Responses to RC4

We thank the reviewer for a detailed and constructive review. All corrections and modifications made in response to this review are highlighted in blue in the revised manuscript file. For several comments requiring additional data, co-author confirmation, or original source files (Comments 1, 4, 11, 13, 14, 17), we describe below precisely what has been completed and what remains in progress, rather than presenting provisional or unconfirmed material as final.

Comment 1: The readability and resolution of the figures need to be improved.

Response 1: We have re-exported and replaced all figures containing field photographs and maps at substantially higher resolution, verified by effective print DPI at their displayed size in the manuscript. Maps: Figure 1 (150→~733 DPI), Figure 2 (193→~733 DPI), Figure 10 (→469 DPI). Structural damage photographs: Figure 3 (165–189→sharp), Figure 4 (220→~1097 DPI), Figure 5 (220→303 DPI), Figure 6 (220→~762 DPI), Figure 7 (220→346 DPI), Figure 8 (220→366 DPI), Figure 9 (220→469 DPI), Figure 11 (150–177→~249 DPI). Geotechnical section: Figure 12 (194→228 DPI), Figure 13 (150–195→381 DPI), Figure 14 (220→270 DPI), Figure 15 (150→392 DPI), Figure 16 (150→834 DPI). All 16 figures in the manuscript are now above, at, or substantially closer to the 300 DPI print standard, verified by re-rendering the manuscript to PDF after each replacement.

Comment 2: The abstract should be rewritten to better represent this study, rather than simply detailing the research conducted on this earthquake.

Response 2: We agree, and have replaced the original Abstract with a revised version that leads with the study's integrative contribution rather than opening with earthquake description alone: "This study presents a field-based, multi-disciplinary assessment of reinforced concrete (RC) building performance following the February 6, 2023, Kahramanmaraş earthquake doublet, integrating structural damage mechanisms, geotechnical conditions, and code-compliance evaluation across eleven affected provinces. Unlike prior reconnaissance studies that treat these dimensions separately, this work systematically links recorded near-fault ground-motion demand — which locally exceeded the design spectra of the Turkish Building Earthquake Code (TBEC-2018) — to observed damage patterns in both older and current code-era buildings. Damage in older buildings remained governed by well-documented deficiencies (inadequate detailing, poor material quality, soft-story and torsional irregularities), whereas damage in newer, code-compliant buildings appears more closely related to system-level shortcomings such as insufficient shear-wall ratios and construction-quality gaps. Geotechnical effects — including liquefaction, lateral spreading, and differential settlement — further modulated damage severity independently of superstructure design. These results demonstrate that code compliance alone does not guarantee satisfactory seismic performance under extreme near-fault demand, underscoring the need for integrated design, construction-supervision, and site-assessment frameworks to improve earthquake resilience in Türkiye."

Comment 3: In the introduction, it will be useful to highlight the importance and necessity of the study, especially in light of the destructive impact of seismic activity and the devastating earthquakes that have occurred worldwide. In order to reveal the importance of the study, it would be useful to add the effects of the major destructive earthquakes that have occurred in the world in recent years on the structures to the beginning of the introduction section. Thus, the importance of the study can be revealed more clearly.

Response 3: We have added the following as the opening paragraph of the Introduction: "Destructive earthquakes around the world — including the 1999 İzmit earthquake in Türkiye, the 1995 Kobe earthquake in Japan, the 2004 Indian Ocean earthquake off the coast of Sumatra, Indonesia, the 2010 Haiti earthquake, and the 2011 Tohoku earthquake in Japan — have repeatedly demonstrated that reinforced concrete (RC) building stock remains highly vulnerable to strong ground shaking, even as seismic design codes and construction practices continue to evolve. Post-earthquake field reconnaissance following such events has played a central role in translating observed structural performance into improved design provisions and construction-quality standards worldwide. The earthquake continues to be a current issue with its active and destructive impact worldwide. For example, on August 10, 2026, a 7.4-magnitude earthquake occurred in the Chocó region of Colombia. As of August 17, 2026, according to updated figures published by the United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA), the disaster had directly affected 186,182 people in 121,470 families, with a reported death toll of 304 and 26,558 houses destroyed (UN OCHA, 2026)." The Colombia figures were verified against the UN OCHA Flash Update of 17 August 2026 prior to inclusion, and a corresponding reference entry was added to the bibliography.

Comment 4: It is important to include current literature in the article, taking into account the main topics considered in this study. In this way, the novelty/difference of your study can be more clearly demonstrated. For example, there are numerous recent studies that examine in detail the damage occurring in reinforced concrete structures (Hatay, Adıyaman, Kahramanmaraş, Malatya, Gaziantep, Adana, Gölbaşı, Elbistan, Pazarcık etc.). There are also many current studies comparing ground motion characteristics and PGA values, and their effects on target displacements in RC structures. And there are many studies that have been done using building examples in the field. The majority of the references considered in this study belong to the authors. The self-citation rate should be checked.

Response 4: We thank the reviewer for raising this point directly. Regarding the specific, checkable part of this comment, we identified and corrected a duplicate reference: "Onat et al., 2026a" and "Onat et al., 2026b" were in fact two entries for the same publication (Buildings 16(5): 1012). We have merged them into a single reference (2026a) and updated both in-text citations accordingly. On the broader self-citation rate: of the 50 references in the current bibliography, 11 have a co-author of this manuscript as an author, giving a self-citation rate of 22.0%, down from 33.3% (11 of 33) before this revision round. We have added twelve independent references to the Discussion, directly addressing the topics the reviewer named and broadening the international comparative scope of the paper: Chen et al. (2025, npj Natural Hazards), an independent fragility-based analysis of building damage across all 11 affected provinces; Işık et al. (2025b, Applied Sciences), an independent province-level comparison of PGA and target displacements — directly matching the reviewer's request for target-displacement studies; Nayir et al. (2026, Natural Hazards), an independent material-quality investigation of 400 collapsed RC buildings across Kahramanmaraş, Adıyaman, Hatay, and Gaziantep; Zhao et al. (2026, Buildings), linking our design-spectrum-exceedance finding to ASCE 7-22 and Eurocode 8 code evolutions; Galvis et al. (2020, Earthquake Spectra) and Villalobos et al. (2018, Earthquake Spectra), on the 2017 Puebla-Morelos (Mexico) and 2016 Ecuador earthquakes respectively; Sarrafzadeh et al. (2017, Bulletin of the New Zealand Society for Earthquake Engineering), on the 2016 Kumamoto earthquakes; Sharma et al. (2016, Engineering Structures), on the 2015 Gorkha (Nepal) earthquake; Kam et al. (2011, Bulletin of the New Zealand Society for Earthquake Engineering), on the 2011 Christchurch earthquake; Ricci et al. (2011, Bulletin of Earthquake Engineering), on the 2009 L'Aquila (Italy) earthquake; Zhou et al. (2013, Bulletin of Earthquake Engineering), on the 2008 Wenchuan (China) earthquake, whose vulnerability index was itself calibrated using Turkish earthquake damage data; and O'Brien et al. (2011, Earthquake Spectra), on the 2010 Haiti earthquake, which found an even higher frequency of severe RC damage than had been observed in comparable Turkish earthquakes. Together these additions situate the present study's findings within a substantially broader international evidence base spanning nine earthquakes across eight countries. We remain open to identifying further independent references (particularly further Adana, Gölbaşı, Elbistan, and Pazarcık case studies) should the reviewer feel additional reduction in the self-citation rate is needed.

Comment 5: A very large portion of the introduction needs to be moved to section 2.1. Therefore, the introduction needs to be completely redesigned.

Response 5: We have relocated the tectonic-setting and fault-rupture description, together with Figure 1 (epicenter/fault map) and Figure 2 (affected-area map), from the Introduction to the beginning of Section

2.1 (Study area and earthquake features), where they now open that section. A single bridging sentence in the Introduction now directs the reader to Section 2.1: "The tectonic setting, fault-rupture geometry, and territorial extent of the sequence are described in Section 2.1 (Figure 1)." The remainder of the Introduction (literature review, research gap, problem definition, study stages, and novelty statement) has been retained, restructured, and expanded as described in our responses to Comments 3, 6, 7, and 8.

Comment 6: The introduction should include a definition of the problem and a description of the direct and indirect studies conducted on this topic.

Response 6: We have added the following problem-definition paragraph to the Introduction: "The central engineering problem motivating this study is that reinforced concrete building performance during the Kahramanmaraş sequence cannot be reliably explained by any single factor — neither by ground-motion intensity alone, nor by construction period alone, nor by site conditions alone. Existing post-earthquake studies have typically examined structural damage, geotechnical effects, or code compliance as separate, direct lines of inquiry (see Section 5 for a detailed discussion of this literature); comparatively fewer have combined these dimensions within a single field-based framework applied consistently across a large, multi-provincial dataset. This gap in integrated, field-verified evidence is the specific problem this study addresses."

Comment 7: The stages of the study should be added in detail at the end of the introduction.

Response 7: We have added the following paragraph at the end of the Introduction: "The remainder of this study is organized as follows. Section 2 describes the study area, the ground-motion and demand evaluation procedure, the field survey strategy, and the damage classification framework used to structure the comparison between older and current code-era buildings. Section 3 presents the recorded ground-motion characteristics together with the observed structural damage patterns. Section 4 reports the geotechnical field observations and their influence on damage distribution. Section 5 discusses these findings jointly and situates them within the broader post-earthquake reconnaissance literature, and Section 6 concludes with the study's main engineering and policy implications."

Comment 8: There are many studies on the Kahramanmaraş earthquakes. Please add a comparative analysis of how your study differs/is novel compared to other studies at the end of the introduction.

Response 8: We have added the following paragraph: "Numerous valuable reconnaissance studies have already documented individual damage mechanisms from the Kahramanmaraş sequence — including column and soft-story failures (Sezgin et al., 2024; Ince, 2024), near-fault ground-motion effects on specific collapsed structures (Kazaz et al., 2024b; Tura et al., 2024), and design-code implications (Erbaş et al., 2025; Vuran et al., 2024). What distinguishes the present study is not the identification of new individual failure modes, but the systematic, field-verified integration of structural damage patterns, geotechnical conditions, and code-era classification within a single consistent framework applied across eleven affected provinces — allowing damage in older and current code-era buildings to be compared on a common, regionally consistent basis rather than through isolated case studies."

Comment 9: More theoretical information about the figures should be added, and the results should be included in more detail after the figure.

Response 9: We have added brief theoretical framing directly into the manuscript at three points. Following Figure 4 (Section 3.2): "Mechanistically, a soft story develops when the lateral stiffness of one story is substantially lower than that of adjacent stories, causing seismic drift to concentrate at that level rather than distribute over the building's height; this concentration produces disproportionately large ductility demand on the columns of the flexible story and is a well-established trigger for story-level collapse in RC frames." Before Figure 6: "Torsional response arises when a building's center of mass and center of lateral stiffness are not coincident, producing an eccentricity that generates additional twisting moments under seismic loading; the resulting amplified displacement demand on perimeter columns, illustrated in Figure 6, is a recognized consequence of asymmetric shear-wall or infill-wall placement." Before Figure 12 (Section 4): "Liquefaction-induced bearing-capacity loss occurs when seismic shaking causes a sudden rise in pore-water pressure within loose, saturated, cohesionless soils, temporarily reducing effective stress and shear strength toward zero; once the soil can no longer sustain the foundation load, differential settlement and, in severe cases, progressive rotation and overturning of the superstructure can occur, independent of the building's own structural adequacy." We remain open to adding further framing for additional figures if the reviewer feels specific ones still need it.

Comment 10: 2018 Turkish Seismic Code (TSC-2018). This must be Turkish Building Earthquake Code

Response 10: Corrected. The nomenclature has been updated to "Turkish Building Earthquake Code (TBEC-2018)" wherever it appeared in the manuscript.

Comment 11: This large-scale study conducted in 11 cities lacks precise information on the exact number of buildings examined and the approximate classification of these buildings as new and old. At the very least, a numerical or percentage distribution table should be provided for the buildings examined, categorized by type.

Response 11: We thank the reviewer for this valuable comment; we agree it strengthens the manuscript considerably. We have added the approximate scope of our own field survey (≈4,000 buildings, TÜBİTAK-funded rapid-response project) to Section 2.3. For the numerical/percentage distribution table requested, we did not compile our own field observations into this format during the rapid-response fieldwork, and we are not able to retroactively construct one without overstating what our own records support. Instead, we have added Table 1 to Section 2.3: an official building damage distribution table restricted to the 28 districts across eight provinces in which the co-authors conducted field observations, sourced from Damcı et al. (2025, Journal of Building Engineering), who compiled it from the records of Turkey's Ministry of Environment, Urbanization and Climate Change (hasartespit.csb.gov.tr). This table covers 562,174 officially assessed buildings and is presented explicitly as an independent, literature-sourced statistical complement to our qualitative field survey, not as our own survey sample, so as not to conflate the two.

Comment 12: Figure 3 compares seismic demand with TSC-2018 (Turkish Building Earthquake Code) design spectra. However, the soil classifications (ZA, ZB, ZC, etc.) of the station data (Stations 4614 and 4612) and the seismic distances of the buildings from these stations should be clearly presented in the text and/or on the figure.

Response 12: We have added the following paragraph before Section 3.2, sourced from Boğaziçi University's Kandilli Observatory and Earthquake Research Institute (KOERI/KRDAE) preliminary evaluation report: "According to the preliminary strong-motion evaluation report of Boğaziçi University's Kandilli Observatory and Earthquake Research Institute (KOERI/KRDAE), Station 4612 (Kahramanmaraş–Göksun, shown in Figure 3b) is classified as local soil class ZD (Vs30 = 246 m/s) under TBEC-2018, and its recorded response spectrum for the Mw7.6 Elbistan earthquake exceeded the DD-2 design spectrum across nearly the entire period range. Station 4614, shown in Figure 3a, corresponds to a Vs30 of 671 m/s, placing it in soil class ZC under TBEC-2018." The approximate distance from these stations to the representative building clusters is still being compiled and will be added once verified against our field records.

Comment 13: It should be clearly distinguished which regulatory period "old" buildings belong to (1975, 1998, etc.), and whether "new" buildings are directly subject to the 2018 regulation or the 2007 regulation. Examining the causes of damage according to the regulatory boundary lines will increase academic depth.

Response 13: We agree this would add academic depth. We confirmed with the co-author team that documented construction-year records for the surveyed buildings are not available, so the precise historical code-period boundaries requested (e.g., pre-1975 / 1975-1998 / 1998-2007 / 2007-2018) cannot be assigned to individual surveyed buildings. We have instead clarified in the manuscript that classification is field-assessed rather than record-based, adding the following text: "the 'older' versus 'current code-era' classification used in this study is based on field-assessed structural characteristics consistent with the applicable code era at the time of apparent construction (e.g., presence or absence of shear walls, detailing practices, and other visually identifiable design features associated with pre- and post-TBEC-2018 practice), rather than on documented construction dates. We acknowledge this as a limitation of the classification and note that a subsequent study incorporating verified construction-permit records would allow a more precise, code-period-based comparison." We have identified a follow-up study using verified construction-permit records as the appropriate way to achieve the regulatory-boundary-level analysis the reviewer requests.

Comment 14: In Figure 1, Base map data from (https://tadas.afad.gov.tr) contributors created by Onur Onat is not required. This is already stated in the figure caption.

Response 14: Resolved. The Figure 1 map graphic has been fully replaced with a newly produced, higher-resolution map that does not include this redundant text overlay; the base-map attribution is now retained only in the figure caption, as requested.

Comment 15: The article should include sample size, observation criteria, and evaluation method.

Response 15: We have added the following to Section 2.3: "The field investigation was carried out within the framework of a post-disaster rapid-response project funded by the Scientific and Technological Research Council of Türkiye (TÜBİTAK) following the Kahramanmaraş earthquake sequence of February 6, 2023. Approximately 4,000 buildings were inspected across the most affected provinces. All field data were collected directly by the authors, each with up to 20 years of specialized professional and academic experience in earthquake engineering and structural/geotechnical damage assessment, which supported consistency across observations and reduced inter-investigator variability." As noted in our responses to Comments 11 and 13, a fully itemized, formally logged observation-criteria and evaluation-method protocol beyond what is described in Sections 2.3-2.4 was not maintained during the rapid response fieldwork; we state this explicitly as a limitation in Section 2.6 rather than imply a more formal protocol than was actually followed.

Comment 16: The Discussion and Conclusion sections are largely identical. Please revise them.

Response 16: We agree there is overlap, and we have revised the manuscript accordingly. The opening paragraph of the Conclusion, which previously repeated the interaction narrative already developed in Discussion Section 5.6, has been rewritten to focus instead on concrete, distinct engineering priorities: "For engineering practice, these findings translate into two distinct priorities: for older building stock, systematic seismic retrofit programs targeting well-known detailing and material deficiencies remain essential; for current code-era construction, the priority shifts toward stronger design-stage review of lateral load-resisting system adequacy and stricter construction-site supervision, since code compliance on paper did not, in this dataset, guarantee compliant system-level performance in practice." This removes the direct duplication between the two sections.

Comment 17: The maps need to be improved from an academic perspective; they are too simplistic.

Response 17: Resolved. We have replaced Figures 1, 2, and 10 with newly produced, professional-quality GIS maps including a scale bar, north arrow, coordinate grid, and clearer basemap styling, addressing the concern that the original maps were too simplistic for an academic publication.