Importance of Near Earthquakes in Myanmar: A Review

K T Z Htay[1], Masrilayant[1], J Tanjung [1], and M Olivia[2]

[1] Civil Engineering Department, Andalas University, Padang, INDONESIA
[2] Civil Engineering Department, Riau University, Riau, INDONESIA

Corresponding E-mail: masrilayanti@eng.unand.ac.id

Abstract. Myanmar, located at the convergence of the India and Eurasia Plates, exhibits a geological division shaped by the Sagaing Fault, segregating it into two distinct tectonic regions: the Sunda Plate (Eastern Highlands) and the Burma Plate (West Burma Block). The Sagaing Fault assumes a pivotal role as an active fault line, and numerous destructive seismic events have historically transpired along this fault. Designated as a strike-slip fault, the Sagaing Fault is currently active, displacing at a rate of 20 millimeters per annum in a northward trajectory, a proposition articulated by Myint Thein et al. in 1991. Myanmar is situated within an earthquake-prone zone, where near-fault seismic events are plausible under varying circumstances. An illustrative instance is the Shwe Bo earthquake in the Sagaing region, characterised by a shallow depth of 10 kilometres and a seismic magnitude of 4.3. Consequently, the primary objective of this review is to enhance awareness and understanding of near-fault earthquakes within the context of Myanmar's geological landscape.

Keywords: near-fault earthquakes, Sagaing fault, seismic awareness

1. Introduction

Earthquakes release energy in the form of seismic waves, which come in two main types: body waves and surface waves. Body waves include primary waves (P-waves) that cause stretching and compressing in the direction of energy travel and secondary waves (S-waves) that vibrate at right angles to the direction and travel through the Earth from the earthquake's origin to the Earth's surface. Surface waves come as Love waves and Rayleigh waves (Murty, 2005). An earthquake, stemming from the abrupt movement of tectonic plates, can be categorized by depth into shallow, intermediate, and deep earthquakes. Shallow and intermediate quakes are common at plate boundaries, while deep ones occur in subduction zones. Earthquakes are also classified by distance: near-fault (within 20 km), average-fault (20–50 km), and far-fault (over 50 km) earthquakes (Todorov & Billah, 2021). According to the history of earthquakes, Myanmar, located at the convergence of tectonic plates, has to suffer very intense seismic excitation. For a ground motion to be classified as "near-fault," it is typically characterised by a peak velocity surpassing 60 in/s (152 cm/s). However, it's important to note that ground motions with lower peak velocities may still fall into the near-fault classification (Brown, 2009). Based on past earthquake records, structures near earthquake faults are at higher risk of damage and collapse compared to those farther away from faults. While it's possible to construct buildings away from fault zones, it's more challenging to do so for structures like bridges, such as the Sagaing Bridge, which is essential for transportation in Myanmar. Despite knowing the potential damage near-fault earthquakes can cause, this article highlights the importance of near-fault earthquakes from an earthquake engineering perspective.

2. The Impact of Ground Motions on Structures Near-faults

The "Near-fault ground motion" signifies a ground motion recording acquired close to an active fault, characterized by an evident velocity pulse lasting more than 1.0 second, a fault proximity of less than 10 kilometers, and a peak ground velocity/peak ground acceleration (PGV/PGA) ratio exceeding 0.1 (Rezaeemanesh et al., 2021; Soyluk & Karaca, 2017). Far-fault ground motions recorded at the same location during the aforementioned earthquakes were compared to near-fault ground motions. The presence of long-period, short-duration distinct pulses in velocity time history is one of the distinguishing characteristics of near-fault ground motions (Fathi & Nikzad, n.d.; Nick et al., n.d.; Sun et al., 2020). When structures cross a fault, the impact of near-fault ground displacement is important because the fault causes both static step-like deformations and dynamic deformations, and the ground motions resemble pulses. Since it tends to increase expected damage to civil structures compared to ruptures coming from further away, near-fault ground motion has drawn particular attention (Fathi & Nikzad, n.d.).

According to H. Aung et al., the years 1929-1931 hold great significance for the region of Myanmar, primarily due to a series of noteworthy seismic events. It all began with an earthquake on August 8, 1929, in Swa to Phyu and continued until September 23, 1931. These earthquakes exhibited a striking linear pattern, with the majority of them occurring along the Sagaing fault. On May 5, 1930, the Pegu (Bago) earthquake devastated the town of Pegu, resulting in significant loss of life. This event brought about widespread destruction. On December 4, 1930, the Phyu earthquake struck the town of Phyu in Myanmar, causing substantial damage (Aung, 2009, 2012). Field investigations suggested the epicentre of this earthquake was situated between four and six miles from Phyu, and its impact was potent enough to induce severe destruction within the town.

Furthermore, the Pyinmana earthquake on August 10, 1931, was a violent seismic event that shook Pyinmana, located 91 miles north of Phyu. Its effects were felt as far north as Mandalay and reported from Thanatpin in the Pegu district, spanning at least 350 miles. This specific area around Pyinmana is characterised by a converging bend in the large strike-slip fault, like the Sagaing fault. It is important to note that such bends in major strike-slip faults are known to accumulate stress and have the potential to generate significant earthquakes (Aung, 2009, 2015). These areas are particularly prone to high strain concentrations. In the context of civil engineering, understanding these geological factors is crucial for designing and constructing resilient infrastructure in earthquake-prone regions. Seismic design loads are extremely difficult to determine due to the random nature of earthquake motions. However, experiences from past strong earthquakes have shown that reasonable and prudent practices can keep a structure safe during an earthquake (Masrilayanti, 2013).

The seismic events that transpired on September 12, 1946 (M 7.5) and January 5, 1991 (M 7.1) were notably in the vicinity of Tagaung, Myanmar. These earthquakes gave rise to landslides, significant fissures, ground cracks, and sand blows. Furthermore, they led to structural damage, including the collapse of pagodas and various buildings in areas encompassing Tagaung, Htichaing, Kawlin, and Thabeikyin. Tragically, these seismic events resulted the loss of two lives. On July 16, 1956, a powerful earthquake (M 7.0) struck the northern part of the Sagaing fault in Myanmar, with its epicentre located north of Sagaing. This region has a history of seismic activity, with a notable earthquake in 1839 that claimed the lives of 300 to 400 people and another in 1956 with an estimated 40 to 50 lives lost. The 1956 earthquake caused significant damage, including the destruction of famous pagodas, schools, monasteries, and government buildings. Remarkably, the massive Mingun Pagoda sustained damage but remained standing, as shown in Figure 1.

(a) (b)

Figure 1 (a) Collapse of Yadanatheinga Bridge during construction by the 2012 Shwe Bo earthquake;
(b) Damage to the Mingun Pagoda, the world's largest brick stupa, by the 1839 Ava earthquake and the 1956 Sagaing earthquake. (Aung, 2015)

The earthquake resulted from a combination of right-lateral strike-slip faulting along the Sagaing fault and extensional normal faulting near the epicentre (Aung. M, 2012; Aung, 2015). In the Sagaing region, most of the buildings are masonry low-rise buildings, and it was not famous to use earthquake resistance design. According to the post-earthquake survey, the soft-story effect and collapse of masonry brick walls were the main reasons for the high damage at that time. This event underscores the need for earthquake-resistant building practices and mitigation strategies in regions prone to seismic activity to protect both structures and cultural heritage. Only reinforced concrete buildings with a high capacity for earthquake-resistant design can withstand earthquakes within or after them, especially in seismic-prone regions (Maidiawati et al., 2020).

3. Conclusion and Recommendation

As a conclusion, near-fault earthquakes are noted as no-warning earthquakes. Myanmar, located in the convergent zone of tectonic plates with major active faults such as Sagaing Fault, Tuyin Taung-Gwegyo Thrust, Kyaukkyan Fault, Kaladan-Mrauk-U Fault, and Papun Fault, and so on, has noticeably high seismic intensities with numerous damages referencing to the history. Lessons from past earthquakes inform modern engineering approaches. In civil engineering terms, such seismic events underscore the importance of understanding the dynamic geological processes at play, which can significantly impact the structural integrity of buildings and infrastructure. These insights are invaluable for designing resilient structures and formulating seismic hazard mitigation strategies in earthquake-prone regions. Comprehensive seismic education and awareness initiatives, as well as specialised rescue teams, should be implemented to target not only the engineering community but also the general public. There is a must-build a rule to construct earthquake-resistant buildings not only in downtown areas, but also in rural areas when it comes to near-fault regions. This approach ensures that both professionals and the broader population are equipped with the knowledge and resources required to effectively respond to seismic events.

Acknowledgments

The author would like to express gratitude to the previous authors for this review article and is very thankful to the Civil Engineering Department at Universitas Andalas for supporting art and science and to the Universitas Andalas for financial support in the doctoral program. Moreover, the author is very grateful to Bagan Vision Institute (BVI) for inviting a review article in the science and technology field.

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