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Towards safer public school buildings in Lebanon: An advocacy for seismic retrofitting initiative

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ABSTRACT

The essential priority of protecting children who attend schools that are vulnerable to collapse during an earthquake is irrefutable. The structural integrity of public schools in Lebanon is a source of deep concern due to their outdated design, deteriorated status and apparent lack of compliance with seismic design regulations. The purpose of this article is to advocate the seismic retrofitting of school buildings and to demonstrate the financial gain of such retrofitting procedures when compared with the cost of repair or replacement. In this paper, the authors offer practical information supported by numerical data, regarding the urgent priority of retrofitting school buildings and enhancing their functional capacity to withstand future destructive earthquakes. The aim is to alert school administrators, public leaders, government officials and international agencies regarding the seismic vulnerability of public school buildings and their subsequent effects on the safety of children in Lebanon. In addition, the authors demonstrate the economic advantages of seismic retrofitting in protecting children and their schools and calls for government intervention to assess and retrofit public school buildings to reduce their vulnerability to collapse during future earthquakes.

1. Introduction

There is no shortage of public schools in Lebanon as they are adequately dispersed throughout the country's populated regions. However, most of the existing school buildings are ageing, deteriorating and do not meet the safety standards of public buildings [29]. The lack of regular maintenance and the buildings' outdated designs and poor construction methods have contributed cumulatively to this grave situation. In addition, school buildings have not been designed to be earthquake resistant. This deficiency will be catastrophic in the event of a strong earthquake as it increases the children's vulnerability to such a hazard. Prioritizing seismic retrofitting strategies for public school buildings at a minimum cost to the institutions is the key to preventing the sudden collapse of these facilities and reducing the number of tragic fatalities among children and teachers. Therefore, public schools in Lebanon must be upgraded to enhance their seismic resistant capacity and ensure the safety of the children and survivability of the buildings.

Earthquakes have serious consequences on educational services, not only because they induce structural collapse and massive loss of lives of teachers, staff and students, but also due to the sudden interruption of the educational process and psychological disruption of students [25]. Schools are places where a vulnerable part of society is located; therefore, it is essential that children are protected as much as possible from the effects of earthquakes [33].

The destruction of vulnerable school buildings by earthquakes has been documented in many places around

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the world. These events reduce the functional capacity of the educational system, thereby hindering students' academic progress. The 1995 Kobe earthquake caused extensive and varied damage to approximately 4500 educational facilities. Fortunately, no fatalities resulted from this damage to schools because the quake struck the area early in the morning [32]. In the 1999 Chi–Chi earthquake, a total of 700 schools were destroyed in Taiwan. The 2001 Gujarat earthquake in India caused damage to more than 11,600 schools [45]. More than 10,000 school buildings collapsed as a result of the 2005 Pakistan earthquake [21], leaving surviving children without educational facilities. After hurricane Katrina, hundreds of students in New Orleans were turned away from public schools due to the lack of space and shortage of teachers [43]. As many as 1150 schools in Indonesia were damaged or destroyed in the 2004 earthquake [41]. During the Sichuan earthquake of May 2008, approximately 10,000 students were crushed in the more than 7000 school classrooms that collapsed [42]. In addition, approximately 38,000 students died in the Haiti earthquake, which also killed 1300 teachers and other personnel [7]. The Ministry of Education offices were destroyed, along with 4000 schools—close to 80 percent of the educational sector in the Port-au-Prince area.

In 2006–2007, the United Nations International Strategy for Disaster Reduction (UNISDR) carried out a global campaign titled Disaster Risk Reduction Begins at School, with support and contributions from all UNISDR system partners. This programme resulted in a significant mobilisation of efforts to promote school safety and the integration of disaster risk reduction into school curricula, as well as the recognition of non-formal education activities as a crucial contribution to awareness raising, knowledge building, and skill development for disaster risk reduction [42].

Ninety percent of Lebanon's population of four million is concentrated in a band approximately 20 km wide and 200 km long that extends along the coast of the Eastern Mediterranean Sea while two-third of the population lives within 10 km of the coast [22,28]. The entire coast of Lebanon is located on the African–Arabian tectonic transform boundary, with the African Plate to the west and the Arabian Plate to the east. The resulting tectonic activity creates an earthquake hazard for the country. Historically, major cities of Lebanon have suffered repeatedly from moderate-to-strong earthquakes that have caused massive casualties and destruction.

Lebanon has been successful in making education compulsory for its citizens up to middle school; however, no special attention has been paid to the seismic safety of the school buildings. Consequently, it is highly possible that thousands of children will face death or injury at the occurrence of an earthquake while they are attending school. Recent research released by World Vision revealed that despite being at risk of both manmade and earthquake hazards, Lebanon has few disaster risk reduction measures in place to minimize the human and economic costs of such disasters. The lack of awareness about disasters and preparation for them is one of the main reasons for the poor resilience of these communities after disasters. For example, information regarding disasters is not shared with children in schools [31]. The scope of this article is to advocate the safety of poor and innocent Lebanese children who are obliged to attend ageing, ill-maintained and seismically vulnerable public schools. The intention is to motivate school administrators and teachers to exert enough pressure on government officials to prioritize the structural safety of the existing schools to prevent future tragedies. Although private school buildings have not been seismically designed, they are in excellent conditions and have better resistance to moderate earthquakes, due to their high level of design and construction standards, their regular maintenance and the high revenue generated by the high student enrolment numbers—the number of students enroled in private schools is almost two third of the total student population [8,14].

2. Earthquake hazard in Lebanon

Although geologists have indicated that Lebanon is covered by seismic fault systems [11,28], the seismicity of Lebanon cannot be properly understood in isolation from the rest of the Eastern Mediterranean region, including Israel and Syria. The Dead Sea Transform (DST) is extremely important, as it has been responsible for the majority of the seismic activities and devastating earthquakes in Lebanon [19] and along the eastern Mediterranean region [13]. This fault, which originated from interactions and collisions between the African and Arabian plates, is the deepest and most powerful fault system in the eastern Mediterranean region, stretching from Ethiopia through Aqaba, Jordan, Israel, Lebanon and Syria and continuing north to join the East Anatolian Fault in Turkey. In his writings, ancient Jewish historian Flavius Josephus recounted a massive earthquake in 33 BC that killed 50,000 people. Three additional large earthquakes devastated the region in 363, 749 and 1033 AD [34].

The Mount Lebanon Thrust (MLT), another active major fault, was recently discovered along the coast between Beirut and Enfeh [16]. A disastrous 7.5 moment magnitude earthquake occurred along this fault on July 9, 551 AD and destroyed most of Lebanon's coastal cities. Scientists have predicted that similar earthquakes on the same fault will occur every 1500 to 1750 years. An earthquake that occurred on May 20, 1202 AD caused severe destruction in Beirut and Damascus and has been estimated to have an equivalent moment magnitude of approximately 7.5 [10,16]. In the year 1759 AD, significant seismic events occurred on October 30 and November 25; the equivalent moment magnitudes of these events were approximately 6.7 and 7.4, respectively [10].

The seismicity of Lebanon is generally characterized by strong earthquakes with very long occurrence intervals [27]. Although no record regarding the horizontal to vertical acceleration of previous earthquakes in Lebanon is available, most of the earthquakes that have occurred are the shallow type, with a focal depth of less than 60 km [28]. Due to the existing seismic activity and the historic catastrophic events, several studies have been conducted to evaluate the seismic hazard in Lebanon [3,19,20], as well as in neighbouring countries along the Eastern Mediterranean [1,5,15,37].