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MATERIALS AND TECHNIQUES FOR TRADITIONAL ROMANIAN RESIDENTIAL HOUSES

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Abstract. *A significant number of traditional houses in Romania are having timber structure. Depending on the availability, the structures have different types of infills, from mud mortar, to mud bricks and wattle and daub. Due to the appearance of concrete and also due to fire and biological attack vulnerability of timber, these types of traditional houses are not built nowadays. But in the rural areas, the quality control for houses' building is almost absent, and in fact, the new RC structure houses may present dangerous defects of structural conception. In this situation, what is best to choose: a traditional timber house or an RC house? Recently, a reason to choose the latter is that the traditional construction methods are being lost with time passing, and the real carpenters are disappearing. Thus, the long tradition of Romania in wooden structures is also dying. The paper presents a review of the construction methods of some traditional types of houses observed in field investigations in rural areas, and shows how the construction details changed with time from the original to nowadays, depending on economic and materials' availability reasons.*

1 INTRODUCTION

Nowadays, most of the people wish new materials for their new houses and this is a sound reason, to actually use the recent research results on new materials. Other people want to learn from tradition and use it in a modern and more practical way in the present, taking advantages of the new technologies applied for natural materials, such as insulation panels, rammed earth, cob, etc. But in order to learn from tradition it is necessary to understand it, and for this, the present paper focuses on the identification of construction details for traditional timber frames.

Romania is a moderate seismic country, but one of the most affected countries in Europe by this hazard type. Last big earthquake occurred in 1977 and had a magnitude of 7.2 on Richter scale. The characteristics of that event showed that the Vrancea seismic source gives earthquakes with long period which affect the flexible or tall structures (many high-rise buildings in Bucharest collapsed). For that event, there are not many reports on what happened to the traditional residential houses and people generally think that they have a good seismic behavior. During the field investigations, though, owners recall that their traditional house withstood some damages, and they made some small to extensive reparations (infill replacement, to sometimes demolition and reconstruction).

The archives of traditional architecture [1] show the main types of houses, but in reality, the existing houses do not respect all the details. Some of them are mixed, and some of them are completely lacking and found more practical (and easier to execute) solutions to serve the same (apparent) purpose.

Due to the long tradition of Romanian wooden structures (some of the tallest wooden structures in the world – churches - can be still found in Bucovina area), the present study aims

to bring forth the construction details of existing traditional houses and to investigate the reasons they were used, and when compared to the original type to try to understand why they might be lacking. Field investigation was concentrated around the seismic source Vrancea, in order to learn how this influenced the construction details, by local seismic culture.

2 TRADITIONAL ROMANIAN ARCHITECTURE

Traditional Romanian architecture for houses is mainly based on timber structures, having different types of layouts depending on the location (mountain, fields, etc.) with direct consequence in the availability of the raw material. As stated in [1] the model of the houses, even though it was part of some architectural type, evolved in time, starting from Dacians, changing with Roman occupation, and throughout history adapting on the availability of the timber. An example may be the fact that the lack of timber in some area lead to the replacement of the timber planks (forming the panels between the timber columns) with some mud mortar infill (Figure 1). The evolution was also affecting the way the rooms are divided within the house. Recently owners want more space, wider spans, more rooms with different functionalities.

Figure 1: The adaptation of house structure, due to lack of timber: left [2] is typical for mountain areas (where timber is easy to find) and right is in a hill area (where timber is not so cheap)

The spreading of traditional houses types within Romanian territory was studied in [1] and several maps were issued depending on the type of house (Figure 2) and the construction materials (Figure 3). Starting from the “paianta” structural type of traditional house, shown in Figure 5, the field investigation presented in this study found several types of traditional houses, with mixed details, a little different than the types recognized in [1].

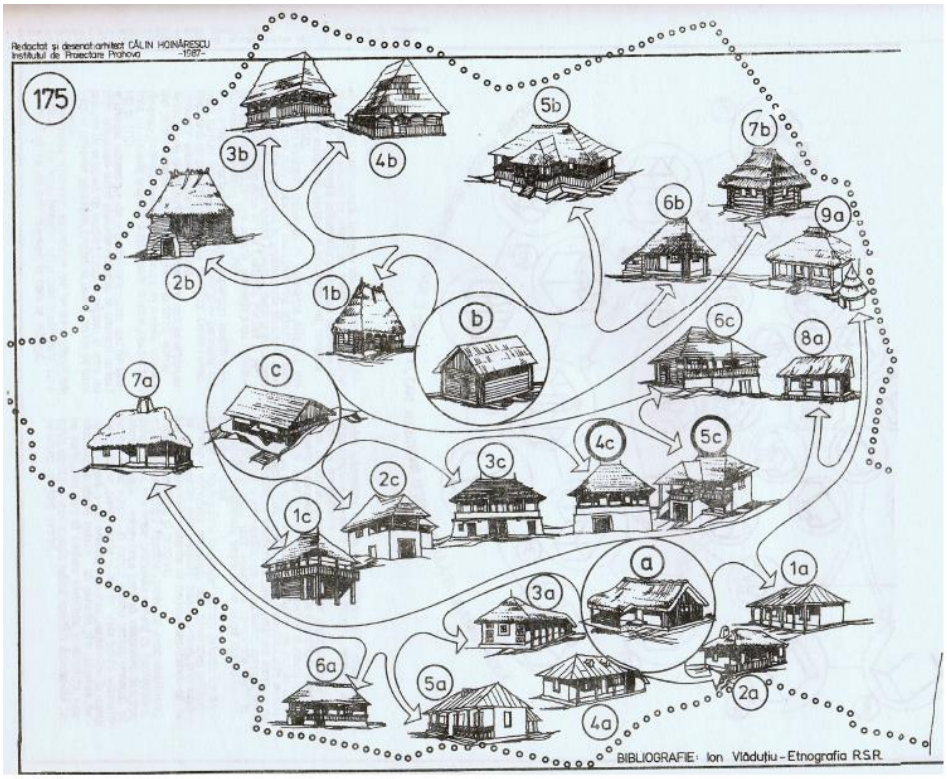

Figure 2: Map of Romania with three different architecture types of residential houses: a. Dacian type of house specific to plain field area; b. Dacian type of house specific for areas rich in wood (Maramures, Bucovina and Transilvania); c. Dacian type of house with tower, specific to sub-Carpathian area [1]

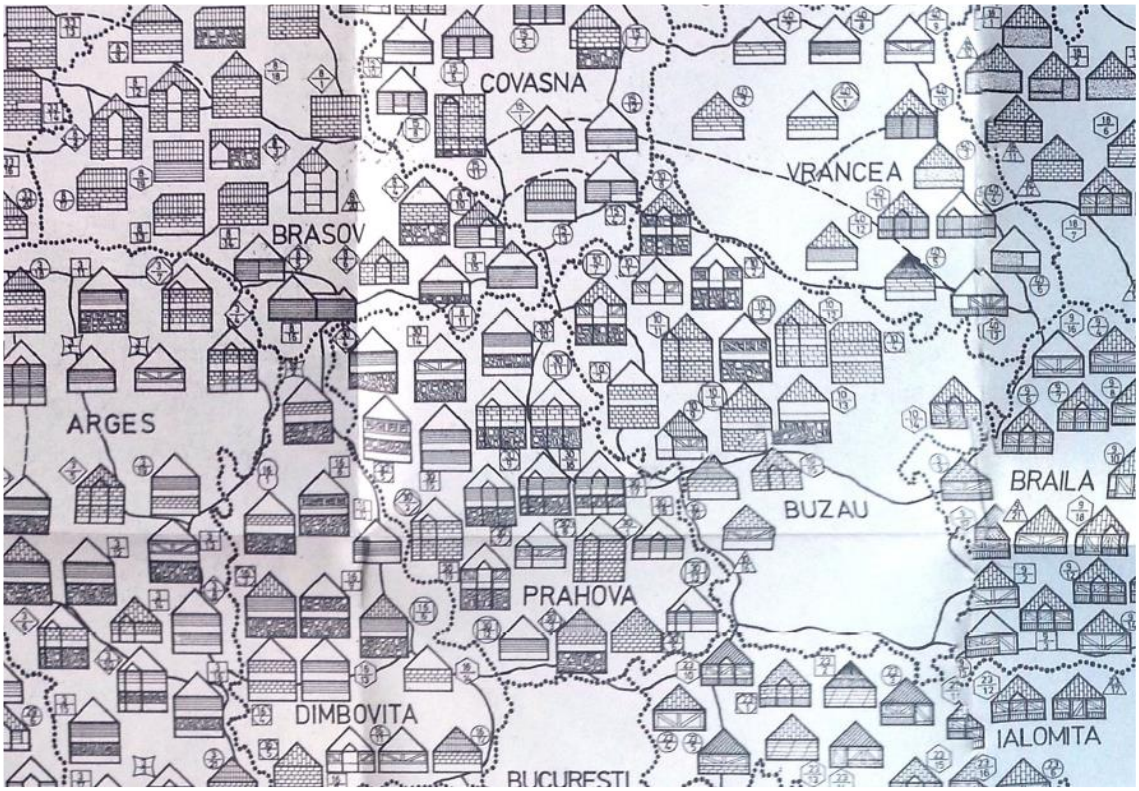

Figure 3: Piece of Romanian map (around the Vrancea seismic source) showing the different construction materials of houses [1] (for the legend, see Figure 4)

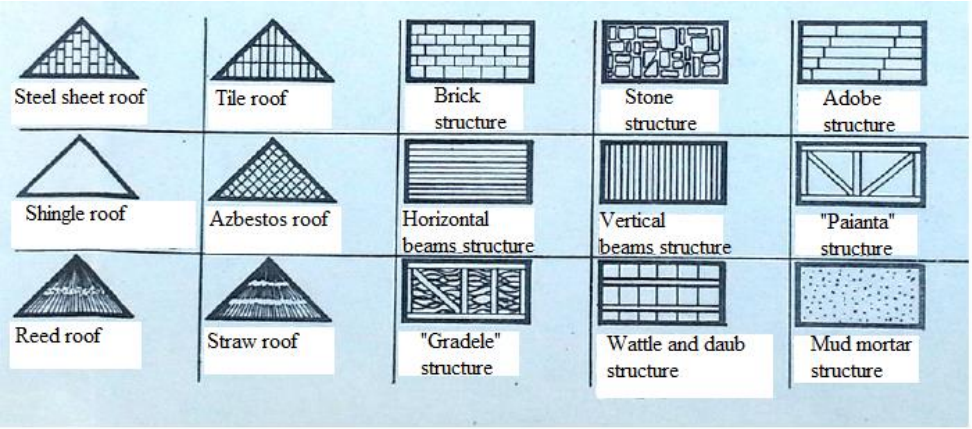

Figure 4: The legend of the house drawings corresponding to each material [1]

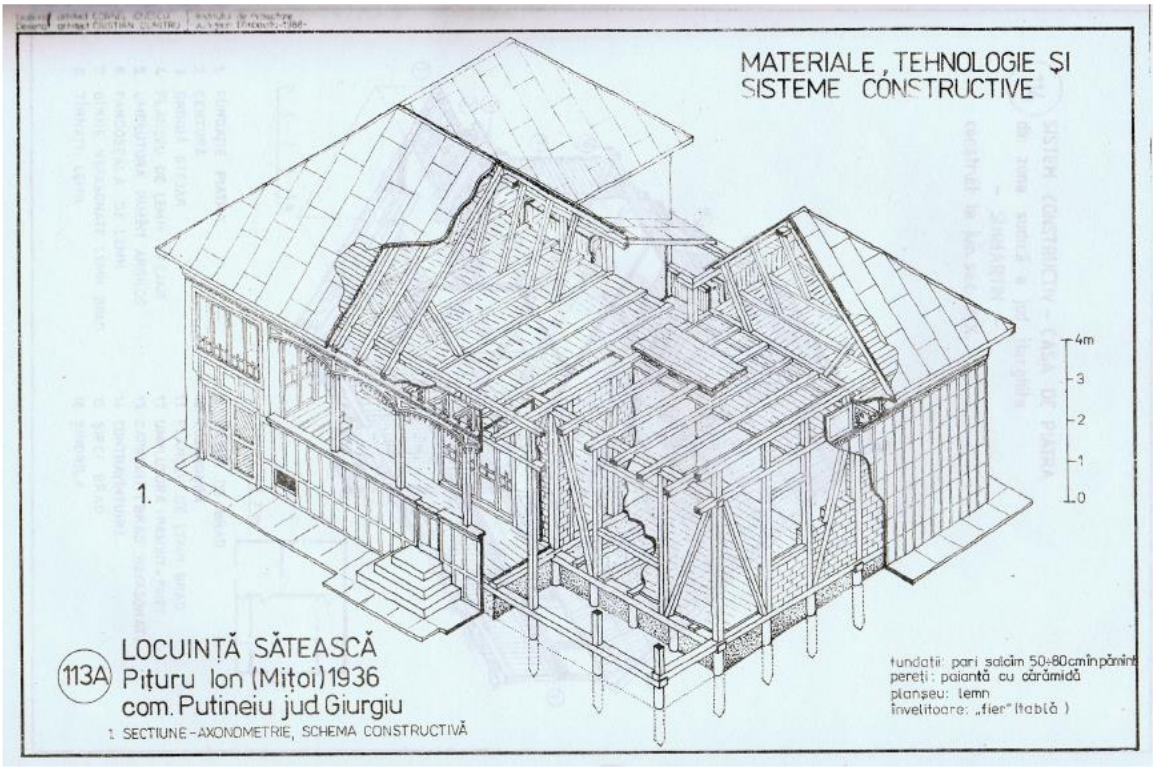

Figure 5: The "paianta" (timber posts and beams, with diagonals from place to place) with brick masonry infill type of traditional house [1]

3 FIELD INVESTIGATIONS

As mentioned in [1], generally the traditional houses with timber skeleton and various infill ("paianta" house) were built mainly in seismic regions and nearby the material's sources (wood, stone, clay), such as the mountain regions (where there are forestry and quarries) or hill regions. In order to study the seismic behavior of the traditional houses in Romania, for the field investigation only some regions were selected, located near the Vrancea source and nearby mountain and hill regions in Buzău county, Vrancea county [2], Dâmbovița county, Prahova county, Argeș county and Vâlcea county (Figure 6).

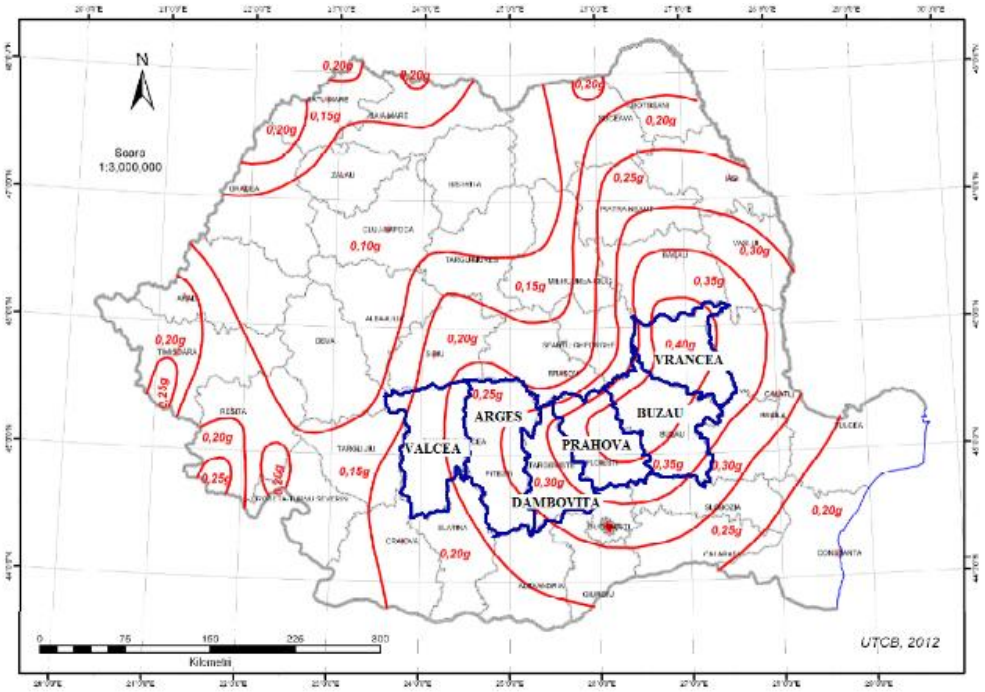

Figure 6: The seismic location of the investigated regions (according to national seismic code P100-1/2013)

Within the field investigation, five types of houses were observed (having resemblance with traditional houses), such as:

- with timber skeleton and brick masonry infill structure (Type 1- "paianta", Figure 7);
- with timber skeleton and strips applied at 45^{o} and clay plaster (Type 2, Figure 9);
- with timber skeleton and wattle and daub (Type 3- "grădele", Figure 11);
- with timber and earth with straw infill structure (Type 4, Figure 13).
- with timber skeleton and AAC (autoclaved aerated concrete) masonry infill (Type 5, Figure 19).

Figure 7: Traditional house with timber skeleton and brick masonry infill (Type 1) from Teiș village, Dâmbovița county

a. The foundations are made only from stone (river rocks)

b. The diagonals are stopped below the upper connection between beam and column, and the last row of bricks is laid in an inclined position

Figure 8: Details of traditional house with timber skeleton and brick masonry infill (Type 1) from Teiș village, Dâmbovița county

The Type 1 house has some details such as the diagonals being stopped lower than the connection between the beam and the post and also, the last layer of bricks, beneath the beam, is laid in an inclined position. In some situations, over the upper beam of the wall, few layers of bricks exist and another beam, supporting the roof (Figure 8 a and b). If we compare with the original type (Figure 5), we can see these details are not seen, and also the original foundation would be with wooden piles, driven in the soil.

For Type 2 house (Figure 9) it can be observed the presence of the storage room at the ground floor, beneath the living rooms of the house. The internal structure of the wall could not be very well identified, since it is embedded in mud, but a timber structure made of posts should be the main structure, on which the 45° wood strips (Figure 10) are attached with nails, and infilled with mud. This structural type is very similar with the next one presented, Type 4, where the strips are horizontal instead of inclined at 45°.

Figure 9: Traditional house with timber skeleton and strips applied at 45° and clay plaster (Type 2) from Mustăţeşti, Argeş county;

Figure 10: Detail of traditional house with timber skeleton and strips applied at 45° and clay plaster (Type 2) from Mustăţeşti, Argeş county;

Type 3 house (Figure 11) is made with similar structure type as Type 2, but instead of strips applied on the exterior of the main timber structure (posts, smaller size posts and beams),

between the posts and smaller posts, hazelnut branches are braided and they are covered with mud mortar, which by drying it forms together the wattle and daub system.

Figure 11: Traditional house with timber skeleton and wattle and daub (Type 3 – ”grădele”) from Băbeni, Vrancea county

Figure 12: Details of traditional house with timber skeleton and wattle and daub (Type 3) over 100 years, from Băbeni, Vrancea county

Figure 13: Building with timber and earth with straw infill structure (Type 4), from Viperești, Buzău county

a. No foundation

b. Corner detail

c. The bottom beam joint seems to lack joining pieces (nails or clamps)

Figure 14: Details of a building with timber and earth with straw infill structure (Type 4), from Viperești, Buzău county

Figure 14 shows the details of a Type 4 house which is a very poor executed house, due to the economic situation of the owners, it has no foundations, the walls simply sitting on the ground, and the connections between the bottom beams are also very poorly executed, lacking any nail or clamp to connect them and also having significant gaps (Figure 14 c).

For all types presented so far, most of the foundations are made only from stone (river rocks) with or without earth mortar, but sometimes the foundation is absent, the bottom timber beam simply sitting on the ground (Figure 15 and Figure 16).

Figure 15: The foundations are made only from stone (river rocks)

Figure 16: The bottom timber beam is simply sitting on the ground

The bottom timber beam is usually made of hardwood (oak tree, locust tree, etc.), and the other are generally from softwood (pinewood). The timber structure is not embedded in foundations, it is only simply supported, and this detail can allow sliding of the walls during earthquake. In this situation, the connections between the walls, if carefully executed, can allow the house to slide as a whole and not be much affected by the movement of an earthquake.

The timber frame structure is built by vertical and horizontal elements and bracings, which are positioned at the corner's and intersections of the walls, but not always in coherent distribution (Figure 17a). The joints are mostly cross-halved at the intersection of the walls (Figure 15), but they can also be joined simply with nails (Figure 17b). Occasionally, steel clamps are added to increase the resistance and stiffness of the joint (Figure 17c). The roof covering of a traditional house, in traditional solution was made by wood shingle, but now most of them are replaced because they were damaged (biological decay).

a) b) c)

Figure 17: a) Stone foundations (river rocks); b) bracings positioned at the corner's house; c) cross-halved joints

From locals' testimony (personal communication) the past earthquakes didn't seriously affect this type of traditional houses. Some damages occurred after earthquakes, which were repaired immediately, but the serious damages were caused by the xylophage bacteria attack and moisture (lack of drainages, roof damages).

Most of them are abandoned and they aren't maintained properly, and also, the geotechnical phenomena (settling, landslides, etc.) mainly caused cracks and walls overturning. Most of the houses are one story high, but occasionally, they can be with upper story (Figure 9), having the architecture as a house with the living space at the upper floor, while at the ground floor the owners have the storage rooms. Due to this reason, the ground floor walls are made of stone or brick masonry, while the upper floor can be made of one of the 5 types described in this paper. In rare situations, one can find also a combination of several types (Figure 18), and this may be explained as reparations after earthquakes (maybe different earthquakes), as the houses seems very old and might have exhibited also both 1940 and 1977 seismic events in Romania.

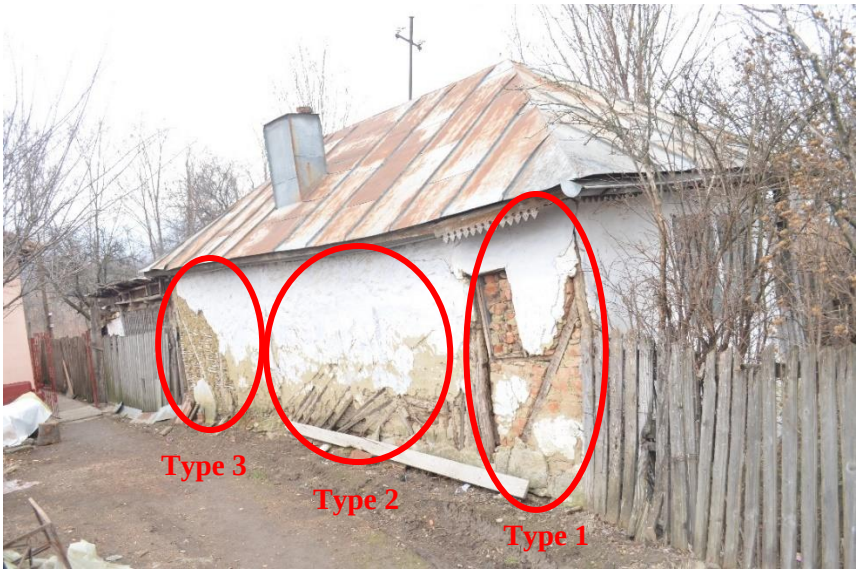

Figure 18: Traditional house with Type 1+2+3, from Viperesti, Buzău county

Newer type of house was found in few cases (Figure 19), and while the AAC brick has good thermal insulation properties, some details coming from traditional architecture (the timber frame and the bracings) have no meaning in the new application, due to their incoherent display.

This is a proof that the construction methods with the corresponding meanings are being lost, and this phenomenon can be dangerous for the future earthquake.

Figure 19: Building with timber skeleton and AAC (autoclaved aerated concrete) masonry infill (Type 5), from Viperesti, Buzau county

4 CONCLUSIONS

The study presented in this paper showed a small part of the situation of rural buildings, with a reference to the traditional architecture which is a part of Romania's national heritage. It seems the construction methods do not keep the same details as the one's considered original traditional type, the owners (building them by their selves) mixed the execution details depending on the access to materials and maybe the ease of manufacture.

As it can be seen, for example for type 1 – "paianta" structure house – instead of having small piles foundation (Figure 5), the ones found in the investigation sometimes even lack the foundation, but most of them have stone foundations (Figure 15). This variation makes the seismic evaluation very difficult for this type of house, and this may be one of the reasons why the traditional architecture house is not anymore encouraged to be built.

However, as recent earthquakes in other countries showed **(**Turkey [3], Haiti [4], China [5], Myanmar), the traditional infilled timber frames behave very ductile in earthquake, and although exhibit damages, they rarely collapse. And since it represents a cheap solution for residential houses, attention is necessary to establish the importance of the construction details within the seismic behavior, and promote them to the wide public (non-engineered) to be applied.

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