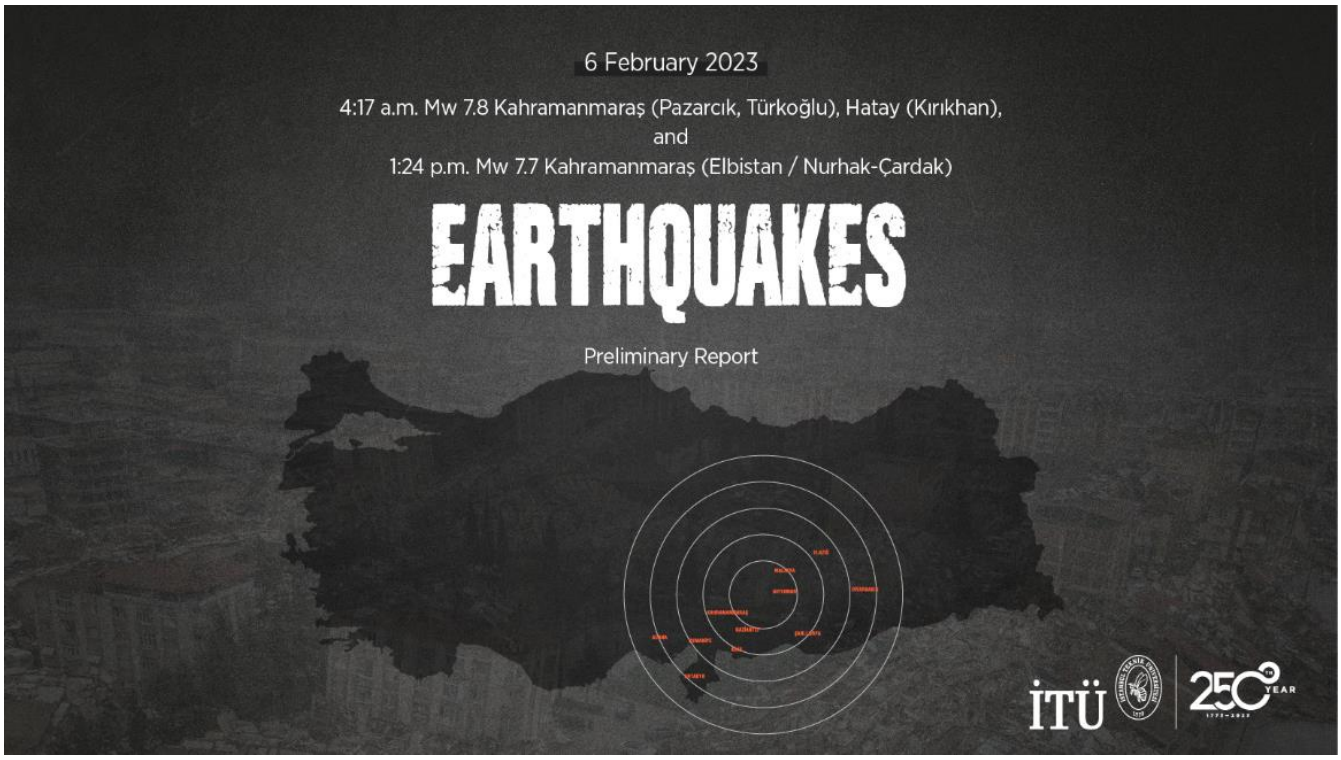

Executive Summary

1. Preliminary Geological, Geophysical, Geodetic and Geomorphological Findings Regarding the Earthquake

1.1. Geological Assessment

Two earthquakes (Mw 7.8 and Mw 7.7) occurred at 04.17 and 13.24 in Turkish time, with epicenters in Pazarcı k (Kahramanmaraş) and Elbistan (Kahramanmaraş). Surface ruptures resulting from these earthquakes were mapped in satellite images over a wide area. Surface ruptures are observed in certain parts of the fault in the field. Although the segmented structure and trace of the fault are close to the known lines in the field, it can be seen that morphologically it progresses from the ridges and slopes of the Çardak Fault. The field traces and surface rupture map of this earthquake contain brand new information. The slip distribution of interrelated segments suggests that the Amanos Segment broke with 2, the Çardak Fault with 2, the Pazarcı k Segment with 1, and the Gölbaşı Segment with 1 independent earthquakes in the region simultaneously. Another notable factor is that the active fault map of Türkiye and the surface ruptures do not overlap and pass through different areas.

1.2. Geophysical Assessment

With joint inverse solution of far and near field seismologic (BB and SGM) and geodetic (GPS) data and observations, instrumental moment magnitudes (Mw) of the 6 February 2023 Nurdağı -Pazarcı k and Ekinözü earthquakes were calculated as 7.8 and 7.7, respectively. Small differences can be expected between the calculated instrumental magnitudes depending on the method applied and the dataset analyzed. The strike-slip models developed based on multiple datasets give displacement values varying approximately in the range 8-10 m and consistent with field observations on more than one fault segments for both earthquakes. The modeling results also clearly reveal that the rupture times of the Mw 7.8 Nurdağı -Pazarcı k and Mw 7.7 Ekinözü earthquakes are approximately 100 s and 60 s, respectively.

1.3. Geodetic Assessment

The observation data of 4 TUSAGA-Active Fixed GNSS stations named ANTE (Gaziantep), EKZ1 (Ekinözü), MLY1 (Malatya) and ONIY (Osmaniye), which were able to continue collecting GNSS data during the earthquakes, were used for geodetic identification of the co-seismic effects of the relevant earthquakes. Satellite observation data of these stations with 1 second intervals on the day of the earthquake were evaluated statically and kinematically with the absolute method using the GNSS Precise Point Positioning technique, and the horizontal displacements occurring at the stations were obtained. According to the static evaluation, the largest horizontal displacement after both earthquakes was obtained at EKZ1 station as 4.7 m. The horizontal displacement values at MLY1, ANTE and ONIY stations were found to be 69.9 cm, 39.6 cm and 29.2 cm, respectively. The results obtained from the kinematic evaluations generally support the static evaluation results.

2. Evaluation of Strong Ground Motions

As the acceleration recorders and/or the buildings in which they were placed were damaged during the earthquake, reliable data could not be obtained from some stations. Spectral acceleration, velocity and displacement quantities calculated using the acceleration records downloaded from https://tadas.afad.gov.tr/ on 9 February 2023 are presented. As the acceleration records get inspected in detail in the coming days, it may be necessary to revise some records and update the results. The elastic design acceleration spectra defined for ZC, ZD and ZE ground classes in case of “earthquake with 10% probability of exceeding in 50 years (return period of 475 years)” in Türkiye Building Earthquake Regulation 2018 were compared with the spectral acceleration graphs generated from the earthquake records. It is noteworthy that the elastic acceleration spectrum generated for 5% damping ratio is well above the DD2 earthquake spectral curves in the wide period band at Hatay Station No. 3129.

3. Evaluation of Structural Damages

In the massive earthquakes of magnitude 7.8 and 7.7 that occurred in the Pazarcı k and Elbistan districts of Kahramanmaraş, respectively, a large number of reinforced concrete buildings in 10 provinces on the East Anatolian Fault Line were destroyed and turned into rubble. Although many parameters are effective in the destruction of the collapsed buildings, the age of the buildings, the low bearing capacity of the soils on which the foundations sit, low quality of the materials used in the construction, the inadequacy of the cross-sectional dimensions and reinforcement amounts of the columns and beams, the fact that the load bearing system elements were not constructed in accordance with the regulations in force at the time of construction, other construction defects and the different floor levels of the buildings built in contiguous order were seen as the most prominent causes of collapse. In Kahramanmaraş and Adı yaman provinces, it was observed that the majority of the wrecked buildings were pancaked on top of one another with their first floors being crushed either completely or partially, or they collapsed by twisting to the side completely or partially. In regions such as Hatay-Antakya and Adı yaman-Gölbaşı , it was also observed that buildings collapsed due to soil liquefaction, either by sinking into the ground or tilting to the side entirely or partially sinking into the liquefied ground obliquely depending on the characteristics of their foundation system.

As a result of these earthquakes, hospitals and some public buildings, which were built in accordance with their projects to the maximum extent in areas with high ground capacity in accordance with the regulations of all structures, such as reinforced concrete buildings, have shown once again that structural damages that may occur in buildings as a result of such severe earthquakes can remain very limited. It was concluded that a significant part of the relevant damages occurred due to the fact that the connection between the load-bearing system elements and the pumice concrete block bricks used as infill walls was built in a way that did not allow deformation during the earthquake.

4. Evaluation of Future Implications for Urban Planning and Construction Techniques That Can Be Used to Meet the Need for Rapid Housing

The Kahramanmaraş-Pazarcı k earthquake with a magnitude of 7.7 and the Kahramanmaraş-Elbistan earthquake with a magnitude of 7.6, which occurred with the break of the Southeastern Anatolian Fault Line, the center of which is the Pazarcı k district of Kahramanmaraş province, were recorded as the second and third largest earthquakes experienced in Türkiye. For 10 provinces affected by the earthquakes, where 13.5 million people live, the findings and projections made in the Provincial Disaster Risk Reduction Plans prepared by AFAD for 2019-2021 underline that most of the cities are located on soils that are not suitable for development and that the old and weak building stock in these areas needs to be renewed. Decisions on the location of existing settlement areas and especially the zoning and building practices brought about by the rapid urbanization process of the last 50-60 years, authorities and responsibilities in the preparation and approval processes of zoning plans, zoning amnesties and the accompanying high-risk building stock can be listed as existing building inspection problems.

Taking into account the situation before and after the earthquake in terms of urban planning principles and dynamics, evaluations and recommendations that examine the region through public policies, spatial planning, governance and social participation, and guide a sustainable, safe, fair and livable reconstruction process are summarized below.

● Regulations such as zoning amnesty and zoning peace, which are not based on scientific grounds and legalize the unhealthy and unsafe building stock that has not received engineering services, should be terminated; natural thresholds should be taken as basis in the reconstruction process, and in the new planning process, constructions should not be allowed in these areas, except for cultural assets.

● In the regions affected by the 6 February 2023 earthquakes, a “post-disaster recovery and development plan” should be implemented, including the city’s reconstruction process, and the reconstruction process should be initiated. Instead of uniform buildings, contemporary architectural designs that take as reference the values of the traditional urban fabric, which is a reflection of the social and cultural structure of the provinces damaged by the earthquake, should be proposed. They should be planned and designed as settlements with sufficient open space and social infrastructure, in line with universal design norms, aiming to increase the resistance of cultural assets and historical fabric against earthquakes, and respectful to nature and people.

● In urban transformation/renewal works, “resource creation based solely on increasing imputed value” approach, which is localized, fragmented and increases the risks in the existing urban fabric, should be abandoned. Urban transformation projects should be carried out in accordance with upper-scale plans and should be designed by considering alternative financing models.

● Culture, with its value in the continuity of society, the meaning of identity and economic development, should be recognized as a fundamental force in the process of “better”

post-disaster reconstruction, and a model of urban transformation and community governance that is inclusive of the whole society should be developed. In the houses to be reconstructed, bearing systems built with tunnel formwork, prefabricated reinforced concrete houses and modular steel systems should be considered together, taking into account many different conditions such as ground conditions, etc.

With tunnel formwork systems, it is possible to rapidly construct mass housing consisting of multi-storey blocks. However, it is recommended to develop specific type of architectural projects for the blocks, to limit the depth of the foundation and the number of basement floors, or to limit the excavation, construction of basement floor perimeter curtain walls, etc. with a certain cycle in a way that does not adversely affect the construction of the upper floors with good planning, considering that the foundation and basement floors will be constructed with conventional formwork and this process will extend the construction period, and the superstructures can be constructed quickly with tunnel formwork systems. It is estimated that the ground floor and normal floors can each be built with a speed of 2 days/floor. For example, it is estimated that a 7-storey block above the ground level, with ground floor and 6 normal floors, can be built in approximately 15 days, excluding foundation and basement construction periods.

Prefabricated reinforced concrete is a construction technique that is widely used in the world to meet the intense need for housing after earthquakes. Since the entire production process takes place in factories with an industrial discipline, it is ideal in terms of quality control. Multi-storey prefabricated systems are more economical than conventional solutions in repetitive multiple projects. Prefabricated reinforced concrete systems have shown appropriate structural performance in previous earthquakes experienced in our country.

It is thought that it would be very rational to use the advantages of steel material in some of the buildings to be reconstructed. Steel systems can be used for low-rise detached or apartment type houses planned in the short term. Buildings between 1 and 2 floors can be designed as “family houses” using systems with cold-formed light steel elements. Modular steel systems, which are properly designed in terms of architecture, can be easily preferred in reconstruction (residences and social buildings) as they will provide functionality and aesthetic requirements as well as earthquake safety. Modular design will also ensure fast and high quality production. Manufacturers of both light steel and structural steel products in Türkiye are highly experienced in modular construction.

5. Evaluation in terms of Environmental Infrastructure and Earthquake Waste Management

Earthquakes damage infrastructures as well as superstructures. In particular, acute problems may be experienced in water supply and wastewater disposal due to damage to water mains and sewerage pipelines. Therefore, the risk of infectious diseases, which have a high potential for transmission through water, increases after an earthquake. For this reason, it is vital to take technical measures for safe water supply quickly in order to prevent waterborne epidemics after an earthquake. Safe water supply should be ensured in the short term in temporary accommodation areas such as tent cities by using one or more of the methods of filtering, boiling, disinfecting with bleach. In case of problems with the supply of safe water in hospitals, mobile treatment systems should be provided immediately. In addition to safe water supply, the necessary solutions to make the infrastructure functional again should be planned and implemented by classifying them as short, medium and long term. In the short term, damage assessment studies on the existing network and sewerage infrastructures should be completed, especially with the participation of SUKİ (water and sewerage administration) technical teams from the neighboring provinces in the improvement works. For a medium-term solution, septic tank areas should be created for the collection of wastewater in temporary accommodation areas such as tent cities. As for long-term solution, it is necessary to design and build durable infrastructures that will receive the least damage in future earthquakes.

In case of great damage and impact in disasters such as earthquakes, a significant amount and volume of disaster waste is generated. Within the scope of damage assessment studies carried out by the MoEUCC (Ministry of Environment, Urbanization and Climate Change) in

13 provinces after the earthquakes that occurred in our country on 6 February 2023, 263,800 independent units in 61,722 buildings were determined to be in need of urgent demolition, heavily damaged and collapsed as of 16 February 2023. Accordingly, the estimated amount of waste to be generated on a provincial basis was calculated based on the preliminary calculations of the amount of earthquake waste. The total amount of earthquake waste is estimated to be between ~50 million tons and ~110 million tons. The provinces expected to generate the highest amount of earthquake waste are Hatay, Kahramanmaraş, Malatya, Gaziantep and Adı yaman, which were the most affected by the earthquake. Therefore, the need for temporary and final storage areas for earthquake waste is highest in these provinces. In this respect, first of all, the remaining capacity of existing sites should be determined and new temporary and final storage areas should be identified if necessary. These provinces are followed by Osmaniye, Diyarbakı r and Elazı ğ according to the amount of waste generated. For Adana, Kayseri, Kilis, Niğde and Şanlı urfa, it is thought that the existing sites may be sufficient due to the relatively low amount of earthquake waste. However, capacities of the existing sites still need to be checked. Necessary occupational health and safety measures should be taken during the process of demolition of buildings, and transportation and management of wastes.

Earthquake wastes should be transported to temporary storage areas, where the materials in the wastes should be separated and re-use, recycling/recovery should be ensured to a large extent, and the remaining wastes should be disposed of according to their level of hazardousness within the framework of the provisions specified in the relevant regulations. Temporary and final storage areas should have the capacity to accommodate the amount of waste and unauthorized access to these areas should be restricted. Due to the risk of fire, wastes should not be stacked above a certain height, especially in temporary storage areas. Necessary safety measures should be taken for situations such as fire risk.

In addition to the issues raised in this report, it is known that earthquakes cause great psychological and sociological trauma in societies. In addition to technical considerations, this issue is also extremely important and vital. Short and medium term studies are required to observe and remedy the social effects of the earthquake. In short-term studies, recommendations about remedying the social effects of the Kahramanmaraş earthquakes will be useful, based on studies examining various post-disaster relief, recovery and reconstruction experiences in the world and in Türkiye.

In the medium and long-term post-earthquake practices, participatory studies aiming at observing social change and setting goals for eliminating socio-ecological problems and establishing institutional mechanisms in this direction are important.

Link to full report:
https://haberler.itu.edu.tr/docs/default-source/default-document-library/2023_itu_deprem_on_raporu.pdf?sfvrsn=77afe59e_4