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MANUAL OF EVALUATION PROCEDURES FOR PASSIVE FIRE PREVENTION FOLLOWING EARTHQUAKES

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This report originated with a research project that has focused on the postearthquake safety evaluation of the passive fire prevention features of buildings. Coordination with the structural inspection process is an important component of how the results of this research will be put into practice. In large buildings such as hospitals, jails, nursing homes, and apartment buildings, (with, or without automatic sprinklers) the accepted means of controlling fire damage is by the application of water by the fire department. In general, sufficient fire resistance is built into these structures to give one or two hours of fire containment to allow the fire fighters enough time to stop the fire. In many instances in the initial postearthquake time period, however, there is little or no water obtainable, and few fire fighters are available to extinguish the fires in such large structures. Passive fire protection needs to be evaluated for its ability to contain a fire with limited fire fighting capability. Consideration should also be given to the concept that certain occupancies may not be safe in some structures while these same structures could be safely used for other occupancies. For instance, a hospital may be safe housing shelter for able-bodied people, whereas it might not be safe for its intended occupants. As time passes and the fire fighting capabilities of the local fire service are reinforced and strengthened, these buildings may then once again become safe for their original occupants. A number of conclusions and recommendations have been presented to further the development of an ATC 20 Evaluation Safety Assessment for post-earthquake inspection of passive fire prevention.

KEY WORDS (MAXIMUM OF 9; 28 CHARACTERS AND SPACES EACH; SEPARATE WITH SEMICOLONS; ALPHABETIC ORDER; CAPITALIZE ONLY PROPER NAMES)

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REPORT

To the

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

MANUAL OF EVALUATION PROCEDURES FOR PASSIVE FIRE PREVENTION FOLLOWING EARTHQUAKES

Robert Brady Williamson

LBNL Environmental Energy Technology Division

FEBRUARY 1998

Table of Contents

INTRODUCTION

When an earthquake occurs, a well defined approach now exists for the rapid inspection of structural damage. Some of the best sources of information are contained in the Applied Technology Council's series of publications:

1. ATC-20 - *Procedures for Postearthquake Safety Evaluation of Buildings*[1] -- This provides guidelines for the assessment of structural safety of building types commonly found in the United States.
2. ATC-20-1 - *Field Manual: Postearthquake Safety Evaluation of Buildings*[2] -- This field manual was developed within the ATC-20 framework. It is intended to be taken into damaged areas and used by "structural engineers and building inspectors" who are "required to make on-the-spot evaluations and decisions regarding continued use and occupancy of damaged buildings."
3. ATC-20-2 - Addendum to the ATC-20 *Postearthquake Building Safety Evaluation Procedures*[3] -- The first topic listed as a concern is the "training and qualifications of the volunteers". This is consistent with the idea that some of the thinking behind ATC-20 had changed. The original concept that non-specialists would undertake the initial inspections was now thought to maybe not be the best approach. Another feature of ATC-20-2 is the introduction of a new set of inspection forms with changes to the red and yellow categories.

The last of these documents was published after the January 17, 1994 Northridge, California earthquake, but all the lessons learned from that earthquake were not incorporated into ATC-20-2. In this report extensive use is made of the ideas and approach of all the ATC-20 series of publications, but when there are differences among these documents, the ATC-20-2 report is being used.

This report originated with a research project that has focused on the postearthquake safety evaluation of the passive fire prevention features of buildings. Coordination with the structural inspection process is an important component of how the results of this research will be put into practice.

In large buildings such as hospitals, jails, nursing homes, and apartment buildings, (with, or without automatic sprinklers) the accepted means of controlling fire damage is by the application of water by the fire department. In general, sufficient fire resistance is built into these structures to give one or two hours of fire containment to allow the fire fighters enough time to stop the fire. In many instances in the initial postearthquake time period, however, there is little or no water obtainable, and few fire fighters are available to extinguish the fires in such large structures. Passive fire protection needs to be evaluated for its ability to contain a fire with limited fire fighting capability.

Consideration should also be given to the concept that certain occupancies may not be safe in some structures while these same structures could be safely used for other occupancies. For instance, a hospital may be a safe housing shelter for able-bodied people, whereas it might not be safe for its intended occupants. As time passes and the fire fighting capabilities of the local fire service are reinforced and strengthened, these buildings may then once again become safe for their original occupants.

Another important area of study is the exterior passive fire protection. The envelope of a structure can be more vulnerable to a fire if the building has been "pounded" by impact with adjacent structures. In hilly areas, the pounding of buildings often means that the floor level of one structure can impact the mid-height of another and thus cause more damage than would be the case if the structures were on level ground. In urban areas, the lack of exterior fire resistance of adjacent structures may require that the occupancy of some buildings be restricted until the damaged buildings are torn down since if they were to burn, the fire could spread to the adjoining buildings. It may not be possible to check the effects of "pounding" between structures to determine if the passive fire protection features of the exterior walls has been compromised during the earthquake.

In the aftermath of a major earthquake, both paid and volunteer inspectors will conduct the rapid evaluation of buildings. The rapid evaluation in a number of past earthquakes has been reviewed. It appears that there are two situations that might be best characterized as a "small" event or a "large" event. The 1989 Loma Prieta is an example of a "small" event in the sense that the major damage was confined to rural regions outside major urban centers and to limited areas within the urban San Francisco Bay Area. On the other hand, the 1994 Northridge earthquake is an example of a "large" event. In both the Loma Prieta and the Northridge earthquakes, the "life safety" of buildings was an important part of the evaluation. In some cases, well qualified fire professionals were part of the survey teams, but in other cases volunteer structural engineers performed the rapid evaluation with little knowledge of fire safety. We also believe that volunteers gave Green Tags* that were accepted by the *Authority Having Jurisdiction* (AHJ) without, in most cases, any further checking. If a building received a Yellow† or Red‡ Tag, the AHJ required the owner to obtain the services of an architect and/or engineer, but the buildings with Green Tags were not reevaluated by any regular process[4]. Ranous[5] noted that "all inspectors were performing rapid evaluations until a more detailed evaluation could be performed."

SAFETY EVALUATION PROCEDURES

In this report we assume that the postearthquake safety evaluation is being conducted by a "rapid evaluation team" which, in the first instance, identifies both the apparently safe and the obviously unsafe structures and then proceeds to evaluate more difficult damage conditions[6].

The assessors'+ initial assignment is assumed to be the evaluation of seismic damage to the structure, and the condition of fire protective features is a secondary concern. If the building appears to be in a potential Green Tag§ condition, the assessors should begin to consider the fire protection features of the building even if the assessment is under the "rapid" guidelines. From a fire safety perspective, the first item for their consideration is the "***occupancy classification***" which is also a part of both the "rapid" and "detailed" ATC-20 assessment. The "*Building Description*" portion of both the ATC-20 *Rapid* & *Detailed* Evaluation Safety Assessment Form is shown in Table I at the top of the next page. Note that both the "Type of Construction" and the "Occupancy" on these safety assessment forms are not the same as those defined in the model building codes. A number of the occupancy definitions in the Uniform Building Code are shown in Table II. It is clear that the "occupancy" classifications on the ATC-20-2 forms[7] do not map closely with the model code occupancy classifications. However, the assessors need to recognize the important fire safety implications of the occupancy classification. We will address this discussion by describing various **Inspections scenarios.**

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* The term "Green Tag" will be used in this report to mean the green "INSPECTED" placard which indicates a building that might have suffered some damage but does not pose a risk for entry or occupancy. [ATC-20-2, p. 23]

† The term "Yellow Tag" will be used in this report to mean the yellow "RESTRICTED USE" placard which indicates a structure that has suffered damage such that the risk of partial collapse, local falling hazard, or other hazard necessitates some entry or occupancy restrictions. [ATC-20-2, p. 23]

‡ The term "Red Tag" will be used in this report to mean the red "UNSAFE" placard which indicates high risk for entry or occupancy. This is usually caused by major damage. It is used when a structure that has suffered severe damage to such that it has collapsed, could collapse, or when falling or other hazards exist. [ATC-20-2, p. 23]

+ In this report **assessor** and **inspector are used interchangeably.**

§ The Green Tag states: "Inspected, lawful occupancy permitted", This structure has been inspected (either exterior only or both exterior and interior) and no apparent structural hazard has been found. [ATC-20-2, p. 11]

TABLE I. A PORTION OF BOTH THE ATC-20-2 *RAPID* & *DETAILED* EVALUATION SAFETY ASSESSMENT FORM. This information appears on both forms. This is a change from the original ATC-20 form.

Building Description	***Type of Construction***		
Building name:______________________	☐ Wood frame	☐ Concrete shear wall	
Address: ______________________	☐ Steel frame	☐ Unreinforced masonry	
______________________	☐ Tilt-up concrete	☐ Reinforced masonry	
Building contact/phone______________________	☐ Concrete frame	☐ Other: ____________	
Number of Stories above ground:____ below ground ____	***Primary Occupancy***		
Approx. "Footprint area" (square feet): __________	☐ Dwelling	☐ Commercial	☐ Government
Number of residential units: ______________	☐ Other residential	☐ Offices	☐ Historic
Number of residential units not habitable:__________:	☐ Public assembly	☐ Industrial	☐ School
	☐ Emergency services	☐ Other: ____________	

TABLE II. SELECTED *OCCUPANCIES AS DEFINED BY THE 1997 UNIFORM BUILDING CODE*

GROUP B. "Business" Occupancies are defined in Section 304.1 as follows:

Groups B Occupancies shall include buildings, structures, or portions thereof, for office, professional or service-type transactions..... Such occupancies include occupancies for the storage of records and accounts, and eating and drinking establishments with an occupant load of less than 50. Business occupancies shall include, but not be limited to, the following: Animal hospitals, kennels, pounds, automobile and other motor vehicle showrooms, banks, barber shops, beauty shops, car washes, civic administration, outpatient clinic and medical offices (where 5 or less patients in a tenant space are incapable of unassisted self-preservation), dry cleaning pick-up and delivery stations and self-service, educational occupancies above the 12th grade, electronic data processing, fire stations, florists and nurseries, laboratories - testing and research, laundry pick-up and delivery stations and self-service, police stations, post offices, print shops, professional services such as attorney, dentist, physician, engineer, radio and television stations, telephone exchanges.

GROUP R. "Residential" Occupancies are defined in Section 310 of the UBC as follows:

Division 1. Hotels and apartment houses. Congregate residences (each accommodating more than 10 persons)

Division 2. Not used.

Division 3. Dwellings and lodging houses. Congregate residences (each accommodating 10 persons or less)

Definitions as defined in Chapter 2 of UBC

Dwelling Unit is any building or portion thereof which contains living facilities, including provisions for sleeping, eating, cooking and sanitation as required by this code, for not more than one family or a congregate residence for 10 or less persons.

Dwelling is any building or portion thereof which contains not more than two dwelling units.

Apartment House is any building or portion thereof which contains three or more dwelling units and, for the purpose of this code, includes residential condominiums.

Congregate Residence is any building or portion thereof which contains facilities for living, sleeping and sanitation, as required by this code, and may include facilities for eating and cooking, for occupancy by other than a family. A congregate residence may be a shelter, convent, monastery, dormitory, fraternity or sorority house but does not include jails, hospitals, nursing homes, hotels or lodging houses.

Inspection Scenario 1a for Means of Egress for an R-3 Occupancy

Now if we assume that the assessors are going through a residential building, that appears to rate a Green Tag, the first fire safety question should be, what is its Occupancy: Should it be considered

Group R, Division 1. Hotels, apartment houses, or congregate residences (each accommodating more than 10 persons)? or

Group R, Division 3. Dwellings, lodging houses, or congregate residences (each accommodating 10 persons or less)?

For this scenario let us assume that it is a Group R, Division 3, (also written R-3) "**Dwelling**" which is defined as any building or portion thereof which contains not more than two dwelling units. Further let us assume that the entire building contains only two dwelling units. Note that the building code uses the phrase "any building or portion thereof", and when a given occupancy only occupies a portion of a building it is called a "*mixed occupancy building*" which we will consider as a separate classification.

Once the occupancy is determined, the exit path and its passive protection should be the second item for the assessors' consideration. The assessors should walk through the exit paths for each dwelling unit in the building. R-3 occupancies are allowed to have one exit from the second story if the area of that story is less than 3,000 ft^2 (279 m^2). Table III contains a discussion of the "*Means of Egress*" as defined in the 1997 UBC. The assessors should be able to walk from the interior of each dwelling unit and reach a "public way", as defined in Table III. The exit path should not be obstructed by earthquake damage, and doors should open freely. There is no requirement for fire resistance of the walls or ceilings of the exit path for this R-3 occupancy classification.

TABLE III. "MEANS OF EGRESS" AS DEFINED IN THE 1997 UBC

Chapter 10 of the 1997 UBC is entitled "*Means of Egress*" but in the 1991 UBC the same material was in Chapter 33 with the title of "*Exits*". This chapter establishes the basic approach to determine safe exiting systems for all occupancies. Every building or portion thereof shall be provided with means of egress. The terms "Means of Egress" consists of three separate and distinct elements:

1. The exit access
2. The exit, and
3. The exit discharge

The terms "Exit" and "Public Way" are defined in Sections 1005.1 and 1002 of the 1997 UBC, respectively:

EXIT is that portion of a means of egress system between the exit access and the exit discharge or public way. Components that may be selectively included in the exit include exterior exit doors, exit enclosures, exit passageways and horizontal exits, in addition to those common means of egress components described in Section 1003.3.

PUBLIC WAY is any street, alley or similar parcel of land essentially unobstructed from the ground to the sky that is deeded, dedicated or otherwise permanently appropriated to the public for public use and having a clear width of not less than 10 feet (3048 mm).

Inspection Scenario 1b for Means of Egress for an R-1 Occupancy

Now if we assume the assessors are going through a residential building, that appears to rate a Green Tag, the first fire safety question should be, what is its Occupancy: Should it be considered

Group R, Division 1. Hotels, apartment houses, or congregate residences (each accommodating more than 10 persons)? or

Group R, Division 3. Dwellings, lodging houses, or congregate residences (each accommodating 10 persons or less)?

For this scenario let us assume that it is a Group R, Division 1, (also written R-1) apartment house which is defined as any building or portion thereof that contains three or more dwelling units and, for the purpose of the 1997 UBC, includes residential condominiums.

Once the occupancy is determined, the exit path and its passive protection should be the second item for the assessors' consideration.. The assessors should walk through the exit paths for each dwelling unit in the building. R-1 occupancies are required to have at least two independent exit paths from each dwelling unit in the building. In addition, the building should not contain any "dead end corridors" longer than 20 ft (6 m). This usually means that there are two "ways out" of each dwelling unit. If the exit path is an interior corridor, there are enclosed exit stairways for the use of people in those corridors.

Table III contains a discussion of the *"Means of Egress"* as defined in the 1997 UBC. The assessors should be able walk from the interior of each dwelling unit and reach a "public way" as defined in Table III. The exit path should not be obstructed by earthquake damage, and doors should open freely. The second exit path may be in the form of an exterior "fire escape" which has been constructed outside one or more doors or windows of the unit. There is usually a requirement that the walls and ceilings of the corridors in the exit path for this R-1 occupancy classification be one hour fire resistive. In addition, the doors to the stairways need to be fire resistive, and the stairways themselves need to be contained in fire resistive shafts of one or two hour fire resistance, (two hour usually being required for taller buildings). There also may be "smoke control" doors that block off open stairways or elevator shafts. These doors may be on electro-magnetic "hold-open" devices so that they are normally open and only close if a fire alarm and/or smoke detector are activated. Elevators are not considered part of the fire exit path. If the building has exterior fire escapes, the assessors should be sure that these exit paths are accessible, structurally sound, and passable.

If the building is a hotel, the assessment procedures are the same as for the apartment house, except there is often no requirement for a second exit path from each room. Rather it is assumed that once an occupant from a room or suite of rooms reaches the corridor, he or she has two ways out of the building. If the building under inspection is from an older era, even apartment houses may not have a second exit path separate from the corridor system. On the ATC-20-2 "Detailed" Evaluation form, reproduced in Table IV, there is a section entitled "Nonstructural hazards" which has an entry labeled "Stairs, exits", that refers to the type of analysis described in inspection scenarios 1a and 1b.

Inspection Scenario 2a for Means of Egress for a B Occupancy

Now if we assume the assessors are going through a "non-residential building", and as in the earlier inspection scenarios, it appears to rate a Green Tag, the first fire safety question should be what is its Occupancy: Should it be considered **Group B. "Business" Occupancies** which are defined in Section 304.1 of the 1997 UBC and reproduced in Table II? At least seven of the "Primary

Occupancies" from the ATC-20-2 Evaluation forms shown in Table I could be classified as a Group B occupancy in the UBC. From a fire prevention point of view, are there discrepancies when considering all these occupancies as just one category? They probably can be ranked as one category if we only consider whole buildings being classified as B occupancies. The basic concept is that a Group B occupancy has a limited number of occupants, and there is little or no sleeping overnight in the building. Furthermore, the exit path analysis for the apartment houses or hotels discussed above would be adequate for the egress analysis of these buildings.

***TABLE IV ATC-20-2 THE SECTION ENTITLED "NONSTRUCTURAL HAZARDS "FROM THE DETAILED EVALUATION FORM*[8]** This is only one of four hazard categories. The others are "Overall hazards", Structural hazards, and Geotechnical hazards.

EVALUATION

Investigate the building for the conditions below and check the appropriate column. There is room on the second page for a sketch

Nonstructural hazards:	Minor/None	Moderate	Severe	Comments
Parapets, ornamentation	☐	☐	☐	______
Cladding, glazing	☐	☐	☐	______
Ceilings, Light fixtures	☐	☐	☐	______
Interior walls, partitions	☐	☐	☐	______
Elevators	☐	☐	☐	______
Stairs, exits	☐	☐	☐	______
Electric, gas	☐	☐	☐	______
Other ______	☐	☐	☐	______

Inspection Scenario 2b for Means of Egress for a "Mixed" Occupancy

Let us assume the assessors are going through a "non-residential building", and that it appears to be a Green Tag situation. The principal reason that it should not be considered simply as a **Group B "Business" Occupancy** would be if it were a "Mixed" occupancy. In Table II the **Group B "Business" Occupancy** applies to a complete building, *or a portion thereof.* This means that only a portion of the building may be classified as having a particular occupancy. When other portions of a building are used for different occupancy purposes, the building is called a "*Mixed Use*" or "*Mixed Occupancy*" building, and there are special provisions in Section 302 of the UBC which cover such a situation. The most common mixed occupancy building is one that combines a **Group B "Business" Occupancy** with a **Group A. "Assembly" Occupancy** as defined in Section 303.1 of Chapter 3 of the 1997 UBC. Section 303 begins with a general definition that states: "**Group A Occupancies** include the use of a building or structure, or a portion thereof, for the gathering together of 50 or more persons** for purposes such as civic, social or religious functions, recreation, education or instruction, food or drink consumption, or awaiting transportation." Group A Occupancies are divided into four "Divisions" which are given in Table V. The most common Division of Group A Occupancies found mixed with Group B occupancies is Division 3, (or simply A-3). The basic definition of this occupancy is "a building or portion of a building having an assembly room with an occupant load of less than 300". Thus if a building which would be classed as a Group B occupancy contains one or

** In each of the model codes in the USA a relationship is established between floor area and the number of persons expected to occupy a space, and thus the provision which allows an assembly room for less than 50 persons to be included as a part of the surrounding occupancy means that small assembly rooms do not require Mixed Occupancy status. We will see that Mixed Occupancies require special fire walls to separate them as well as other requirements.

more rooms which could contain more than 50 persons, (but less than 300 persons), those rooms would be considered A-3 occupancy mixed into the Group B building. If there were rooms that could contain more than 300 persons, those rooms would be considered an A-2.1 occupancy. The "Public assembly" "Primary Occupancy" from both the "*Rapid* "and "*Detailed*" versions of the ATC-20-2 Evaluation forms shown in Table I could be classified as a Group A occupancy in the UBC. From a fire prevention point of view, the primary concern in assembly occupancies is the adequacy of the egress system to provide sufficient capacity for the escape of large number of people.

TABLE V. IN THE 1997 UBC GROUP A OCCUPANCIES ARE DIVIDED INTO FOUR "DIVISIONS" AS FOLLOWS:

Division 1. A building or portion of a building having an assembly building with an occupant load of 1000 or more and a **legitimate** stage[††].
Division 2. A building or portion of a building having an assembly room with an occupant load of less than 1000 and a **legitimate** stage.
Division 2.1 A building or portion of a building having an assembly room with an occupant load of 300 or more without a **legitimate** stage, including such buildings used for educational purposes and not classed as a Group B or Group E Occupancies.
Division 3. A building or portion of a building having an assembly room with an occupant load of less than 300 without a **legitimate** stage, including such buildings used for educational purposes and not classed as Group B or E Occupancies.
Division 4. Stadiums, reviewing stands, and amusement park structures not included within other Group A Occupancies. Specific and general requirements for grandstands, bleachers, and reviewing stands are to be found in Chapter 10.

In this scenario we assume that the assessors are going through a "non-residential building", that appears to be a Green Tag situation. Furthermore, we assume that the building would not be classified simply as a class B occupancy. In the previous paragraph we have introduced the concept of a "mixed occupancy" building, and included the common combination of assembly occupancies. There could be other combinations. A complete list of occupancies[‡‡] from the 1997 UBC (with appropriate Section) is as follows:

Group A - Assembly (See Section 303.1.1)

Group B - Business (See Section 304.1)

Group E - Educational (See Section 305.1)

Group F - Factory and Industrial (See Section 306.1)

Group H - Hazardous (See Section 307.1)

Group I - Institutional (See Section 308.1)

Group M - Mercantile (See Section 309.1)

Group R - Residential (See Section 310.1)

[††] The word "legitimate" was added with the publication of the 1988 UBC, and the definition of a legitimate stage is given in Section 405.1.2 with a number of special terms. In that section a "***Stage, Legitimate***", is defined as "a stage wherein curtains, drops, leg drops, scenery, lighting devices or other stage effects are retractable horizontally or suspended overhead and the stage height is greater than 50 feet (15.24 m). It requires special fire protection treatment.

[‡‡] Prior to the 1994 edition of the UBC the occupancies defined in the UBC were substantially different, and the reader should be aware that buildings approved under the older editions of the code may have different occupancy classifications.

Group S - Storage (See Section 311.1)

Group U - Utility (See Section 312.1)

The assessors should be aware that if they are inspecting a large and/or complex building there might be special fire safety concerns. If we consider the whole building and focus on the adequacy of the *means of egress,* then the exit path analysis for the apartment houses or hotels discussed above would be adequate for the egress analysis of these buildings. There are exceptions to this approach. For example, in hospitals, Group I - Institutional, we do not expect to be able to have bed-ridden patients use the stairways, and each floor is divided into at least two "fire zones" so that occupants can be sheltered from a fire without leaving the floor[§§].

For the general Mixed Occupancy building considered in this scenario, we recommend that the assessors walk through the exit paths for the entire building. All spaces which contain more than approximately ten people are required to have at least two independent exit paths from each area in the building. In addition, the building should not contain any there "dead end corridors" longer than 20 ft (6 m). This usually means that there are two "ways out" of each occupied area, and if the exit path is an interior corridor, there are enclosed exit stairways for use of people in those corridors.

Inspection Step after "Means of Egress" - Structural Integrity of Passive Fire Protection

In this scenario we assume that the assessors are going through a "building" that appears to be a Green Tag situation with regards to earthquake damage, and whose means of egress have not been compromised by the earthquake. It is now the task of the assessors to determine if the "***Fire Resistance***" of the building has been jeopardized by the earthquake. "***Fire Resistance***" or "***Fire-Resistive Construction***" is defined in the 1997 UBC[9] as "construction to resist the spread of fire, details of which are specified in this code". Another definition of fire resistance is "the ability of an element of building construction to withstand the effects of fire for a specified period of time without loss of its fire separating or load bearing function[10]". If the building is a large and/or complex building, the designed fire resistance may be extensive. On the other hand, if the building is small, there may be little or no designed fire resistance. If the assessor in a given building is not familiar with fire resistant construction details, then the following recommendations may be difficult to follow. However, as with any rapid evaluation, "when in doubt", give the building at least a Yellow Tag and recommend further inspection. Non-loadbearing interior walls and ceilings which are supposed to be fire resistant should not be heavily damaged[***]. In steel frame buildings the sprayed-on "*fireproofing*" should have remained in place. The integrity of the exit walls and ceilings, and the operation of fire doors along the exit paths were already reviewed in the exit path analysis above. It should be recognized that the building under inspection may originally have been designed, constructed and granted an occupancy certificate when the code requirements were very different from today's. So there may not be as much fire resistance as in a current building of the same size and occupancy. In the final analysis, the assessors should identify any interior fire resistance of the structure which should be relatively undamaged by the earthquake.

[§§] This concept is called a "***horizontal***" exit, and it may also be used in other occupancies to replace stairways.

[***] If an inspector finds "minor" cracking of corridor walls or ceiling, it is probably not a life safety issue. Of course the difficulty in this evaluation is the definition of "minor". One can take comfort in the fact that 20 minute doors are allowed in one-hour corridor walls, and unless the cracks a large enough to decrease the fire resistance from 60 minutes to 20 minutes there is no problem in the eyes of the UBC.

FINAL INTERIOR INSPECTION STEP - ELECTRICITY AND GAS

In this scenario we assume that the assessors are going through a "building", that appears to be a Green Tag situation as regards earthquake damage to the building, and the means of egress have not been compromised by the earthquake. The assessors should then determine if the electrical service is connected to the building, and if it is operating without any problems. If the electrical service has not been connected, the assessor should perform a visual inspection of the system, and he/she should note on the Green Tag that the electricity has not been restored as of the date inspected. In a similar fashion, the assessors should determine if the gas service is connected to the building, and if it is operating without any problems. If the gas service has not been connected, the assessor should perform a visual inspection of the system, and he/she should note on the Green Tag that the gas service has not been restored as of the date inspected. The furnace and/or hot water heaters should be visually inspected, and the assessors should be particularly careful to note if the flues are aligned properly.

EXTERIOR INSPECTION OF PASSIVE FIRE PROTECTION

Once the assessors have completed the internal evaluation and the earthquake damage of the building, and they have decided to issue a Green Tag, there still remains the evaluation of the exterior fire protection features of the building. The exterior envelope of a building may need to be of fire resistive construction that is governed by Section 503 of the 1997 UBC.

SECTION 503 - LOCATION ON PROPERTY

503.1 General. Buildings shall adjoin or have access to a public way or yard on not less than on side. Required yards shall be permanently maintained.

503.2 Fire Resistance of Walls

503.2.1 General. Exterior walls shall have fire resistance and opening protection as set forth in Table 5A and in accordance with such additional provisions as are set forth in Chapter 6.

The provisions for exterior fire resistance shown in Table 5A are intended to prevent fire spread from building to building. If one building is consumed in fire, the intent of the fire resistive exterior walls and "protected openings"[†††] is to protect the adjacent building. Part of the protection comes from the fire resistance of the burning building and part from the "exposed" building. In the field of Fire Protection Engineering this fire scenario is called an "exposure fire", and in the post earthquake environment the assessors should determine if the building under inspection is vulnerable to an exposure fire from its neighboring structures.

[†††] If a fire resistive door or window is installed in an opening, that opening is said to be a "protected opening".

TABLE 5A [Abridged) EXTERIOR WALL AND OPENING PROTECTION BASED ON LOCATION ON PROPERTY FOR *SELECTED OCCUPANCIES AND* ALL CONSTRUCTION TYPES For exceptions, see Sect. 503.4

OCCUPANCY GROUP	CONSTRUCTION TYPE	EXTERIOR WALLS		OPENINGS
		Bearing	Nonbearing	
		Distances are measured to property lines (See Section 503) x 3.05 for m		
B	II One-hour	One-hour N/C	Same as bearing except NR, NC 40 feet or greater	Not permitted less than 5 feet Protected less than 10 feet
F-1	II-N	One-hour N/C less than 20 feet NR, N/C elsewhere	Same as bearing except N/R, N/C 40 feet or greater	Not permitted less than 5 feet Protected less than 10 feet
M	V One-hour	One-hour	Same as bearing	Not permitted less than 5 feet Protected less than 10 feet
S-1, S-3	V-N	One-hour less than 20 feet NR elsewhere	Same as bearing	Not permitted less than 5 feet Protected less than 10 feet
	I-F.R. II-F.R. III One-hour III-N IV-H.T.	Four-hour N/C less than 3 feet Two-hour N/C elsewhere	Four-hour N/C less than 3 feet Two-hour N/C less than 20 feet One-hour N/C less than 40 feet NR, N/C elsewhere	Not permitted less than 3 feet Protected less than 20 feet
R-1	II One-hour	One-hour N/C	Same as bearing except NR, N/C 40 feet or greater	Not permitted less than 5 feet
	II-N	One-hour N/C less than 5 feet NR, N/C elsewhere	Same as bearing except NR, N/C 40 feet or greater	Not permitted less than 5 feet
	V One-hour	One-hour	Same as bearing	Not permitted less than 5 feet
	V-N	One-hour less than 5 feet NR elsewhere	Same as bearing	Not permitted less than 5 feet
	I-F.R. II-F.R. III One-hour III-N IV-H.T.	Four-hour N/C	Four-hour N/C less than 3 feet Two-hour N/C less than 20 feet One-hour N/C less than 40 feet NR, N/C elsewhere	Not permitted less than 3 feet Protected less than 20 feet
R-3	II One-hour	One-hour N/C	Same as bearing except NR, N/C 40 feet or greater	Not permitted less than 3 feet
	II-N	One-hour N/C less than 3 feet NR, N/C elsewhere	Same as bearing	Not permitted less than 3 feet
	V One-hour	One-hour	Same as bearing	Not permitted less than 3 feet
	V-N	One-hour less than 3 feet NR elsewhere	Same as bearing	Not permitted less than 3 feet

Inspection Scenario 3a for B, M, F, or S Occupancies

These buildings are commercial buildings used for offices, stores, factories or warehouses, and the requirements in the 1997 UBC are given in the top row of the abridged version of Table 5A shown above. The most common type construction for buildings housing these occupancies is Type V-One-hour, and Table 5A requires that the exterior walls have one hour fire resistance no matter what the distances to the property lines. However, if the type construction is Type II-N or Type V-N there is no fire resistance requirement if the distance to the property line is more than 20 ft. If there is less than 20 ft to the property line, Table 5A requires that the exterior walls have a one hour fire resistance. Fire resistive doors or windows are required if the distance is between 5 and 10 ft, and no openings are permitted with less than 5 ft to the property line.

The assessors should look at the distances between the building under inspection and the neighboring buildings. This may mean buildings on either side and, potentially, in back may need to be inspected. The question to address is: *If the neighboring building caught fire, would the building under inspection be subjected to a fire more severe than one that might have occurred before the earthquake?* There are two distinct possibilities:

1. The fire resistance of the exterior of the building under inspection is decreased by the earthquake; and/or
2. The neighboring building has been damaged and presents a greater exposure fire.

To assess the first possibility, the inspector needs to determine what fire resistance might be required by the code, and then to determine if the earthquake has damaged the exterior walls in such a way that they are no longer effective fire barriers. Obviously, large cracks or gaps in exterior cladding can allow the fire to penetrate the building under inspection. Likewise, broken fire resistive windows or doors will also allow a fire to penetrate the building. In many urban areas buildings stand side-by-side with little or no distance between them and in this situation it is difficult to assess the condition of the fire resistance of the common wall. Usually, each building has been constructed separately, and regardless of type of construction, the exterior wall has at least a one hour fire resistance. The inspector needs to determine if that fire resistance has been affected by the "pounding" that might have occurred during the earthquake. It may be necessary to enter the adjoining building, and at that time it would be appropriate to check the second possibility that the neighboring building has been damaged and presents a greater than normal risk for an exposure fire.

The second possibility is a very important point. If the building under inspection is going to be given a Green Tag, it is important that the adjoining buildings in "zero-clearance" lot line situations are not going to present a dangerous fire exposure condition. A potential fire scenario is given below in the "box" and labeled "***POST EARTHQUAKE SCENARIO 1***". This scenario illustrates how a damaged neighboring building can present a exposure fire. If one extends this analysis, it may be necessary to inspect all the buildings in a city block to be sure that conditions are safe for people to live in the neighborhood. Even for the inspection of buildings in Group B, M, F, or S Occupancies, the potential for exposure fires started by homeless people is a real possibility after an earthquake. In the more serious earthquakes thousands of people are displaced by the loss of their home, and in cold and wet conditions they can be expected to seek shelter wherever they can find it.

POST EARTHQUAKE SCENARIO 1

Take a city block in which buildings date from many different years; some are Pre-WWII and others have been built in the late 1990's. The block contains many occupancies: retail stores in the ground floors of buildings with multiple living units on upper floors, individual single family residences, apartment houses and condominium buildings. In the days following a major earthquake, all the buildings are inspected and there is a mixture of green, yellow and red tags. The older buildings are generally in an obvious "Red Tag" condition, but not in danger of imminent collapse. The newer buildings are found to be in a "Green Tag" condition, and the occupants are allowed to remain in the dwelling units.

Two weeks following the earthquake, a group of homeless people break into one of the Red Tag buildings and build a fire to keep warm[‡‡‡]. In the early morning hours the fire gets out of control, and the building is fully involved in fire. The power, water, and gas are shut off to the fire involved building making smoke detectors unworkable and there is no access to a ready way to extinguish the fire. The homeless people are trapped in the building, and no one sees the fire causing a substantial delay in the fire department being called.

When the fire department arrives, the fire has spread to the adjacent buildings on either side of the building-of-origin. The water supply is not back to its pre-earthquake condition, and the fire department resources are also stretched by other post-earthquake activities.

The fire spreads from the first three buildings to other structures along the street of the building-of-origin, as well as to the other side of the block. At this point, the fire fighters turn to protecting the adjacent blocks. The final fire damage is the loss of a complete block of buildings, and if there had been a wind, the fire would probably have spread to the down wind boundary of the city.

After the fire, the investigators found that the buildings on both sides of the red tagged building-of-origin were zero-lot-line buildings that had received severe pounding damage during the earthquake. This damage allowed the fire to enter those structures quickly and created a very large fire that was beyond the fire extinguishing capabilities of the first responding fire fighters. If the fire resistance between the buildings had not been compromised, it is most probable that the fire fighters could have protected the two adjacent buildings, and confined the fire to the building-of-origin.

The inspectors of the two structures adjacent to the red tagged building-of-origin remembered that their internal inspection of the those buildings showed no problems. The damage to their exterior walls was not visible from the interior of the building, and it was hidden from view on the outside by the adjacent building.

Inspection Scenario 3b for R-1 Occupancies

These buildings are residential buildings with two or more dwelling units, and the requirements in the 1997 UBC are given in the middle full row of the abridged version of Table 5A shown on page 10 of this report. As in the case of commercial buildings, the most common type construction for

[‡‡‡] The author of this report investigated a hotel in San Francisco which suffered a fire after it had been "closed" with an elaborate combination of locks and plywood over windows and doors. It was obvious that homeless people had found ways to enter the building, and the fire spread rapidly through the building because all of the doors to the corridors and stairways had been blocked open.

R-1 buildings is Type V-One-hour, and Table 5A requires that the exterior walls have one hour fire resistance no matter what the distances to the property lines. However, if the type construction is Type II-N or Type V-N there is a one-hour fire resistance requirement if the distance to the property line is less than 5 ft. Fire resistive doors or windows are not required for any distance to the property line, but no openings are permitted with less than 5 ft to the property line.

The assessors should investigate the distances between the building under inspection and the neighboring buildings. This may mean buildings on either side and, potentially, in back may need to be inspected. The question to address is: ***If the neighboring building caught fire, would the building under inspection be subjected to a fire more severe than one that might have occurred before the earthquake?*** The two distinct possibilities are given above in "*Inspection Scenario 3a for B, M, F, or S Occupancies*":

To assess the first possibility, the inspector needs to determine what fire resistance might be required by the code, and then to determine if the earthquake has damaged the exterior walls in such a way that they are no longer effective fire barriers. This is the same inspection procedure described for B, M, F, or S Occupancies. The inspectors should look for large cracks or gaps in the exterior cladding that would allow the fire to penetrate the building under inspection. In many urban areas buildings stand side-by-side with little or no distance between them, and in this situation it is difficult to assess the condition of the fire resistance of the common wall. Usually each building has been constructed separately, and regardless of type of construction the exterior wall has at least a one hour fire resistance. The inspector needs to determine if that fire resistance has been affected by the "pounding" that might have occurred during the earthquake. It may be necessary to enter the adjoining building, and at that time it would be appropriate to check the second possibility that the neighboring building has been damaged and now would present a greater than normal exposure fire condition.

The second possibility is a very important point. If the building under inspection is going to be given a Green Tag, it is important that the adjoining buildings in "zero-clearance" lot line situations are not going to present a dangerous fire exposure condition. A potential fire scenario is given above in the "box" and labeled "***POST EARTHQUAKE SCENARIO 1***". This scenario illustrates how a damaged neighboring building can present a possible exposure fire. If one extends this analysis, it may be necessary to inspect all the buildings in a city block to be sure that conditions are going to be safe for people to live in the neighborhood. It is particularly important in the inspection of buildings in Group R-1 Occupancies where the potential for exposure fires started by homeless people is a real possibility after an earthquake. In the more serious earthquakes there are thousands of people displaced by the loss of their home, and in cold and wet conditions they can be expected to seek shelter whereever they can find it.

Inspection Scenario 3c for R-3 Occupancies

These buildings are residential buildings with one or two dwelling units, and the requirements in the 1997 UBC are given in the middle full row of the abridged version of Table 5A shown above. The most common type construction for R-3 buildings is Type V-N, and Table 5A requires that the exterior walls have one hour fire resistance if the distance to the property line is less than 3 ft. Fire resistive doors or windows are not required for any distance, but no openings are permitted with less than 3 ft to the property line.

This is a very common occupancy in cities of all sizes, but in the congested portions of large cities like San Francisco and Los Angeles one often finds R-3 buildings in between B or R-1 occupancies. In many cases these structures are small enough to come through the earthquake without substantial damage, particularly if they have been seismically upgraded or constructed in recent years. But the assessors should look at the distances between the building under inspection and it neighbors. This may mean that buildings on either side and, potentially, behind the building need to be inspected. The question to address is: ***If the neighboring building caught fire, would the building under inspection be subjected to a fire more severe than one that might have occurred before the earthquake?*** There are several distinct possibilities:

1. The fire resistance of the exterior of the building being inspected is decreased by the earthquake; and/or
2. The neighboring building has been damaged, and it presents a greater exposure fire.

To assess the first possibility the inspector needs to determine what fire resistance might be required by the code, and then to determine if the earthquake has damaged the exterior walls in such a way that they are no longer effective fire barriers. This is the same inspection procedure as described for R-1 as well as B, M, F, or S Occupancies. The inspectors should look for large cracks or gaps in the exterior cladding that would allow the fire to penetrate the building under inspection. In many urban areas buildings stand side-by-side with little or no distance between them, and in this situation it is difficult to assess the condition of the fire resistance of the common wall. Usually each building has been constructed separately, and regardless of type of construction the exterior wall has at least one hour fire resistance. The inspector needs to determine if that fire resistance has been affected by the "pounding" that might have occurred during the earthquake. It may be necessary to enter the adjoining building, and at that time it would be appropriate to check the second possibility that the neighboring building has been damaged and now would present a greater than normal exposure fire condition.

The second possibility is a very important point. If the building under inspection is going to be given a Green Tag, it is important that the adjoining buildings in "zero-clearance" lot line situations are not going to present a dangerous fire exposure condition. A potential fire scenario is given above in the "box" and labeled "***POST EARTHQUAKE SCENARIO 1***". This scenario illustrates how a damaged neighboring building can present a possible exposure fire. If one extends this analysis, it may be necessary to inspect all of the buildings in a city block to be sure that conditions are going to be safe for people to live in the neighborhood. Piles of rubble and trash (fuel) are abundant after an earthquake. It is particularly important to the inspection of buildings in Group R-3 Occupancies where the potential for exposure fires started by homeless people is a real possibility after an earthquake. In the more serious earthquakes there are thousands of people displaced by the loss of their home, and in cold and wet conditions they can be expected to seek shelter wherever they can find it.

FINAL EXTERIOR INSPECTION STEP - CONDITION OF THE NEIGHBORHOOD

If a building has passed all the steps discussed above and the assessors are ready to grant a Green Tag, they must consider one final passive fire prevention aspect, namely, what is the general condition of the neighborhood with respect to fire. Large piles of combustible litter should not be around structures. There should be good access to the buildings. The inspectors should realize that the passive fire protection of buildings "buys time" for the fire fighters to reach a structure. If the streets appear impassable to fire engines, the inspector should check with the fire department about its abilities to fight a fire in the neighborhood.

SAFETY ASSESSMENT MANAGEMENT

As discussed in the Introduction to this report, the rapid evaluation of buildings after a major earthquake can be expected to be conducted by both paid and volunteer assessors. The rapid evaluation in a number of past earthquakes has been reviewed, and two inspection scenarios were described in the Introduction. The first inspection situation is characterized as a "small" event and the second as a "large" event. The 1989 Loma Prieta is an example of a "small" event in the sense that the major damage was confined to rural regions outside major urban centers and to limited areas within the urban San Francisco Bay Area. On the other hand, the 1994 Northridge earthquake is an example of a "large" event. In both the Loma Prieta and the Northridge earthquakes the "life safety" of buildings was an important part of the evaluation. In some cases, well-qualified fire professionals were part of the survey teams, but in other cases, it appears that volunteer structural engineers performed the rapid evaluation with little knowledge of fire safety. Richard Ranous of the California Governor's Office of Emergency Services states,[11]: "Typically, we do not have ready access to the interiors of buildings and most rapid evaluations are performed from the exterior only." This means that much of the interior inspection described above cannot be performed. On the other hand, N. G. Delli Quadri of the Department of Building and Safety[12] stated that, "it was hard to get across that the Red, Yellow, and Green Tags have to do with safety of occupancy, not just structural damage. If a building has no sewer line, Buildings and Safety tagged it red." Obviously, if "safety of occupancy" is a concern, the inspection cannot be alone from the exterior. Ranous[13] goes on to note: "The ATC-20 safety assessment process is intended to address the immediate high risks in the post-earthquake environment. They are falling hazards, collapse, and partial collapse resulting from aftershocks. Though post-earthquake fire is a legitimate risk, that risk tends to diminish as time passes and more fire resources (including water) are available. Most post-earthquake fires are a direct result of the initial event not aftershocks occurring in the weeks immediately following the event. On this basis, our limited resources must be used to their full advantage." The concerns of Mr. Ranous are very important, and in this section we will discuss the "*Management of Safety Assessment*" in the post-earthquake environment.

As discussed in the Introduction, we assume that the AHJ has access to structural engineers and others who are trained to perform inspections consistent with ATC-20 *"Procedures for Postearthquake Safety Evaluation of Buildings"* as well as the other ATC-20 documents listed in the Introduction. If we look at the Northridge Earthquake, we can see the difficulty of assessing damage in an urban area. Starting on the afternoon of the Northridge Earthquake, Ranous[14] noted that the California Office of Emergency Services (OES) implemented a crash program to evaluate as many buildings as possible. They "provided mutual assistance to seven jurisdictions from one state agency with approximately 600 individuals from its Safety Assessment Volunteer Program and 280 engineers from the U. S. Army Corps of Engineers." Two weeks after the earthquake 67,000 buildings had been inspected, and by mid-July, (6 months after the earthquake), 113,915 buildings had been inspected. Of that total 90,311 or 79% of the buildings were given Green Tags. Ranous further points out that "most jurisdictions elected to perform only rapid evaluations," and Green Tag buildings were accepted by the AHJ without, in most cases, any further checking, even though the rapid evaluation could be performed without ever going into the building. Ranous[15] believes that the Northridge assessors tried to cover "Life Safety" aspects of the building during the review process. This included obvious damage to sprinklers, fire doors and other fire safety system components. The most important aspect of the post-Northridge assessment is that the volunteer program put large numbers of persons into the field with little knowledge of fire safety in general, and no real knowledge of passive fire protection. It was probably not important in most of the affected areas around the San Fernando, Woodland Hills, and Burbank areas. Possibly, there may have been some fire safety problems in the more densely populated areas such as Beverly Hills and Hollywood, but nothing happened in the aftermath of the earthquake to cause anyone to identify a problem.

In dense urban areas such as San Francisco or Oakland, there may be more important fire safety problems following a major earthquake. The AHJ and the OES as well as other organizations involved in the building inspection process should take precautions to deploy rapid evaluation teams that know how to include fire safety considerations into their inspection of buildings. In ATC 20-2[16] the training and qualifications of volunteers are discussed with specific attention to the makeup of the rapid evaluation team:

> ***"Rapid Evaluation team***: The Rapid Evaluation team, which usually has two members, first identifies both the apparently safe and the obviously unsafe structures and then continues to evaluate more difficult damage conditions that may require the Restricted Use posting. Ideally, two building inspectors or a building inspector and an engineer make up a team. Under more pressing circumstances, a building inspector and an unlicensed engineer might form an acceptable team."

After the Northridge Earthquake, it appears that most of the rapid evaluation teams were made up of Civil Engineers. Only very few code officials, building inspectors, or fire marshals were used to inspect structures for fire safety.

The San Francisco Department of Building Inspection established a novel plan that has building owners retain qualified persons to inspect their building after an earthquake. It is called the "Building Occupancy Resumption Emergency Inspection Program[17]" which is part of the Earthquake Emergency Management Plan for the city and county of San Francisco. Building owners may participate at any time except during the aftermath of an earthquake resulting in a declared state of emergency. A building having met the requirements outlined below shall be placed on a list of buildings accepted for private emergency inspection. There is no charge for participation from the city government, but there is a cost associated with the retention of the inspectors.

The steps to be taken in order to participate in the program are as follows:

1. Selection of emergency inspection team;
2. Obtain building plans;
3. Write inspection plan;
4. Develop building information, evacuation plan, inspector response requirements, equipment and drawing locations, and other pertinent information;

5. Prepare precertification documentation;
6. Submit written building emergency inspection program, including inspection plan;
7. Obtain and store emergency earthquake safety and inspection equipment and supplies;
8. Establish and maintain an emergency inspection program;
9. Update inspection plan, supplies, personnel changes and training as necessary; and
10. Submit an annual update form by Oct. 17 of each year.

There is a requirement that calls for a minimum of one primary and one alternate inspector and the costs of training are to be borne by the building owner. A set of minimum qualifications is as follows:

> Structural inspectors: CA license as professional civil or structural engineer or architect, experience, proficiency in ATC-20 evaluation procedures, familiarity with DBI administrative posting guidelines for post-earthquake emergency inspection.
>
> Elevator inspectors: employed in a firm engaged in elevator maintenance or installation, familiarity with building elevator installation.
>
> Life safety system inspectors (required for high-rise buildings): CA license as mechanical or electrical engineer, familiarity with the building life-safety system. Note that a licensed fire protection engineer is not listed, but it could be argued that a fire protection engineer generally will know more about life-safety systems than most mechanical or electrical engineers.

The San Francisco Emergency Inspection Program is one form of preplanning that is part of the city and county's Earthquake Emergency Management Plan. However, most owners will not opt for that approach because of the expenses involved. In addition, it is not clear what obligation the engineers who prepare the inspection plan and review the expected earthquake performance of the building have to inform the owner of the expected failure of old or poorly designed buildings. It may be practical for a new building, and it could be required for new buildings. Another approach to this problem may be to institute a general inspection procedure for the local jurisdiction. John Hall discussed this in some detail[18] in an article entitled "Regular Inspections Prevent Fires". He described a study funded by the U.S. Fire Administration (now part of FEMA) in which 11 cities with diverse inspection practices were selected for in-depth study. Their findings and suggestions are as follows:

1. Fire frequency rates appeared to be substantially lower in cities that annually inspected all or nearly all buildings[§§§]. - Fire departments should provide annual fire code inspections to all buildings covered by fire codes. Fire departments should monitor their success by screening building fires to see whether the properties had been inspected within the past year.
2. Cities that used fire fighters for a large share of regular fire code inspections appeared to have substantially lower fire rates than those that used full-time fire prevention bureau inspectors exclusively. - Cities should use fire fighters for fire code inspections.
3. Cities defining the inspectors' duties in terms of areas instead of particular buildings to be covered appeared to be more successful. In an area approach, city blocks or streets were systematically covered. Fire departments. should assign inspections by geographic areas of responsibility, and combine this with a systematic street-by-street check-off.

[§§§] Apartments were excluded because most apartment fires begin inside private units where inspectors do not go, and one- and two-family residences where excluded because many cities' codes do not cover them.

4. Fire caused by carelessness or by electrical or mechanical failure constituted 40-60% of all building fires, while those caused by visible hazards that inspectors are likely to remove constituted only 4-8%. The remaining fires were of incendiary, suspicious, natural, or unknown cause.

5. Deficiencies in building features and absence of automatic fire protection equipment were factors in most of the 48 incidents involving 10 or more civilian deaths in public US buildings. The deficiencies included:

a. Unenclosed stairways or other stairway-related problems were cited as major factors in 7 of 13 apartment fires, and 6 of 9 hotel fires.
b. Lack of sprinklers and detectors cited in 6 of 9 hotel fires, in at least 2-4 in restaurants and lounges, in 7 of 10 nursing home fires.
c. Absence of partitions subdividing long corridors and other necessary separations cited in 9 of 10 nursing home fires.
d. Presence of wood paneling on walls in 4 of 10 nursing home fires, and 3 of 4 restaurant and lounge fires.

This discussion of non-earthquake inspections by Hall contains a number of important lessons for organizing post-earthquake inspections. The most obvious is that the AHJ should assign inspections by geographic areas of responsibility, and combine them with a systematic street-by-street check-off. The use of hundreds of volunteer and/or outside inspectors can be managed much more efficiently if the inspections are organized by geographic area. In addition, there can be some command structure imposed on the inspection teams, and "block-captains" can coordinate the passive fire prevention problems illustrated in "***POST EARTHQUAKE SCENARIO 1***" which appears in the box on page 12. The block-captain can be in communication with the local fire department, and decisions can be made about the appropriateness of giving Green Tags to structures which may be close to Yellow or Red Tag structures. The use of fire fighters for post-earthquake inspections is an interesting idea. They would have to be trained in ATC 20 type procedures in order to be called upon to examine the fire safety conditions of buildings. And those fire fighters who are normally assigned to inspecting buildings would be very useful to the inspection process. If the inspections were organized on a geographic area basis, one or two fire fighters could be assigned to each block and they could convey information to the block-captain about exposure fires between buildings as well as participate in the interior inspections.

TECHNOLOGICAL ASPECTS OF FIRE SAFETY EVALUATION

There are a number of technical issues raised by the discussion of post-earthquake inspection of passive fire resistance. One of the most important issues is illustrated by the passive fire prevention problems brought up in the "***POST EARTHQUAKE SCENARIO 1***" which appears in the box on page 12. In the United States as well as elsewhere, a mix of buildings usually exists in most urban areas. When structures are constructed on the boundaries of the property, called earlier in this paper a "zero-clearance" lot line situation, "pounding" will often occur during earthquakes between such structures and one or both structures might be damaged. It may not be "structural" enough to be have the structure classified as Red or Yellow Tag, but the fire resistance can be compromised. This deficiency of fire resistance should be repaired, yet the building could still be occupied as long as there are no special fire hazards such as a Red Tagged building next door with its combustible structure compromised or its interior likely to be used by homeless people. In a sense, there should be some provision in the building code to require "stand-off" distances between structures so that they will not touch in an earthquake, but this has not been mandated as of this time. The zero-clearance situation certainly introduces a difficult inspection and/or repair problem since if both structures are still standing it is difficult to gain access to the space between buildings.

Another technical issue is that some fire resistance given in the building code such as the four hour requirement between some kinds of buildings is too restrictive and dates back to earlier days when fire fighters were not as effective, and modern construction did not exist. On the other hand, there are some non-rated construction, (such as Type II-N and Type V-N construction) which have almost no fire resistance. One example are composite wood "I-joists" which structurally fail in five minutes of a minor exposure. In addition, these same wood I-joists are used for "fire stopping" at the boundaries of protection areas. They will burn through with a very small fire and should not be used in this application.

CONCLUSION AND RECOMMENDATIONS

A number of conclusions and recommendations have already been discussed in the course of presenting our analysis of post-earthquake inspection of passive fire prevention. The idea was introduced that the ATC 20 Evaluation Safety Assessment Forms do not follow the occupancy classifications used by the building codes. It is currently planned to have one model building code in the United States by the year 2000, and it would seem reasonable to alter those forms to conform with the new code. In addition, the organization of building inspection teams might well include building or fire department personnel who are familiar with the terminology of the code. If the work of the volunteers and/or outside inspectors is organized by geographic area, the pre-earthquake information from the AHJ could be in notebook computers ready for the inspectors to use at the start of their duty. It would make sense to put this into the language of the building code. Simple plans could also be included in the notebook computer, as well as the results of the last one or two regular inspections. This information would eliminate some of the guesswork from the inspection process. To take an idea from the San Francisco Emergency Inspection Program, the AHJ could develop building information, evacuation plans, inspector response requirements, equipment and drawing locations, and store them, together with any other pertinent information, in a standard format in the notebook computer to be used during the inspection process.

We have been learning a great deal from our recent major earthquakes, and since we are likely to experience further large earthquakes in or close to urban centers, it would appear prudent to incorporate more fire safety into the current state-of-the-art approach to post earthquake inspection. It is conceivable to have a large fire associated with the post earthquake environment that could sweep through a large area of urban structures. In many ways, it could be worse than the great San Francisco fire of 1906 since today many cities have more densely packed and larger buildings than in 1906. Yet wood is still one of the principal construction materials, and it is often unprotected except for a few pieces of gypsum wall board slipped in between the buildings. One can also imagine the additional hazard of California fire weather, conditions, which have routinely accounted for the loss of thousands of buildings in the last ten years without the added destruction of a major earthquake to modify the fuel packages. Just the breakage of windows by the earthquake could substantially shorten the time needed for an exterior fire to enter s a building.

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