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Studies on Inca architectural heritage

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The intention of this research is to participate in the studies that have been made in recent years in the attempted to understand Andean civilization through minute research into particular human activities, in this case building and architectural technology. Achievements reached by the Incas, especially in architectural and engineering skills, have been admired ever since 1532, the time of the Spanish conquest. The first walls in the Americas appeared along the coast in Peru about 2500 B.C. Masonry walls were constructed extensively in the Peru-Bolivia highlands. The use of the wall was reflected in the quality of construction in the later Inca masonry, 1200 A.D.-1500 A.D. The fitting of the blocks was very precise, with either very thin clay mortar or no mortar. The surface texture of the stones suggests that they were shaped by pounding with small hard stones, followed by surface grinding with stones and sand. Because of the irregular coursed, notched corners, and close fitting, the walls have demonstrated unusual resistance to earthquakes.

As Inca dry-stone masonry resists seismic load by its frictional force, it is important to measure its frictional properties and also surface properties. The friction coefficient of Inca stone at Machu Pichu and Qorikancha was measusured using a mobile friction meter. Surface properties and averaged roughness index Ra were determined with a 3-D laser scanning microscope.

Using small blocks of wood and resin, shaking table tests were carried out as a preliminary research to study the influence of notches used in dry-joint Inca stone masonry. On the other hand, using a shaking table and JMA Kobe (1995) earthquake signal as an input, a two-layer small-scale stone assembly was tested to investigate the seismic behavior of Inca stone walls.

A multiple rigid body model with friction and impact was proposed to investigate the analytical seismic behavior of the dry-joint Inca stone walls. The model considers friction coefficient or frictional forces acting in the horizontal joints between blocks. In the vertical joints of adjacent blocks it is considered that forces due to impact are developed. To investigate uniform friction and variable friction among the blocks, sinusoidal waves with different amplitudes and frequencies were used as input motion. The maximum displacement response became larger for low frequencies while for high frequencies this maximum decreases. Therefore it is believed that actual earthquake motions with low frequency content may produce more severe damage to this type of historical structures.

Micro tremor measurements were performed in representative stone constructions of Machupicchu citadel. This provides a basis for the evaluation of the dynamic characteristics of this type of historical buildings. For example frequencies of 5.5 Hz (E-W) and 8.2 Hz (N-S) of fundamental period was found at Huayrana building. Using FEM analysis, an equivalent elastic modulus of 0.9 kN/mm2 was established. A probable mode of failure was also studied. In Colca building for example, the gable wall presents concentration of tension stresses at the bottom and therefore the overturning of this portion of the structure is probable.

Beyond the technical issues of Inca Construction, site-planning skills developed by the Incas are another important achievement. The Inca planners took into account the particular topography and hydrology when laying out a site; they often built on high places, rocky outcrops, and sites with particular panoramas or particular views of a river, mountain, or lagoon. They also had strategic considerations in mind when sitting new administrative centers; they paid attention to ease of access, supply lines, and issues of control of local populations.

Because it’s multidisciplinary approach, this study, which focus into particular human activity such us building and architectural technology, could be considered representative for future approaches to understand the Andean civilization through minute researches.