Earthquake Waste Generation After February 6, 2023 Earthquakes in Türkiye: Field Study on the Examination of Unit Area Debris Amounts

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Abstract

The southeastern region of Türkiye had two significant earthquakes on February 6, 2023, resulting in an intensive impact on 11 cities in the area. The earthquakes caused destruction and heavy damage in the provinces. According to the statistics, the earthquakes affected 13 million people in the region, representing 15% of the total population of 85 million in Türkiye (Khan, 2023). The Ministry of Environment, Urbanization and Climate Change (MEUCC) announced that 279,000 buildings and 821,302 independent units were damaged requiring demolition (URL1).

Different types of buildings generate different quantities of earthquake debris. For instance, Hirayama et. al. (2010) stated that demolition debris from wooden houses was estimated at 0.40 ton/m^2 to 0.61 ton/m^2 during the Great Hanshin-Awaji Earthquake. In the Great East Japan Earthquake, 1.107 tons of waste was generated for each m^2 (URL2). During the Gorkha Earthquake (Nepal), it ranged from 1.9 to 3.23 ton/m^2 (Abhimanyua and Raj, 2019). To be able to predict waste generation amounts more accurately, it is crucial to predict unit area debris (UAD) amounts. According to the data announced for this earthquake, different estimated debris waste amounts have been presented in the literature. For instance, Xiao et. al. (2023) stated that, the estimated amount of demolition waste generated after this earthquake ranges from 450 to 920 million tons. In addition, UNDP's early estimates on that earthquake indicate that the earthquake have generated between 116 million and 210 million tons of rubble between 9-16 times more than the Marmara earthquake (1999) which is one of the significant earthquakes that took place in Türkiye (2023). According to the report of ITU (2023), earthquake waste generation ranges from 100 to 138 million tons. The aim of the study is to determine how the quantity of building debris has changed in accordance with the earthquake regulations implemented in Türkiye and to identify the post-earthquake waste amount per unit area specific to Türkiye with respect to the achieving appropriate waste management.

A field study was conducted in Malatya province, one of the cities heavily affected by earthquakes. The research was conducted in different stages which included the selection of buildings, removal of excavation, weighing of trucks carrying excavation, examination of UAD amounts over the selected buildings, and quantification of earthquake debris generation in the whole region. Heavily damaged concrete buildings requiring urgent demolition were selected. Construction periods of buildings were categorized into three groups before 2000, 2000–2011 and 2011–2018 according to the earthquake regulations in Türkiye. After that, 3 buildings for each category in total 9 buildings were selected randomly for representativeness of the study. The information about the buildings (construction year, total area, floor number, etc.) was gathered from the district municipalities of Malatya. Controlled demolition of the selected buildings was conducted by contracted companies. The removal of the excavation from demolished buildings was provided. Then, trucks working on the removal of excavation were weighed to obtain the total debris amount. After having the total debris amounts for each building UAD amounts were calculated in ton/m^2. Examination of UAD amounts was made based on two different approaches. In the first approach, truck weighing amounts for the foundation and basement floors of buildings on the site were increased by approximately 10-30%, depending on the construction years of the building. In the second approach, in addition to truck weighing, the amount of UAD was calculated by using the land surface area of buildings for the amounts buried in the debris field and with the assumptions given below (Table 1).

Table 1. Assumptions for calculation of UAD amounts

Floor height (m)	2.4
Safety coefficient	1.2
Ratio of void volume/rubble volume	0.2
Rubble expansion rate	1.5
Waste density (t/m^3)	1.6

The UAD amounts were calculated for different construction periods, revealing variations. In order to have more reliable values, the mean of the two approach values in Table 2 has been taken. For buildings built before 2000, the average UAD was 0.880 ton/m^2, while between 2000-2011, it increased to 0.966 ton/m^2. In the 2011–2018 period, the average UAD reached 1.058 ton/m^2.

Table 2. UAD Amounts of the Buildings

Building Construction Year	Building Code	Approach 1, UAD (ton/m^2)	Average ±Standard Deviation (ton/m^2)	Approach 2, UAD (ton/m^2)	Average ±Standard Deviation (ton/m^2)
	B1	0.925		0.979	
Before 2000	B2	1.035	0.845±0.24	1.035	0.916±0.16
	B3	0.575		0.734	
	B4	0.879		0.880	
2000-2011	B5	1.023	0.952±0.07	1.058	0.979±0.09
	B6	0.955		1.000	
	B7	1.072		1.178	
2011-2018	B8	1.055	1.009±0.09	1.074	1.107±0.06
	B9	0.901		1.069	
Total			**0.935±0.08**		**1.001±0.10**

The field study's results showed that there is a strong relationship between the UAD amounts and the construction year of the building. On the other hand, the study acknowledges that the buildings were emptied before demolition, potentially affecting UAD values. Therefore, after the earthquake collapsed buildings UAD values might differ from urgently to-be-demolished buildings. Future research should consider different building occupancy scenarios post-earthquake to enhance the understanding of UAD dynamics.

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