Responses to RC2

We thank the reviewer for a thorough and constructive review that has substantially improved the manuscript. All corrections and modifications made in response to this review are highlighted in green in the revised manuscript file.

Comment 1: The manuscript mainly summarizes column failures, soft-story collapse, pounding, torsional effects, liquefaction, settlement, and landslides, all of which have already been extensively documented in previous studies following the 2023 Kahramanmaraş earthquakes. Although the authors repeatedly state that they compare "older" and "newer" buildings, this comparison remains largely qualitative. Therefore, the manuscript should clearly demonstrate what new scientific insights this study provides beyond the existing post-earthquake reconnaissance literature. At present, this aspect is not sufficiently addressed.

Response 1: We thank the reviewer for this important comment. We have added the following paragraph at the end of the Introduction: "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." We acknowledge that this comparison remains qualitative rather than statistical in the present version; we address this directly in our response to Comment 4 below.

Comment 2: The Methods section is insufficiently detailed. Although the authors mention conducting field surveys, they do not provide essential methodological information, such as the number of inspected buildings, selection criteria, survey dates, inspection protocol, building age classification, damage classification criteria, sampling strategy, inter-investigator consistency, or uncertainty assessment. Without these details, the study cannot be reproduced or its robustness adequately evaluated.

Response 2: We agree. We have added the following to Section 2.3 (Field survey strategy): "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." A fully itemized sampling protocol (formal selection criteria, exact survey dates per province, and a quantitative inter-investigator agreement assessment) was not implemented as a formal protocol during the rapid-response fieldwork; we state this transparently as a scope limitation in Section 2.6 rather than retrofit an implied protocol that was not actually followed. Immediately following this paragraph, we have also added Table 1, an official district-level building damage distribution sourced from Damcı et al. (2025), which provides additional quantitative context for the damage classification criteria used in this study (see our response to Comment 4 for details).

Comment 3: Throughout the manuscript, the authors use terms such as older buildings, newer buildings, and code-era buildings without providing clear definitions. The criteria used to distinguish these categories should be explicitly stated. For example, which construction years define each category? Which version of the Turkish Seismic Code applies to each group? Are these classifications based on construction records, occupancy permits, or field estimates? Without objective and reproducible definitions, the comparison between building categories remains subjective.

Response 3: We have added the following explicit definition: "In this study, 'code-era' refers specifically to buildings designed and constructed in compliance with the current Turkish Building Earthquake Code (TBEC-2018)." We confirmed with the co-author team that documented construction-year or occupancy-permit records were not available for the surveyed buildings. We have therefore added the following clarification to the manuscript: "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."

Comment 4: Nearly all conclusions are descriptive and lack quantitative support. The manuscript would be considerably strengthened by including quantitative analyses, such as the percentage of buildings exhibiting each failure mode, the frequency of soft-story failures, the proportion of damaged newer versus older buildings, statistical comparisons, GIS-based spatial analyses, the relationship between damage and site class, correlations with PGA and PGV, and the relationship between damage and distance from the fault. At present, the conclusions are not sufficiently supported by quantitative or statistical evidence.

Response 4: We thank the reviewer for this valuable suggestion and agree that such quantitative and statistical analyses would substantially strengthen the study's conclusions. As stated in Section 2.6 (Methodological scope and Limitations), the present study was designed and executed as a qualitative, field-based reconnaissance effort, and we do not hold a validated, building-by-building quantitative dataset of our own that would support statistically defensible claims of the kind requested (e.g., failure-mode percentages, PGA/PGV correlations tied to individual buildings). Rather than retrofit such analysis from incomplete records, we have (i) revised the Abstract, Section 3.3, and Conclusion to use appropriately qualified language rather than causal claims (see our response to Comment 7), (ii) made the qualitative scope of the study explicit and prominent via a new Conclusion bullet point, and (iii) added Table 1 to Section 2.3: an official, literature-sourced building damage distribution table (Damcı et al., 2025, Journal of Building Engineering, compiled from Turkey's Ministry of Environment, Urbanization and Climate Change records) covering 562,174 officially assessed buildings across the 28 districts in which the co-authors conducted field observations. This table is presented as an independent statistical complement to our qualitative survey, not as our own dataset, and provides the district- and province-level quantitative context that GIS-based or percentage-based analysis at the individual-building level cannot yet offer from our own records.

Comment 5: Section 3.1 discusses the recorded response spectra; however, the manuscript does not establish a clear link between the observed building damage and the corresponding nearby strong-motion stations. This weakens the interpretation of the observed damage mechanisms. The discussion would be considerably strengthened by relating each representative building (or study area) to the nearest strong-motion station, together with the corresponding spectral demand, PGA/PGV values, and the observed failure mechanisms.

Response 5: We agree that this linkage would strengthen the manuscript considerably. We confirmed with the co-author team that station-to-building distances for the representative case-study buildings were not systematically compiled during the rapid-response fieldwork and are not available for this study. We have therefore added the following statement to Section 2.6 (Limitations): "station-to-building distances for the representative case-study buildings and precise construction-year records for the surveyed building stock were not systematically compiled during the rapid-response fieldwork and are not available for this study;

consequently, damage patterns are discussed by construction era (older versus current code-era) rather than by exact regulatory-period boundaries or station-linked ground-motion demand at the individual-building level." We have, however, added the official soil classifications for the two representative stations shown in Figure 3, sourced from Boğaziçi University's Kandilli Observatory and Earthquake Research Institute (KOERI/KRDAE) preliminary evaluation report: Station 4612 (Kahramanmaraş–Göksun, Figure 3b) is classified as local soil class ZD (Vs30 = 246 m/s) under TBEC-2018, and Station 4614 (Figure 3a) corresponds to a Vs30 of 671 m/s, placing it in soil class ZC — which partially addresses the ground-motion side of this comment.

Comment 6: The geotechnical section is primarily based on field photographs and qualitative observations, while quantitative geotechnical data are largely absent. Essential information, such as borehole logs, groundwater table depth, SPT and CPT data, Vs30 values, soil classification, liquefaction susceptibility analyses, and settlement estimates, is not presented. Without these supporting data, several geotechnical interpretations are insufficiently substantiated and remain largely qualitative.

Response 6: We agree that such quantitative geotechnical parameters are indispensable for detailed characterization and design. Systematic subsurface data (borehole logs, SPT/CPT profiles, Vs30) were not uniformly available across all investigated sites within the scope of this reconnaissance study. We have revised Section 2.6 (Limitations) to state this explicitly, and the geotechnical observations reported (liquefaction, lateral spreading, differential settlement) are presented as field-verified qualitative evidence, with site-specific quantitative geotechnical characterization identified as a priority for follow-up investigation. Where official quantitative data were available, we have added it: Station 4612 (Kahramanmaraş–Göksun) is classified as local soil class ZD (Vs30 = 246 m/s) under TBEC-2018, and Station 4614 corresponds to a Vs30 of 671 m/s (soil class ZC), sourced from Boğaziçi University's Kandilli Observatory and Earthquake Research Institute (KOERI/KRDAE) preliminary evaluation report.

Comment 7: Several statements imply direct cause-and-effect relationships, such as attributing damage to liquefaction or to low shear-wall ratios, without providing sufficient engineering evidence. Field observations alone are generally insufficient to establish causality. The authors should adopt more cautious language throughout the manuscript. For example, expressions such as "may have contributed to" or "is likely associated with" would be more appropriate than definitive statements such as "caused" or "led to."

Response 7: We have revised the identified causal statements throughout the manuscript to use more cautious language. In the Abstract and Section 3.3: "was more closely related to" was changed to "appears more closely related to structural system inadequacy," and "reduced the effectiveness" was changed to "are likely to have reduced the effectiveness" in the sentence on shear-wall ratios and wall distribution. In Section 4 (geotechnical evaluation): "the combined effects of liquefaction and lateral spreading caused severe damage" was changed to "the combined effects of liquefaction and lateral spreading are likely associated with severe damage and, in some cases, collapse."

Comment 8: The discussion mostly repeats observations. A proper discussion should compare findings with previous Kahramanmaraş studies, Christchurch, Kobe, Wenchuan, Türkiye earthquake experience, recent code developments.

Response 8: We agree that broadening the comparative scope of the Discussion would strengthen the manuscript. We have added the following to Section 5.1: "These findings are consistent with the broader international experience of near-fault earthquakes on RC building stock. The 1999 İzmit earthquake in Türkiye similarly exposed widespread detailing and construction-quality deficiencies in pre-code buildings, prompting the successive strengthening of Turkish seismic design provisions that culminated in TBEC-2018; the persistence of system-level vulnerabilities in current code-era buildings observed in the present study suggests that this code-evolution process, while effective at addressing legacy detailing problems, has not yet fully resolved system-level design and construction-quality issues. Similarly, the 1995 Kobe earthquake in Japan demonstrated that even buildings designed under relatively modern seismic codes can sustain severe damage when structural irregularities or construction deficiencies are present, reinforcing the present study's finding that code compliance alone does not guarantee satisfactory performance under extreme near-fault demand. A similar era-dependent shift in vulnerability was documented after the 2017 Puebla-Morelos earthquake in Mexico City, where the large majority of collapsed reinforced concrete buildings were pre-1985 non-ductile construction with soft-story mechanisms, while post-1985, code-era buildings performed comparatively better yet were not immune to collapse. Likewise, the 2016 Ecuador earthquake reconnaissance found that low-rise RC buildings with inadequate wall-and-column index ratios sustained severe structural damage regardless of nominal code compliance, underscoring that system-level proportioning, not code era alone, governs performance under extreme demand." (See also our response to Comment 16 for the two newly added international references.)

Comment 9: The conclusions largely repeat well-known engineering recommendations. The authors should instead summarize new findings, quantitative evidence, engineering implications, limitations.

Response 9: We have added a synthesis paragraph at the start of the Conclusion distinguishing older-building deficiencies from newer-building vulnerabilities, and then revised it further, to avoid duplicating material already developed in Discussion Section 5.6, to focus on concrete 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." We have also added the following new bullet point to the Conclusion to make the study's qualitative scope and limitations more prominent: "This study is based on qualitative field observations rather than a full quantitative damage inventory, material testing, or numerical modeling; the findings should therefore be interpreted within the limits of observational data and complemented by future analytical or quantitative studies."

Comment 10: The abstract claims newer buildings failed mainly because of structural system inadequacy. This statement requires quantitative evidence.

Response 10: We thank the reviewer for this important point, and we withdraw our initial characterization of Figure 9 as providing quantitative evidence. Figure 9 and the accompanying discussion in Section 3.3 present representative field cases rather than a statistical or quantitative comparison; the study's methodology (Section 2.6) is explicitly qualitative and observational in scope. We have accordingly softened the corresponding language in the Abstract and Section 3.3 ("was caused by" → "appears more closely related to," see our response to Comment 7) and made this qualitative scope more prominent in the revised Conclusion. A systematic, statistically supported comparison of failure-mode frequency between older and newer buildings is a valuable direction that we now explicitly identify as a limitation and a target for a dedicated follow-up study (see our response to Comment 4).

Comment 11: The introduction is generally well organized. However, it overemphasizes literature review while insufficiently defining the research gap.

Response 11: We have expanded the research-gap statement into the following dedicated passage: "While extensive studies have evaluated seismic hazard parameters, soil-structure interaction, and building vulnerabilities as individual components, a holistic framework integrating these parameters remains limited. Addressing this gap, this study provides a regional assessment that systematically links site-specific hazard conditions to observed structural failure patterns." We have also added an explicit problem-definition paragraph and a paragraph distinguishing this study from prior Kahramanmaraş-specific literature (see our response to Comment 1), which together make the research gap considerably more prominent.

Comment 12: Figure 2 - The caption contains a grammatical error. "The effected area" should be "The affected area".

Response 12: Corrected as suggested.

Comment 13: Some section titles could be improved. For example, "Geotechnical Evaluation" could become "Influence of Geotechnical Conditions on Observed Damage"

Response 13: We have adopted this suggestion exactly; Section 4's title now reads "Influence of Geotechnical Conditions on Observed Damage."

Comment 14: Several grammatical issues should be corrected. Examples, "the affected area", "missing of an adequate seismic separation gap" → "absence of an adequate seismic separation gap", "low bearing capacity of soil" → "low soil bearing capacity", "inconvenient wall distribution" → "unfavorable wall distribution"

Response 14: All four examples have been corrected exactly as suggested

Comment 15: Figures - The manuscript contains a very large number of photographs. Several figures appear repetitive. The paper would benefit from fewer figures, more interpretation.

Response 15: We agree and have made a concrete reduction rather than deferring this. The former Figure 17 (Rockfalls observed in the investigated areas) was removed: its content was essentially duplicative of Figure 16 (Landslides), as both documented the same underlying phenomenon (loss of soil strength on sloping terrain) at the same investigated locations, and the manuscript text already discussed them jointly in a single sentence. Figure 16 now stands alone to represent both failure modes, and we have added a short interpretive sentence noting that both failure modes were concentrated on the same steep, previously destabilized slopes and compounded the roadway and retaining-wall damage discussed earlier in that section. All subsequent figure numbers were unaffected, as Figure 17 was the last figure in the manuscript. We remain open to consolidating further multi-panel figures if the reviewer identifies additional specific candidates.

Comment 16: The manuscript would benefit from citing additional international post-earthquake reconnaissance studies.

Response 16: We agree and have added two directly relevant international studies to the Discussion (Section 5.1) and reference list: Galvis et al. (2020, Earthquake Spectra), on collapsed RC buildings after the 2017 Puebla-Morelos earthquake in Mexico City, which found an era-dependent shift in vulnerability between pre-1985 and post-1985 construction; and Villalobos et al. (2018, Earthquake Spectra), a damage-assessment survey of low-rise RC buildings after the 2016 Ecuador earthquake, which found severe damage linked to inadequate wall-and-column proportioning independent of nominal code compliance. Both findings reinforce and contextualize the present study's core conclusion regarding system-level vulnerability.