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Basic Techniques for Quick and Rapid Post-Earthquake Assessments of Building Safety

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Abstract

Immediately after and during the first days after a strong earthquake occurs, thousands of buildings may result damaged, while new shocks can still occur. Of main interest is to carry out as quickly as possible the evaluation of building safety in order to identify which buildings are safe or not for immediate use (or for entering them) mainly against subsequent aftershocks. Furthermore, the area affected by heavy damage can be so extended that expert engineers are always insufficient to make all building safety evaluations within a limited timeframe. The success of inspections depends upon the manner it has been designed and planned in advance. This work presents two single and direct methods designed for post-earthquake building inspections and safety classifications in small-to-medium size towns stricken by a damaging earthquake. The first Post-Earthquake Building Safety Assessment (PEBSA) method, here named Quick-PEBSA, is an easy way to achieve general and approximated initial information on damage distribution, and to detect heavy damaged and unsafe constructions (4 and 5 damage degree in EMS scale). This early data are necessary to emergency assistance, local disaster statement, external aid requesting, and for organising rapid building inspections. The second method, named Rapid-PEBSA, follows conventional approaches for post-earthquake safety inspections in seismic prone countries (USA, Japan, Italy, ..) but a different classification method. A Field Guide describing procedures for post-earthquake inspection and classification of building safety has been performed. For Q-PEBSA, Reconnaissance Team members preferably must be capable and trained technicians. The members of Local and External Construction Safety Teams for R-PEBSA have to be engineers, architects, or building inspectors. Fast methods here presented have advantages like to use less timeframe and be more easy to be applied; disadvantages could be to underestimate or overestimate the seriousness of damage when is applied by inexperienced voluntary technicians.

Key-words: Post-earthquake building safety assessment, damaging earthquake, rapid building inspection, habitability of damaged building, earthquake emergency.

Introduction

The Betics region is acknowledged to be the most hazardous seismic zone in Spain. Historical documents show that most of the strongest onshore Spanish earthquakes since XV century occurred in this region e.g. the 1431, 1522, 1680, 1804, 1829 and 1884 events (with an intensity I ≥ IX, EMS Scale,). Other events reached an intensity I ≥ VIII, e.g. the1406, 1504, 1518, 1531, 1644, 1658, 1674, and 1806. Consequently, a potential earthquake scenario where there is extensive damage to buildings and infrastructure over an extended area, and where people are potential victims of the disaster, it is considered as probable in this region. Furthermore, the Spanish seismic code NCSE-02 requires a safety evaluation of all affected constructions in areas of intensity I≥ VII.

In the aftermath of destructive earthquakes, rapidly quantifying the extent and severity of building damage is a high priority. After the occurrence of these earthquakes, the regional and local authorities have the responsibility to coordinate building inspections to provide for public safety. The rapid identification of the constructions with serious damage is a crucial task because insecure buildings can represent a danger for public safety, mainly during relevant subsequent aftershocks. Of main interest is also the identification (as quickly as possible) of safe buildings and facilities that can be used for people. People need to be kept from entering or using unsafe buildings or be informed which structures are classified as safe for essential activities.

A variety of *post-earthquake building inspections* (PEBI) are required following an earthquake. Three types are generally considered: the *Rapid* and *Detailed Evaluations*, in the earthquake emergency phase, and the *Engineering Evaluations*, in the recovering phase (Figure 1). Others two PEBI could be considered in emergency phase: *Quick* (or *Initial)* and *Rescue Inspections* (Table 1). The first one is addressed to assess aggregate damage for affected area and focused on total numbers of collapses or severely damaged buildings and with identification of rescue sites. The second one is a short-term assessment to ascertain safety needs of searchers/rescuers, and focused on detection of likely hazard to victims or rescue workers. Local and regional authorities are responsible primarily for the earthquake emergency phase evaluations and must be familiar with these evaluation procedures.

The constructions of old quarters in small and medium-size urban areas generally are more vulnerable and stronger earthquake damage will appear there probably, but these towns have less resources to response efficiently in earthquake emergency case. Furthermore, there it is not possible to make all building safety evaluations by local experts in earthquake engineering, being clearly insufficient (Carreño et al, 2007), especially in these towns. For these reasons, an important action is to address the safety of buildings and in consequence procedures for evaluating building safety after the earthquake must be carefully planed, developed and implemented before.

The post-earthquake fast inspection procedures, that are presented herein, are focused on small-to-medium size towns (less than 10.000 inhabitants) stricken by a damaging earthquake. Two single and direct methods are here designed for post-earthquake building inspections and safety classifications: the *Quick* and *Rapid Evaluations*. The second methodology is similar to that outlined in ATC-20 and other analogous publications (e.g. Salmeron et al 1994; CENAPRED, 1998; Dandoulaki et al.,1998; NZSEE, 1998; SMIS, 1998; Goretti, 2001; ASCIG, 2001, 2002, 2003; Carreño et al., 2004, 2005; Agnastopoulos & Moretti, 2006), but incorporates a different approach to placard use. *Detailed* and *Engineering Evaluations* have not been included in this work (Figure 1).

Detailed Evaluations involve that buildings are inspected more thoroughly, with more investigation into the framing systems. These evaluations can take anywhere from one to five hours. Usually this level of evaluation will be for all those buildings that may have been weakened by the earthquake, those classified as *limited use* from a rapid inspection or those in which the hazard condition, if any, associated with them could not be identified. Nevertheless, all critical facilities and also other important buildings must undergo detailed inspections from the beginning of the emergency phase.

Post-Earthquake Building Safety Assessment Methods

The emergency phase inspections of damaged buildings should start within hours, if possible, after the earthquake strikes. The quick and rapid inspections are easier to carry out and require less time and less experience than the detailed ones. The objective of these inspections is to determine what critical facilities, buildings and areas can and cannot be generally used and what is necessary to reduce danger from and around damaged buildings (Table 1).

The important short-term operations are:

1. Identification of hazards for safety of search and rescue operations
2. Inspection of emergency facilities and all the affected buildings and posting them as to their safety.
3. Identification of hazards associated with damaged buildings and their removal or temporary securing for safety use of streets adjacent to those buildings.
4. Identification of those buildings that require emergency shoring up to avoid collapse.
5. Identification as soon as possible all buildings that are safe to use and temporary shelter sites to serve as temporary housing.

Table 1. *Summary of post-earthquake building inspections*

Type of inspection	Timing	Time per building	Purpose	Conducted by/	Comment
Quick or Initial	Within hours after event,	10-30 sec.	Assess aggregate damage for affected area	Emergency services, Local Reconnaissance Teams	No entry of premises; no formal records; emphasis on total numbers of collapses; identify rescue tasks, etc.
Rescue	Within first day	10-30 min.	Ascertain safety needs of SRA workers; record search results, prioritise rescues (triage)	Fire Service; other emergency groups; rescue teams; engineers; trained technicians of emergency	Short-term assessment focused on likely hazards to victims or rescuers; shorthand marks on buildings as hazard and evacuation reference.
Rapid (safety and usability)	1 to 10 days	10-30 min.	Quickly screen the obviously safe and unsafe buildings; ascertain level of damage; detection of hazards; assess appropriate level of safety and occupancy; security and shoring requirements	Engineers; architects; building inspectors; experienced building professionals; trained disaster workers	Examine visually the outside of the building, any damaged part of them (when secure) and the ground around the building. Formal system; placards posted on buildings. Note made of sites needing further detailed inspections; unsafe areas cordoned off. Central record maintained
Detailed	2 to 20 days	1 to 5 hours	Further inspection as identified by *Rapid Insp.* or subsequent requests, dealing with critical or essential facilities. To identify the need for an engineering evaluation	Structural engineers; architects; building services, geotechnical and hazardous material specialists	Formal system; evaluation of questionable structures, more investigation into the framing systems; revised placards posted on buildings; unsafe areas cordoned off. Central record updated
Engineering	Longer-term	1 to 5 days	Establish long-term future of buildings, establish how to stabilize and repair the building.	Structural engineers, architects and loss adjusters	Ordered by the owner. Strengthening or demolition; loss and insurance.

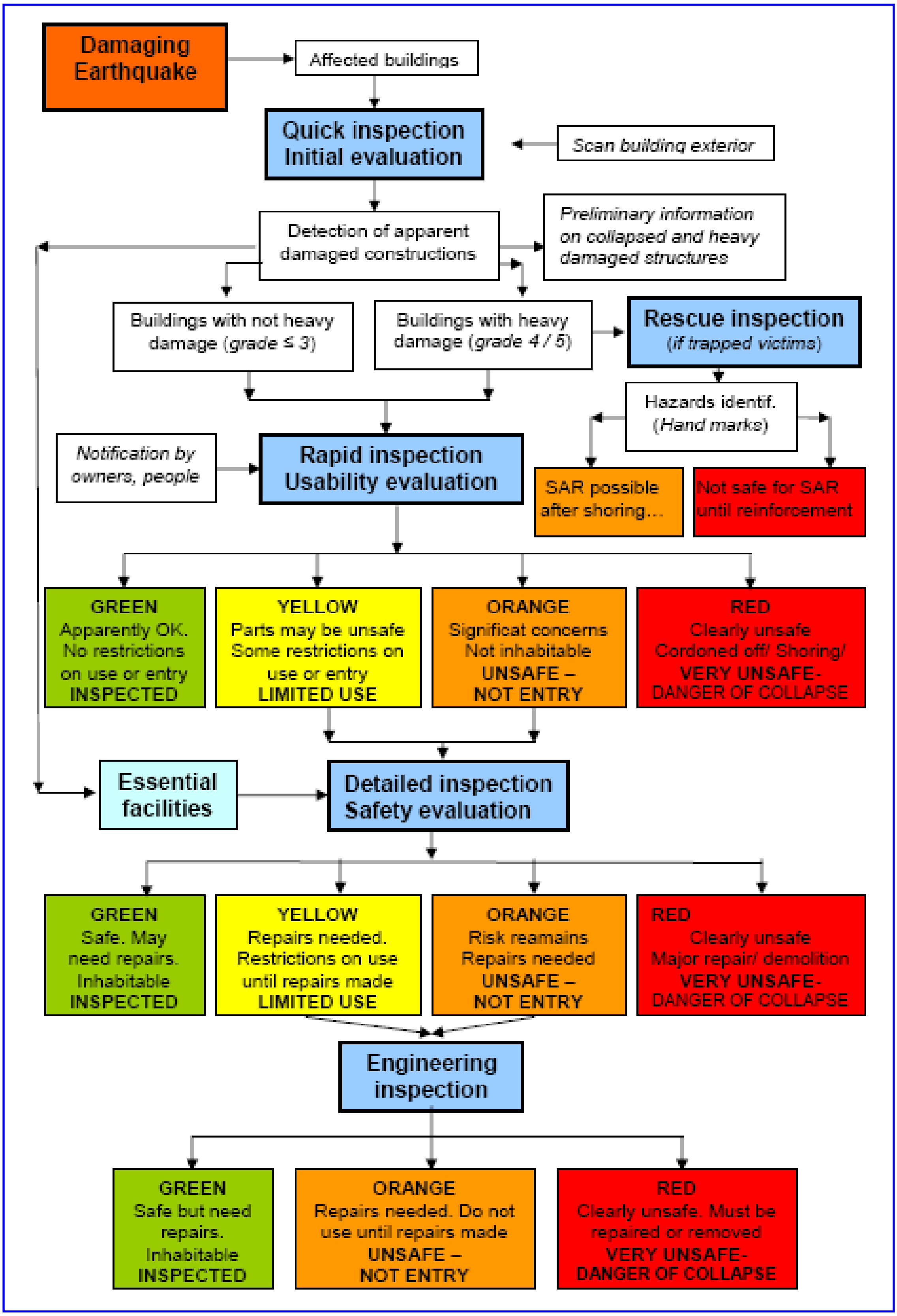
Emergency phase (Quick, Rescue, Rapid, Detailed) — *Recovering phase* (Engineering)

The primary aim of this work has been to provide a methodology for post-earthquake inspection and classification of building safety in the emergency phase. A set of guidelines for the technicians and engineers involved on the emergency inspections, including procedures for deciding what buildings must be firstly investigated, safety classification criteria, descriptions of typical levels of damage for different types of buildings and the relation of such damage to safety has been already developed. Present work is an upgrade of Salmeron et al (1994) work about earthquake damage and post-earthquake inspection and classification of building safety. In addition, the subsequent training actions, and responsibilities of evaluation participants and recommendations about their safety precautions it also taken into account as well as the organization of the information collected. Present work is an upgrade of Salmeron et al (1994) study about earthquake damage and post-earthquake inspection and classification of building safety.

The first Post-Earthquake Building Safety Assessment (PEBSA) method, here named *Quick-PEBSA*, is an easy way to achieve general and approximated initial information on damage distribution for affected area, to detect heavy damaged constructions and identify possible rescue sites. This early data are necessary to emergency assistance, local disaster level statement, external aid requesting, and for organizing rapid inspection of buildings (Table 1).

The second method, named *Rapid-PEBSA*, follows conventional approaches for post-earthquake inspections and safety classification in seismic prone countries (USA, Japan, Italy, México, Colombia, etc.). Nearly the same method can be used in *Rescue Inspections* for safety evaluation of constructions and potential hazards in rescue areas.

Figure 1. *Flow Chart of post-earthquake inspections and safety evaluation and posting process.*



Quick-PEBSA Method

It is essential to carry out a fast reconnaissance across the whole area affected by earthquake to discover the severity and distribution of damage. This is a responsibility of regional authorities. An urban reconnaissance is also vital, on the other hand, to know where the worst-hit areas are, and to quickly screen all collapsed and heavy damaged buildings because possible rescue and evacuation operations could be necessary. All these critical incidences must be reported to local authorities as quickly as possible. This information is fundamental to emergency management operations, and rescue actions. The local level is the first line for official emergency management activity. At this level potential hazards are seen most clearly, resources most fully known, and first response is made. At local level are those technicians and civil protection staff who know where vulnerable buildings and facilities are and consequently where damage can appear or something in life-lines may go wrong, especially when they have been prepared to earthquake response.

There are several ways to carry out urban damage exploration in the aftermath of an earthquake: detailed aerial survey by experts; blind damage prediction from earthquake damage scenarios; object-oriented methodology applied to high-resolution optical satellite imagery captured before and soon after the event; Local Reconnaissance Teams (LRT) on patrol of two or three members.

The main purpose of quick inspections is to obtain preliminary information about damage extent and serious damaged or unsafe buildings location, for quantifying the number of collapsed or quasi-collapsed buildings in order to begin emergency assistance procedures, to establish local disaster statement, external aid requesting, and for organising rapid building inspections.

Among the different ways to assess aggregate damage in small and moderate size localities the Local Reconnaissance Teams on patrol could be the only one available. The LRT members preferably must be capable technicians, but trained civil protection staff also. The LRT must systematically inspect street by street to discover all collapsed and heavy damaged buildings (at less buildings with 4 and 5 damage degree in EMS scale) and to report immediately to local authorities (by mobile-phone, radio communication, etc.). Into the local emergency management organization, a specific "*call centre*" must receive and process requests for quick and rapid inspections. Citizens are likely the first to indicate about building collapse, people trapped inside collapsed buildings and hazardous buildings and another "*call centre*" must be established to receive that helping data for inspection and rescue processes. A central record of buildings seriously damaged must be maintained from the beginning.

Timing for quick-PEBSA is within hours after event. Each LRT has two or three members, one of them preferably trained technician, and the required time per building could be around 10 to 30 seconds. Collapsed buildings detected by LRT with entrapped people inside must be reported immediately to local authorities and Search and Rescue (SAR) teams because victim survival effectiveness depends on the speed of rescue assistance.

Rescue-PEBSA Method

During the first days, but mainly during the first one, a special *Rescue Inspection* team must accompany the Search and Rescue (SAR) and triage operations. Before to penetrate and advance to entrapped victims inside buildings, a short-term assessment of the building damage pattern and potential hazards (falling debris, further collapses, fire, etc.) to victims or rescue workers must be performed to find unsafe level of buildings or areas. These inspections need trained engineers and architects, better with experience with emergency groups. During inspections it is difficult engineering judgments because inspectors are under pressure, at disorderly disaster site and with incomplete information. This surveying operation must be planned before. The efficacy of SAR operations and, in consequence, of great importance for survival of trapped victims, it depends on the speed of rescue operations because survival rates of trapped earthquake victims go from 90% during first hour to 30% after three days and less than 10% five days after (Osteraas, *et al*., 2006).

The evaluation method to be used is similar to that used for *Rapid Inspections* but time depends on damage features and rescue operations. For safety needs of victims and rescue workers safety inspections must go on when tunnelling or other likely destabilizing operations may be necessaries.

After rescue inspection a set of hazard shorthand marks must be made on building entry identifying hazards and giving information for relatively safe SAR operations. Hand marks generally are squares with other symbols. Empty square means a structure with little chance of further collapse;

an square with a diagonal means a structure significantly damaged, and may need shoring, bracing, removal, and/or monitoring of hazards; finally, an square with two diagonals (cross-shaped) means a not safe structure for rescue operations and may be subject to a sudden collapse.

Rapid-PEBSA Method

Rapid evaluation is a fast assessment to quickly identify and post the obviously unsafe or apparently safe structures, to identify buildings requiring *Detailed Evaluation* and to establish necessary restrictions on building use. The buildings are rapidly inspected, spending typically 10 to 30 minutes per building. The members of Local and External Construction Safety Teams for Rapid-PEBSA could be structural engineers, architects, building inspectors, and skill building professionals. In small and medium size towns the most experienced professionals must be oriented to evaluate critical facilities such as hospital, fire stations, emergency services, etc. Trained disaster workers could participate in rapid evaluation, mainly to declare unsafe buildings, because there are insufficient qualified personnel available to perform it, especially in small towns.

Rapid evaluation procedures and criteria.

For an *efficient operation*, a rapid assessment is first carried out to screen obviously safe and unsafe buildings. Firstly, the outside of the building (all easily accessible sides) is examined visually looking for signs of: residual drift (building or parts of it out of plumb), damage to outward non structural elements (exterior walls, façade, chimneys and roof, etc). Examine visually the ground storey, looking for damage to all visible structural elements, (especially columns, core elements, beams and stairways) and also checking all infill or partition walls. Secondly, perform a visual inspection of the ground and pavement around the building and nearby area looking for ground fissures, settlements, signs of liquefaction or slope movement or rock-fall hazards, in case of buildings at or close up hillside.

Afterwards, if access to the interior is available, the building is safe enough, and when there is a suspicion or an occupants report about any significant damaged area, a quick walk-through followed by a more detailed inspection are performed. This allows a best usability classification of questionable buildings and the detection of any potentially serious damage or hazardous areas and the discovery of imminent hazards within and outside the building.

On the basis of the visual inspection carried out and using a proper engineering judgement, an assessment of the detected damage on building and corresponding safety classification must be performed taking into account the criteria described afterwards.

Finally, post the building according to the results of the evaluation. Post every entrance with one of the four appropriate placards mentioned below (INSPECTED, LIMITED USE, UNSAFE-NOT ENTRY or VERY UNSAFE -DANGER OF COLLAPSE). If some local hazard is present, post and barricade any unsafe areas. It is also important to explain the purpose and meaning of the posting to the building occupants and advise them accordingly, especially to leave unsafe buildings immediately and unsafe areas also.

The *basic criterion* for building classification is the safety of people inside and nearby the building, taking into account reduction on original building seismic capacity, therefore the extent of structural damage. Damage on non structural elements and the presence of any hazardous condition are also considered as a second criterion. Dangerous conditions could exist even in buildings whose seismic capacity has not decreased.

The inspected buildings must be classified in one of the four following four categories:

1) *Habitable,* corresponding to buildings that experienced minor or negligible damage and have no signs indicating a reduction of their original seismic capacity should be posted as INSPECTED (*green colour*). This means that buildings are apparently safe and no restriction on use or occupancy exists.

2) *Limited use*, corresponding to buildings where some local hazard exists, or some questionable damaged area would then be scheduled for a detailed evaluation. It means that parts of a structure could be occupied. Such buildings must be posted LIMITED USE (*yellow colour*). The dangerous areas have to be barricaded and posted “AREA UNSAFE” and are not usable but can be entered for a brief period of time only to remove possessions or for emergency purposes but it is a risk.

3) *Not entry,* corresponding to buildings with damage affecting to the lateral force and/or vertical load resisting systems (moderate structural damage) and are not inhabitable, although they are still able to resist loads. Such buildings must be posted UNSAFE-NOT ENTRY (*orange colour*), entry in them must be prohibited and must be cordoned off. Further actions to improve safety in and around the building may be identified and recommended by the inspectors.

4) *Danger of collapse*, corresponding to heavily damaged buildings, those whose original seismic capacity has greatly decreased (heavy structural damage or near to collapse), There are extreme hazards and thus are subject to sudden collapse even in minor aftershocks. Typically, these are structures that represent a threat to life-safety ad are unsafe for occupancy or entry except by experienced building professionals. Such buildings must be posted VERY UNSAFE -DANGER OF COLLAPSE (*red colour*), entry in them must be prohibited and the need for emergency support as well as protection of the surrounding areas must be considered.

It is advisable that a *Detailed Evaluation* should be carried out for all the buildings (or part of them) classified as unsafe (types 2 and 3) by the LCST or ECST inspectors. Buildings belong to 1 and 4 classes could be also inspected in detail at the discretion of Building Department.

In order to estimate damage and safety of constructions a single *evaluation form* has been developed for both *Rapid and Detailed* inspections (Table 2). This evaluation form is a basic tool for managing inspections and damage and safety assessments of buildings. The form has been organized in five sections related to 1) inspection data; 2) building description, 3) evaluation of observed damage; 4) posting and 5) further recommended actions. To facilitate its use the four type of damage (slight, moderate, heavy and very heavy) and also the overall building damage classification in six degrees (0, 1, 2, 3, 4, 5) of the EMS scale have been considered. Thus, joint to team judgement, and overall building damage degree (according EMS scale) are the main criteria for building use classification after *Rapid Inspections.* For *Detailed Inspection* both the damage severity and the damage extent (dark grey boxes in the evaluation form) are taken into account. This methodology make easy understanding and training of building damage and its safety classification and also its application in small-to medium size towns by technicians and civil protection staff.

The building classification proposal is the following: building damage degree 0 and 1 correspond to habitable (*green colour*); degree 2, inclusive with small parts of moderate structural damage, corresponds to limited use (*yellow colour*); degree 3, corresponds to unsafe – not entry (*orange colour*), and finally degrees 4 and 5 correspond to very unsafe- danger of collapse (*red colour*).

Establishing priorities and general safety rules for inspections

The initial pre-event steps are to identify all of the essential service facilities within the town and where they are located. These are the facilities that need to be operational after the earthquake and require inspection immediately after, in the first few hours of the earthquake emergency.

It is recommended to inspect facilities based on the community's needs for the services provided and those that will more rapidly move the town into recovery. Therefore, the inspections could be prioritized as follows:

1) *Critical and Essential Facilities,* because these facilities are the first priority to face up to earthquake emergency and to the continued operation of the town, but must be Detailed Evaluations.

2) *High-density and other residential structures*, because these buildings (typically hotels, motels, designated civil defence gathering places, rest homes and other places of accommodation, schools, food distribution centres, etc.) can be used for assistance or for short- and long-term sheltering or of victims.

3) *Single family and low-density residential units,* because it is important to inspect residences in order to identify as soon as possible all buildings that are safe to occupy and use and those obviously unsafe avoiding their use. It is important to restore also the feeling of protection and support within the citizens.

There are *several general safety rules* that must be applied during safety evaluation:

1) Do not enter unsafe or potentially unsafe buildings or unsafe internal areas.

2) Be conscious and cautious of where you are working and what hazards are in the area around you and always work wearing a hard hat.

3) During inspection, always work in teams of two or more individuals.

Table 2. *Post-Earthquake Evaluation Form (in Spanish).*

Inspección				
Identificación Inspector:	Fecha ___//___//_____	Tipo de Inspección	Exterior	
Organismo ______________________	Hora ____________ Tiempo usado ____		Parcial	
			Completa	

Datos del edificio	Tipología construcción			
	Muros de carga		Hormigón armado	
Nombre edificio _______________ Dirección C/ ________________ Nº ________ Población _________________ CP.____ Provincia ____________	Fábrica de ladrillo		Forjado unidireccional	
	Fábrica de bloques		Forjado bidimensional	
	Mampostería		Muros corte	
	Tapial/adobe		Acero	
	Otras		Otras	
Persona de contacto _____________ Teléfono ___________________	**Uso predominante**			
Nº de plantas Sobre rasante ________ Bajo rasante _________	Residencial		Servicios emergencia	
	Comercial		Salud / Hospital	
	Hotelero		Educacional	
	Industrial		Oficinas/ Institucional	
	Patrimonio histórico		Otro	

Estado de daño (L=leve, M=Moderado, G=grave, MG=muy grave) % de daño de cada elemento (solo detallada)		L	M	G	MG	%
General / Exterior	Colapso total o parcial					
	Inclinación / Desplome					
	Grietas en el terreno					
	Deslizamientos					
	Caída de rocas					
Estructural	Columnas / Pilares					
	Vigas					
	Forjados					
	Muros de carga					
	Cimentación					
No estructural	Cerramientos					
	Balcón / Antepecho / Chimenea					
	Paredes / Tabiques interiores					
	Escaleras y salidas					
	Elementos exteriores/ Revestim.					
	Instalaciones					
Otro	Indicar ________________					
	________________________					

Evaluación y clasificación daño general del edificio		
Grado (EMS)		Clasificación
0 - 1		Verde
2		Amarillo
3		Naranja
4		Rojo
5		Rojo
Observaciones:		

Porcentaje aproximado de daño general	*0-1%*	*2-10%*	*11-30%*	*31-60%*	*>60%*

Señalización			
Colocar en cada una de las entradas (o zonas inseguras) el cartel correspondiente a la clase de seguridad del edificio			
Verde Inspeccionada	Amarillo Acceso limitado	Naranja No entrar	Rojo P. De Colapso

Recomendaciones y medidas de seguridad			
Evaluación detallada ☐	Estructural ☐	Geotécnica ☐	Instalaciones ☐
Medidas de seguridad: Acordonar, apuntalar, evacuar, elementos peligrosos...			
RELLENAR CASILLAS DE GRIS OSCURO SÓLO EN CASO DE INSPECCIÓN DETALLADA			

Results and Discussion

The *Quick* (or Initial), *Rescue* and *Rapid Post-Earthquake Inspections* and *Building Safety Assessment methods* herein proposed have been specifically designed for their application to small and medium-size towns in the aftermath of destructive earthquakes. These towns generally are more vulnerable and have poor resources to response efficiently in earthquake emergency case, especially there is a clear inadequacy of local experts in earthquake engineering for building safety evaluations.

Two different kinds of local inspection teams have been proposed. The first one, here named *Local Reconnaissance Teams*, preferably must be organized with capable and trained technicians, but trained disaster workers could be also part of them. LRT working on patrol have to achieve general and approximated initial information on damage distribution, to detect heavy damaged and clearly unsafe constructions (at less buildings with 4 or 5 damage degree in EMS scale) and possible rescue sites. This kind of very fast inspection is here so-called *Quick Inspection*, and in spite of importance for emergency phase it has not been sufficiently considered before.

Rescue Inspection team members are trained engineers and architects, better if they have experience with emergency or Search and Rescue groups. They must find unsafe level of buildings or areas where rescue and triage operations are need in order to protect to victims or rescue workers during those operations.

Rapid Inspections must be performed by *Local Construction Safety Teams* (LCST) (and also for External ones). LCST members could be preferably structural engineers, architects, and experienced building professionals. In small and medium size towns there are insufficient qualified personnel available to perform rapid evaluation; for this reason, other professionals such us trained disaster workers could participate in that evaluation, at less up to there are sufficient external CST to carry out such kind of inspections. In that case, disaster workers must be mainly focused to detect and declare unsafe and doubtful buildings, to avoid their use. The most experienced professionals must be oriented to evaluate critical facilities such as hospital, emergency services, fire stations, life lines, etc. following *Detailed Inspection* procedures.

An only form is proposed for both rapid and detailed inspections. The safety evaluation and building classification methods here developed are more single and direct that previous ones. They are based on expert judgement having as reference mainly overall building damage degree in EMS scale for rapid inspections and evaluations. For detailed inspection, not presented herein, the severity and extent of damage in different elements in the building have to be considered. The main advantages of the fast methods here presented are to use less timeframe, and be more easy to be applied by engineers, architects and civil protection technicians also; disadvantages could be to underestimate or overestimate the seriousness of damage when is applied by inexperienced voluntary technicians.

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