transform for engineering criteria.

1.0. Introduction

The need for the post-earthquake inspection and evaluation of building damage has been highly recognized in the most countries of the world to prevent the increase of loss of human lives and properties caused by aftershocks.

In Japan it has become a matter of significant concern since the 1981 southern Italy earthquake. One of many important lessons leaned from the investigation of the earthquake was that a large number of people who had left their homes in fear of those possible collapse wanted a safety inspection of their dwelling houses.

A guideline for the post-earthquake inspection and evaluation of earthquake damage in buildings had been developed from 1981 through 1985, as a part of the National Project titled "Development of Seismic Repair Techniques for Damaged Structures". The guideline covered wood structures, steel structures, reinforced concrete structures, and created housing lots, and included seismic repair techniques for them. It had three sequential stages; (1) first stage to determine the building risk and usability posting, (2) second stage to classify damage levels, to change the category of usability posting if necessary and to decide on necessary treatments such as re-use without any structural repairs, re-use after repair and/or strengthening, or demolition without restoration, (3) third stage, to decide on treatments for those situation left unclear after the previous stages.

The method in the guideline for reinforced concrete buildings was partially modified and was applied to twenty buildings damaged by the 1985 Mexico earthquake. The modification was made so that the method could be applied to flat slab structures. The effectiveness of the guideline was verified by the reasonable results.

ATC-20 post-earthquake Safety inspection program was successfully used in the 1989 Loma-Prieta earthquake and the operation system was observed in Japan. To spread the knowledge of these kinds, "Standard for Evaluation of Damage Level of Earthquake Damaged Buildings and Guideline for Repair Techniques (Evaluation Standard and Repair Guideline) was edited based on the above-mentioned guideline and was published by the Japan Association for Building Disaster Prevention under the supervision of the Ministry of Construction of Japan. "Evaluation Standard" contains the first and second stages of the guideline and "Repair Guideline" does the third stage.

The local government since 1990 has prepared the post-earthquake safety inspection plan, which determines the risk level and usability posting. The plan consists of the field manual and operation system for the inspection work. The field manual for wood, steel and reinforced concrete structures, which was made based on the first stage of "Evaluation Standard and Repair Guideline", includes the repair techniques for short-term safety. The system for operating the inspection work has been improved considering the lessons from the recent earthquakes in United States, especially from the 1989 Loma-Prieta earthquake in which many volunteers played an important role in the inspection work. The Shizuoka Prefecture is the first local government to prepare the safety inspection plan and is followed by the Kanagawa Prefecture and the Tokyo Metropolis, each manual of which contains the items of site. More than five thousand people have already received training and had the license for the safety inspection in the Shizuoka Prefecture and the Kanagawa Prefecture.

There are some problems to be solved in operating the inspection work, which include the description and authorization of usability posting, the immunities for civil damages after the inspection of safety and the compensation for injuries on volunteer's inspection work.

This paper describes the concept and procedure of "Evaluation Standard", a new idea in the local government inspection plan and some comments on the technique transform for engineering criteria.

2.0. Concept and Procedure of Evaluation Standard

"Evaluation Standard" consists of the method for the quick evaluation of the risk level of buildings and for usability posting (Quick Inspection) and the method for the classification of the damage level (Damage Level Classification), which correspond to the first and second stages of the above-mentioned guideline, respectively.

One of the important objectives of "Quick Inspection” in Japan is to inspect the safety of slightly damaged buildings and to determine the suitability of use as a shelter for rescue, evacuation and rehabilitation immediately after a major earthquake. If the large fire due to a major earthquake devoured a large number of wood dwelling houses, many shelters would be necessary.

For reinforced concrete buildings, the investigation is carried out primarily from outside of buildings for the urgent screening of damaged buildings, which may increase the earthquake hazard, by aftershocks. If necessary, however, the safety inside the building should be carefully investigated in addition to the items for the decision on the suitability of use especially as a shelter for rescue, evacuation and rehabilitation.

"Quick Inspection" sheets to determine the building risk and usability posting for reinforced concrete structures are shown in Appendix I, in which some simplification is made. The damage ranking of columns and walls is rated on a scale from I (non) to V (severe) as shown in Table I of Appendix I. On the basis of evaluated damage degree of structural members and possible overturning and falling objects, the risk level of the building against following aftershocks is determined by the following criteria: the category of "Safe", "Caution" and "Unsafe" from the structural members depends on the number of B-and C-degree and the existence of a structural member with the damage ranking over Va.

If one or more C-degree or two or more B-degree items in structural members exist, the entire building shall be determined as "Unsafe". If one B-degree item or any structural member with the damage ranking over Vaβxists, the entire building shall be determined as "Caution". The other cases are "Safe". The criteria for falling and overturning objects are all the same except for the item related to the damage ranking over Va. The overall evaluation is executed, as shown in Appendix Ta, based on the matrix of the two categories of "Safe", "Caution" and "Unsafe" which are attributed to the damage degree of structural members and falling and overturning objects. The entire building and the definite area shall be designated as "Off-Limits", "Entry Limited" and "Usable".

For wood dwelling houses with one or two stories and steel buildings, the outside and inside investigation is required. The items to investigate in "Quick Inspection" for wood dwelling houses contain the story drift and the damage degree of nonstructural interior and exterior wall to evaluate the damage of structures. The items in "Quick Inspection" for steel buildings contain the story drift, buckling of members, damage of braces, and damage of joints and damage at the bottom of columns. "Repair Guideline" also recommends the temporary shoring to all kinds of buildings, if necessary.

"Damage Level Classification" to classify damage levels and to decide on necessary treatments is completed on a basis of the remaining seismic capacity which consists of vertical-load carrying capacity and lateral-load-carrying capacity. The classification of damage level is rated in terms of non or slight, small, moderate, severe, coliapse. Figure I shows a correlation between the category of "Quick Inspection" and the classification of "Damage Level Classification" in a relationship between force and displacement. The repairing and strengthening for long-term safety are decided as shown in Table I . This means that if there will be a building suffered from the severe damage under the low intensity of ground shaking, its seismic capacity will be relatively low.

3.0. Self Evaluation in Local Government Inspection Plan

The field manual is established on the basis of "Quick Inspection" and includes the temporary repair techniques such as shoring in "Repair Guideline". In addition to Quick Inspection, Self Evaluation Safety Assessment in the safety inspection is prepared in the Shizuoka Prefecture. The form is shown in Appendix II. The Tokai area including the Shizuoka Prefecture has experienced severe earthquake every a hundred years. More than a hundred and forty years have past since the last major earthquake in 1854. It has been predicted by a subcommittee of experts organized by the Central Disaster Prevention Council and the National Land Agency of Japan that an extremely severe earthquake with a Richter Magnitude of 8 will occur on the Tokai-Coast in this century; tremendous devastation in the Tokai area, is expected, especially in the Shizuoka Prefecture. The Shizuoka Prefecture recognizes that the trained manpower to do "Quick Inspection" would be in short supply, and has the idea to involve the owners and occupants in the operation plan for the inspection work. According to the form the simple visual examination of their buildings can be carried out and if necessary, "Quick Inspection" will be required by themselves.

4.0. Technique Transform for Engineering Criteria

A fundamental assumption for assuring the safety of buildings is supposed to be that the intensity of ground shaking in the site of buildings under following aftershocks is at least less than that of a main shock. According to the assumption some of buildings can be apparently judged safe for the situation of little damage. some of buildings may be obviously judged unsafe for the situation of severe damage. Criteria of this kind can be easily completed by experts in every country under the consideration of the local condition of buildings and earthquakes. However, buildings not clearly judged, so-called gray area structures must remain to the last, and be left for more detailed evaluation which must be provided with criteria based on the remaining seismic capacity and the intensity of ground shaking. The very research of the evaluation for the seismic capacity, and especially the remaining seismic capacity which can be connected with a repairing and/or strengthening planing, can reduce the member of gray area buildings. On the other hand, it is hoped that every inspector when examining the same building could reach at the same conclusion regarding a structure's safety. The conclusion may depend on the knowledge of inspector.

These facts show that the basically research and education regarding the seismic capacity of various types of structures is essentially required. The steady-going research and education in the various fields of earthquake engineering should be continued in every country, and their technique and information should be exchanged. The exchanging of information regarding renewal operation system for the safety inspection work is more useful to make up a deficiency.

Figure 1

Table 1

APPENDIX I

Appendix II

SELF EVALUATION SAFETY ASSESSMENT FORM

Shizuoka Prefecture

- - TO KEEP YOUR FAMILY SAFE FROM AFTERSHOCKS - -
SELF EVALUATION SAFETY ASSESSMENT FORM
FOR WOOD BUILDING

EARTHQUAKE damaged buildings or houses are very hazardous, because they might collapse or partially collapse due to aftershocks.

TRY! The self evaluation safety assessment using this form, if your building or house was damaged.

CONTACT! The Emergency Office if the result is "Unsafe" or 'Limited Entry",

Building Description

Building Name:
Address:
Owner or Resident: Phone #
Manager: Phone #
Inspector: Phone #
Primary Occupancy
- A. Detached Dwelling
- B. Apartment House
- C. Dwelling with Shops
- D. Of f ice
- E. Commercial
- F. Department Store, Market
- G. Hotel
- H. Industrial
- I. Storage
- J. Other (School, Government,

Year of Construction ( )

Ql. Slope Failure, Crack on Ground, Soil Liquefaction

a. No
b. Yes Somewhat
c. Yes Severely

Q2. Damage of Foundation

a. No
b. Yes Somewhat
c. Yes Severely

Q3. Building or Story Leaning

a. No
b. Yes Somewhat
c. Yes Noticeably

Q4. Damage of Floor

a. No
b. Yes Inclined
c. Yes Severely

Q5. Column Broken

a. No
b. Column Cracked
c. Column Broken

Q6. Damage of Interior Wall

a. No
b. Cracked
c. Wall Mud or Board Swelled

Q7. Exterior Wall Mortar falling Hazard

a. No
b. Threatening to Fall
b. Yes
(NO Answer as c.)

Q8. Roof Tile Falling Hazard

a. No
b. Moved
c. Yes

Q9. Damage of Window and Door

a. No
b. Hard to Operate
c. Impossible to Operate

Q10. Glass Broken

a. No
b. Yes Some Panes
b. Yes Many Panes
(NO Answer as c.)

Q11. Ceiling and Lighting Fixtures Falling Hazard

a. No
b. Threatening to fall
c. Yes

Q12. Other Hazard Present
(ex. Leakage of Water or Gas)

Rating

Total Number of Answers	Answer - a	Answer - b	Answer - c

“Unsafe” If the total number of Answer c is >/= **1**

“Limit Entry” If the total Number of Answer b from Q1-Q8 is >/= **1**

Contact building officials for professional inspection and temporary rehabilitation.

-- TO KEEP YOU AND YOUR FAMILY SAFE FROM AFTERSHOCKS --

Don' t Enter Severely Damaged Buildings
Don' t Get Close to Dangerous Spots

Contact Building Official for Detailed Information
Shizuoka Prefecture

- - TO KEEP YOUR FAMILY SAFE FROM AFTERSHOCKS - -
SELF EVALUATION SAFETY ASSESSMENT FORM
FOR STEEL BUILDING

EARTHQUAKE damaged buildings or houses are very hazardous, because they might collapse or partially collapse due to aftershocks.

TRY! The self evaluation safety assessment using this form, if your building or house was damaged.

CONTACT! The Emergency Office if the result is "Unsafe" or 'Limited Entry"

Building Description

Building Name:
Address:
Owner or Resident: Phone #
Manager: Phone #
Inspector: Phone #
Primary Occupancy
- A. Detached Dwelling
- B. Apartment House
- C. Dwelling with Shops
- D. Of f ice
- E. Commercial
- F. Department Store, Market
- G. Hotel
- H. Industrial
- I. Storage
- J. Other (School, Government,

Year of Construction ( )

Ql. Slope Failure, Crack on Ground, Soil Liquefaction

a. No
b. Yes Somewhat
c. Yes Severely

Q2. Settlement of Building or Ground

a. No
b. Settlement over 10cm
c. Settlement over 20cm

Q3. Building or Story Leaning

a. No
b. Yes Somewhat
c. Yes Noticeably

Q4. Exterior or Wall Tile, Mortar and Sign Boards, Falling Hazard

a. No
b. Partially Fallen
c. Fallen or Widely Swelled

Q5. Damaged of Interior Wall

a. No
b. Cracked
c. Wall Mud or Board Swelled

Q6. Damage of Floor

a. No
b. Yes Inclined
c. Yes Severely

Q7. Damage of Column Base

a. No
b. Concrete Cracked
c. Concrete Crushed

Q8. Damage of Diagonal Brace

a. No
b. Buckled or Slippage Noticed at Bolt Joint
c. Broken

Q9. Damage of Window and Door

a. No
b. Glass Broken
b. Hard to Operate
(NO Answer as c.)

Q10. Ceiling and Lighting Fixtures Falling Hazard

a. No
b. Threatening to fall
b. Yes
(NO Answer as c.)

Q11. Other Hazard Present
(ex. Leakage of Water or Gas)

Rating

Total Number of Answers	Answer - a	Answer - b	Answer - c

“Unsafe” If the total number of Answer c is >/= **1**

“Limit Entry” If the total Number of Answer b from Q1-Q8 is >/= **1**

Contact building officials for professional inspection and temporary rehabilitation.

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Don' t Enter Severely Damaged Buildings
Don' t Get Close to Dangerous Spots

Contact Building Official for Detailed Information
Shizuoka Prefecture

- - TO KEEP YOUR FAMILY SAFE FROM AFTERSHOCKS - -
SELF EVALUATION SAFETY ASSESSMENT FORM
FOR REINFORCED CONCRETE BUILDING

EARTHQUAKE damaged buildings or houses are very hazardous, because they might collapse or partially collapse due to aftershocks.

TRY! The self evaluation safety assessment using this form, if your building or house was damaged.

CONTACT! The Emergency Office if the result is "Unsafe" or 'Limited Entry"

Building Description

Building Name:
Address:
Owner or Resident: Phone #
Manager: Phone #
Inspector: Phone #
Primary Occupancy
- A. Detached Dwelling
- B. Apartment House
- C. Dwelling with Shops
- D. Of f ice
- E. Commercial
- F. Department Store, Market
- G. Hotel
- H. Industrial
- I. Storage
- J. Other (School, Government,

Year of Construction (   )

Ql. Slope Failure, Crack on Ground, Soil Liquefaction

a. No
b. Yes Somewhat
c. Yes Severely

Q2. Settlement of Building or Ground

a. No
b. Settlement over 10cm
c. Settlement over 20cm

Q3. Building or Story Leaning

a. No
b. Yes Somewhat
c. Yes Noticeably

Q4. Damage of Floor

a. No
b. Yes Inclined
c. Yes Severely

Q5. Damage of Column

a. No
b. Concrete Spalling
b. Severe Cracking
b. Bar Appearing
c. Column Crashing

Q6. Damaged of Wall

a. No
b. Concrete Spalling
b. Severe Cracking
b. Bar Appearing
c. Wall Crashing

Q7. Exterior or Wall Tile, Mortar and Sign Boards, Falling Hazard

a. No
b. Threatening to Fall
(No Answer for c)

Q8. Ceiling and Lighting Fixtures Falling Hazard

a. No
b. Threatening to fall
b. Yes
(NO Answer as c.)

Q9. Damage of Window and Door

a. No
b. Glass Broken
b. Hard to Operate
(NO Answer as c.)

Q10. Other Hazard Present
(ex. Leakage of Water or Gas)

Rating

Total Number of Answers	Answer - a	Answer - b	Answer - c

"Unsafe" If the total number of Answer c is >/= **1**

"Limit Entry" If the total Number of Answer b from Q1-Q8 is >/= **1**

Contact building officials for professional inspection and temporary rehabilitation.

-- TO KEEP YOU AND YOUR FAMILY SAFE FROM AFTERSHOCKS --

Don' t Enter Severely Damaged Buildings
Don' t Get Close to Dangerous Spots

Contact Building Official for Detailed Information
Shizuoka Prefecture

Discussions of the Afternoon Session

The afternoon session of this one-day seminar was chaired again by Tsuneo Okada, who had also chaired the morning session. The following three papers were presented for discussion:

1) “Emergency Assessment of Damaged Buildings in the Philippines: Its Necessity and Possible Parameters" by Fidel Sarausad;
2) “Issues to be Solved in the Establishment of the Institution of Assessing the Safety of Damaged Buildings in Japan” by Keishi Isoda; and
3) “Post-Earthquake Inspection and Evaluation of Earthquake Damage in Buildings for Countermeasure" by Masaya Murakami.

Chairman Okada made a brief summary of the entire day's presentations, which had covered a wide range of contexts and experiences. He noted that the assessment techniques in China, Japan, the US, and the Philippines differed considerably and emphasized the usefulness of exchanging experience and knowledge. Adequate time remained for discussions and questions, which were invited from the floor.

The first to pose a question was Prof. Sazanami of Ritsumeikan University. He inquired of Murakami on the subject of investigating damaged buildings. He added that also important was the danger of falling block walls, landslides, floods, and location issues in general related to the sites. Assessment was also required for building site conditions, was it not?

Murakami agreed that this was important and stressed that the original guidelines included assessment of building site conditions.

Okada added that there were three categories to be covered by the national guidelines, proposed by builders' groups: a) buildings; b) civil engineering structures; and c) site condition information. This was clearly seen.

A JICA participant from Colombia questioned Isoda about the system described in his paper (section 3, page 2) wishing to know if was widely used in Japan and requesting some experiences. Isoda responded that the various colored assessment sheets were used indicating various degrees of damage. He requested again that participants study section 3B of his paper in page 2. He noted that the previous week's mild earthquake in Hachino in Aomori Prefecture had provided a useful setting for testing the emergency assessment. The paper also contained experience from the Kushiro earthquake in Hokkaido of 1993.

Dr. Ogawa of UNCRD on the question of the Hokkaido earthquake doubted whether all the buildings in Kushiro were assessed. No response was forthcoming to this query. Isoda continued responding to the previous question, adding that the assessment system was developed in 1985, however in five mild earthquakes many damaged buildings were assessed and repaired ad hoc, before the system could be applied.

Ogawa (potentiously, in the light of the succeeding events!) felt that in the next earthquake to hit Japan, efforts should be made to conduct this assessment for training purposes, as well as for direct experience.

Finally responding to Ogawa's earlier query, Isoda added that only fifteen buildings were assessed in Kushiro in Hokkaido, but the data collected was confidential.

Kornfield was interested to know how much time was required to conduct a rapid assessment evaluation on a damaged building. Moderator Okada recalled that an average time of 30 minutes per building would be necessary for a team of two engineers. He added that this system is more detailed than the ATC-20 system developed in Shizuoka. He also recommended a self-evaluation system. Ogawa observed that a Tokyo standard of between twenty and thirty buildings per day was requested. Again referring to the previous month's mild earthquake in which around 20 buildings were damaged, Okada said that he was in possession of all the relevant data within two days. There had been no systematic inspection following this earthquake - the scale of damage had been relatively small however. Larger earthquakes required a more systematic approach.

A questioner from the Tokyo Fire Department, who had had the interesting experience of being chief of a rescue team dispatched by the government to Malaysia 2 years previously. He observed that in this case three condominiums had been affected by landslide. He had coordinated rescue operations among the group members (police relief, medical team, and an expert team). He strongly felt that a damage assessment system os necessary for buildings affected by other disasters in addition to earthquakes. The rescue team had three components but no one to judge damage assessment. Experts in this area were needed. Did anyone have any questions?

Okada quickly responded that he had been recommending to JICA the inclusion of structural engineers in each team, but up till now there had been no response.

Sazanami drew upon his experience as past-Director of UNCRD and observed that in large-scale disasters, international efforts are necessary, international collaboration and coordination and international team of experts. The UN clearly has a great role to play in this undertaking. There are agencies such as those for humanitarian affairs and disaster relief functions, which carry out such activities. There is also the UN-sponsored "International Decade for Natural Disaster Reduction" or IDNDR but the system is quiet weak, he felt. A new relief task force should be set-up, for rapid response to large-scale disasters.

Ogawa requested experiences from some of the JICA participants, regarding how their countries dealt with earthquakes.

1. Costa Rica: Special programmes operated within civil engineering organizations, National government or municipalities make requests and recommendations following prompt evaluation and inspection similar to the Japanese system although less technical.

   Okada wondered whether there was any published material on this system, but the response was negative.

2. Venezuela: Earthquake preparation was generally from the perspective of the civil industry and associated infrastructure. Vulnerability assessments were ongoing (pre-earthquake) and the subject of hazard assessment was the main consideration of earthquake awareness.

3. Bulgaria: There was no published material and no reai national system. Individual engineers (experts) made estimates of damage resulting from earthquakes. Due to the countries nuclear power plants, there was clearly a need for rapid assessment techniques. A large earthquake is clearly pending! (The participant felt)

4. Mexico: Okada had interesting information from the 1985 experience of the Mexico City Earthquake. Apparently, no onc had been killed inside badly damaged buildings during the aftershocks. The city had 400 building inspectors and a very smooth evacuation process had taken place, from vulnerable buildings. Thus effective assessment of damaged buildings had forestalled people continuing to live in damaged structures. (He had no information on Mexico beyond 1985)

Sarausad recapped on the idea of making structural engineers an important component of any relief and rescue team and voiced surprise that there had been no response to Okada's suggestion to this effect, from the Japanese government. However, he went on to say that any external expert teams should always coordinate with local experts as different countries have different codes. It was essential that the local people filled up questionnaires regarding the earthquake. Reports were only useful if policy-makers can implement them. He provided an idea for UNCRD, suggesting the job of producing sheets for each country. After data has been collected from a target country, decisions can be made based upon local codes.

Ogawa felt the suggestion useful noting that international assessment teams were a form of technical transfer. Emergency rescue teams should be aware of building codes. (The proposal would be submitted to JICA)

Okada recalled that when he was a JICA team member he had to study local building codes.

A Japanese participant who had investigated the recent Hachino earthquake had interesting information. He noted that high-rise buildings were less damaged and that lower buildings sustained relatively more damages. Systematic damage assessment should be carried out - aftershocks represented ever-recurring danger. He hoped that Isoda would bc able to expand his system throughout Japan.

Isoda was grateful for the encouragement and noted that committee work would begin soon on future rapid assessment systems. In Hachino there were 90,000 houses, 10,000 of which were non-wooden. There were insufficient numbers of earthquake engineers to cover every building. Special buildings were investigated however.

On this note the proceeding were drawn to a halt by Chairman Okada It remained of UNCRD's Yujiro Ogawa to provide a concluding address.

He began by noting that the seminar was the first to be held on this particular theme "Emergency Assessment of Damaged Buildings". The exchange of knowledge and experience on both technical and administrative matters was both timely and useful. A number of questions had arisen during the course of the seminar, which required answering, briefly, in the operational field, who must be authorized to take decisions, seemed to be an important area of debate. Questions of technology transfer to other countries, areas of international cooperation assistance, guidelines on emergency rescue, the role of the UN on disaster relief, and the strengthening of the administrative power were discussed during deliberations to the mutual benefit of all. There were many areas where cooperation was vital to strengthening disaster relief - the seminar had provided a useful forum to bring them into focus. The topic should be kept in mind and cooperation maintained. On behalf of the UNCRD he thanked the participants and speakers for their contributions. With this, the "Eight International Research and Training Seminar on Regional Development Planning for Disaster Prevention - Emergency Assessment of Damaged Buildings" came officially to a close.

Opening Address

for the
8th International Research and Training Seminar on Regional Development
Planning for Disaster Prevention

Emergency Assessment System of Damaged Buildings
16 January 1995, Met Hall, International House, Osaka

Hideki Kaji
Director, UNCRD

Distinguished participants, ladies and gentlemen.

It gives me great pleasure to deliver my opening address at the United Nations Centre for Regional Development's 8th International Research and Training Seminar on Regional Development Planning for Disaster Prevention, here at the Met Hall of Osaka's International House.

The United Nations Centre for Regional Development (UNCRD) has been mandated to act as a training centre for regional development in developing countries since its inception in 1971. When considering regional development in developing countries, one of the issues, which we should not neglect, is Disaster Prevention and Mitigation Planning.

Natural disasters such as earthquakes, typhoons, cyclones, volcanic eruptions and others have taken away many lives and properties. Natural disasters also produce tremendous delay in the development process of these developing countries.

From this point of view, the UNCRD has been at grips with disaster prevention and mitigation issues through the help of professional experts since 1986 when its 15th anniversary was celebrated and since then, it has been contributing to the activities of the International Decade for Natural Disaster Reduction or IDNDR.

This International Research and Tra< ining seminar is also one part of UNCRD'S ongoing programmes for Disaster Prevention and has held 7 Seminars of similar themes in the past.

Like for example, the 6th Seminar was held in December 1992, and was based on the topic "Disaster Education in School in Developing Countries". The 7th Seminar was held last November in Tokyo and discussed about "Improved Fire-safety Systems in Developing Countries".

In this 8th Seminar, we take up the theme of "Emergency Assessment System of Damaged Buildings". An Emergency Assessment System means the technical guidelines and operational systems to be applied for assessing the safety of the use of damaged buildings after an earthquake disaster.

A lot of concerted efforts for disaster prevention and mitigation have been done in the world for a long time now, such as the Prediction or Forecasting of Typhoons, Earthquakes, and Volcanic Eruptions. However, most of these efforts are for preparedness planning before the event or for emergency response during the event. Unfortunately, post-event procedures are not sufficiently prepared comparing with pre-event countermeasures or responses in general.

Just last month, my staff and I visited the Philippines to investigate the Mindoro Earthquake, which occurred on November 15. In a state high school, which we visited, the teachers were forced to give lectures in tents in the school yard because of the lack of safety assessment of the damaged school buildings.

Most of the residents still live in damaged houses without receiving any warning of the risks of what aftershocks can do to these houses.

Professor Murakami, who will present a paper today, developed the technical guidelines for the assessment of damaged buildings from more than ten years ago by Professor Okada, who is today's chairperson, and. These guidelines have been applied in the Mexico Earthquake of 1985 and the Armenia Earthquake in the former Soviet Union in 1988.

In the United States, the emergency assessment system started in 1989 and was applied immediately after the Loma Prieta Earthquake in 1989 and the Northridge Earthquake in 1994.

Presently it is a well-known fact that there are not much designed-for-earthquake buildings in developing countries compared to developed countries. This may be due to the fact that in developing countries there are many difficulties to discriminate differences and quality of building materials, building technologies and building construction management.

In other words, the need for emergency assessment of damaged buildings is much higher in developing countries than in the developed countries.

The objective of this seminar is to discuss the possibility of a technology transfer of technical guidelines and operation systems of damaged buildings developed in the United States and Japan to the Developing Countries where the need for such is much higher.

I hope that you, the participants and the members of the audience, would be able to discuss the state of the art of emergency assessment systems and its necessity in developing countries and the possibility and the problems on technology transfer of these technical guidelines and its operation systems.

The UNCRD will continue the research of post-earthquake procedures by taking into account the results of the discussions, which will be made today in this seminar and during the following Japan/US workshop on Urban Earthquake Hazard Reduction.

Finally I express our sincere gratitude to the Institute of Social Safety Science of Japan and the Earthquake Engineering Research Institute of the United States for their valuable cooperation in organizing this seminar.

Now, ladies and gentlemen, with heartfelt appreciation to you all, I would like to open this seminar on the Emergency Assessment System of Damaged Buildings and I hope that we will have fruitful deliberations culminating in the most meaningful results.

Thank you all very much.

Keynote Address

for the
8th International Research and Training Seminar on Regional Development
Planning for Disaster Prevention
Emergency Assessment System of Damaged Buildings
16 January 1995, Met Hall, International House, Osaka

"Towards The Safer Cities In Developing Countries"

Yujiro Ogawa
Disaster Management Planner, UNCRD

Distinguished participants, ladies and gentlemen;

It is a great honor and pleasure for me to extend a few words as keynote address of UNCRD's 8th International Research and Training Seminar on Regional Development Planning for Disaster Prevention.

Let me make short presentation at the beginning of this seminar so that we could have a common understanding of the theme of this seminar, which is "The Emergency Assessment System of Damaged Buildings". There are basically two topics within this theme that are of great importance. The first topic is the Emergency Assessment System itself and second one is the technology transfer of this system to developing countries.

1. BUILDING ASSESSMENT

There are two phases in the safety assessment of buildings for earthquake. One is safety assessment in pre-event and other is in post-event.

Pre-Event Assessment

Pre-event safety assessment is the judgment of the capability of existing buildings against n earthquake before the occurrence of such a disaster in order to avoid building damage and loss of lives. When the infrastructure capability is not sufficient for the expected earthquake ground motions, some reinforcements will be required. Since there are many buildings in big cities, it is usually a big challenge when the city is situated in an earthquake prone area. Also, building codes are usually revised many times according the different technical advancements so that buildings constructed at different times have different capabilities against earthquakes.

Post-Event Assess ment

Post-event safety assessment also has two phases. The first phase is the assessment of the risk of use or occupancy of the damaged building by the earthquake to avoid the loss of lives and secondary damages caused by aftershocks or other causes. We call this phase as the Emergency Assessment, which is the theme of this seminar. The second phase is the evaluation of the necessity and methodology of restoration. This phase is called Engineering Evaluation in ATC 20 in the United States.

Emergency Assessment

As I have mentioned before, today's theme is the Emergency Assessment System of Damaged Buildings.

One important point that is directly related to this topic relates to the prevention of the loss of human lives. Another important point is that emergency assessment does not only relate to engineering matters but also to the administrative response in the management of the disaster for municipalities.

Emergency Assessment is also composed of the engineering or technical criterion of assessment and the system to operate the emergency assessment.

Engineering Criterion

The engineering criterion for construction has been developed for various types of buildings such as for Reinforce Concrete structures, Wood Frame Structures, Masonry Structures and others.

Emergency Assessment System

As mentioned before, Emergency Assessment is an immediate necessity after an earthquake occurs. Therefore the operation system for the assessment is essential in practice and should be established beforehand. Expectedly, these operation systems will be different for each country depending on the administrative structure, the policy for disaster management, the policy for building inspection and others. The usual common elements of the operation systems are:

- **ORGANIZATION**
  - -The Organization responsible for the Emergency Assessment Central or Local Government, Private Sectors
  - -Finance
  - -Preparedness
    Equipment, Transportation, Food
- **INSPECTORS**
  - -The Inspectors who will do the assessment in the affected areas
    Government Staffs, Volunteer Engineers
  - -Qualification of Inspectors
    Authorized Structural Engineers,
  - -Number of Inspectors
  - -Communication Network
  - -Insurance
- **OBJECTIVE BUILDINGS**
  - -Number of Damaged Areas
  - -Buildings to be inspected
    Public or Important Buildings/ Residential Buildings
- **FOLLOW UP PROCEDURES**
  - -Restrictions of occupancy
  - -Preparedness of Shelters
  - -Guideline for Restoration and Reconstruction

Technology Transfer

As Director Kaji mentioned in his Opening Address, the need for emergency assessment of damaged buildings is much higher in developing countries than in the developed countries because of the difference in the capabilities of buildings against earthquake in developing countries and the disaster management abilities in emergency response and post-event response in the developing countries.

Capabilities Against Earthquake

The quality of building materials, building construction technologies and building construction management contributes to the great difference in capabilities of newly constructed buildings.

If we consider that the aseismatic design concept was only introduced recently in most developing countries, the growing risk of cities, as it becomes more complex with many buildings, is now much greater in the developing countries than in the developed countries.

Disaster Management Abilities

The operational timing of The Emergency Assessment of damaged buildings is usually several days after the earthquake occurs. Therefore it may be recognized as not only a part of emergency response but also a part of post-event response such as restoration and reconstruction procedures. Disaster management ability in emergency and post-event response is a very important factor to minimize the damages and effect of disasters. With this viewpoint technology transfer of the emergency assessment system to developing countries becomes one of the issues that should be discussed.

An international meeting related this to this issue has not been held since emergency assessment systems were developed in the United States and Japan. We hope that this seminar will be the start of further international cooperation and research regarding this issue.

Now I would like to conclude my address by urging all the participants to actively participate in the following discussions so that we will obtain the goals that we have stated here today.

Thank you all very much.

Programme

16 January 1995

Chairman: Tsuneo OKADA. Japan

10:00 Opening Address
by Hideki KAJI, Director, UNCRD

10:10 Keynote Address
by Yujiro OGAWA, Disaster Management Planner, UNCRD

10:30 Loma Prieta Earthquake Response: A First Application of Standardized Building Evaluation
by Laurence M. KORNFIELD, U.S.A.

11:00 Safety Assessment of Damaged Buildings
by Richard A. RANOUS, U.S.A.

11:30 Assessment Criteria of Seismo-Damaged Buildings in China
by ZHANG Weiyue, China

12:00 Discussion and Comment
Comment by Chairman

12:30 Lunch Break

14:00 Emergency Assessment of Damaged Buildings irt the Philippines: Its Necessity and Possible Parameters
by Fidel R. SARAUSAD, Philippines

14:30 Issues to be Solved in the Establishment of Institution of Assessing the Safety of Damaged Buildings in Japan
by Keishi ISODA, Japan

15:00 Post-Earthquake Inspection and Evaluation of Earthquake Damage in Buildings for Countermeasure
by Masaya MURAKAMI. Japan

15:30 Coffee Break

15:45 Discussion and Comment
Comment by Chairman

16:50 Closing Address
by Yujiro OGAWA

17:00 Closing

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