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Earthquake in Bangladesh from the Perspective of the Second Most Populous City in the World

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ABSTRACT: Earthquakes and volcanic eruptions reshape geography by triggering dynamic activity of the earth's tectonic plates. Bangladesh is situated at a critical tectonic junction where the earth's structure is very complex. Most studies suggest that Bangladesh is likely to experience mild to moderate earthquakes. However, seismic hazard alone does not determine disaster risk. Given the other contributing factors like groundwater depletion, ongoing land subsidence etc. can contribute to building vulnerability and the consequences in a densely populated city like Dhaka may be catastrophic even in case of a mild earthquake. This paper reviews the tectonic scenery of Bangladesh, very recent seismic activity, and compounding urban vulnerabilities focusing on Dhaka, the second largest city by population today. It highlights the tectonic activities, urban and geotechnical vulnerability, emphasizing the need for risk-informed urban planning and structural measures.

KEYWORDS: Earthquake, Dhaka, anomalous subduction zone, Building collapse.

INTRODUCTION

Dynamic activity of the earth's tectonic plates leads to earthquakes and volcanic eruptions thus reshaping geography. Earthquakes and volcanic eruptions are caused by the movement of tectonic plates of the earth. Large earthquakes originate from faults along the boundaries of these tectonic plates, especially where subduction, conservation and transformation activity is seen. Bangladesh is located at a critical tectonic junction where the earth's structure is very complex due the movement of the Indian plate, rising Burmese sub-plate and thick sedimentary deposits of the Bengal delta. This complex geological position of the country has long raised concerns regarding earthquake, although the magnitude and possible damage is still unclear.

Background

The earth's crust, the lithosphere, is divided into 7 major and numerous micro-plates, the largest of which is the Pacific plate that almost completely encircles the Pacific Ocean. The North American plate consists of North America, Greenland and North Atlantic, while Eurasian plate includes large portions of Asia and Europe. Entire African continent and South Atlantic is in the African plate and South American plate consists of South

America and South Atlantic. Antarctic plate includes Antarctica and neighboring areas.

There are several micro plates, the notable ones being Indian, Arabian, Somalin, Philippine Sea, Nazca, Cocos, Caribbean, Scotia, Juan de Fuca, Anatolian, Aegean, Okhotsk, Amurian, Burmese, Caroline, Yangtze, Sunda and Rivera Plates [1, 2]. The Indian plate is moving at a pace of 4-5 cm every year in North-North East direction getting subducted into the Eurasian plate, which led to the creation of the Himalayas. Consequently, the Eastern side of the Indian plate started sinking beneath the Burmese sub-plate [3, 4]. The hill tracts in Chattogram and Sylhet in today's Bangladesh and the Arakan mountain chain arose from this tectonic subduction. However, this particular subduction is unique. While tectonic subductions occur along intercontinental or oceanic tectonic boundaries, this subduction near Bangladesh is on land, where the Eastern part of the Indian plate was once in the sea [4]. This is the reason why experts label this subduction as 'obscured' or 'anomalous subduction zone'. This anomalous subduction zone offers one advantage because unlike other active subduction zones, this particular zone is seismically much less active.

Bangladesh Perspective

Whether a large plate boundary fault crosses Bangladesh or not is a matter of debate among experts [5]. Such faults usually give rise to earthquakes of 8-9 magnitude on the Richter scale. Bangladesh is however located close to the Seguin Fault, which is a very active strike-slip plate boundary fault in Western Myanmar and has resulted in several major earthquakes [6]. Earthquakes experienced in Bangladesh have mostly originated from the Dauki fault, Indo-Burma subduction zone, plate boundary related minor faults and Arakan megathrust. However, extensive geological research is yet to be conducted.

The recent earthquake of 5.7 magnitude on the Richter scale that shook Bangladesh, possibly originated from a secondary fault. According to United States Geological Survey (USGS), more severe earthquakes follow preceding earthquakes only in approximately 5% cases. In case of Bangladesh, this likelihood is possibly even less, only 2-3% due to the 'anomalous subduction zone'. The milder earthquakes that have been experienced after the above-mentioned earthquake in Bangladesh are possibly the consequence of 'after slip'. However, the above-mentioned earthquake, although a mild one in scientific terms, gave Dhaka - the Bangladesh capital, a major shaking, as the city is situated on alluvial soil that leads to 'basin effect' of earthquake increasing severity of the tremors.

Possible impact of earthquake on Dhaka city

According to a recent United Nations (UN) report, Dhaka only next to Jakarta, is now the second most populous city in the world housing approximately 36.6 million people [7]. Once the rich river ecosystems of Dhaka city are now squeezed between industrial effluents and urban wastes. Rivers, canals and lakes, which were once the lungs of this city are disappearing fast to pave way to new townships springing up all around the city in order to accommodate the ever-growing number of people who are calling this city their home. The loss of these natural buffers has increased flood risk and reduced the city's capacity to absorb environmental shocks. However, in terms of land area, Dhaka stands much below in the list and is not among the top 10 mega cities in the world. This clearly shows how overcrowded the city is, not to mention the disastrous consequences that await if buildings of this city collapse in large numbers in case of an earthquake.

Building collapses are known to be major disaster across the globe. Between 1970 to 2020, more than 180 major building collapses have been reported in different cities claiming more than 330 lives per year on average [8]. Although, not directly related to seismic events or climate change, the factors responsible for these collapses include soil issues [9] and foundation movements [10] in addition to poor design standards and material [10], aging and wear [11], inadequate maintenance [12], land subsidence [13-16] and natural disasters like floods and cyclones [17], which are more applicable for developing countries like Bangladesh. Seismic events can magnify the risk of building collapse under such circumstances to great extent.

There are additional concerns regarding possible collapse of large number of buildings in Dhaka in case of a major seismic event. Seismic shaking can substantially magnify these existing vulnerabilities. Alluvial soil contributes to non-

uniform ground deformation leading to varying stress distributions on overlying structures or in other words, increasing likelihood of foundation distress and structural weakening [18 - 22]. If such structures experience uneven ground movement like that during an earthquake, cracks in foundations and walls will be facilitated [21]. As a result, during earthquakes capacity of buildings to absorb seismic forces is reduced thus increasing collapse risk [22]. In flood-prone cities like Dhaka, earthquakes can alter drainage patterns and damage utilities thus increasing vulnerability of buildings [23].

In megacities like Dhaka, reduced surface water supply leads to increased demand for groundwater. Overexploitation of groundwater stresses aquifer system accelerates aquifer compaction [24, 25]. Besides hydrocarbon extraction, which is vital for the economy of Bangladesh, further facilitates reservoir rock compaction [26]. All these factors increase the vulnerability of buildings in cities like Dhaka in the event of an earthquake.

The future risk of building damage in a megacity like Dhaka during an earthquake has also been magnified because of climate change as wet years are becoming wetter and dry years drier, thus increasing the likelihood of floods and draughts [27]. As shortage of surface water will be faced more often in the coming times, this will increase our dependence on groundwater contributing to reduced pore pressure and pore space closure further facilitating land subsidence. The impact will be more in cities like Dhaka, which are built on alluvial soil [28].

A recent study reported that, 2264, 110 and 32 buildings in 3 Indian megacities namely, New Delhi, Mumbai and Chennai are at high damage risk due to differential land subsidence [29]. The study further predicted that in next 30 years 3169, 255 and 958 buildings in these 3 major cities will be at high risk of damage, while in another 50 years from now, 11457, 3477, 8284, 112 and 199 buildings in New Delhi, Mumbai, Chennai, Bangaluru and Kolkata will be similarly vulnerable. This study clearly demonstrates that large number of buildings in these megacities are at amplified risk of structural failure during an earthquake. The situation in Dhaka is unlikely to be anything different.

After the earthquake on 24 November, 2025 having a magnitude of 5.7 on the Richter scale, the Rajdhani Unnayan Kartripakkha (RAJUK), which is the government organization overseeing infrastructural development in Dhaka city, reported that at least 300 buildings in the city had been damaged of which 25 partially collapsed. Under the World Bank funded Urban Resilience Project, RAJUK earlier surveyed parts of the Dhaka city and found that of the city's 2.145 million buildings, approximately 40% were at the risk of collapse in an earthquake of magnitude 7+ [30].

In case of such a disaster the aftermath is likely to be beyond imagination. The Government of Bangladesh has adopted a National Plan for Disaster Management (NPDM) 2021-2025 for earthquakes and other disasters [31]. We also have an Earthquake Preparedness and Awareness Committee (EPAC) headed by the Hon'ble Minister for Disaster Management and Relief (MoDMR), which is one of our key national level disaster management institutions [31]. In NPDM 2021-2025, earthquake has been identified as an emerging disaster risk for building a resilient Bangladesh. The national plan admits that earthquakes pose risk, specially to the growing cities of Bangladesh [31]. It has been anticipated that earthquakes are not only likely to cause huge economic loss but also claim uncountable human lives, at the same time having long lasting negative impact on national economic growth and poverty reduction. This is why NPDM 2021-2025 has prioritized earthquake risk reduction as a key action plan. Earthquake risk assessment and mapping to the level of small and medium-sized cities and current standards of preparedness and safety to identify existing capacities, gaps and risks are some of the key priority activities in in NPDM 2021-2025. The planned interventions include retrofitting important buildings, supporting resilient rural and urban housing and infrastructure, building emergency back-up centres outside Dhaka for earthquake evacuation, creation of open spaces in high-density urban areas, tree plantation, ensuring all future constructions in compliance with the Bangladesh National Building Code (BNBC) and ensuring earthquake-resilient construction in high earthquake risk areas to name a few. Besides

capacity building of relevant service personnel and volunteers on emergency response including first responder search-and-rescue, first aid and rapid deployment and establishing Disaster Management and Rescue Network and volunteer's database are also on the to do list. The government further plans to establish Seismology and Earthquake Engineering Departments in public and private universities [31].

However, as of today the ground reality is grim. A recent study by the US National Bureau of Economic Research (NBER) that covered 1200 cities in 152 countries, all having minimum 300,000 population, identified Dhaka as the slowest city in the world having an index of -0.60, where a 9 km journey from the airport can take up to 55 minutes [32]. Besides, Chattogram and Mymensingh cities in Bangladesh were identified as the 12th and 9th slowest cities in the world in the same study. In 2020, a study by the Bangladesh University of Engineering & Technology (BUET) found that average speed of vehicles plying on Dhaka city at peak hours was 6.5 kms per hour [33]. When this same university repeated the same study 2 years later in 2022, they found that this speed had further dropped to 4.5 kms per hour. Interestingly this speed was slower than the average walking speed of a physically fit person [34] Dhaka also has very little road infrastructure offering less than 10% of its space for roads, 76% of which again is taken up by the private car owners who constitute only 6% of the city's population [34]. This tells how difficult the rescue operation will be if the city is struck by a major earthquake.

At present the city's disaster rescue capability is also grossly inadequate. There are only 27 fire stations in and around Dhaka city to cater to the disaster relief of the second most populous city in the face of the globe in case of earthquake or any other major calamity for that matter [35]. The same also applies to city's capability to treat its ill-fated dwellers in the aftermath of a catastrophic earthquake. There are only 6 tertiary level specialized hospitals and 13 post-graduate medical institutes having around 6500 and 6000 beds respectively with their bed-occupancy rate varying from minimum 68.63% to maximum 187.45% at normal times [36]. The private sector adds approximately another 2000 hospital beds to the city. The city had only 28 Intensive Care Unit (ICU) beds in 1980. Despite significant increase in the number of ICU beds in recent times, there were only 223 ICU beds across all government hospital in Bangladesh and the general bed: ICU ratio was 219:1, whereas the ideal ratio should be 10:1 [37]. All ICUs were also not up to the mark with the ideal nurse: bed 1:1 ratio being followed in only 42% ICUs and only 7% ICUs had arterial blood gas (ABG) analysis machine [38]. Transporting critically ill patients is also a challenge, as the city has handful of such specialized ambulances capable of transporting patients requiring ICU support [38]. There is also a huge shortage of specialists with only 3 institutes offering post-graduation in Critical Care Medicine [39]. These figures are by no standards adequate to meet the requirements of a mega-city like Dhaka, not to mention that with such high bed-occupancy rate at normal times, these health infrastructures will prove futile in case of a major earthquake.

Conclusion

Dhaka being the most densely populated megacities of the world is in added risk of being the part Bangladesh, of as the country located in world most complex tectonic settings. Although subduction is ongoing on the eastern aspect of the Indian tectonic plate, it is unique from other subductions as it is situated in land. Although much research is needed, most experts argue that Bangladesh is likely to experience mild to moderate earthquakes, but major earthquake in this territory may be unlikely. However, given the other contributing factors that contribute to building vulnerability, the consequences in a densely populated city like Dhaka may be catastrophic even in case of a mild earthquake. Further work is needed to enhance fault mapping, strengthen subsidence monitoring, and develop integrated seismic and geotechnical assessments relevant to the urban environments of South Asia's expanding megacities. At the same time preparedness for facing earthquakes must also be prioritized.

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