SUSTAINABLE CONSTRUCTION TECHNIQUES WITH BAMBOO AND ICHU STRAW AS A CONTRIBUTION TO ANDEAN ARCHITECTURAL IDENTITY

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The present study evaluates the contribution of the use of sustainable construction techniques with plant fibers: bamboo and ichu straw in the architectural identity of Tarma, Junín region. For which the research method considers two phases, in the first, sustainable construction techniques are evaluated and developed, taking into account two dimensions: "the use of local bamboo and ichu straw", with the selection of three species of bamboo from the environment: a native of the genus Chusquea, and two exotics of the genera Guadua and Phillostachys, and the species Stipa ichu; and the “design and application”, with the construction of three architectural models, using the four species, in which the local population participated by adapting traditional weaving techniques with ichu straw. In the second phase, a semi-structured survey is prepared to collect data related to the identity of the local people regarding their territory and the architecture, and the perception and impact generated by the three models. Among the results of the first and second phase, the possibilities of using bamboo as a construction material according to the species, the adaptability and fusion of traditional techniques in contemporary designs, the identification of the local people with the proposed models, as well as verification of sustainable guidelines applied in design and construction.

Keywords: Sustainability, Vegetal fibers, Natural techniques, Sociocultural identity.

1 INTRODUCTION

The architecture of this era has been distancing itself from its roots, omitting adaptation to the natural and cultural physical environment, which leads to the loss of identity and unsustainability of the territory, causing problems, such as increased construction costs due to import costs, non-renewable energy consumption and others closely related to the life cycle of buildings (Chaos Yeras 2015). One of the most current problems in the world of architecture and urban planning, in particular, the preservation of heritage, is that of the progressive and until today inexorable loss of the various traditional local identities in the face of the effects of globalization on our built environment. (García Hermida 2018). With or without identity, global homogenization is the new stage of our life, which advances by absorbing cultures and omitting the roots of people with traditions and vernacular architectural identity (Romero Solís 2014). And we ask ourselves, how to recover identity? How to propose architecture with construction techniques that contribute to identity and the environment? How to respond to the sociocultural ties established between people
and their places of residence through architecture? The loss of identity references such as vernacular architecture is a phenomenon that requires debate and action (Chaos Yeras 2015). Even more so in our Andean cities where buildings have been aggressively invading the urban sectors in a decontextualized manner and, in turn, expanding to rural areas, violating the natural and traditional architectural landscape, forgetting materials, local construction techniques, ancestral knowledge, which by for many years they forged a history, a memory, in harmony with nature, respecting their culture and their people. Such is the case of the district of Tarma (Figure 1) in the Central Andes of Peru, baptized as “The Pearl of the Andes” by the wise Antonio Raimondi (Yupanqui 2018) and where Tarmatambo (Figure 2) is located, important Inca installation, on the Inca trail, on its route from Cuzco to Quito. The buildings, for the most part, were built with stone and mud and almost all of them are located on terraces (Ministry of Culture of Peru 2020), lintels with local wood, alder or quinual, tied with twisted or braided rope in ichu chilliwa (Flores Espinoza and Varón Gabai 2002). Materials that continued to be used for many years in village, farms, rural homes and in the first buildings of the city, until they were discarded due to the use of conventional materials and construction systems from the capital, losing at an accelerated pace all the legacy and vernacular architectural wealth, added to the pollution that has been generated by the construction sector. In this context, this work is part of a project that won a contest from the Ministry of Tourism of Peru – “Turismo Emprende” 2019 Program, which aimed to enhance a traditional house in the town of Pomachaca (Tarma), with materials local natural materials such as earth, wood, tile, ichu straw, use of native bamboos from the Andes and exotic ones from the Amazon, revaluing traditional construction systems and proposing sustainable techniques in contemporary designs with natural fibers, which activate value chains and generate identity in the area, within the framework of the SDGs with emphasis on number 11, “sustainable cities and communities.”

1. Junín Region, Peru  
2. Tarma Province  
3. Tarma District, Urban center  
4. Tarma peripheral area  
5. Sacamarca, rural area Tarma

Figure 1. Junín region, Tarma province.

2 METHODOLOGY

The research took as a starting point the recognition of renewable natural resources, architecture and traditional construction systems, local in the Tarma - Pomachaca area with earth and Pasco - Junín regions with plant fibers, to establish the design criteria and techniques that consider aspects of sustainability and identity, materiality, perception of form and space. Surfaces were identified for the collection of natural materials: native plant fibers in Andean areas and exotic in Amazonian areas. The study is carried out in two phases: 1) Sustainable construction techniques, which considers two dimensions: a) “use of bamboo and local ichu straw”, with the evaluation and identification of three species of bamboo and one of ichu, which have one of the following characteristics: structural properties, commercial use and/or traditional use; and b) “design and application”, with the development of the architecture and construction of 3 models, using techniques with identified plant fibers, contemplating premises of sustainability and regional-local
identity. 2) Surveys for validation, a questionnaire is constructed with closed and open questions, the data collection instrument of the author Julio Egaña (2021) is taken as a basis, validated by an expert and socialized with the local population of Pomachaca – Tarma, which formed the study population, made up of 24 locals from different families, which represents the sample size of 937 inhabitants, with a confidence level of 95% and margin of error of 20. The semi-structured survey collects data related to the identity of the premises, the architectural identity and the perception and impact generated by the three models. It is divided into four dimensions (D): D1 Sociocultural Identity, subdivided into four aspects, regional relevance (Junín), provincial relevance (Tarma), local relevance (Tarma - Pomachaca) and historical legacy; D2 Architectural Identity; D3 Social Imaginaries, D4 Sustainability of the Models and D5 Impact of the Models. In addition, an artistic activity was incorporated with local children so that they could register in their visual perception the application of construction techniques and identify the spatial and formal organization achieved.

![Figure 2. Tarmatambo, traditional houses, colcas incas (photography: Cajahuanc, G., Cerron, T.)](image)

### RESULTS

#### 3.1 Phase 1: Sustainable Construction Techniques

##### 3.1.1 Use of local bamboo and ichu straw

Selection of three species of bamboo and one of ichu straw; *Guadua Takahashiae* (Figure 3 - 1 and 2), exotic species, plantation in Chanchamayo, Junín region. Physical-mechanical characteristics similar to *Guadua Angustifolia*, the most studied in Latin America and recognized for its structural properties, used for construction in round form, slats and mat. *Phyllostachys Aurea* (Figure 3 - 3 and 4), exotic species, plantations of La Merced, Junín region. Local name bambucillo, which is most marketed and used in the central region of Peru, mainly for furniture, crafts and/or coverings. *Chusquea Dombeyana Affin* (Figure 3 - 5 and 6), native species, Ninacaca mountains, Pasco region. Traditional use of the chusquea genre on roofs, Church of Ninacaca with more than 500 years old, currently experimental use on bicycles. *Stipa ichu* (Figure 3 - 7 and 8) native species, Huaricolca mountains, Tarma, Junín region. Traditional use in roofs, adobe, rammed earth, to cover food.

![Figure 3. Vegetable fibers: bamboo and ichu.](image)
3.1.2 Design and application

Development of 3 Models (architecture and construction), as part of the recovery project of the traditional house of the Villa Justina Eco lodging, highlighting the use of bamboo as a construction material according to the species and the adaptability of traditional techniques with ichu straw in designs contemporaries, described below:

a) **Model 1 – Potato Interpretation Center** (Figure 4). First level with traditional adobe system with a double bamboo beam, second level with bamboo structure composed, of 6 straight-curved structural elements is anchored, where two techniques are applied for joints, with 3/8 metal bolts to the culms straight and with a ½” band-it system for the curved laminated beams, composed of groups of bamboo slats. Two species are used, *Guadua Takahashiae* (Ø12.5cm) in round form and in slats, and Philllostachys Aurea in round form for joists and floors. For the cover, the Andean technique of weaving with ichu was used, adapted to the shape, tied with hemp fiber to the bamboo slats.

b) **Model 2 – Water Pit Structure** (Figure 5), use of the Ø2.5cm *Chusquea Dombeyana Affin* species for the 4 diagonal supports, made up of 4 bamboos, which support the grid cover. Application of two techniques for joints, ½” band-it system for the supports and hemp fiber to hold the grid. For the enclosure of the roof, another Andean technique was adapted to the shape with the ichu straw.

c) **Model 3 – Meditation dome** (Figure 6), use of the Ø2.5cm *Phillostachys Aurea* species to generate a geodesic section, composed of 5 rings and a fabric. The heat technique was applied to bend the bamboos and form the rings. For the enclosure, rings of bamboo slats were placed every 30 cm. The Andean technology of weaving with ichu straw was used, tied with hemp fiber to the slats. In the three models, the participation of locals was achieved, who transmitted their construction knowledge, adaptability and fusion of traditional techniques with contemporary designs, giving added value to native Andean and exotic Amazonian species, inserting themselves into the local landscape (Figure 7).

![Figure 4. Model 1- Potato Interpretation Center.](image)

![Figure 5. Model 2 - Water well structure.](image)

![Figure 6. Model 3 - Meditation dome.](image)

![Figure 7. Three models related to the context.](image)

3.2 Phase 2: Survey for Validation

Among the main results, D1 Sociocultural Identity, the majority have a feeling of belonging.
They feel proud and identified with their origin from the regional to the local level, with their culture, community, natural landscape. Regarding D2 Architectural Identity, the materiality of its architectural legacy is recognized with the use of land, ichu straw, wood, they consider that it is important that the house has natural spaces to grow plants and raise animals, they believe that adobe and/or rammed earth houses with red Andean tiles are beautiful, in harmony with the landscape of the earth-colored mountains.

Figure 8. Survey results related to dimensions D1 and D2 (source: own elaboration).

The results for D1 and D2 are seen positively in Figure 8, the respondent had to respond from 1 to 5, where 1 = totally agree and 5 = totally disagree. In D3 Social Imaginaries, there are interesting answers that reflect the feelings of locals in words. To the question: How would you describe this place? Answer: tranquility, beauty, silence, away from noise, fresh air, green fields, nature. To the question, what identifies you most with the place? Answer: old house, adobe houses on hills, countryside, nature, plants, hills, traditions, cut mountain and chonguinada dance. To the question: Do you remember what houses and buildings were like several years ago? Answer: there were not many houses, there were no houses in the hills, the few houses were made of adobe, rammed earth, like a hut, there was no electricity or water, everything was mud and tile, cement was unknown. To the question: Would you build your house with earth (adobe or rammed earth), bamboo and Andean tiles? Those who answered yes supported it because it is warmer with dirt, mud walls and a beautiful bamboo roof, others answered no because it does not seem safe to them. However, they know that the town of Pomachaca will become populated and the tranquility, the fields and the natural and traditional houses will be lost. Nostalgia when listening to his response to the future of his people. As a result of D4 Sustainability of the Models, 100% fully agree on the environmental and sociocultural component as shown in Figure 9, however, in the economic component there are still doubts regarding the cost. In relation to D5 Impact of Models, answers to the following questions stand out: What impression do the Models generate on you? They are beautiful, out of the ordinary, they are related to nature. Do any of these models remind you of any place? Recreation in Chanchamayo, colcas, countryside, the Middle East, jungle and mountains, my town of Palcamayo. What do you relate or associate the Models with? Space to rest, a hut to store food, potatoes, corn, chulpas, houses from Africa, from other countries, colcas, houses in my town of Palcamayo, houses in the jungle. The adaptability and identity of the locals with respect to the proposed models is highlighted, as well as the verification of sustainable guidelines applied
in the design and construction. Finally, the perceptual and sensory impression of the children in front of the Models is recorded, where they draw, paint and identify with the space (Figure 10).

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<tr>
<th>Environmental Component</th>
<th>Socio-Cultural Component</th>
<th>Economic Component</th>
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<tbody>
<tr>
<td>1. Respect nature. The model is integrated into the natural landscape.</td>
<td>4. Protect the local landscape. The Model blends in with the environment. It feels Andean</td>
<td>7. Promotes the value of local resources. The model is the final product with an economic value, value is given to vegetable fibers: bamboo and ichu.</td>
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<td>2. Use of local, natural and renewable resources. Plant fibers are used in the Model: bamboo and ichu grass, species from the Amazon and the Andes.</td>
<td>5. Transmits and revalues traditional construction systems. In the construction of the model, in the cover phase, the ichu weaver family participated.</td>
<td>8. Activate the local economy. Work is provided in all phases of bamboo production. The techniques with ichu straw are owned by the locals, a value for the local workforce.</td>
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<td>3. It generates minimal impact on the environment. The techniques and construction processes of the Model use minimal energy and most of the waste generated is biodegradable and is reused.</td>
<td>6. Protect local culture. The model promotes the use of local techniques with contemporary techniques to generate architecture with identity.</td>
<td>9. Low-cost construction techniques. The use of energy is minimal, low-cost machinery and equipment, local materials.</td>
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Figure 9. Results of the surveys related to D4 Sustainability Models (source: own elaboration).

Figure 10. Artistic manifestations of children (source: own elaboration).

3 CONCLUSION

It can be concluded that sustainable construction techniques with bamboo and ichu straw are presented as an alternative that contributes to the Andean architectural identity of Tarma. It is recommended to continue studying the use of bamboo, especially Andean species (little studied), linked to traditional techniques and contemporary proposals, as well as, with greater diversity of techniques with ichu straw for wall or roof enclosures.

References

Ministry of Culture of Peru, Ancestral Routes of the Qhapaq Ñan, Lima, Peru, May, 2020 (in Spanish).