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INVESTIGATION OF THE RELATIONSHIP BETWEEN EARTHQUAKE INTENSITY AND CONCRETE PROPERTIES, THE EXAMPLE OF HATAY PROVINCE

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ABSTRACT

Hatay is one of the provinces most affected by the Kahramanmaraş-centered earthquakes (7.7 M_w and 7.6 M_w) that occurred on February 6, 2023. Post-disaster assessment studies of building stocks in the Hatay region were initiated shortly after the earthquake. As a result of the assessment studies, 67346 heavily damaged buildings were identified in the region exposed to the earthquake disaster. It has been determined that most of these structures (approximately 21800 buildings) are in Antakya district. In this study, in-situ non-destructive testing (NDT) techniques were used to determine the concrete quality of the building stock in order to determine the cause of this high rate of damage in the Antakya region. In this case, surface hardness value was determined with Schmidt hammer and P-wave velocities were measured. Within the scope of the study, the effects of earthquake intensity on concrete quality were investigated by selecting samples from buildings built close to each other and on the same soils in two different locations. It was determined that the NDT measurements were low in both locations, and the amount of damage to the buildings due to the earthquake was high.

Keywords: Earthquake, Antakya, Non-Destructive Tests, Concrete Quality

INTRODUCTION

After major earthquakes, numerous reinforced concrete structures are damaged all around the world. The extent of these damages directly relates to the earthquake's magnitude. In-situ damage

assessment of concrete properties is very important prior to inspection of damages and reconstruction and reinforcement of damaged structures (Ahmadizadeh and Shakib 2004; Suzuki and Ohtsu 2014). Non-destructive testing (NDT) has recently gained importance in the practical in-situ determination of concrete properties of such structures. Sbartai et al. (2012) stated that the use of multiple NDT methods is more beneficial in determining the properties of in-situ concrete. The NDTs that are widely used for in-situ determination of concrete properties are P-wave velocty and Schmidt hammer surface hardness value (Poorarbabi et al 2020). In addition, the effect of the concrete quality of the building on the damage status can be investigated by using NDTs. For this purpose, Hatay province Antakya district, where damage and loss of life were concentrated after two major earthquakes (Pazarcık: 7.7 M_w and Elbistan: 7.6 M_w) according to the Kahramanmaraş-centered Richter magnitude classification on February 6, 2023, was determined as the study area. In this region, the relationship between the causes of different damages observed in buildings built on soils with similar soil properties and concrete properties was investigated using two different NDTs (P-wave velocty, and Schmidt hammer surface hardness value).

MATERIAL AND METHOD

This research was carried out in two phases as visual and experimental studies in-situ. Within the scope of the in-situ study, visual inspection and photographing were carried out at two locations in order to determine the damages observed in the buildings due to the earthquake. Two buildings (S1 and S2) located next to each other in location 1 were examined, and 4 buildings (S3-S6) located on the same street in location 2 were examined. During the in-situ test phase, P-wave velocity and Schmidt hammer rebound value from non-destructive testing techniques (NDT) were determined in the concrete of the selected buildings (Figure 1). The Schmidt hammer rebound value (SHR) of concrete was determined according to the standards recommended in ASTM C805 (2018), while the P-wave velocity (V_p) was determined by considering the methods recommended in ASTM E494 (2010).

Figure 1. NDT measurements on building concrete

RESULTS AND DISCUSSIONS

Earthquake effects on structure

After the earthquakes that occurred in Kahramanmaraş on February 6, 2023, the damages observed in the structures in the two selected locations are given in Figure 2, and Figure 3. When Figure 2 is examined, it was determined that the first floor of S1 failed at the junction of the column and beam (Figure 2a). It was also determined that this building was buckling around its axis. In S2, however, no deformation was observed in the structural system of the structure, and shear cracks were detected on its walls (Figure 2c).

Figure 2. View of buildings with different types of damage on Uğur Mumcu Street (location 1), a) Building 1 (S1), b) Google.maps image of buildings before earthquake (https://www.google.com.tr/maps/), c) Building 2 (S2)

When Figure 3 is examined, it has been determined that the first floor of S3 has lost storey as a result of plastic failure between weak columns and strong beams and the collapse of the soft storey (Figure 3b). In S4, there are only shear cracks on the walls of the building (Figure 3c). Plastic failures occurred at the junction of the column and beam of the structure in S5 (Figure 3d). Building 5 (S5) was hit while building 6 (S6) was collapsing, causing an increase in the damage rate. The structure in S6 collapsed in the form of a press. It was also determined that the building was slightly buckled around its axis (Figure 3e). Plastic failure has occurred at the junction of the column and beam of the ground floor of the building.

Properties of structure

In order to determine the concrete properties of the structures in both locations, the NDT properties measured in situ are given in Table 1. The V_p values of the buildings in Location 1 were determined as 3.60 km/s for S1 and 5.78 km/s for S2. SHR values of S1 and S2 were determined as 30 and 42, respectively. The highest V_p value was measured at 3.45 km/s at S6 in the buildings in Location 2, and the SHR value was determined as 34 in the same building. In Locations 1 and 2, the most damaged structures are the buildings with the lowest SHR and V_p values

Table 1. Average NDT values measured in buildings

NDT	S1	S2	S3	S4	S5	S6
Vp – km/s	3.60	5.78	2.60	2.95	3.45	1.51
SHR	30	42	26	30	34	26

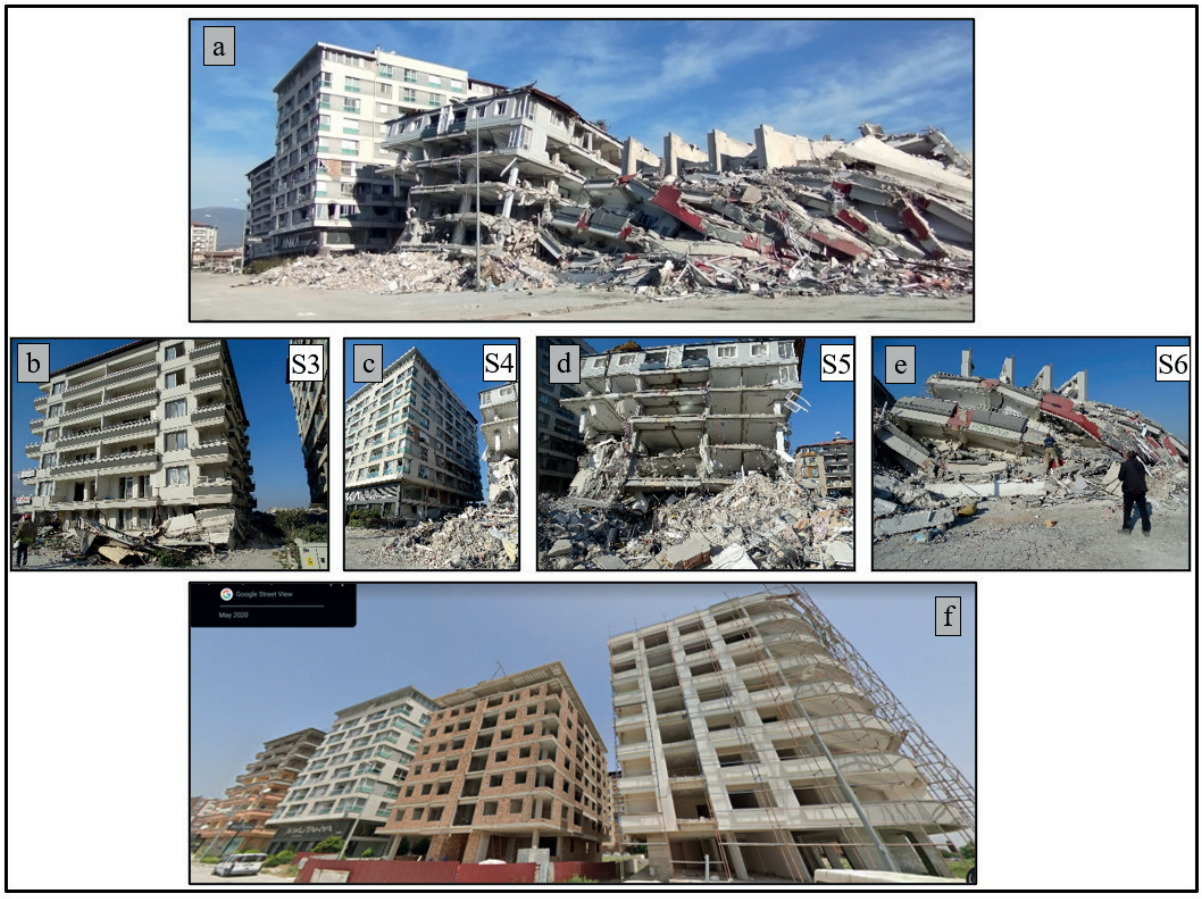

Figure 3. a) View of buildings with different types of damage on Atatürk caddesinde (location 2), b) Building 3 (S3), c) Building 4 (S4), d) Building 5 (S5), e) Building 6 (S6), f) Google.maps image of buildings before earthquake (https://www.google.com.tr/maps/)

CONCLUSION

With the effect of Kahramanmaraş earthquakes, the effect of concrete quality and structural properties on the damage occurred in different buildings on similar soils in Antakya district of Hatay province was investigated. Field observations and in-situ test results are summarized as follows.

- The concrete used in the buildings does not comply with the standards,
- Presence of relatively weak columns and strong beams,
- Insufficient engineering knowledge of designers,
- Lack of supervision by control institutions, and
- The low NDT values of the concrete properties of the building, it has been determined that the factors listed above increase the damage observed in the structures.

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