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Building Damage Assessment of the March 2025 Myanmar Earthquake

Manoochehr Shirzaei, Shubham Awasthi, Esther O. Oyedele, Mohammad Khorrami, Nivedita Kamaraj, Susanna Werth, Mir Matin, Kaveh Madani

Executive Summary

1. On March 28, 2025, Myanmar experienced a devastating 7.7 magnitude earthquake centered near the city of Mandalay. This event, which also affected China and Thailand, stands as Myanmar's deadliest earthquake in nearly a century with 3,600-5,350 people dead and over 11,000 indivsiduals injured in Myanmar.
2. Satellite radar data acquired over 7 cities of Mandalay, Pyin Oo Lwin, Madaya, Kyaukse, Sagaing, Shwebo, and Woundwin indicate that over 157,000 buildings were likely damaged due to the earthquake, leaving approximately 200,000 people homeless in Myanmar.
3. The catastrophic loss of life was a direct consequence of the widespread collapse of vulnerable building typologies, such as unreinforced masonry, exacerbated by systemic failures in the enforcement of the Myanmar National Building Code 2016 and the complexities of the ongoing political and security situation.
4. The extensive damage shows that Myanmar's seismic vulnerability is the result of a complex interplay of technical deficits, profound governance challenges impacting enforcement and resource allocation, and socio-economic fragilities that must be addressed holistically.
5. Rapid damage assessment after an earthquake is vital for guiding emergency response and reducing the risk of future disasters. Modern remote sensing technologies and artificial intelligence (AI) play an invaluable role in this regard.

Context

Earthquakes are among the most devastating natural disasters, often causing widespread building collapse, immense human casualties, and economic losses. The collapse of buildings is the main cause of fatalities in earthquakes[1]. On March 28, 2025, a powerful magnitude 7.7 earthquake struck near Mandalay, Myanmar, at a shallow depth of 10 km[2]. This event resulted in widespread devastation across central Myanmar and was felt in neighboring countries, including Thailand and China.

The earthquake severely damaged healthcare infrastructure, destroying at least three hospitals and partially damaging 22 others, including major facilities in Mandalay and Naypyitaw[3]. It also disrupted water infrastructure, leading to widespread shortages of clean drinking water[4] and caused significant damage to the energy infrastructure, leading to prolonged power outages in major cities like Mandalay, Naypyitaw, and Yangon[5].

This event also caused significant damage to numerous cultural sites, including religious buildings and historical structures. Thousands of pagodas, monasteries, and other religious buildings were destroyed or damaged. Several historical sites, like Innwa, Mandalay Palace, and Amarapura, also sustained damage[6].

Understanding why earthquakes damage buildings is crucial for developing safer construction practices and disaster-resilient and sustainable communities. In addition, rapidly assessing damage after a quake is vital for guiding emergency response and disaster risk mitigation, and modern remote sensing technologies have become invaluable in this regard. Equally important are proactive measures – from engineering design to urban planning – that can prevent or mitigate building damages.

Findings

This Incident Brief by the United Nations University Institute for Water, Environment and Health (UNU-INWEH) provides a rough estimate of the properties damaged by the Myanmar earthquake based on synthetic aperture radar (SAR) data from the Sentinel-1 satellite of the European Space Agency. The analysis focuses on seven cities reportedly hit hardest by the earthquake: Mandalay, Pyin Oo Lwin, Madaya, Kyaukse, Sagaing, Shwebo, and Woundwin. Between 20% and 73% of buildings in these cities had a 99% damage probability. Using the Microsoft database of building footprints, we estimate that a total of over 157,000 buildings in these cities were damaged with a high likelihood.

This data quantifies the immense physical impact on these urban areas and is fundamental for understanding the disaster's scope, prioritizing immediate response, and planning long-term reconstruction. The variation in damage percentages across cities like Wundwin (73%), Sagaing (67%), and Kyaukse (62%) compared to Shwebo (20%) highlights the geographical disparities in destruction, likely influenced by proximity to the fault rupture, local soil conditions, and differences in building stock vulnerability.

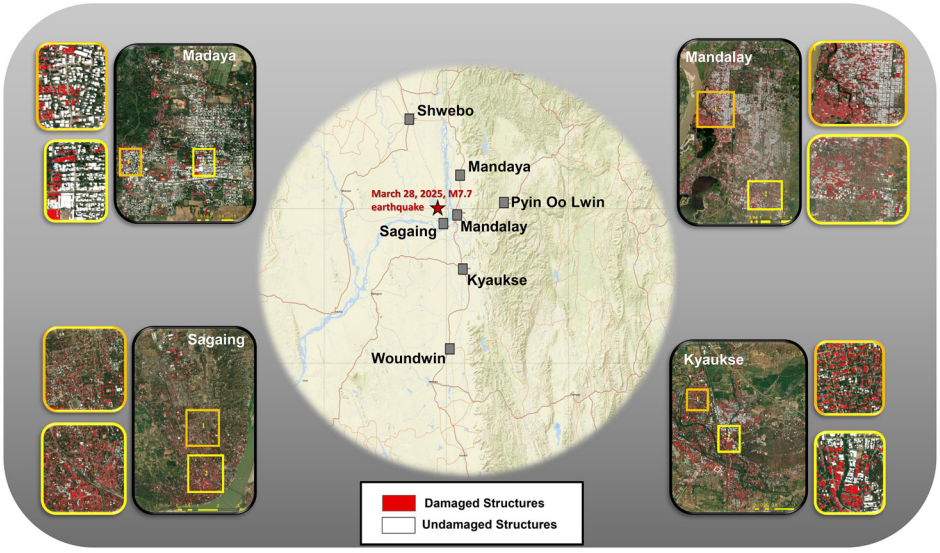


Figure 1. Building damage map for four of the seven cities. Damage probability for each building was calculated by applying a Bayesian image classification framework[7,8] to the interferometric coherence map of a SAR interferogram covering the earthquake. Buildings with a damage probability exceeding 99% are highlighted in red for clear identification.

City	Total No. of Buildings	No. of Damaged Buildings	Ratio of Buildings Damaged (%)
Mandalay	266,921	96,037	36
Pyin Oo Lwin	39,356	15,045	38
Madaya	7,264	2,349	32
Kyaukse	11,366	7,057	62
Sagaing	38,157	25,620	67
Shwebo	19,132	3,761	20
Woundwin	10,291	7,545	73

Table 1. Total number of damaged buildings and the percentage of the buildings damaged by the earthquake in the main Myanmar cities affected by the March 28, 2025 earthquake.

Recommendations

Historical and recent earthquakes—such as Myanmar's catastrophic Mw 7.7 earthquake on March 28, 2025—demonstrate the high seismic potential and extensive societal vulnerability. That event alone caused between 3,600 to 5,350 fatalities (based on different estimates) and widespread destruction across central Myanmar, including infrastructure collapse in Mandalay and damage in distant locations like Bangkok due to long-period ground motion amplification[9,10]. Additionally, many cultural heritage sites, such as ancient pagodas, sustained significant damage.

There are lessons to learn from the March 2025 earthquake that can help improve preparedness for disasters and community resilience in Myanmar and the rest of the world. Myanmar's seismic vulnerability is compounded by several interrelated factors, including rapid urbanization in seismically active areas without adequate enforcement of

seismic building codes, high population density along major fault zones, and the widespread presence of non-engineered structures.Additionally, the lack of robust early warning systems and insufficient disaster preparedness measures exacerbate the risks. To address these challenges, there is a need for comprehensive mitigation strategies such as upgrading and enforcing seismic building codes, expanding seismic and geodetic monitoring networks, and advancing paleoseismological and tectonic research on active faults like the Sagaing, Kyaukkyan, and Kabaw[11]. Equally important are efforts to raise public awareness, integrate disaster education into school curricula, retrofit critical infrastructure, and establish a coordinated national emergency response framework[10].

The most fundamental way to prevent earthquake damage is to build structures that can withstand strong shaking. Adopting and enforcing modern seismic building codes is one of the most cost-effective strategies to safeguard communities. Such codes have been shown to significantly reduce both casualties and building damage in earthquakes[12]. New buildings that meet or exceed these standards must be designed and built to ensure the structure can tolerate the expected ground motions. A code-designed building will generally experience controlled damage (for example, cracks in walls, yielding of beams) but not complete collapse, thereby protecting lives[13]. For critical infrasrtcuture (hospitals, schools, etc.), it is advisable to go beyond minimum code requirements and incorporate high-resilience design features. Extensively tested technologies and strategies – such as base isolation bearings (which allow a building to shake less), energy dissipating devices (dampers), and ultra-ductile materials can dramatically improve a building's seismic performance. While these enhancements may add upfront costs, they can prevent catastrophic damage and lengthy downtime. In parallel, existing older buildings known to be vulnerable should be prioritized for retrofitting. Retrofitting techniques include adding steel or reinforced concrete braces, tying walls to floors and roofs (especially in unreinforced masonry buildings), and jacketing columns – all aimed at increasing strength and ductility. Such upgrades have successfully saved many structures in recent earthquakes and are crucial in historic city centers and developing regions where many buildings predate modern codes.

Beyond the buildings themselves, where and how humans build can greatly influence earthquake risk. Effective land-use planning can help avoid placing buildings in areas with extreme seismic hazards. For example, construction should be limited on steep hillsides with landslide potential or on soft, water-saturated soils that are prone to liquefaction. Relocating communities or facilities away from known fault lines and unstable ground is an effective, albeit very challenging, mitigation measure. As an analysis of earthquake losses in China suggests, reducing exposure by relocating people and assets out of the most hazard-prone areas and lowering vulnerability by improving building types are effective ways to reduce overall risk[14].

Even the best building codes and plans are only effective if properly implemented. It is essential for local governments to enforce construction standards through rigorous inspections and qualified engineering supervision to prevent poor-quality construction that could lead to disasters. Investing in training for builders and engineers, as well as public education about earthquake-proof practices, is part of this effort. Community preparedness programs can educate residents about the importance of retrofit programs (e.g., securing heavy furniture and strengthening weak houses) and encourage compliance with safety regulations. Ultimately, a culture of safety and prevention, backed by strong policies, ensures that mitigation measures are not ignored. When building safety is treated as a public priority akin to fire safety or public health, the devastating impacts of earthquakes can be greatly reduced.

Final Remarks

Building damage due to earthquakes and other natural hazards is a multifaceted challenge that lies at the intersection of natural forces and human decision-making, affecting both modern infrastructure and ancient cultural heritage. By analyzing why buildings fail—from seismic intensity and local soil conditions to structural vulnerabilities and inadequate design—we can develop engineering solutions, planning strategies, and governance policies that reduce future risks of natural hazards. This is especially critical in regions like Myanmar, where repeated natural hazards[15] have devastated not only residential and public buildings but also iconic cultural heritage sites such as pagodas, temples, and monasteries. Many of these historic structures were constructed centuries ago using unreinforced masonry and without the benefit of modern seismic understanding, making them particularly susceptible to collapse during earthquakes. Retrofitting these buildings presents technical and financial challenges, necessitating a delicate balance between structural safety and the preservation of historical integrity. Further complicating this issue is a lack of dedicated funding, limited expertise, and underdeveloped policy frameworks for seismic preservation—especially in contexts where immediate human safety and infrastructure recovery take precedence. The 2025 earthquake, among other hazards, has underscored the consequences of such oversight, demonstrating that earthquake resilience must extend beyond new construction to include proactive protection of cultural heritage. Advances in remote sensing and AI now enable rapid post-disaster damage assessments, facilitating more efficient monitoring and faster emergency responses and recovery. More broadly, science-based mitigation strategies—such as resilient building design, targeted retrofitting, and smart land-use planning—can dramatically reduce the impacts of natural

hazards. While earthquakes and other natural disasters are unavoidable, the destruction they cause is not. With continued research, technological innovation, and inclusive policy-making, communities can build resilience that protects both lives and legacies.

REFERENCES

1. Zhang, L., Tao, Z. & Wang, G. Assessment and determination of earthquake casualty gathering area based on building damage state and spatial characteristics analysis. International Journal of Disaster Risk Reduction 67, 102688 (2022).
2. U.S. Geological Survey. "M 7.7 - 2025 Mandalay, Burma (Myanmar) Earthquake." U.S. Department of the Interior. March 28, 2025. https://earthquake.usgs.gov/earthquakes/eventpage/us7000pn9s/executive.
3. World Health Organization. (2025, March 30). WHO medical supplies reach hospitals in earthquake-hit areas. how to https://www.who.int/southeastasia/news/detail/30-03-2025-who-medical-supplies-reach-hospitals-in-earthquake-hit-areas.
4. Le Poidevin, Olivia. "Water and Medicine in Short Supply after Myanmar Earthquake, Says UN." Reuters, April 1, 2025. https://www.reuters.com/sustainability/land-use-biodiversity/un-agency-shelter-clean-water-medicine-short-supply-after-myanmar-earthquake-2025-04-01/.
5. Peck, Grant. "Many Survivors of Myanmar's Devastating Quake in March Still Live in Leaky Tents." The Associated Press, 30 May 2025, https://apnews.com/article/myanmar-earthquake-mandalay-naypyitaw-shelter-4d7966e1be9d747e33fd1eb8aeab61eb.
6. Wikipedia contributors. (2025, March 30). List of populated places affected by the 2025 Myanmar earthquake. Wikipedia. https://en.wikipedia.org/wiki/List_of_populated_places_affected_by_the_2025_Myanmar_earthquake.
7. Sherpa, S. F. & Shirzaei, M. Country-wide flood exposure analysis using Sentinel-1 synthetic aperture radar data: Case study of 2019 Iran flood. Journal of Flood Risk Management 15, e12770 (2022).
8. Sherpa, S. F., Shirzaei, M., Ojha, C., Werth, S. & Hostache, R. Probabilistic Mapping of August 2018 Flood of Kerala, India, Using Space-Borne Synthetic Aperture Radar. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 13, 896-913 (2020).
9. Shahzada, K., Noor, U. A. & Xu, Z.-D. In the Wake of the March 28, 2025 Myanmar Earthquake: A Detailed Examination. Journal of Dynamic Disasters, 100017 (2025).
10. Thein, M., Myint, T., Tun, S. T. & Swe, T. L. Earthquake and tsunami hazard in Myanmar. Journal of Earthquake and Tsunami 3, 43-57 (2009).
11. Wang, Y., Sieh, K., Tun, S. T., Lai, K. Y. & Myint, T. Active tectonics and earthquake potential of the Myanmar region. Journal of Geophysical Research: Solid Earth 119, 3767-3822 (2014).
12. Federal Emergency Management Agency. (2020). Building codes save: A nationwide study. U.S. Department of Homeland Security. https://www.fema.gov/emergency-managers/risk-management/building-science/building-codes-save-study.
13. U.S. Resiliency Council. (n.d.). What modern building codes do—and do not—ensure. https://www.usrc.org/commentary/what-modern-building-codes-do-and-do-not-ensure/.
14. Wu, J. et al. How earthquake-induced direct economic losses change with earthquake magnitude, asset value, residential building structural type and physical environment: An elasticity perspective. Journal of environmental management 231, 321-328 (2019).
15. Tun, T. & Lassa, J. A. Governing disaster risk in Myanmar: Institutions and policy pathways during 1885–2015. International journal of disaster risk reduction 96, 103992 (2023).
16. ASF. Copernicus Sentinel data. Retrieved from Alaska Satellite Facilities (ASF) DAAC on October 20, 2024 at https://search.asf.alaska.edu, processed by ESA. (2024).

Authors

Dr. Manoochehr Shirzaei is the Land Subsidence Analytics Lead at UNU-INWEH and an associate professor at the Department of Geosciences and National Security Institute of Virginia Tech., working on satellite radar interferometry and environmental security.

Dr. Shubham Awasthi is a postdoctoral researcher at the Department of Geosciences of Virginia Tech working on satellite geodesy and hazards.

Esther Oyedele is a Ph.D. student at the Department of Geosciences of Virginia Tech working on satellite geodesy and water resilience.

Mohammad Khorrami is a Ph.D. student at the Department of Geosciences of Virginia Tech working on satellite geodesy and water resilience.

Nivedita Kamaraj is a Ph.D. student at the Department of Geosciences of Virginia Tech working on satellite remote sensing and water quality.

Dr. Susanna Werth is an assistant professor at the Department of Geosciences of Virginia Tech, working on satellite geodesy and large-scale hydrology.

Dr. Mir Matin is the Manager of the Geospatial, Climate and Infrastructure Analytics Programme of UNU-INWEH, working on the application of earth observation and geoinformation solutions to mitigate risk and enhance resilience.

Professor Kaveh Madani is the Director of UNU-INWEH and a Research Professor at the City University of New York's Remote Sensing Earth Systems Institute (CUNY CREST), working on modeling complex human-nature systems to advise policy.

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Open Research

European Space Agency, Sentinel-1 SAR images were obtained through Alaska Satellite Facilities[16]. Microsoft's building footprint data were obtained from https://github.com/microsoft/USBuildingFootprints/tree/master

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