

# Impact of Moisture Decay on Seismic Vulnerability: Haiti’s Wood-Framed Vernacular Buildings

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## Abstract

A major and shallow earthquake with a moment magnitude of 7.2 hit Tiburon Peninsula on 14 August 2021, damaging over 137,000 buildings. A hybrid reconnaissance activity was conducted in the aftermath, jointly by EEFIT/STeER/GHI, to evaluate the impact of the event on buildings, infrastructure and communities. The study also included an investigation of the performance of local vernacular homes -wooden frames with infill, which were found to be one of the most vulnerable typologies. Moisture was identified as an agent of damage for 14% of the damage-assessed vernacular housing. This paper examines semi-quantitatively how moisture decay increases the seismic vulnerability of this typology of Haiti. Peer-review under the responsibility of the organizing committee of the ICMB23.

**Keywords:** earthquake damage assessment; moisture; vernacular buildings; wood frame; timber; Haiti

## 1. Structural Damage to Wood-Framed Buildings following the 14 August 2021 Mw7.2 Haiti Earthquake

Haiti experienced a devastating earthquake on August 14, 2021 (Figure 1). The event with the moment magnitude of 7.2 took place within the onshore faulting through the Tiburon Peninsula (southern Haiti) and affected more than 800,000 people in over 137,000 buildings [1,2]. A hybrid reconnaissance activity to evaluate the post-disaster state in Haiti was carried out with the joint effort of Earthquake Engineering Field Investigation (EEFIT), Structural Extreme Events Reconnaissance (StEER) and GeoHazards International (GHI) teams. The damage data was collected by Haitian volunteers and populated on the Fulcrum platform of the StEER. EEFIT members then used this data for an assessment of structural damage to several building types (housing, schools, hospitals and churches) with various construction types (wood-framed, masonry and RC). Our research summarises the key findings and observations made during the remote mission on the wooden frame with infill typology (N=407), comprising almost half of the residential building records in our dataset.

In general terms, this vernacular typology is typically a single-story building composed of wooden posts, (roughly) sawn and/or round, confining the infill, which is of stone fixed by cement- or mud-based mortar, and with a lightweight twin-sloped roof. In often cases, the framing is poorly built, lacking wall and foot plates, with the thin wooden posts directly secured into the earth ground without a masonry base.

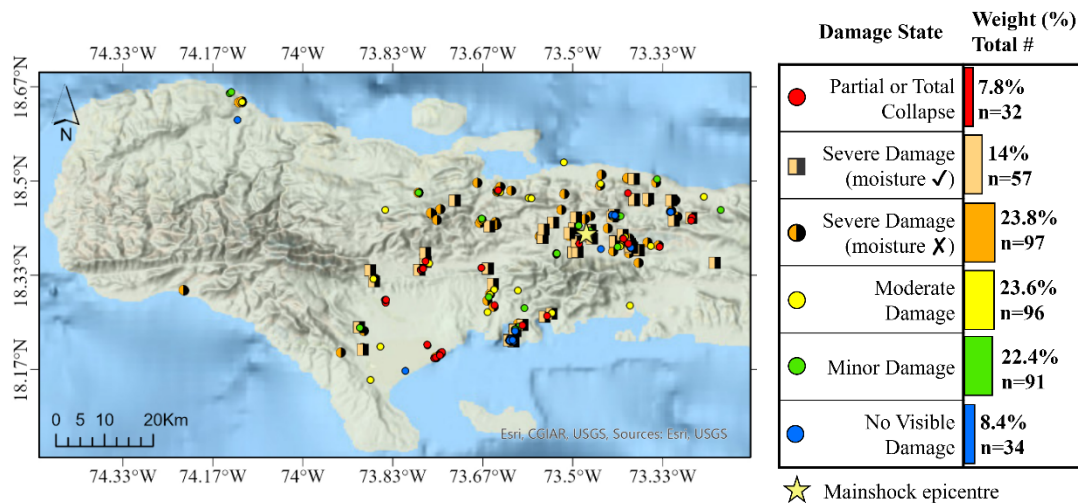


Figure 1. Tiburon Peninsula: Spatial distribution of the structural damage following the 2021 Haiti earthquake for infilled wood frame typology (N=407). Map legend indicates the weight of damage grades, including severe damage with and without moisture-induced decay.

In the primary assessment process in guidance of the proposed procedure [3], one of the five damage grades (DS1: no visible damage, DS2: minor, DS3: moderate, DS4: severe and DS5: partial/total collapse) was assigned to each building

through consideration of available information, such as peripheral/detail photographs (like samples in Figure 2) and also written damage notes where applicable. Based on the initial evaluation of the damage, two main conclusions have been made: (1) Infilled wood frame building type is one of the most vulnerable typologies since ~70% of buildings performed at least to take moderate damage, i.e., sectional loss of infill by out-of-plane failure. 37% of buildings are classified as the severely-damaged, which means heavy failure of infill due to lack of proper framing and/or wooden post-infill interaction. (2) In addition to earthquake loading, the remote team observed that structural problems, particularly those induced by moisture, were also able to be a governing factor causing failure by the visual inspection of detailed photographs per building.

## 2. Key Findings concerning Moisture and Conclusions

Mentioned conclusions led us to have a closer look at the severely damaged cases by secondary assessments. 14% of these demonstrate clear degradation due to moisture leading to heightened levels of seismic vulnerability. Damage-assessed buildings are mostly concentrated around the earthquake epicentre within the peninsula: ~15 km to the northern shores, ~20 km to the southern shores, and ~45 km to the west. However, their spatial distribution does not lead to a regional effect for moisture-induced decay.

During the damage assessment process, we identified moisture-related problems decreasing the resilience of the typology: weathering, insect attack, rising damp, and moisture decay on wooden posts, which then manifest as significant section losses lessened adhesion between framing and infill, and loss of connections adversely impacting on structural performance under seismic loading as demonstrated by more than a third of severely damaged buildings (57/154). Figure 2 displays some of the severe damage cases that moisture decay observed in the framing. In both (a) and (b), longitudinal posts seem to have been rotten due to moisture, which prominently affects the quality of wood and connection. On the other hand, the affected section of posts in (c) is at the foot, which has traces of rising damp.



Figure 2. Examples of moisture decay were observed in wooden frames (Earthquake-induced structural damage is severe for each).

Key post-disaster messages in light of these observations include that the vernacular buildings detailing should be amended such that the contact between wooden posts and ground moisture is cut, for example through a masonry base. Additionally, precautions against moisture brought on by precipitation should be taken through the surface waterproofing of wood-frames. Consequently, it is important to enhance not only the seismic but also climatic resilience of such vernacular typologies, and this perspective should be implemented in the reconstruction/built-back-better efforts.

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