

DECONSTRUCTION OF EARTHQUAKE-DAMAGED BUILDINGS IN TURKEY

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ABSTRACT

Turkey has suffered major natural disasters during the past few years, in the form of devastating earthquakes in its southern and northwestern regions. Thousands of homes and businesses were destroyed in these thickly populated urban areas, while the death toll rose to more than sixteen thousand. The degree of damage to the buildings varied from totally collapsed structures to slightly damaged ones. Consequently, there were thousands of dangerously damaged buildings that had to be demolished and their rubble cleared, along with the debris of those that had collapsed completely.

A study was conducted in the disaster-stricken areas to record demolition, site clearance and salvaging activities, prior to re-building and rehabilitation works. It was observed that a fair amount of deconstruction was going on, even in the precariously tilted buildings, in order to recover as much building material as possible. This study is based on a visual record of the deconstruction and demolition works undertaken by the municipality, the private sector, and the individuals, after the earthquake in northwestern Turkey.

KEYWORDS: Deconstruction; Demolition; Recovery of Building Material; Recycling; Earthquakes; Turkey

INTRODUCTION

Turkey has experienced several major earthquake disasters in the last decade, which have caused devastating losses of life and property. Apart from intermittent tremors along major fault lines, intense earthquakes occurred in Erzincan (1992), Dinar (1995), Adana (1998), Marmara (August 1999), Düzce (November 1999), Corum (2000) and Afyon (2002). Of these, the earthquakes in the Adana and Marmara regions were the most severe, causing varying degrees of damage to more than 80,000 buildings each.

The city of Adana and its environs were struck with an earthquake disaster in June 1998. According to the authorities concerned, some 4,000 houses were completely destroyed and another 4,000 had to be demolished because they were unsafe for habitation. Meanwhile, another earthquake of magnitude 7.2 on the Richter scale shook the Marmara region on the 17th of August 1999. The resulting devastation was incomparably greater than any experienced before. Tens of thousands of people were killed or injured. Thousands of buildings were razed to the ground and more were rendered uninhabitable. Severely damaged and semi-collapsed structures had to be demolished and the rubble cleared away. This was an extremely difficult, dangerous, and time-consuming task. The resulting pollution in the form of noise, dust, debris, and smell was a physiological as well as psychological health hazard. Figure 1 shows the damaged buildings along one of the main roads in Adapazari a few days after the earthquake in the Marmara region. Figure 2 shows the same road a few weeks later, portraying the resulting chaos after the demolition and site clearance work started.



Figure 1: Extensive damage caused to the buildings located on one of the main roads in Adapazari, as a result of the devastating earthquake of 1999 in the Marmara region [ii].



Figure 2: Another view of the main road, shown in Figure 1, after demolition work had started on the dangerously damaged buildings [iii].

Buildings in the Marmara region could be divided into five categories according to the degree of damage caused by the earthquake of August 17, 1999:

- a. *Totally collapsed structures*: buildings that were completely razed to the ground into huge mounds of rubble (Figure 3).

- b. *Partially collapsed structures*: buildings with some parts left still standing, but so precariously as to require immediate demolition (Figure 4).
- c. *Severely damaged structures*: buildings with irreparably damaged structural elements; Figures 8 and 14 show two such buildings.
- d. *Moderately damaged structures*: buildings with some structural and other damage rendering them unsafe, if not uninhabitable, in case of after-shocks (Figure 3).
- e. *Slightly-damaged structures*: buildings with damaged glazing and/ or superficial cracks that were repairable.

The rubble of the first category took top priority and, accordingly, was the first to be cleared away. The second category was pulled down next, and those belonging to the third category were evacuated and earmarked for demolition. The fourth category consisted of buildings whose structure was unharmed but required major repair works. The fifth category did not need more than a few minor repairs, which were not urgent.



Figure 3: A moderately damaged building next to totally collapsed ones after the earthquake in the Marmara region [ii].

RESEARCH METHODOLOGY

Data regarding the Adana and Marmara earthquakes was collected from the Devlet İstatistik Enstitüsü (DİE - State Institute of Statistics), from the Chamber of Civil Engineers in Adana, from the province of Sakarya's official website, and from the Afet İşleri Genel Müdürlüğü (AİGM - Directorate-General of Disaster Affairs). In this connection, sites of various earthquake disasters in the southern and northwestern regions of Turkey were also visited to gather information with regard to demolition processes and the use or disposal of demolition waste. It was anticipated that particulars of recovery, re-use, and recycling practices pertaining to building materials and components might also be obtained. A trip to Adana was undertaken in February 1999, and the quake-stricken areas in the Marmara region were visited during the months of September and October 1999.

The visit to Adana was scheduled after the area had been cleared of all the debris. It was therefore not possible to make any observations related to the process of demolition, site clearance and dumping of rubble, or recovery of building materials. However, demolition and site clearing operations were underway when the devastated settlements of the Marmara region, i.e. Adapazari, Gölcuk and Degirmendere were inspected. It was thus possible to record the efforts of individuals while they were salvaging their belongings from the debris, as well as the process of recovering building materials and fittings from buildings that had been declared severely damaged or uninhabitable, and that were scheduled to be pulled down.

FINDINGS

The following information, with regard to the Adana quake, was gathered during a visit to the AIGM on 17.05.99:

- a. A total of 9,048 houses and 441 workplaces were demolished or were in irreparable condition. 19,949 houses and 1,334 workplaces were extensively damaged and 48,764 houses and 3,017 workplaces were slightly damaged.
- b. Approximately 4,000 severely damaged buildings were assessed to be a source of danger as they stood, and were demolished by local authorities while the rest were left to be demolished by the owners, the cost being too high to be borne by the Municipality alone.
- c. As the residents/owners themselves salvaged material that had any re-use value, no records were available in this regard.
- d. Debris from the sites of disaster was cleared away by the Municipality, the State Water Works department, the Department of Agriculture, and the residents, working in conjunction.
- e. The rubble was disposed of in landfills and other areas that needed leveling.

Data regarding the Marmara region was obtained from the province of Sakarya's website. A total of 24,662 houses and 5,090 workplaces were completely or partially demolished; 18,911 houses and 3,665 workplaces were moderately damaged, and 27,692 houses and 2,828 workplaces were slightly damaged. Pertinent figures for the different types of damage to buildings in Marmara and Adana are presented in Table 1 below. Although the total number of buildings that suffered damage in both the regions is approximately the same, a closer look at the distribution of the data shows that the number of collapsed or severely damaged buildings in Marmara were three times as many as those in Adana. This is an indication of the greater magnitude of the earthquake in Marmara.

Table 1. Damage caused by the two earthquakes in Turkey.

Degree of damage	Adana (1998)	Marmara (1999)
Collapsed/severely damaged Buildings	9,489	29,752
Moderately damaged	21,283	22,576
Slightly damaged	51,781	30,520
Total	82,553	82,848
Source of data	AGIM	www.sakarya.gov.tr

Deconstruction and/or Demolition of Earthquake Damaged Buildings

Demolition, site-clearance, and salvaging activities were observed in Gölcük, Adapazari, and Degirmendere five weeks after a devastating earthquake had hit this region. These towns were revisited a fortnight later, and on-going recovery and recycling operations were visually documented. It was observed that, where possible, damaged buildings were being deconstructed before demolition work started.

Second-hand dealers were also seen collecting demolition waste materials along with abandoned household equipment, probably with the intention of selling them for re-use elsewhere. Recovery and recycling activities in disaster areas were evident in the form of accumulated building material from demolition debris and damaged buildings, heaped at various locations in the quake-stricken towns.

Modes of Recovery

Manpower was employed to retrieve personal belongings, household effects, and building components from the damaged buildings and debris. Machines employed for building demolition and site clearance can be enumerated as follows: excavators, cranes, bulldozers, loaders, power shovels, pneumatic drills, and dump trucks.

Debris of wholly-collapsed buildings was scooped up by loaders and deposited into large trucks, to be towed away to dumping sites designated by the local authorities. Since the building had, in essence, turned into a huge mound of rubble, it was not possible to retrieve any thing intact from it, except roofing tiles.

Partially-collapsed buildings were pulled down with the help of excavators, cranes, and bulldozers, while the rubble was carried away by dump trucks. However, prior to demolition activities, selective recovery of building materials was observed. Likewise, selective recovery of building materials and personal belongings was also witnessed in buildings that had been earmarked for demolition at a later date. Section 3.1.2 enumerates the different types of material recovered from damaged buildings, while Figures 4 to 6 show a semi-collapsed building in Adapazari, where selective demolition was in progress.



Figure 4: Semi-collapsed buildings in Adapazari, which were to be demolished soon [iii].



Figure 5: Recovery of building material from the severely damaged building in Figure 4; the structures beyond have been already been deconstructed and demolished [ij].



Figure 6: Deconstructing earthquake-damaged buildings: Selective demolition in progress on the building shown in Figures 4 & 5 [ij].

Most of the demolition work was being done by excavators, which worked their way in from the front to the rear of the structure. This approach not only caused immense pollution but also was also dangerous. Moreover, the debris created by such haphazard demolition made recovery of materials even more difficult. Figure 7 shows demolition work in progress on a severely damaged building.



Figure 7: A semi-collapsed structure being pulled down in Adapazari [iii].

Some buildings were demolished by pulling out their columns one-by-one, starting from the ground floor and moving upwards (Figure 8). The movement of the excavators was limited by the high-tension cables passing overhead; at one point during the demolition work, the arm of one excavator got entangled in the power lines and was in danger of bringing them down too. Had a top-down technique been adopted to demolish the structure, much of the building material could have been recovered for re-use elsewhere.



Figure 8: Columns of a building being pulled out in Gölcük [iv].

Damaged sections of buildings were being removed without taking into consideration the support of the upright portions. Figure 9 shows two such buildings in Adapazari with partially-collapsed sections; notably, there were two upstanding structures on the top floor of

the building to the left. When the site was visited two weeks later, it was observed that, because the collapsed sections at the front had been removed in the accustomed manner, the rear had collapsed too, bringing down with it the structure on the roof (Figure 10).



Figure 9: Partially-collapsed buildings with penthouse on the structure to the left [v].



Figure 10: Removal of collapsed sections of the building shown in Figure 9 led to the collapse of an upstanding one at the rear, bringing down the penthouse with it [ij].

Salvage operations were carried out even in semi-demolished buildings tilted at precarious angles. Figure 11 shows recovery of building materials from one such building in Adapazari, while Figures 12 and 13 show recovery efforts in a similarly damaged building in Gölcük. The soft story of this building had buckled under, and the whole structure had tilted to one side. Construction workers were employed for selective dismantling of buildings that were severely damaged, with the aim of salvaging as much of the building materials and

components as possible, before the municipality excavators and bulldozers moved in to demolish them. Figure 14 belongs to another earthquake-damaged building in Gölcük; selective recovery of fittings and fixtures was also witnessed here.



Figure 11: Dismantling the roof of the building in Figures 9 & 10 above [i].



Figure 12: Building material being recovered from a dangerously damaged building: roof tiles stacked in the foreground (Gölcük) [i].



Figure 13: Rear view of the building in Figure 12 shows men working in this dangerously tilted structure to dismantle building components and fixtures; salvaged fenestration units are seen collected in the foreground [i].



Figure 14: Deconstructing a severely damaged, newly constructed building in Golcuk: Bath tub being lowered from the 5th floor of the building whose ground floor had buckled under [i].

Materials Recovered

Materials and equipment being recovered from the debris, and buildings destined for demolition, can be classified into the following two groups: personal belongings and building materials.

- i. Personal belongings: Goods belonging to this group can be listed as furniture, carpets, curtains, appliances, clothing, memorabilia from homes, and merchandise from shops. It should be noted, however, that this group of recovered materials was considered outside the scope of the investigation.
- ii. Building materials: Materials that can be cited in this group are all types of steel and aluminum components, fenestration, steel reinforcement, hardware, fittings, bathroom and kitchen fixtures, roof tiles, cabinets, grill-work, roofing timber, planks, and doors. Notably, building material and components salvaged through selective demolition in disaster-stricken areas was similar to that recovered from pre-planned demolition of buildings in cities [1]. Characteristically, recovery efforts were concentrated towards salvaging those building materials, which, as in the case of intentional-demolition projects, had a resale value in the market for second-hand goods. Likewise, material that was ordinarily dumped into landfills was also destined to end up in dumps after the steel reinforcement had been recovered from it.

Disposal of Rubble:

Although it had not been possible to witness the demolition, recovery, and site clearance activities subsequent to the earthquake of June 1998 in southern Turkey, the following information regarding disposal of debris was gathered from representatives of the Chamber of Civil Engineers and from city officials in Adana:

- a. Squatter settlements on the outskirts of the city had suffered widespread damage. Hence, being illegally built, all such housing was demolished to clear up the area. Rubble from demolished structures in these settlements was spread out to level off the land, which was to be covered later with a layer of earth, in order to convert it into a green area.
- b. Rubble from demolition of collapsed and severely damaged structures in other areas was dumped alongside and into the Ceyhan and Seyhan rivers. This narrowed the riverbed; hence, some of it was retrieved later and used as hardcore for road building along the riverside. Figure 15 shows rubble dumped along the banks of the Seyhan River in Adana; note the road-roller leveling off a layer of retrieved rubble as hardcore for the under-construction road.

According to the province of Sakarya's official website [2], after the earthquake in the Marmara region, 1,200 trucks took 40 days to remove 2,500,000 tons of debris. A news item from the Turkish daily "Aksam," as quoted on the Arkitera website [3], reports that a local recycling firm is reclaiming dumped rubble from the Kum Ocaklari Lake near Adapazari. During the past one year, after separating metal and plastics from the debris, 500,000 tons of rubble has been processed into hard core for road-building. Moreover, reinforcement steel that was recovered from this demolition waste is being sold at the rate of \$100 per ton. It is estimated that this work will continue for at least another year.



Figure 15: Rubble from the demolished earthquake-damaged structures was initially dumped along the banks of Seyhan River in Adana [i].

CONCLUSION

Building components that already have a resale potential in the market were being recovered, even from perilously tilted buildings in the afflicted areas. In fact, while demolition and site-clearance work was in full-force, recovery efforts of individuals and professional teams to salvage personal belongings or construction material from damaged or demolished buildings occurred concurrently.

The priority was to remove the dangerously damaged structures as fast as possible; hence, demolition work proceeded at a great speed, seemingly regardless of the safety of the demolition squad or passers-by. At times, debris from partially collapsed structures was removed prior to the demolition of the upstanding portions. This posed a danger to the surroundings, since the rubble might have been supporting some un-collapsed section(s) of the building. Contrary to the prevalent practice of demolishing a structure from its sides inwards with excavators, as observed in Adapazari and Gölcük, it would have been safer to adopt a top-down demolition technique.

Furthermore, debris from thousands of demolished structures was disposed of without much forethought. Most of the rubble was dumped into a river in Adana, and into a lake in the Marmara region. Consequently, additional resources had to be wasted in order to retrieve this rubble and put it to a more environmentally friendly use.

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