

San Francisco's response to Loma Prieta earthquake damage

D.W.Cocke & D.R. Bonneville

H.J.Degenkolb Associates, Engineers, San Francisco, Calif., USA

ABSTRACT: Immediately following the October 17, 1989 Loma Prieta earthquake, the document ATC-20, *Procedures for Postearthquake Safety Evaluation of Buildings* was used successfully by San Francisco Building Officials to make initial assessments of damaged buildings. However, no published information was available to determine what should be done with the red-tagged buildings, those considered most dangerous. An approach was developed for the assessment of these buildings relying upon on-site engineering judgement of experienced structural engineers. It resulted in a classification of red-tagged buildings as follows: Unsafe, but secured; Unsafe, requiring emergency temporary shoring; Unsafe, requiring emergency demolition; Incorrectly red-tagged. Over three-hundred buildings were evaluated using this program. The success of the program can best be assessed by the few demolished historical buildings and no further injuries after the earthquake. This experience, working with a large number of heavily damaged buildings, can be useful in furthering the methodology for dealing with similar conditions in future earthquakes in other cities.

1 INTRODUCTION

In the autumn months of 1989, San Francisco building officials had started a preparedness program for response to a nearby damaging earthquake. At a seminar in San Francisco, the Applied Technology Council (ATC) introduced a new methodology for post-earthquake rapid assessment of damaged buildings and it was adopted by the San Francisco officials for use in their own preparedness program. However, this methodology addressed only the rapid assessment of red-tagged buildings and offered no further detailed recommendation for those buildings. When tested by the Loma Prieta earthquake on October 17, 1989, the San Francisco building officials soon realized the need for a more detailed assessment of those buildings most heavily damaged.

The earthquake occurred at 5:04 p.m. and was centered near Mt. Loma Prieta, approximately 60 miles south-southeast of the City. It registered 7.1 on the Richter scale and the duration of strong shaking was about 7 to 10 seconds. In San Francisco, the observed intensity was ranked from VII to IX on the Modified Mercalli Scale. Recorded horizontal peak ground accelerations in San Francisco ranged from 5% to 21% of gravity and was largely dependent on the local soil conditions.

San Francisco's building stock numbered approximately 120,000 before the earthquake. After the earthquake, the Department of Public Works set out

immediately to organize a program for inspecting damaged buildings. The number of buildings damaged in the City was unknown following the event and all buildings within known zones of damage and when otherwise suspected of damage had to be inspected. There was a vital and immediate need to assure public safety and to provide adequate and safe shelter for residents at the same time. In addition to this overriding issue of public safety, there were secondary needs to preserve valuable building properties, including many historically significant buildings, and to insure some direction to the owners of damaged buildings. Of course, each of these issues had to be addressed in a timely manner.

2 ATC-20 POSTEARTHQUAKE PROCEDURES

Fortunately, just months before the earthquake, *Procedures for Postearthquake Safety Evaluation of Buildings*, ATC-20, had been published (Applied Technology Council, 1989). Although largely untested, this document had been presented in the first of a series of seminars to the engineering community and municipal authorities, including those in the San Francisco Bay Area.

ATC-20's purpose is to address the technical aspects of making rapid building structural safety evaluations; it does not address the organizing and managing of the inspection work. The document provides a systematic

procedure for the rapid structural evaluation of earthquake damaged buildings. The procedure acknowledges that initial rapid screenings are required immediately, and that those will largely be performed by a manpower base of building inspectors, volunteer inspectors and others not specifically qualified to perform detailed structural seismic evaluations. A plan had been developed jointly between the Structural Engineers Association of California (SEAC) and the Governor's Office of Emergency Services (OES) to provide volunteer engineers for the rapid assessment of damaged buildings after an earthquake. Engineers and building inspectors from all over California were used for these assessments. The program was very successful, especially in terms of buildings inspected and protection to the public. More than 9,000 buildings were inspected in the weeks following the earthquake, about 365 were posted UNSAFE and 1,700 to 1,800 were posted LIMITED ENTRY.

The procedure basically provides guidelines to be followed by the inspectors enabling them to classify every building in one of three categories: INSPECTED (green-tag), LIMITED ENTRY (yellow-tag), and UNSAFE (red-tag). The ATC-20 procedure is basically a screening procedure. In the procedure, buildings in the "gray" area, i.e. those posted as LIMITED ENTRY, require a more detailed evaluation to be performed by engineers with structural experience in order to classify as either "Red-Tag" or "Green-Tag".

After classification, a building posted INSPECTED or UNSAFE is no longer addressed by the procedures. No specific follow-up steps are provided in the flowchart for those buildings posted UNSAFE. ATC-20 is primarily concerned with public safety and the initial rapid inspections of the buildings. Yet, those buildings posted as UNSAFE, after the rapid inspection procedure, are left unaddressed by the document while they represent the greatest threat to pedestrians and to adjacent buildings. The fate of these most severely damaged buildings is left in the hands of the local building official.

3 SAN FRANCISCO'S EMERGENCY SHORING PROGRAM

The City of San Francisco's Emergency Shoring Program for Red-Tagged Buildings was initiated about one week after the Loma Prieta earthquake. The Department of Public Works, Bureau of Building Inspection contacted Degenkolb and another local structural engineering consultant and asked for their participation in the program. Initially, the Bureau of Building Inspection recognized a need to provide structural engineering services where temporary shoring might be required. At that time, it was anticipated that there would likely be several buildings requiring some form of emergency temporary shoring to minimize the

hazards to the surrounding public.

After discussions between the building officials and the consultants, it was determined that an additional phase of inspections for the red-tagged buildings would be required. It was agreed that there was a need for a detailed follow-up evaluation to the ATC-20 rapid evaluations, performed by qualified structural engineers. It was also agreed that these evaluations should be performed by impartial consultants, not representatives of the owners.

The intent of this detailed follow-up evaluation would be to determine the next step for those buildings posted as UNSAFE after the ATC-20 rapid evaluation. The flowchart in Figure 1 is an extension to the ATC-20 procedures and in it, the authors have outlined the procedure used in the San Francisco Red-Tagged Building Program.

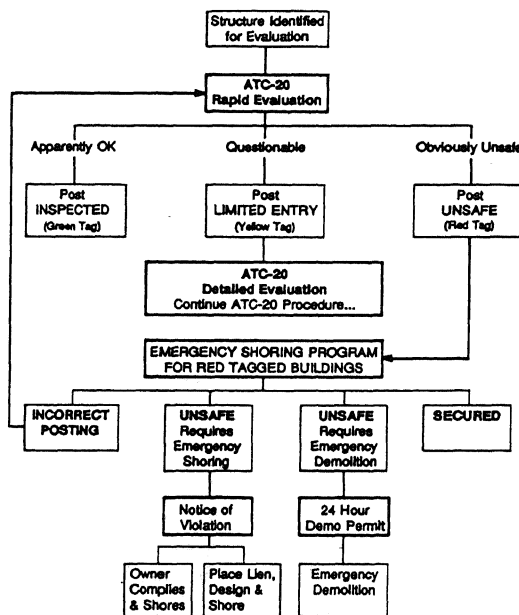


FIGURE 1 - FLOWCHART OF SAN FRANCISCO EMERGENCY SHORING PROGRAM FOR RED TAGGED BUILDINGS (FOLLOW UP TO ATC-20 PROCEDURES)

In setting up the program, it was agreed that the consultants would work in teams of two engineers and that each team could work independently. Only one team would be necessary to evaluate each building. After classification by the consultants, the owner was to be notified by the Bureau of Building Inspection of the requirements and was to take action when required. When emergency shoring was required, a Notice of Violation would be posted on the building giving the owner up to forty-eight hours to respond to the City. The response was to indicate an intent to hire an engineer and a contractor to provide the installation of the shoring to the satisfaction of the Department of Public Works. If no response from the owner was received, the owner was to be cited, and a lien was to

be placed on the property. The lien amount was to cover the costs of the consultants to design the emergency temporary shoring and the contractor to install it as designed.

It was agreed that in the event that it would be necessary that the consultant design temporary shoring, a video tape would be made of conversations between the consultant and the contractors that would install the shoring. The contractors were to be chosen from a list of interested firms that were contacted during the initiation of the program. It was agreed that for each building where work was required, and not provided by the owner, three contractor firms would be chosen by a drawing, and each would be asked to provide an estimate of the costs based on video-taped discussions with the design consultant.

Difficulties in setting up the program included those associated with contracts, liability of the consultants, access into the closed buildings, communications, bookkeeping of both information for payment and for technical decisions, and criteria for evaluations.

Unfortunately, the need to satisfy both the City's and consultants' requirements for protection from liability was the first issue. Recognizing the emergency nature of the work, a contract was promptly approved by the City Attorney providing a generous indemnification clause to the consultants. It is felt that this step is absolutely required for the consultant to remain impartial, objective and effective during this type of work.

Accessibility of the buildings was another problem to be addressed during the implementation of the Emergency Shoring Program. Most of the heavily damaged buildings in the City were locked up, barricaded or guarded. A City Building Inspector was assigned to each of the two teams to give them legal authority to enter any red-tagged building and a letter written by the City Attorney was carried by the consultants at all times. Communications problems between the teams and the Bureau of Building Inspections were also minimized when accompanied by the Building Inspectors and their hand radios.

Careful bookkeeping was required. The time spent on each building was recorded separately. Anticipating that the associated costs would be paid by building owners or reimbursed by the Federal Emergency Management Agency, a detailed accounting of costs was kept.

In addition, technical information for each building was recorded. The number of "red-tagged" buildings in San Francisco eventually grew from over 230 on November 16, 1989, about one month after the earthquake, to eventually over 360. Damaged buildings varied in construction types, owner, uses, size and shapes. In looking at this large number of different buildings in a time span of about three months, careful notes of the observations of each were necessary.

The procedure for the detailed evaluation of the "red-tagged" buildings was loosely based on the Detailed Evaluation in Chapter 5 of ATC-20. However, in general, less time was available to the inspecting consulting engineers to complete these evaluations than that assumed in ATC-20. After notification of a particular "red-tagged" building by the Department of Public Works, the consultant team visited the site, accompanied by a Building Inspector. A walk-through of the building was completed and photographs were taken. A general description of the building's vertical and lateral load carrying systems was recorded and areas of damage were noted. In addition to the limited time, the objective of the evaluation was different from that of ATC-20. The emphasis of the evaluation was on potential hazards to pedestrians and/or adjacent buildings and the need to shore or demolish.

Following the site visit, the notes and photographs were examined and each building was placed in one of four status classifications by the consultants. This placement was not based on calculations or analysis but was largely dependent on the professional judgment of the consultant team performing the evaluation. These four classifications, as developed by the consultants and the Bureau of Building Inspection, were:

- (1) Unsafe for Occupancy, but Secured
- (2) Unsafe and Requiring Emergency Temporary Shoring
- (3) Unsafe and Requiring Emergency Demolition
- (4) Incorrectly Red-tagged by Previous Evaluations (Change to Yellow- or Green-tag)

The second, third and fourth classifications were intended to represent a temporary status for a building and indicated a need for immediate action by the Bureau of Building Inspection and the owners. In reporting of each building's designation, the consultants also informally prioritized the buildings so that the most serious hazards could be quickly addressed. Based on the consultant's classifications, the Bureau of Building Inspection was to take the required action. The goal was to remove all buildings from the temporary status classifications so that all buildings remaining as red-tagged could be considered "Secured".

A building was judged to be Secured when it did not represent a hazard to pedestrians or adjacent buildings. Temporary shoring was judged to be necessary if the building was in a state of imminent collapse due to either vertical loading or loading that could be caused by a significant aftershock. Generally, if both systems were not significantly damaged, no emergency shoring would be required. In some cases, although the pre-earthquake vertical or lateral systems appeared to be inadequate, if no earthquake damage was evident, the building was designated as Secured.

Some buildings' vertical and/or lateral force resisting systems were significantly damaged by the earthquake and it was judged that the installation of emergency temporary shoring would be extremely hazardous.

Examples of this category of buildings include those where temporary shoring would be necessary inside the heavily damaged building, in areas judged to be in an imminent state of collapse. Before recommending emergency demolition for a building of this description, both teams of consultants agreed to evaluate all buildings falling in this category as a quality assurance measure. It is now believed that this practice was vital toward the protection against unnecessary demolition of several heavily damaged buildings. After review by both consultant teams, if designated as requiring emergency demolition, an emergency permit was filed within twenty-four hours, and the lengthy demolition permit process normally in effect, usually a six to twelve month permit process, would be circumvented. In some cases, owners were interested in obtaining permits for emergency demolition in order to remove their building in a more timely manner, but possibly for reasons other than the existence of earthquake-caused hazardous conditions.

After placement of each damaged building in one of the above four categories, a letter was written by the consultants to the Director of Public Works stating the findings. If the building was placed in the category requiring shoring or demolition, a Director's Emergency Order was issued and the owner was notified of the requirement to take action. If the building was judged to be incorrectly posted and a recommendation of a change to "yellow" or "green" tag was given, the building officials would make the posting change based on the engineer's letter.

A data base was created and maintained by the Bureau of Building Inspection of the records for each building posted with a red-tag. All correspondence, including the consultant's letter pertaining to each building's classification was recorded in the data base in chronological order. A report of these records was issued periodically called the *Interim "Red-Tag" Building Status Report* (City of San Francisco, 1989-90).

In the report, four classifications are defined. The four classifications are "Secured", "Limited Entry (Yellow)", "Inspected (Green)" and "Demolished". Active files for damaged red-tagged buildings, those that were "unsecured", were maintained until designated as in one of these four classifications.

As evidenced by the length and content of the report, covering more than 360 San Francisco buildings, there was a definite need for the implementation of the Emergency Shoring Program, although this fact was not immediately obvious prior the Loma Prieta experience of the building officials.

4 CONCLUSIONS

San Francisco's experience with the assessment of thousands of buildings following the Loma Prieta

earthquake made it clear that a systematic approach is needed. Not only do all potentially damaged buildings need to be inspected, but a thorough system for administering and managing the process is required. The buildings posted as UNSAFE, those most dangerous to pedestrians and adjacent buildings, require immediate action to be taken, some requiring emergency shoring or even demolition. In addition, in order for local building departments to have some control over the owners of severely damaged buildings, they must have some technical information about the severity of the damage.

A city's postearthquake program should include a clear outline of steps to be followed by all parties involved, including the building department and its inspectors, outside consultants, owners and their own consultants. The outline should cover all steps until resolution of the fate of every building. The goal of the procedure should be to eventually have all buildings removed from the red- or yellow-tagged list. The program's outline could be in the form of a flowchart based on the original ATC-20 flowchart in that document and combined with that proposed in Figure 1, and expanded.

A written program should be established and consultants should be retained to be promptly available to make the necessary follow-up assessments. The subsequent steps required by the owners should also be outlined in advance and incorporated into the building codes.

It is also recommended that a permanent response team of city officials be set up at each jurisdiction so that guidelines can be written, periodically reviewed and key individuals regularly trained.

The success of San Francisco's Emergency Shoring Program for Red-Tagged Building can be measured to a large extent by the relatively small number of historical buildings that were demolished and that no further injuries or deaths occurred after the day of the earthquake. The knowledge gained during this experience should be used to prepare for the next disaster, before time goes by and key pieces of information are lost.

REFERENCES

- Applied Technology Council, 1989. ATC-20, *Procedures for postearthquake safety evaluation of buildings.*
- San Francisco, Bureau of Building Inspection, Department of Public Works, Laurence M. Kornfield, Chief Building Inspector, 1989-90. *"Red-Tag" buildings interim status report.*
- Structural Engineers Association of Northern California, Tagging Subcommittee of the Professional Practices Committee, December 1190. *Posting of buildings after the Loma Prieta earthquake.*