WORKER HAZARD MANAGEMENT OF BUILDING DEMOLITION

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Abstract: The Ji-Ji earthquake was the most damaging earthquake that Taiwan has ever suffered over the past century. In addition to mountain collapses, landslides, fault slippage, bridge ruptures, and roadway buckling, tens of thousands of buildings were also crushed by the powerful force of the earthquake. In the Ji-Ji earthquake, the most serious damaged infrastructures were building structures. Generally speaking, there were four major reasons that contributed to the damages of the large number of buildings--the strong intensity of the earthquake, the poor architectural design of the buildings, the poor structural design of the buildings, and the poor quality control during the buildings' constructions. After the earthquake, due to the urgent needs to rescue survivors, there was not enough time to implement safety measures for demolition related activities. However, we can not ignore the possibility of occupational injuries and endanger the rescue workers. Therefore, we investigate the workplace safety issues related to the emergency rescue operations after the earthquake. It is hoped that this information can be used by the authorities to implement better operating procedures if similar disasters strike again. Consequently, both the rapid demolition of buildings and the protection of participating workers can be accomplished. This will greatly reduce the mortality rates in the future earthquake-related rescue and demolition operations.

Keywords: earthquakes, occupational injuries, workplace safety, building demolition

1. CASE ANALYSIS OF OCCUPATIONAL ACCIDENTS AFTER THE EARTHQUAKE

Although the construction workers engaged in the rescue, demolition, and reconstruction operations after the earthquake have specific skills to qualify for the jobs that they perform, they do not have the experience of earthquake emergency rescues. Therefore, accidents are not uncommon. For example, the entire building collapsed when a five-story building was being demolished in the city of Douliou. The accident happened as the excavator barely touched one the columns that supported the building (10/15/99, The China Times).

Since the Ji-Ji earthquake, accidents of building demolition similar to the above-mentioned case are numerous. In addition to feeling sorry for the victims, we also hope that similar accidents can be prevented in the future by conducting case analyses. The following are the major accidents that took place:

1.1 A contractor buried alive in the town of Tsautuen, Nantou County

On October 12, 1999, when an old un-reinforced residential building was being torn down in the town of Tsautuen, the demolition contractor entered the tilted building, and was knock down by the excavator. The building subsequently collapsed and buried the man alive. The contractor was pronounced dead when he was finally rescued out of the rubbles.

1.2 The Da-li-wang-chao building in the city of Taichung collapsed during demolition (picture 1)

After heavy rains, the already partially collapsed Da-li-wang-chao building in the Taichung City became dangerously tilted and displaced. Since the building was only temporarily supported by five steel beams, it subsequently collapsed when the building demolition was in progress on April 23, 2000. The collapsed building crushed into the four-story apartment building across the street.

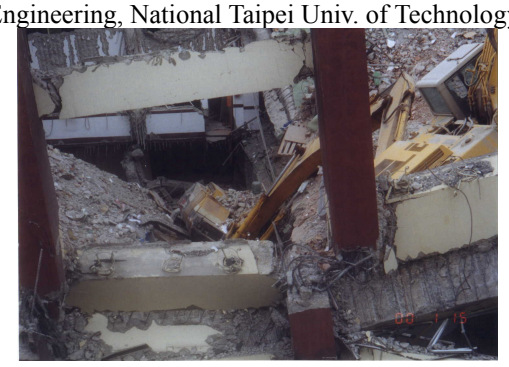
1.3 An excavator and its operator were buried during demolition in Taiping City of Taichung County (picture 2)

When the ADI Corporation in the Taiping City was demolishing a partially collapsed building on January 10, 2000, an excavator and its operator were buried by collapsed rubbles from above. The operator died as a result.

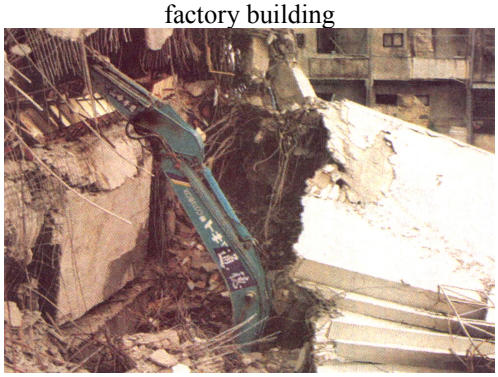
1.4 The floor of the A-li-shan Opera Theater (Jungpu Shiang of Chiai County) collapsed (picture 3)

There have been fire reports during the demolition of the A-li-shan Opera Theater, which started at the end of March of 2000. When the demolition proceeded to April, the slab of the 4th floor suddenly collapsed. Two excavators fell onto the ground. One of the operators of the excavators escaped with terrors, and the other was seriously injured because he was pierced by steel bars protruding from the floors.

Picture 1. The Da-li-wang-chao building in the city of Taichung collapsed and hit the adjacent building (Photo credit: Chung-Wei Chen, Dept. of Civil Engineering, National Taipei Univ. of Technology)



Picture 2. The demolition of the ADI Corporation's factory building



Picture 3. The demolition of the A-li-shan Opera Theater

Carefully analyzing the above accidents, it is easy to see that the main cause for the accidents is the contractors' lack of professional knowledges of structural engineering. For example, according to the structural analysis, the maximum moment is 1/24 WL^2 when a continuous floor slab is subjected to an equally distributed load. (Please refer to Fig. 1, where W is the equally distributed load, and L is the distance.) If the two ends of the slab are no longer continuous due to damages caused by the earthquake, the maximum moment will increase to 1/8 WL^2, three times the previous value. The ADI corporation and the owner of the A-li-shan Opera Theater did not take this into account. Therefore, the floors collapsed when heavy machinery operated on the damaged floor, and caused the accidents.

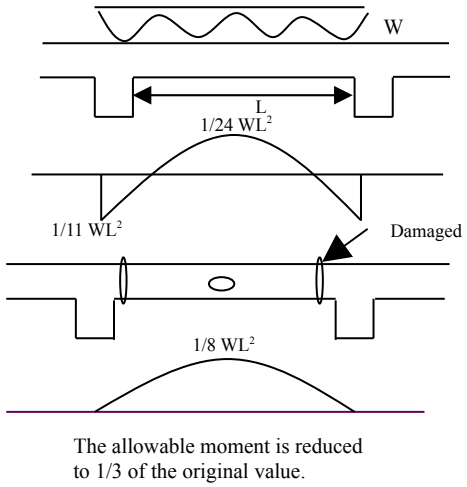


Figure 1. The loading capacity and bending moment of a floor slab (following the ACI standards)

2. THE CHARACTERISTICS OF ENERGENCY BUILDING DEMOLITIONS

The building demolition operation can be divided into two categories--normal demolition and emergency demolition. The difference is that the emergency demolition has the nature of urgency because it is usually called to facilitate the rescue operations. Therefore, it is usually difficult to plan an emergency demolition in advance to take into account the building structures, the demolition plans, the safety measures, and the personnel training. Also, since the object buildings are those damaged in the earthquake, they are usually in an unstable state. As a result, it is much more dangerous to perform emergency demolitions. Generally speaking, there are several major differences between the emergency demolition and the normal demolition operations:

1. The time factor: Because the emergency demolition is performed in an emergency situation, negligence can easily be resulted.

2. The structure factor: Because the object building's structure was damaged in the earthquake, it is sometimes difficult to determine the stability of the structure and the necessary demolition procedures.
3. The space factor: When the rescue operation and the emergency demolition proceed simultaneously, the working space is limited, which increases the difficulty of the operations.
4. The planning factor: There was not enough time to plan a thorough emergency demolition plan.
5. The operating time factor: The emergency demolition is usually a non-stop operation. Fatigue will be a problem for the workers involved in the operation.
6. The personnel factor: The demolition workers sometimes came from different organizations or units. The cooperation between them could be a problem.
7. The safety measure factor: The safety measures are usually not complete or thorough due to the lack of preparation time.
8. The illumination factor: It is sometimes difficult to provide the necessary illumination for the demolition operation because of the power outage and the isolation of the disaster sites.
9. The construction waste factor: Lack of proper disposal of construction waster can easily cause the collapses of the waste piles.
10. The dangerous material factor: It is usually unclear whether dangerous materials were stored in the object building or not. Entering this kind of buildings can cause personnel injuries.
11. The equipment factor: For the purpose of efficiency, a large number of construction machinery is usually used to demolish a given building. This can cause the unexpected failure of the building and premature collapses.
12. The crowd factor: A large crowd gathering at the demolition site can hamper the demolition process.
13. The temporary support factor: The temporary support of a partially collapsed building, if not properly designed by professional engineers, can be unsafe but give the demolition workers a false sense of safety.

Other than the above-mentioned differences, the emergency demolition is the same as the normal demolition. Same standards should be used to regulate the equipment, the safety measures, and the demolition procedures.

3. SAFETY ISSUES OF BUILDING DEMOLITION AFTER AN EARTHQUAKE

These two issues should be considered when performing an emergency demolition:

3.1 The Analysis of possible types of hazards

The major types of hazards during building demolitions are falling objects, structure collapses, electrical shocks, industrial dusts, noises, fires, and explosions. These hazards are also shown in Fig. 2.

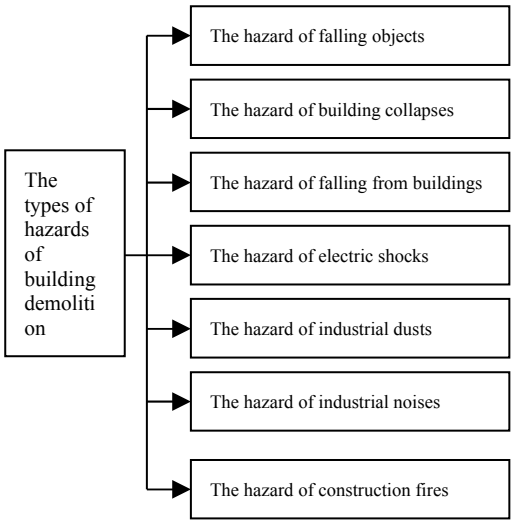


Figure 2. The types of hazards of building demolitions

3.2 The combination of emergency demolition and construction safety

In order to prevent accidents, it is necessary to combine the demolition operation with the safety measures on the demolition site. If the necessary precautions are pointed out clearly, the risk of causing accidents will be greatly reduced. For emergency building demolition, we have created a sample flow chart as shown in Fig. 3.

4. CONCLUSIONS AND RECOMMENDATIONS

Preventing occupational injuries and protecting the safety of construction workers is the basic policy of our government. Therefore, increasing and more aggressively enforcing existing labor, health and safety laws is recommended. After the earthquake disaster, although the safety measures can be properly simplified to accelerate the rescue of survivors, they should not be neglected or ignored. We recommend the following:

4.1 Reduce the secondary hazards

As mentioned earlier, it is essential to pay attentions to the construction workers' safety even in an emergency demolition when the time is limited. Its purpose is to prevent secondary hazards and

injuries. For example, the construction workers should have proper protective gear and the demolition site should have proper site control. Otherwise, accidents are likely.

4.2 Enhance workers' self awareness of safety

Generally speaking, the construction workers in Taiwan (especially those participated in the building demolitions after the earthquake) lack the proper safety concepts, and many resulting accidents are considered preventable. We recommend that the current working conditions of construction workers should be investigated, and efforts to change self-awareness of safety should be made to improve this situation.

4.3 Improve construction workers' professional knowledge

Although the construction workers have specific training to perform the assigned tasks, most of them do not have the experience for emergency demolition after a major earthquake. Therefore, accidents occur. We recommend that the demolition workers should be supervised by professional engineers so that the demolition is executed according to proper procedures.

Acknowledgments

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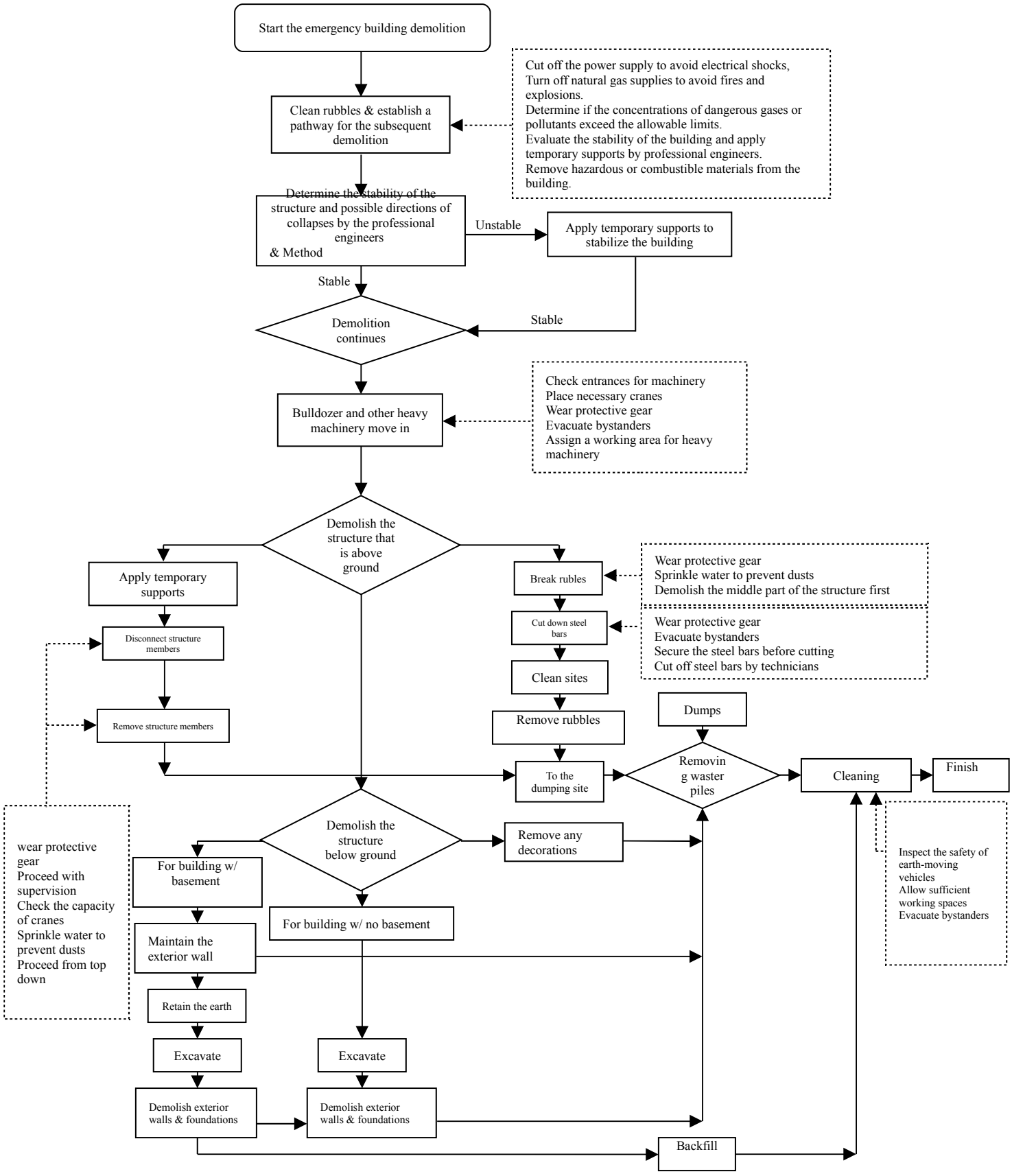

Figure 3. The incorporation of safety precautions into the emergency building demolitions