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HYBRID EEFIT MISSION TO FEBRUARY 2023 KAHRAMANMARAŞ EARTHQUAKE SEQUENCE

Yasemin Didem AKTAS*[1], Emily SO*[2], Cassidy JOHNSON[1], Eser CABUK[3], Fatma Sevil MALCIOGLU[4], Kokcan DONMEZ[4], Mariana ASINARI[3], Orestis ADAMIDIS[5], Pietro MILILLO[6], Tugce TETIK[4,7], Viviana NOVELLI[8], Ahsana PARAMMAL VATTERI[1], Aisling O'KANE[2,9], Akbey KALKAN[10], Ali Tolga OZDEN[11], Anton ANDONOV[12], Enrica VERRUCCI[1], Eyitayo OPABOLA[1], Hristo Pavlov MARKOV[13], Giorgia GIARDINA[14], Gopal MADABHUSHI[2], Ioanna TRIANTAFYLLOU[15], Ji-Eun BYUN[16], Joshua Nathan JONES[17], Matthew FREE[18], Nurullah BEKTAS[19], Ozcan GOZENOGLU[13], Sahin DEDE[1], Sarah Jean BOULTON[20], Sinan ACIKGOZ[5], Tansu GOKCE[21] Teoman EFEOGLU[21]

Abstract: *The southwestern part of Türkiye was hit on 6 February 2023 by an Mw 7.8 (epicentre: Pazarcık) and then an Mw 7.5 earthquake (epicentre: Elbistan). The event was followed by tens of thousands of aftershocks including the Mw 6.3 event on 20 February (epicentre: Uzunbağ). This paper reports on the preliminary findings of the mission organised by the UK's Earthquake Engineering Field Investigation Team (EEFIT) to the Kahramanmaraş Earthquake sequence of February 2023. This mission followed a hybrid model, combining field and remote investigation techniques, to investigate the characteristics of the earthquake sequence, its impact on buildings and infrastructure, as well as the efficacy of relief, response and recovery operations. The key messages include that the building stock is hard to categorise which brings along difficulties with damage assessment, that the recovery and reconstruction require multi-sectoral engagement of key stakeholders, and that the auditing and quality control mechanisms within the construction industry need revisiting in the way forward for better disaster resilience in Türkiye. 166/300*

Introduction

On 6 February 2023 at 4:17 am local time, a large area in southeastern Türkiye and northern Syria was hit by an Mw 7.8 earthquake, which was followed by an Mw 7.5 earthquake at 1:24 pm local time, causing the loss of more than 50,000 lives, some 100,000 injuries and significant damage to buildings and infrastructure, estimated to be in the range of 84.1 billion USD for Türkiye alone. The largest earthquake in Türkiye since the deadly 1939 Erzincan earthquake with however much larger losses, the sequence immediately attracted the attention of the global post-disaster reconnaissance/engineering communities. This included the Earthquake Engineering Field Investigation Team (EEFIT), a joint venture supported by the UK's Institution of Structural

[1] University College London (UCL), London, UK, y.aktas@ucl.ac.uk
[2] Cambridge University, Cambridge, UK, ekms2@cam.ac.uk
[3] Dolfen Engineering, Ankara, Turkey
[4] Boğaziçi University Kandili Observatory, Istanbul, Turkey
[5] University of Oxford, Oxford, UK
[6] University of Houston, Houston, USA
[7] Tekirdağ Namık Kemal University, Tekirdağ, Turkey
[8] Cardiff University, Cardiff, UK
[9] University of Canterbury, Canterbury, NZ
[10] Sellafield Ltd, Manchester, UK
[11] Canakkale University, Canakkale, Turkey
[12] Mott MacDonald, Sofia, Bulgaria & London, UK
[13] Willis Towers Watson (WTW), London, UK
[14] Delft University of Technology, Delft, Netherlands
[15] Center for Security Studies, Athens, Greece
[16] University of Glasgow, Glasgow, UK
[17] AECOM, UK
[18] Arup, Plymouth, UK
[19] Széchenyi István University, Győr, Hungary
[20] University of Plymouth, Plymouth, UK
[21] University of Bristol, Bristol, UK

Engineers (IStructE) for nearly 40 years engaged in disaster reconnaissance work. Within one week of the event, a team was set up with 30 people from academia and industry in the UK (19), Türkiye (5), New Zealand (1), Hungary (1), Bulgaria (1), Greece (1) and USA (1), charged with studying the events and their impacts, and also developing suggestions to reduce the existing vulnerabilities in the future.

The reconnaissance studies conventionally rely primarily on the data collected from the field in the aftermath of a disaster. The “hybrid mission” concept was first put forward by the EEFIT for the missions during the Covid-19 pandemic, when the travel restrictions did not allow for traditional post-disaster reconnaissance practices. In this new model, the mission work is coordinated primarily remotely, focused on the exploitation of alternative data sources that are not typically consulted or not used as primary sources during post-disaster work for formal data collection, and developing partnerships with local communities for local field surveys. First with the 2020 Zagreb Earthquake (So et al., 2020), and then with the 2020 Aegean Earthquake (Aktaş et al., 2021; Aktaş et al., 2022) and the 2021 Haiti Earthquake (Whitworth et al., 2022) this model was adopted – scientific reports, (social) media, drone and CCTV footages, external personal and institutional databases were remotely studied, ethnographic methods, online survey techniques, and remote sensing were used to supplement this information, and local volunteers were recruited for on-site data collection. This model proved beneficial while bringing about open research and practical questions to the reconnaissance community. to further explore this model as a viable way of studying the impacts of an earthquake (Aktaş and So, 2022).

In the EEFIT mission to the February 2023 Kahramanmaraş Earthquake sequence, the team adopted a hybrid strategy. The team was split into 6 groups: Seismology and strong ground motions, geotechnics, infrastructure, structures, remote sensing, and relief-response-recovery. Half of the team with representatives from each sub-group conducted the fieldwork on 12-18 March 2023, while the entire team engaged fully with remote methods and tools to investigate the events. This paper summarises the preliminary findings of the EEFIT team during their mission to the February 2023 Kahramanmaraş Earthquake Sequence.

Characteristics of the Strong Ground Motions

The M_W7.8 Pazarcık event originated by rupturing the Narlı fault and then migrated bilaterally north along the Pazarcık and Erkenek segments and south along the Amanos fault. The later Mw 7.5 Elbistan earthquake ruptured the Çardak fault which is ~100 km North of the epicentre of the M_W7.8 Pazarcık event. The smallest but not less significant event, M_W6.3 Uzunbağ, took place 147 km Southwest of the M_W7.8 events epicentre. The Turkish Accelerometric Database and Analysis System (TADAS), which is operated by the AFAD (Disaster and Emergency Management Presidency), as well as stations of Boğaziçi University, Kandilli Observatory, and the Earthquake Research Institute (KOERI), recorded strong ground motions of all three events. Due to uploads and withdrawals from the data in the TADAS website many times, the data set eventually compiled on April 13, 2023 is the basis for the analysis in this paper.

The EEFIT field team inspected six recording sites with unusual ground motion recordings e.g. unexpected PGA, interruptions in the signal, noise contamination etc. and performed an external visual examination to ensure their huts are undamaged. The station 4614 recording, which provides more than 2.0g of peak ground acceleration (PGA), is the most troublesome one in the dataset. No signs of damage are identified in its hut similar to the other stations. Station NAR, which is the one closest to station 4614, yields one-third of its resultant PGA ($PGA_{NAR,R}$=894 cm/s^2 << $PGA_{4614,R}$=2830 cm/s^2). This inconsistency has caused station 4614 to be removed from the data set. The three-component ground motion recordings of the stations ($N_{station}$=128 for M_W7.8 Pazarcık event; $N_{station}$=154 for M_W7.5 Elbistan event; $N_{station}$=100 for M_W6.3 Uzunbağ event) within 300 km of the epicentral distance have found to be of sufficient quality for the studies after reviewing through and analysing all the records.

Strong ground motions of Kahramanmaraş earthquake sequences can be attributed to the peculiar source, path, and site characteristics, such as near-fault effects, multiple wave packages due to segmental rupture features, and basin effects, which result in high PGAs in both horizontal and vertical directions, high pulse-like velocities, large spectral accelerations at specific periods etc. The spatial distribution of resultant peak ground acceleration (PGA_R), which is one of the most frequently employed indicators for rapid assessment of the extent of shaking, is illustrated in Figure 1 along with the largest horizontal acceleration time histories ($PGA_{3129,NS}$=1379 cm/s^2 in an Antakya basin station) for M_W7.8 Pazarcık event. M_W6.3 Uzunbağ event also yields the largest ground motions in one of the Antakya basin stations ($PGA_{3125,EW}$≈769 cm/s^2) as well. In M_W7.5 Elbistan event, which predominantly impacts the region's north, the closest station to the fault rupture (station 4612) produces 636 cm/s^2 in the East-West component. Due to the extensive rupture length of particularly M_W7.8 and M_W7.5 events (350–400 km in the case of the M_W7.8 earthquake and 150–200 km in the case of the Mw7.5 earthquakes), the Joyner–Boore distance (R_{JB}), which is defined as the closest horizontal distance to the vertical projection of the rupture surface, yields more meaningful evaluation. The stations positioned nearby the fault ruptures (small R_{JB}s) give significant PGA values as exemplified for the M_W7.8 event in Figure 1(top).

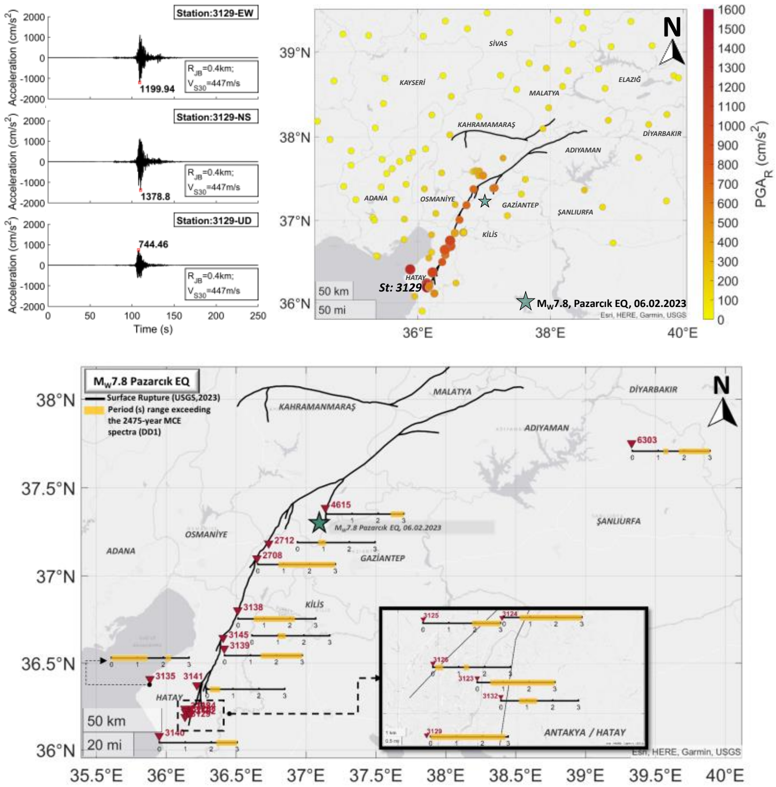

Figure 1. (top) Geographic distribution of resultant peak ground accelerations (PGA_Rs) with respect for M_W7.8 Pazarcık event (bottom) Geographic distribution of stations with period ranges of exceedances of MCE level design spectra of 2018 Türkiye building earthquake code (TBEC 2018) for M_W7.8 Pazarcık event. (black lines on the maps correspond to the surface rupture given by USGS).

The 5% damped response spectra of several recordings of the Kahramanmaraş earthquake sequence surpass the standard design earthquake (SDE) level (Return period: 475 years) design spectra of TBEC2018, which are commonly used in the construction of regular residential buildings, as well as the design spectra specified in the preceding seismic building code, TBEC2007. Figure 1(bottom) also spatially illustrates the period ranges of exceedances of the maximum considered earthquake (MCE, return period: 2475 years) code spectra for the M_W7.8 event. The 5%-damped spectrum accelerations (SAs) of particularly near-field ground motions surpass the MCE level design spectra of TBEC2018 within a wide range of periods. Station 3129 (Antakya basin station) exhibits the highest SA, achieving 5.0 g around 0.25 s of the period. Similarly, the M_W6.3 event exhibits the highest spectral accelerations in the short-period region (SA≈2.5 g around T=0.5 s). The nearest station (station 4612) of the M_W7.5 Elbistan event also provides the largest spectral accelerations, attaining 1.5 g between 1.0 and 4.0 s. Furthermore, substantial vertical ground motions (PGA_{UD}>1.0g) induce significant vertical SAs that occasionally exceed the vertical design spectrum of TBEC2018, specifically in the near-field region.

Geotechnical Aspects

Landslides and rockfalls were identified in an area around Islahiye. Upstream of Değirmencik, a large landslide had taken place, which blocked the local road as well as a stream that passed through the valley (Figure 2a). A large reservoir had formed behind this landslide, which acted as a natural dam for the blocked stream. Piping was visible through it and the local authorities were alerted to its existence. Between Fevzipasa and Türkbahçe, a landslide initiated on a rock cut had blocked approximately 60m along the rail line (Figure 2b). In the same area, multiple rockfalls were observed, which disrupted electricity, communication, and water lines. An example is shown in Figure 2c, where a large rock hit both an electricity tower and a water line. The fault surface rupture was mapped by the virtual reconnaissance team over a length of about 300km. Surface rupture was investigated by the field team at two locations around Islahiye and in the area of Gölbaşı, Adıyaman. Around Islahiye, the surface rupture was mapped both on the plains, as a continuous rupture and on a hill, where multiple parallel features were observed (e.g. Figure 2d). In Gölbaşı, Adıyaman, surface rupture features were observed within the town, where they interacted with shallow-founded structures. When a surface crack interacted with structures with stiff shallow foundations, it was diverted, wrapping around the foundations before continuing (e.g., Figure 2e). When surface cracks met structures with a weak foundation that could not provide a sufficient kinematic constraint, they continued through the structure, imposing differential displacements and causing structural damage (e.g., Figure 2f).

Figure 2. Geotechnical observations from the EEFIT mission (a) Landslide upstream of Değirmencik, (b) Landslide north of Türkbahçe blocking the rail line (c) Rockfall north of Türkbahçe hitting both an electricity tower and a water line (d) Surface rupture on a hill (e) Interaction of surface crack with a stiff, strong foundation (f) Interaction of surface crack with a weak foundation (g) İskenderun Anıt Meydanı square subsidence (h) Lateral spreading at the school of Demirköprü (i) Shallow-founded structure at an area of liquefaction (j) Building with a shallow foundation and high aspect ratio in Gölbaşı (k) Building with a shallow foundation and low aspect ratio in Gölbaşı, and (l) Embankment failure close to Çöçelli

Liquefaction was identified in three main locations visited: the seafront of Iskenderun, around the Orontes River to the northeast of Antakya, and in the town of Gölbaşı, Adıyaman. The soil surface around the seafront of İskenderun, an area that is largely reclaimed, displayed several signs of liquefaction. The seawalls moved towards the sea, a settlement was observed behind them and ejected sandy material was visible at some locations in close proximity. Cracks related to lateral spreading were visible all along the inspected waterfront. Cumulative displacements of more than 40cm towards the sea were measured at multiple locations. Extensive subsidence was observed along Atatürk Boulevard in the districts of Yenişehir and Çay, large parts of which were underwater at the time of inspection (e.g., Figure 2g). Manholes were observed to “float” relative to their surrounding pavement, which had subsided. Finally, liquefaction-related settlement of structures was observed to the south of Atatürk Boulevard in the Çay district. Multiple locations of liquefaction manifestation were identified along the Orontes River. In Demirköprü, lateral spreading was observed along the river (e.g., Figure 2h). Structures with shallow foundations within the zone that liquefied and moved towards the river suffered excessive settlement and rotation. An example is shown in Figure 2i, where the depicted structure settled by 180cm and accumulated a rotation of 14^{o}. Finally, a plethora of structures affected by liquefaction were inspected in Gölbaşı. Most of the affected structures were founded on stiff raft foundations. Structural damage was limited, indicating a rigid-body-like response, which was facilitated by the raft foundations. Many structures experienced more than 1m of settlement. Structures with a high aspect ratio (height of structure over the width of the foundation's narrowest dimension) exhibited significant tilting (e.g., Figure 2j), while structures with a lower aspect ratio settled but exhibited limited tilting (e.g., Figure 2k). Bridges and approach structures were also inspected. Bridges along the Orontes and Karasu rivers displayed damage due to the spreading of the banks, leading to abutments rotating and piers tilting and forming plastic hinges at their connections with foundations. An approach structure close to Çöçelli village was also visited, which was founded on soft clay and suffered a major slope stability failure (Figure 2l).

Structures

According to the building inventory in the area, 47% of the buildings were built post-2000, 40% were constructed between 1980-2000, and 9% are of unknown construction date. The load-bearing system of 87% of these structures is reinforced concrete (RC), 4% is prefabricated, 3% is masonry, and 2% is steel. No information is available for the structural system of the remaining 4% (SBB, 2023). Buildings constructed before 2000 were built without compliance with supplementary regulations such as "TS500 Requirements for Design and Construction of Reinforced Concrete Structures" and "4708 Building Inspection", which include measures to increase the seismic resistance of structures, through improved adhesion of concrete and steel or better-controlled construction processes. Following particularly the Marmara earthquakes in 1999, the Turkish Building Earthquake Code was extensively revised based on risk and hazard studies, soil surveys, and structural analysis methods. However, the success of the recently published 2018 code (TBEC 2018) is not easy to be tested on the ground as the existing building stock in the affected areas was primarily designed following 1975, 1998, and 2007 regulations.

Before the field mission, (social) media and other web-based data sources and remote sensing products were used to gather preliminary information and effectively plan site visits. As part of the pre-fieldwork studies, the EEFIT team also assessed the damage dataset provided by Türkiye's Ministry of Environment, Urbanisation, and Climate Change (TMoEUCC). This extensive undertaking involved a team of over 7,000 experts, primarily comprising the ministry's technical staff, engineers representing vocational chambers, and academics. The Ministry's public dataset, accessed through hasartespit.csb.gov.tr, was last updated on March 1, 2023. Figure 3 illustrates the damage state per province, involving a total of over 1.28M buildings. Hatay, Kahramanmaraş, Adıyaman, and Elazığ were provinces with the highest proportion of collapses and heavy damage. Considering the seismotectonic characteristics of the sequence, it is seen that the structural damage was concentrated within/around the fault ruptures of the two MW7+ events.

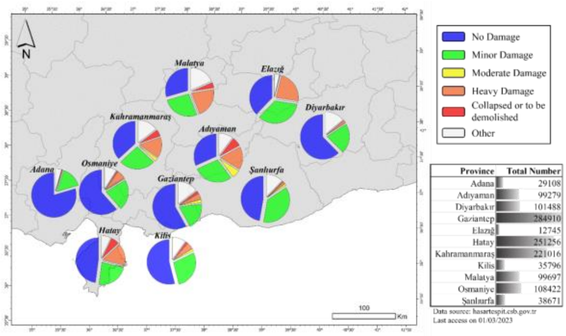

Figure 3. Distribution of damage in the 11 provinces within the disaster region as per the damage assessment data by the TMoEUCC as of 1 March.

The fieldwork lasted for one week, and the EEFIT team strategically covered a large area from the Samandağ region south of Antakya to the Göksun-Afşin-Elbistan arc north of Kahramanmaraş. During the EEFIT mission, a comprehensive assessment was undertaken to identify the primary typologies of structures and their corresponding deficiencies. The mission's objective was to emphasise the significant shortcomings and types of failures observed in these structures.

RC buildings: RC structures constituted the majority of the building stock in the affected area, and issues such as inadequate engineering services, poor workmanship, lack of inspection, and zoning amnesties have made pre-2000 RC buildings the most vulnerable group in the building stock. Consequently, these buildings suffered from problems such as inadequate reinforcement, abnormal granulometry in concrete, design issues like short column effects, soft/weak stories, pounding effects, and soil-structure problems (Figure 4).

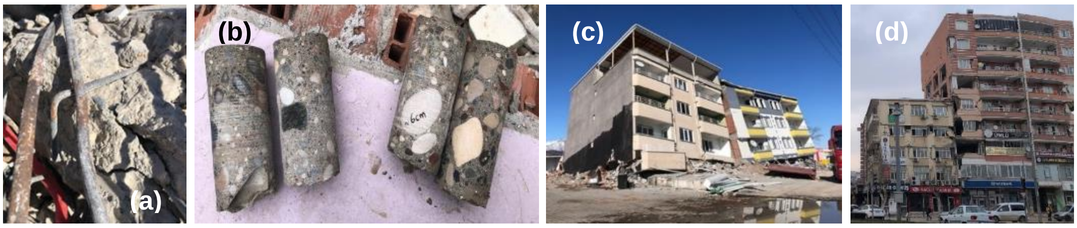

Figure 4. Damage representations from the earthquake-affected cities (a) Plain round rebars and 90° hooks at the end of stirrups, (b) Abnormal granulometry, (c) Soft/weak story, and (d) Pounding effects

<u>*Traditional Buildings:*</u> Traditional buildings typically have 1-3 stories and can be classified into three categories: (1) Unreinforced Masonry load-bearing walls (URM), (2) Timber reinforced masonry; and (3) *Hımış*, a hybrid typology combining masonry ground floor, and wooden framed upper floors with masonry infill or cladding (Aktas, 2017). In big cities, these typologies are more often built with cut or irregular stones using lime mortar, while villages commonly used earth blocks and local stones with mud mortar. Many village houses lack regular maintenance. They exhibit a wide range of flooring options, including timber flooring, masonry vaults, and reinforced concrete (RC) slabs, and supported by steel I beams. One of the major failures observed in URM is the loss of integrity in the wall leaf composed of irregular stones. These issues can lead to various types of failures, which include roof collapse, localised out-of-plane (OOP) failure of individual spandrels and piers, global OOP failure of entire façade, failure at corners, separation of quoins that are unable to strengthen the connections between walls and failure of the gable. Alterations, such as adding extra floors or replacing original floors with heavier RC slabs, were observed to result in failures of entire floors or roofs, as evidenced by on-site observations. Pounding is commonly observed in traditional structures with varying heights, constructed using different structural systems, and at different times (Figure 5).

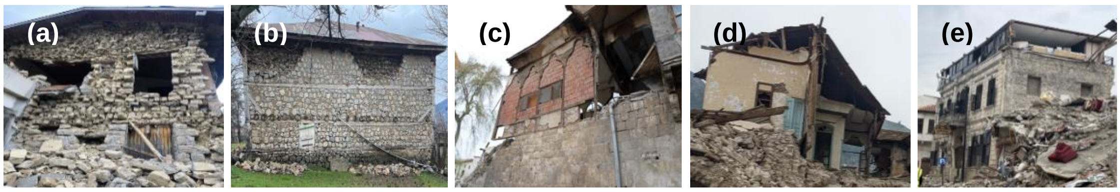

Figure 5: (a) URM (separation wall-leaf); (b) timber reinforced stone masonry (arch failure); (c) Hımış (OOP of bearing wall), (d) gable failure, and (e) addition of a storey

Figure 6: Examples of non-engineered buildings

<u>*Modern Non-Engineered Buildings*</u>*:* In villages, there is a prevalence of non-engineered 1/2-storey buildings made of RC. These isolated structures have demonstrated satisfactory performance during seismic events due to their low rise and lack of attachments to other buildings. In addition, there is a notable prevalence of hybrid systems in villages, which are built with a variety of materials like adobe, clay bricks, stone, and different structural systems such as RC frames and URM load-bearing walls (Figure 6). These constructions often lack engineered design, resulting in irregular structural systems with discontinuous beams and columns that disrupt the regularity of the structure and introduce complexity. Current building codes are insufficient for evaluating non-engineered and hybrid structures, hindering earthquake resistance assessment.

<u>*Monumental Buildings*</u>*:* Southeastern Türkiye has a rich history, hence a multi-layered historic built environment with Hellenistic, Eastern Roman and Ottoman components. The types of

monumental structures for which damage was assessed by the EEFIT team during field deployments can be categorized as mosques - and minarets, i.e. slender tower-like structures - churches, and public and private buildings. The focus areas were decided considering not only the preliminary remote research but also the distance of these historic centres to the ruptured fault during the M_W7.8 earthquake. Following the traces of the fault, Hatay (particularly Antakya, İskenderun, Samandağ, Altınözü districts), Kahramanmaraş and Osmaniye were found to have suffered from extensive levels of damage reaching partial/total collapse cases. In addition to damage surveys, a further data collection campaign including laser scanning, photogrammetry, and non-destructive material testing was implemented on 31 monumental structures. The most common structural system in the evaluated historical stock was multi-leaf load-bearing rubble masonry, where the lack of evidence of proper bonding between multiple leaves was a common agent of vulnerability. The cumulative impact of the earthquake sequence was reflected in many monumental structures in Hatay districts (Samandağ, Altınözü and Antakya). The M_W6.3 shock on February 20, the epicentre of which is very close to the mentioned three districts, increased the damage levels through component(s)-level failures of vaults, arches or side walls.

Retrofitted Buildings: Although many buildings collapsed or sustained significant damage during the earthquake, there were also buildings that performed well compared to regular structures. For example, retrofitted buildings and those constructed by TOKI (governmental mass housing management unit) exhibited satisfactory performance and life safety levels. During our field mission, we visited some of these buildings and investigated the effectiveness of various strengthening techniques, including carbon-fiber reinforced polymer, shear walls, and masonry infills. These retrofit methods demonstrated that even with affordable techniques, buildings that do not meet code criteria can be significantly improved and collapse prevention can be achieved. Additionally, TOKI buildings, which constitute approximately 3-5% of residential buildings, achieved operational or immediate occupancy performance levels due to their high percentage of shear walls. Our observations showed that these buildings sustained mostly non-structural or minimal structural damage and remained occupiable after the earthquake sequence (Figure 7).

Figure 7: (a) 3-building complex before (b) and after the earthquake); (c) Masonry building with carbon-fibre-reinforced polymer retrofit; (d) TOKI building with minor damage.

Healthcare and Educational Infrastructure

According to the initial assessment made by the Ministry of Health and the World Health Organisation, a quarter of the hospitals in the 11 affected provinces were severely or moderately damaged, while 15% of primary healthcare facilities (236 facilities in total) were inoperable following the events. In the most affected districts of four provinces (Hatay, Adıyaman, Kahramanmaraşh and Malatya), more than 40% of district Health Directorates, more than 70% of family health centres, and 50% of migrant health centres were damaged. The operation of some of the hospitals was temporarily interrupted due to the disruptions in the utility lines, and the lack of running water or electricity. The EEFIT team inspected 14 hospital buildings, of which 3 were constructed after 2013 and were built on base isolators and were fully operational. 3 of the visited buildings have collapsed, and 6 had experienced none to minor structural damages but were closed due to severe non-structural losses and 1 was temporarily replaced with a field hospital.

Currently, there are about 56,000 educational institutions under the Ministry of National Education (MoNE), 21% of which are located in the 11 provinces affected by the earthquakes. These include kindergartens (1168), primary schools (5298), secondary schools (3221), high schools (1494), teachers' guest houses (101), public education centres (132), vocational education centres (47) and special education schools (244). Adana, Diyarbakır, Gaziantep, Hatay and Şanlıurfa have recorded student populations of more than 500,000, while others have 50,000 to 350,000 students in the schools. Additionally, there are 5024 private schools and 16 universities in the affected region. As of early March 2023, damage assessment of about 40% of MoNE schools was completed by the authorities, of which 4725 buildings did not have any damage. Each building had on average 9 classrooms, thus affecting more than 38,820 classrooms in various degrees of damage. 2.5% of the private schools and all the universities in the region were also inspected and found to suffer varying levels of damage. At least 41 private schools and 120 university buildings were either collapsed or severely damaged, while the remaining inspected buildings were moderately or lightly damaged.

Remote Sensing

The data collected through remote sensing techniques can provide critical information to ground-based teams, helping them to prioritize their efforts and make informed decisions about where to focus their attention. The use of RS techniques in post-earthquake reconnaissance missions is important because it allows for a rapid response to the disaster. In the aftermath of an earthquake, time is of the essence, and ground-based teams may not have the capacity to cover the entire affected area. RS data can help to fill in these gaps, providing a more comprehensive understanding of the damage caused by the earthquake. The main goal of the RS Team of the EEFIT mission was therefore twofold: Assist ground-based teams in choosing areas of interest (AOI) and where to conduct field surveys, and develop a framework to characterize and validate RS approaches, methodologies and dataset to assist post-earthquake reconnaissance missions. These two objectives were complemented by four main activities including: (1) create a database of damage products produced by different scientists and institutions; (2) produce actionable descriptive products that could guide ground-based teams including building count, area, height per province district; (3) identify existing satellites acquiring optical, lidar, radar dataset over identified AOI, and (4) connect with private satellite vendor to acquire data while the ground-based mission was ongoing.

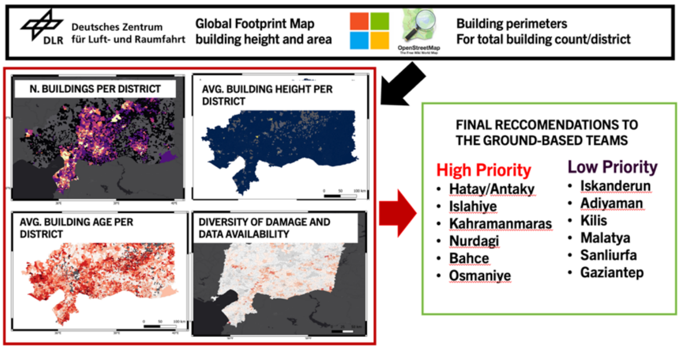

Figure 8. Actionable products generated for delineating the top six high and low priority areas for the EEFIT Türkiye remote sensing mission.

The activities of the RS team resulted in the identification of six high-priority areas where a variety of buildings are located and are highly diversified by height, building age and spaceborne damage maps (Figure 8). These six high-priority AOIs are: Hatay/Antakya, Islahiye, Kahramanmaraş, Nurdağı, Bahçe, and Osmaniye. Additionally, the team was asked to produce a list of six low-priority AOI that presented a lower diversity of damage and building characteristics. These low-priority AOIs are located close to the six high-priority areas and could simplify the logistics of the ground-based team.

We collected datasets from various online sources, including GitHub, AWS, Google, and relevant websites. The task required considerable effort and time to browse and identify necessary data such as damage maps analyzed for different districts in Türkiye. The challenge involved the scattered and unstandardized format of the data and the need to ensure its relevance and up-to-date nature by verifying sources and checking for updates. To disseminate the collected data effectively, we categorized and sorted it for easy access and utilization by the team members. We created a timeline of data by analyzing pre- and post-earthquake sources and news articles related to the earthquake. The reliability and accuracy of the data collected were critical to the decision-making process related to relief and recovery efforts as well as informing future earthquake response efforts. The lessons learned include that the use of remote sensing techniques and datasets available from the international scientific and engineering community plays an essential role in the collection and organization of relevant data required for post-earthquake reconnaissance missions. It facilitates the streamlining of information and data management processes, enabling the team to make informed decisions that guide reconnaissance efforts while informing future response efforts.

Relief, Response, Recovery

Immediately after the earthquake, search and rescue personnel were deployed in the affected areas from the Turkish government, international SAR teams, NGOs and volunteers from the locality. As per the SBB report (March 2023), a total of 271,060 SAR personnel from all such categories were deployed, along with 18,048 heavy machines, 75 aircrafts, and 108 helicopters. A state of emergency was declared for 3 months from 8 February. Fire stations responded in the first 24hrs. In Iskenderun alone, they saved 300 people and attended several local and large fires in the port, but they were inadequate for the scale of the event, as they lacked instruments and suffered damage themselves. There were concerns about the unequal distribution of emergency response, due to various reasons, including the immense geographic scale of destruction. In general, the northern regions such as Kahramanmaraş and Gaziantep, received quicker support in the early days, while Southern regions, especially Antakya in Hatay received help with search and rescue much later, with formal help arriving on the 3rd day. People took their own search and rescue initiatives. Coordination of the general public and other S&R teams with the formal agency, AFAD was often difficult. More than 40 countries sent S&R teams in the early days, among them at least 11 teams with S&R dogs.

The Disaster and Emergency Management Organisation of the Ministry of Interior, known as AFAD, has responsibility for coordination of a wide remit of activities for disaster response and relief. This coupled with the intensity of the damage over a wide geographical region and subsequent impacts on people and workers made providing relief challenging. The numbers of people affected are very large; as of mid-March 2023, a total 1.4 million had been sheltered in tents provided by AFAD, with an additional 1.5 million estimated to have been sheltered in accommodation provided privately or by other organisations, and 1.5 million estimated to have left the earthquake area. This equates to almost one-third of the total 14 million population of the affected provinces that required relief assistance.

When we visited five weeks after the earthquakes, access to relief supplies was a continuing issue. While tent camps appeared better organised and supplied in larger towns, in some smaller towns, people still lacked tents. A network of community soup kitchens had been set up in across the region, and at the height of the relief phase, there were more than 500 kitchens operating in the earthquake-affected areas to feed both survivors and volunteers. We noted many earthquake-affected people were stressed by not having adequate access to basic goods, and this was especially acute for water. Even soup kitchens had to scale back their activities due to lack of clean water. AFAD’s policy was that unless people were considered vulnerable, they would need to move into the tent camps to receive shelter. People who did not wish to live in the tent camps were more prone to being left out of the relief distribution system.

Out of the approximately 14 million people who live in the 11 provinces affected by the earthquakes, over 1.7 million people were Syrian refugees. The close proximity of this region to the Syrian border, meant that the earthquake-affected region was home to over half of all the Syrian refugees living in Türkiye. We observed that Syrian refugees were generally being supported through other networks outside of the AFAD system, including international organisations and NGOs. These organisations were responsible for ‘informal settlements’ of tents, which were often occupied by Syrian refugees or undocumented people. We witnessed that the situation of Syrian families was worse, as they had less access to well organised distribution of relief supplies, food, and their living environments were poorer.

The earthquakes precipitated a huge out-migration from the worst affected areas. As mentioned above, is estimated that 1.5 million people left the affected provinces and mostly travelled west. The main receiving cities are Antalya, Ankara and Mersin, although an influx of migrants was seen across all provinces in the country. The government assisted people to leave the affected areas with free transport in the days following the earthquake and receiving cities have also provided relief support. Families have access to rental support for one year (3000TL/month (£120) for tenants and 5000TL/month (£200) for owners), however, due to rent inflation, many people have struggled to afford to stay in private rented accommodation. The number of people returning to the earthquake-affected provinces has increased in the month following the earthquakes and AFAD is supporting their return with free transport and relief, including container housing. Many people also migrated within the earthquake area, leaving the worst affected cities for rural areas.

For example, we met many people in the villages of Northern Kahramanmaraş who had left the big cities after the earthquakes in search of safe shelter and better living conditions. Syrian refugees, who are normally mandated to stay in the provinces where they are registered were given temporary legal rights to migrate after the earthquakes. Mersin reportedly received 50,000 Syrian migrants in the days following the earthquakes.

The early stages of the recovery operations are currently underway, including debris removal and planning of reconstruction. It is estimated that 252,000 buildings need to be demolished. Currently, the debris is being transported to areas on the peripheries of the cities. There are concerns about the environmental impacts of the debris, as hazardous waste is not being separated, many of the sites are in environmentally sensitive agricultural areas and there is a lack of personal protection for workers and those nearby. Some permanent housing reconstruction has been initiated. The chamber of architects is arguing for reconstruction within the existing built-up areas. Some design ideas for the reconstruction of Antakya’s old town have also been unveiled by the government in a high-profile event in Istanbul, however this has been criticised for lacking local voices. Most of Antakya needs to be rebuilt and this is an important project that requires input from stakeholders.

Key Messages

The February 2023 Kahramanmaraş earthquake sequence was an exceptional series of events that caused immense devastation in 11 cities and the highest death toll due to an earthquake in Turkey. Significant reductions in these could have been made if a higher portion of the building stock was code compliant and land use was better controlled through proper auditing and quality control mechanisms embedded in the construction sector. Furthermore, a remarkable portion of the building stock in the affected areas is characterised by non-engineered, rather hard-to-categorise, buildings. This requires a rather specialised approach to seismic performance assessment. Given the sheer scale of the devastation, it is clear that the recovery will require time, effort and strong institutional collaboration. We advocate that the recovery and reconstruction processes are not centrally dictated but steered with participation from the affected communities and key local stakeholders. This is key to ensuring a more sustainable outcome and sufficient impact on policies and practices against future earthquakes (Platt and So, 2016).

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