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Background information of Adobe in Chile

Chilean History has been created and built among numerous and significant earthquakes, which have destroyed cities on various occasions affecting the adobe architectural heritage and, as a consequence, adobe buildings have been disappearing with each telluric event. The material has several organisations fighting for its protection, nevertheless in not only until 2013 that the first norm for preservation was launched.

On 1985 Chile was shaken by a 7.8 Richter earthquake, where many adobe buildings got seriously affected. The ones still standing were retrofitted, but on February 2010 the country was beaten once again by a strong earthquake of 8.8 Richter destroying, among others, the same buildings retrofitted in the past. However, at the same time many adobe structures, even old buildings constructed more than 100 years ago, were still intact or with minor damages showing that the problem is not the adobe as a construction material, rather the way and process of adobe recovery and retrofitting.

Adobe buildings can be found all along the country, but the zones affected by the last earthquake are concentrated in the VI and VII Regions, where additionally are found the most important heritage villages of the country preserved by the government such as Lolol, Zuniga, Vichuquen or San Pedro de Alcantara (MINVU, 2011). Sadly, buildings located outside the protected zones were not preserved by local authorities and despite the fact that according to experts in adobe many buildings could have been easily retrofitted, the city councils of the affected areas decided to demolish all buildings with damages, because of security and the applicable policies of that times.

Only in Curico city, located in the VII Region, around 2,300 buildings stayed with demolition order (Maule, 2013) and similar measures were taken in several cities and rural areas of VI, VII, and VIII Regions. According to the Ministry of Housing and Urban Development (MINVU) in total 50,576 adobe housings were demolished after the 2010 earthquake, which left a total of 3% of adobe buildings in Chile against the 5% before the earthquake (MINVU, 2013). An inconsistency on Chilean policies ruling on 2010 did not allow the conservation of many of these demolished buildings. On 2010 the building regulation lacked of an appropriate regulatory framework that precisely specified the scopes and minimum requirements of seismic-resistant adobe structures. In fact, this lack of the norm was highly conditioned by the last version of the norm NCh 433: “Earthquake resistant design of buildings”, which stablishes that buildings built with materials without a related norm, will not be accepted by the NCh 433 (CMN, 2013). In other words, adobe buildings were not approved by the Chilean laws.

In light of these facts, the parties of concern worked fast in creating a new norm to protect Chile’s heritage and stop the demolition of adobe buildings. In 2013 the norm NCh 3332: “Structural design - Retrofitting of historic earth buildings - Requirements for the structural design planning” was finally launched. It establishes the minimum requirements that structural project must follow in the restoring, retrofitting, intervention and structure consolidation of adobe buildings with heritage value. Nevertheless, due to the earthquake and the bad reputation boosted by local authorities, the adobe as a construction material lost popularity irremediably and change people’s judgements will take time. Yet, according to the architect Enzio Mosciatti, farmers are not happy with the replacement housings given by the government (EMB Construccion, 2012). The government replaced destroyed adobe housings mainly by prefabricated housings, which does not match with farmer needs due to the house size and the difficulty to afford an extension. This have affected rural dwellers' life style, taking them to think that life was better before (with adobe housing), giving an opportunity to reborn the adobe in Chile.

Adobe characteristics

The adobe masonry is defined as a structure built with sun-dried bricks made of mud, straw and sometimes with additives to improve the quality and mechanical ability that are connected with mud mortar. The seismic capacity of an adobe housing depends on the mechanical properties of the materials (blocks and joints), on the global structural system (structural geometry, connections, etc.), on building foundations, and also on the quality of the construction and maintenance (Varum et al., 2014). Materials such as concrete, baked clay bricks, steel, cement stucco and synthetic paints are incompatible with the mechanical behaviour of the building and the chemical properties of mud (Heinsen et al., 2012).

Maintenance

Adobe structures can be durable, but they present fragilities that can affect the structure so particular care should be taken against erosive agents, such as:

Humidity: Adobe constructions are very susceptible to water. Excessive humidity, exposure to rain or wind with rain, are agents that deteriorate the walls affecting the mud adherence. Even though adobe is vulnerable to rain, in Chile the largest adobe dwellings are located in rainfall zones between 700 mm and 1200 mm per year (Weatherbase, 2015), with satisfactory performance. Therefore the measures used to protect the houses from water have acceptable results.

Biotic agents: living agents such as the growth of mould and damp rising from the soil, the growth of plants and weed, the presence of birds, rats or bats and specially the presence of termites, are agents that considerably weaken adobe buildings, even causing collapses.

Seismic resistance and polymer mesh

The Pontificia Universidad Catolica del Peru (PUCP) have been investigating the seismic behaviour of earthen buildings since 1970s. One of the studies concentrated in find compatible reinforcement materials that helps adobe buildings to resist strong earth movements such as 2010 Chilean earthquake. In fact, the mains construction guidelines and norms for adobe buildings of Chile are based on studies done by Peru in the related field.

According to PUCP (Torrealva et al., 2006), polymer mesh (or geogrid) has proven to be the most appropriate material for reinforcing earthen buildings because of its compatibility with adobe, because of its resistance to biological and chemical agents, and because its tensile strength can be transferred to the wall where it is applied. They state that adobe walls must work jointly with the compatible reinforcements embedded in the walls. This is obtained by the application of mesh-type reinforcement either internally or externally. In the case of external reinforcement, it has to be applied on both sides of the wall and connected by natural or industrial threads in holes through the wall. The plaster mortar has to have a minimum thickness to assure the integrity of the reinforcement with the wall and to provide protection from the environment. Mud mortar mixed with fibres should be used as plaster to allow moisture transfer between the wall and the environment.

Marcial Blondet is professor of civil engineering at PUCP, specialist in earthquake engineering and structural dynamics, and has ample experience in the experimental study of the seismic behaviour of structures. Among many publications about seismic structures reinforcement, he and two colleagues have compiled a peer-to-peer guideline of adobe houses using geomesh reinforcement for the citizens of Peru after 2007 earthquake (Blondet et al., 2007). In general, they recommend to do not build two or three storey buildings and the main characteristics for a seismic resistant adobe house are:

1. Light roof: less forces are transmitted to the walls during a telluric event.
2. Small and centred openings (windows, doors, etc.): improve wall resistance
3. Firm, dry and stable soil: the groundwork of foundation should never rest on loose soil or filled soil.
4. Foundation: cement, concrete and many stones mixture should be used.
5. Plinth walls: Protect the walls from soil humidity
6. Thick walls with geomesh reinforcement: At least 0.4m of thickness or more improves the earthquake resistance.
7. Collar beams: Tied up all walls in order to let them work together on a telluric event.
8. Mud plastering: Plaster the walls in two layers: the first one should be approximately 2.5cm thick and the second one should only be 0.5-cm thick. It protects geomeshes from the sun and increase the resistance of walls.

Conclusions

- In Chile, after the 2010 earthquake the reputation of adobe got damaged due to the large amount of adobe buildings that collapsed. Nevertheless, the reason of the high number of destroyed buildings was because of the lack of proper building regulations for adobe, therefore many handcrafted houses were built or retrofitted with poor knowledge on seismic structures. Recognised Chilean architects are now working hard in boost the anti-seismic adobe technologies and eliminating people judgement on adobe.
- PUCP has been working in the state-of-art of seismic resistant adobe buildings during the last 40 years. Their research has been intense and very helpful for communities in South America such as Chile.
- Thanks to cost-effective building technologies like geomesh, the seismic performance of adobe can be improved, converting it in a safe material capable of resist strong earthquakes such as the 2010 in Chile and the 2007 in Peru.

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