EMERGENCY CONSTRUCTION WASTE MANAGEMENT

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0. Abstract

This paper presents observations and experiences of emergency C&D waste management following The Great Hanshin-Awaji Earthquake on 17 January 1995, Japan. The latest experiences of demolition of war damaged buildings and recycling of rubble materials in the reconstruction of Beirut, Lebanon, and Mostar, Bosnia, will be mentioned briefly.

The presentation will be followed by a survey of the general principles of Disaster Waste Management and a presentation of options and barriers to recycling and reuse of materials, including an assessment of environmental and economic aspects.

Keywords: Emergency Response, Natural Disaster, Waste Management, Recycling, Reconstruction, Environmental Protection.

1. Introduction

Waste control and management is one of the great challenges of modern society. Due to lack of disposal sites and limitation of natural resources, recycling of construction & demolition waste (C&D waste) has attracted considerable attention; much research and development work has been allocated to this subject[1,2]. Today, in most European countries, it is economically feasible to recycle up to 80-90% of the total amount of C&D waste and most demolition and recycling technologies are generally easy to implement and control.

However, when a disaster strikes, especially in densely populated areas, huge amounts of construction waste and other kinds of wastes are suddenly produced, demanding immediate attention. First of all, emergency clearing and rescue of people trapped in destroyed houses and structures is urgently needed. Then, demolition and removal of waste must be undertaken as an important part of the disaster relief work[3].

From reference to the list of natural and man-made disasters in Table 1, this paper presents observations and experiences of emergency C&D waste management following The Great Hanshin-Awaji Earthquake on 17 January 1995, Japan.

2. The Great Hanshin-Awaji Earthquake on 17 January 1995, Kobe, Japan

The great earthquake disaster that struck Japan's Hanshin-Awaji region on 17 January 1995 took the lives of more than 5,400 people and injured approximately another 40,000 people. As the earthquake destroyed the entire social infrastructure of the City of Kobe and its surrounding areas, removal and disposal of earthquake waste became a key issue. The total amount of waste has been estimated at 15 million cubic meters (20 million tons). Full-scale reconstruction work was not possible until the waste had been removed. However, removal of the waste introduced many delicate issues, such as: protection of private property, rights of the victims, safe and efficient methods of earthquake waste treatment at every stage (removal, temporary storage, sorting, transport, recycling, disposal options and raising the necessary funds for the emergency work[4]).

General problems

Generally, the problems arising from the waste generated by the disaster were classified as follows[4]:

1) The removal of rubble and other wastes that had accumulated on roads because nearby buildings and other structures had collapsed was the most important issue. Temporary storage areas were secured for provisional disposal. Removal of debris from major roads was completed in about a month, though about three months were required to remove wastes from smaller roads.

2) Although some waste treatment facilities were damaged, fortunately no treatment facilities suffered total or even partial destruction. Thus the main problems were operations hindered by lack of electricity, water, other supplies and the temporarily crippled collection and transport services.

3) An immense quantity of wastes were generated by the demolition and dismantling of buildings and structures. Such wastes were a serious problem, because they contained asbestos and other hazardous substances. The quantity of waste greatly exceeded the ordinary treatment capacity.

4) Great amounts of wastes contained hazardous substances which contaminated the surrounding soils.

5) The destruction of sewage systems, together with the increase of population in evacuation centres and other temporary houses, led to serious problems with human wastes and septic tank sludge.

6) Waste from the reconstruction work, repair of damaged buildings and structures and construction of new buildings and structures, presented a big problem.

Waste disposal

Normally in Japan, demolition wastes are separated on-site and disposed off for re-use, tipping or further treatment. However, in this case most wastes were mixed, especially during the initial stages of the emergency rescue operations.

Since the capacity of incineration plant in the area was low, wooden wastes were deposited permanently at final disposal sites and temporary storage areas. At the Kobe harbour area temporary incineration plants were established.

Concrete and rubble waste was disposed off

- as filling material for land reclamation,
- at existing permanent disposal sites in each municipal administrative area, or
- at regional permanent disposal sites in the Osaka Bay, for major land reclamation projects.

At the time of the earthquake, the inland landfill and seaside municipal disposal sites in Kobe City had a remaining capacity of 15 million cubic meters, which were designed for normal disposal of solid waste over the next 10 years. However, because they had been receiving massive quantities of solid waste generated by the earthquake, their capacity was filled within just one year.

Following the earthquake, 5,000 waste-filled vehicles arrived at the disposal sites each day. Consequently, the staff was unable to guide each individual vehicle to the correct location for dumping which was not, therefore performed properly. To prolong the lifetime of the disposal sites, waste which had been tipped of inexpediently, had to be removed again for volume reduction by crushing and incineration at some future date. In February 1995, the Kobe Harbour construction plan was revised, and permission was given to dispose of 6.6 million cubic meters of debris for land reclamation in the harbour area.

Immediately after the earthquake, the central and prefectural governments requested that the regional land reclamation organisation, Osaka Bay Centre, receive earthquake-generated, non-combustible wastes and that the Centre should increase its disposal capacity. The existing capacity was satisfactory with respect to rubble waste but there was no spare capacity for hazardous waste at the Osaka Bay Centre. New waste disposal facilities had to be established. The transport of waste to the regional landfill areas in the ocean was based on barges. However, the transfer stations had been damaged by the earthquake and could not be used until they were repaired.

The Osaka Bay Centre began to receive non-combustible waste on 24 January, shortly after which debris from the collapsed Hanshin Highway bridges was brought in. Because repair of the transfer station took some time, debris from Kobe did not start to arrive until

10 February. By 10 May, the total quantity of debris received by the Centre amounted to 767,000 tons.

During waste treatment and disposal, much effort was spent on sorting organic and hazardous material from the rubble waste. Special precautions were made to control and reduce the risk of asbestos emission from the demolition and sorting sites.

Lack of cooperation between local authorities was discussed during the symposium and it was learnt that some cities in the earthquake damaged area did not have space for proper waste handling, whereas other cities had ample sites and facilities.

During the discussions at the Disaster Waste Management Symposium in Osaka on the 12-13 June 1995[4], it became clear that the foreign experts were impressed with the speed at which demolition and clearance of damaged buildings and structures took place. It was noted that the work should be finished before the end of 1996. This seemed to be very ambitious considering the enormous amount of waste.

Recycling of concrete and masonry debris

Concerning recycling of rubble waste, it was mentioned that virgin material is cheaper than recycled materials. However, it was also learned that Japan is not rich in natural resources. Therefore, construction materials are expensive compared with European prices. Except for recycling of small amounts of waste, opportunities for substituting natural quarry materials with crushed demolition rubble waste materials in construction work had, generally, not been utilized.

Due to the need for natural aggregates in reconstruction of damaged/demolished structures, it was recommended that options for reuse and recycling of concrete rubble should be considered in detail. Reconstruction of port facilities and other parts of the infrastructure needed considerable amounts of natural quarry gravel material, of which considerable amounts might be substituted by recycled materials.

Summary of important experiences

The state of affairs 5 months after The Great Hanshin-Awaji Earthquake demonstrated the vulnerability of modern urban densely populated areas to natural disasters and the capability of the society to recover.

All disasters are unique and they strike the exposed society in different ways. Industrially developed societies are better equipped to establish an effective and rapid emergency response system than developing societies. Earthquakes occurring at night strike the societies in another way than earthquakes which occur during the day. Therefore, the emergency response must be planned and implemented in each individual case.

However, some general lessons have been learnt and repeated after The Great Hanshin-Awaji Earthquake, among others the following listed in table 2.

3. The Reconstruction of Central District of Beirut, Lebanon

In June 1994 demolition of buildings in Beirut began in order to implement the reconstruction work of Beirut Central District (BCD). In July 1994, a study of construction and demolition (C&D) waste management was provided by DEMEX Consulting Engineers for the Lebanese company, SOLIDERE, which is responsible for the reconstruction and development project of BCD. On this basis, a recycling plant was procured and established in the summer of 1995.

However, the crushing plant did not work properly and economically, because the sorting of rubble waste from earth and other wastes before loading into the crusher was not carried out adequately.

By the beginning of 1996, most of the demolition work had been completed and reconstruction of the infrastructure, such as roads, sewage systems, power generating plants etc. is in good progress.

The total of C&D waste generated from 1994 to 1999 was estimated as reaching figures of approximately 4 million m^3, of which 1 million m^3 is supposed to be generated before the end of this year.

4. The Emergency Building & Solid Waste Management, Mostar

After more than four years of civil war in Bosnia and Hercegovina, the Dayton Agreement of November 1995 has attempted to put an end to the hostilities and to prepare the ground for normal life in the area. Before normal life can be restored, extensive rehabilitation and reconstruction activities also be implemented, including emergency protection and rehabilitation of buildings.

The protection of buildings comprised all kinds of partial demolition and construction work in order to protect buildings against further destruction and to protect people against the risk of structural collapse and falling objects. Generally, the protection work comprised all historical and cultural buildings, registered by UNESCO, exposed to damage excluding those which must be demolished due to the extent of damage. However, a number of other important buildings did also require protection.

The protection work was planned and conducted according to the engineering design of the individual buildings with respect to future plans of repair and reconstruction. The engineering design was based on a detailed survey of the structural stability and risk analyses of structural failures and collapses, including the risk of seismic impact.

A recycling plant sponsored by the Danish Government was installed in October 1996, with the intention that the plant should be handed over to the local authorities by the end of February 1997.

5. General principles and strategies of Disaster Waste Management

Based on the experiences from the above mentioned three examples of emergency waste management and other experiences of disasters mentioned in table 1 and 2, some general issues of Emergency C&D Waste Management are listed in table 3.

In the emergency phase, just after the earthquake, all efforts are concentrated on rescuing people, knowing that persons may survive up to seven days and nights trapped in ruins. It is necessary to choose the demolition methods which are most rapid and effective in order to rescue people. On the other hand, care must be taken to ensure that no further uncontrolled collapse is provoked, thus creating a risk to other trapped people. Therefore, serious decisions must be taken quickly.

Some of the major problems are related to the construction of modern buildings, which collapse in a "pancake manner" together with the appropriate choice of demolition methods[2]. A lot of heavy equipment is needed, especially with lifting capacity. Often, the lack of heavy equipment and the lack of demolition experience and knowledge creates time-consuming discussions, for instance the discussion concerning the use of explosives and the risk of ground vibrations effecting unstable buildings or initiation of afterquakes due to blastings.

As soon as possible after the disaster, it is recommended that the local authorities should make long term strategies for the disposal of all kinds of wastes, including demolition wastes from the emergency demolition. If the waste streams are not planned and controlled initially, a numerous of problems will arise later in the reconstruction phase and much effort will be expended on moving wastes around.

6. Environmental and economical aspects of Disaster Waste Management

According to the Rio Declaration in 1992 on the environmental challenges for the 21st century, disaster waste must be managed according to the principle of Best Available Technologies not Entailing Excessive Costs (BATNEEC). It is very important to remember that emergency actions and short term activities based on rapid reactions might not comply with long term considerations and environmental policies. In particular, uncontrolled handling and mixing of wastes can be very difficult to sort out later.

From a purely economical point of view, recycling of building waste is only attractive when the recycled products are competitive with natural resources for what concerns cost and quality. Recycled materials will normally be competitive where there is a shortage of both raw materials and suitable deposit sites. With the use of recycled materials, economical savings in transportation of building waste and raw materials can be obtained (see figure).

In larger post-disaster reconstruction projects, e.g. Kobe, Beirut and Mostar as described in the previous sections of this article, the economy will be dominated by the transportation costs. These transportation costs involve the removal of demolition products and supply of new building materials. In these cases the use of recycled materials is very attractive, as shown by European experiences [1,3].

7. Concluding remarks

Based on recent experiences from Kobe, Beirut and Mostar it is evident that one of the most important challenges of the disaster response is C&D waste management. It is also evident that much can be done to improve the capability to meet this challenge.

Generally, the importance of waste management after disasters is usually neglected or underestimated. Many problems could have been avoided if the authorities and others involved in pre- and post-disaster planning and management had a better understanding of opportunities and barriers of demolition and recycling of building waste.

The demand for disaster assistance and relief is global. This demand is much more comprehensive and long-term oriented than the demand for emergency humane relief.

In UN and The World Bank's policies regarding disaster assistance, emphasis is placed on preventive arrangements and analysis of the 'anatomy' of the disaster and its consequences. It is, as an example, important, as soon as possible in the disaster development, to aim at a reconstruction of the infrastructure and supply lines of the stricken area. Recycling of building materials from destroyed structures will in this case play an important role.

References:

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After the *Loma Prieta Earthquake on 17 October 1989 in San Francisco,* several kilometres of double-deck highways were demolished or severely damaged, and the reconstruction and retrofitting work took several years. Both demolition and waste disposal issues caused problems due to the mix of waste materials because organic materials were not accepted in the marine landfills in Oakland bay.

The extensive damages caused by the *Luzon earthquake on 15 July 1990, Philippines,* resulted in huge amounts of building wastes, and thousands of poor people were made homeless. After the emergency rescue and demolition work, squatters moved to the sites of the destroyed houses and earned money on hazardous demolition work and recovering the reusable wastes, e.g. steel from reinforcement bars.

After the *Erzincan earthquake on 13 March 1992 in Turkey,* 6500 dwellings were destroyed or severely damaged. Demolition wastes, estimated from 500,000 tons to one million tonnes, were disposed along roads and at improvised dumpsites outside the city, disturbing the traffic and polluting the environment.

In one day in *August 1992 Hurricane Andrew* damaged or destroyed more than 100,000 homes on the southern tip of Florida.

Following the *Northridge earthquake on 17 January 1994 in Los Angeles* more than 2 million tons of earthquake debris has been collected, and either disposed of or recycled, according to the City of Los Angeles estimates.

One year after the Northridge earthquake, *The Great Hanshin-Awaji earthquake occurred on 17 January 1995* causing the destruction of more than 100,000 buildings as well as infrastructure such as railways, roads and harbour facilities. Approximately 20 million tons of wastes were generated causing one of the gravest problems of the emergency relief work.

In Lebanon, 17 years of war have resulted in a 25-hectare area of uncontrolled disposal of all kinds of mixed waste, some of which is constantly burning due to self-combustion. Demolition and clearance of damaged buildings in the Central District of Beirut requires removal of 2 - 4 million tons of demolition waste. In 1994, demolition and clearance of the waste began. Today, much demolition and waste treatment is still needed.

In the spring of 1995 the *reconstruction of the city of Mostar in Bosnia* began. More than 1000 war damaged buildings need to be demolished, and 200,000 tons of demolition waste are expected in the first year of the demolition programme.

Table 1. Recent examples of natural and man made disasters generating huge amounts of wastes.

- ! Emergency management and handling of solid wastes is one of the great challenges of the response to earthquake.
- ! It is important to establish an Emergency C&D Waste Management System as a part of the integrated Disaster Response System, and it must be planned before the disaster strikes.
- ! The Emergency Waste Management System must focus on different options of use of facilities, allocation of temporary stockyards, and cooperation of local authorities.
- ! Chaos is inevitable for a period of time after an earthquake strikes. The pre-planning and organization of the C&D Waste System is decisive for the duration of the period of chaos.
- ! C&D Waste must be considered as resources, and all opportunities of recycling and reuse of waste must be carefully considered in order to save energy, resources, time and money.

Table 2. General lessons learnt after The Great Hanshin-Awaji Earthquake, 17 January 1995.

Principle of time - Priority of the work,

- ✓ rescue demolition in order to rescue trapped persons,
- ✓ emergency demolition and protection work in order to re-establish supplies and infrastructures, in order to save historic buildings, and to secure unstable buildings, and
- ✓ clearance and demolition work related to the planned reconstruction programmes.

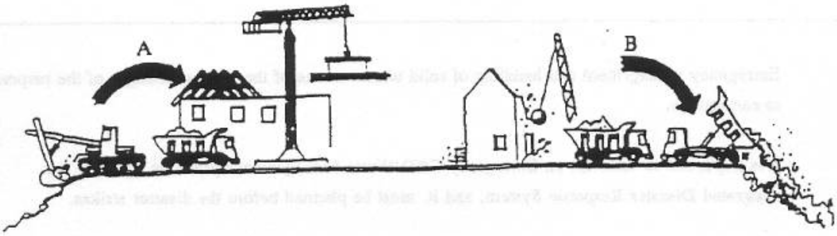
Principle of resources - Integrated waste & resource management,

- ✓ selective demolition and separation of waste,
- ✓ sorting of waste in main fractions with respect to recycling or disposal,
- ✓ optimal utilization of available waste treatment facilities and disposal sites,
- ✓ optimal use of natural and reusable resources,
- ✓ minimum transport of materials for constructions and wastes for disposal.

Principle of execution - Demolition and waste planning and control,

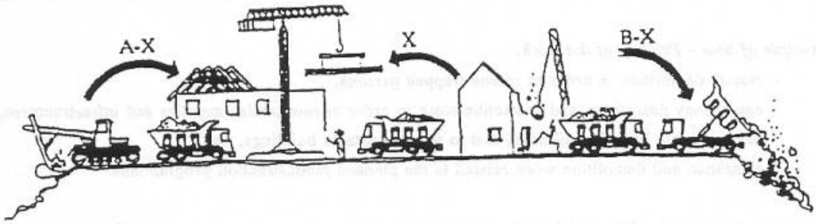
- ✓ damage- and waste assessment and classification of damaged buildings,
- ✓ planning and implementation of demolition work and recycling facilities,
- ✓ waste stream control including assignment of suitable disposal sites,
- ✓ traffic planning and control,
- ✓ protection of buildings etc. of historic or cultural value.

Table 3. General key issues of Emergency Construction Waste Management



Total costs = Cost (A) + Cost (B)

I. Traditional Demolition and Waste handling



Total Costs = Cost (A-X) + Cost (B-X) + Cost (X)

II. Demolition and recycling:

Figure 1 Economic model of (I) Traditional demolition and waste handling without recycling and (II) Demolition and waste handling inclusive recycling of materials.
A: Amount of natural materials and transportation
B: Amount of transportation and disposal of waste materials
X: Amount of recycled materials.