

VERNACULAR AND ENDOGENOUS PARAMETERS: REVISION OF THE MACHUPICCHU WALL AND THE ECOEARTH SANDWICH SYSTEM

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The study of vernacular construction systems as a means to develop coherent local contemporary alternatives consistent with local resources and cultural processes; the results are endogenous buildings that respond to the eminent global energy crisis. Confined earth construction systems with different structural forms have been used throughout Latin America, specifically in the Andes. With these criteria, the eco earth sandwich system, a confined earth wall with metal sheet containment, has been developed as an alternative wall system. Using local resources, materials, and workforce, The Con Lo Que Hay 14 (CLQH 14) workshop, which translates to “With What is Available, edition 14 workshop,” developed the eco earth sandwich for a small suburban community center in the Ecuadorian Andes, based on vernacular contained earth criteria. Through Arellano and Angel vernacular parameters, this study will evaluate Machu Picchu (Peru) walls with dirt nuclei protected by stone and the eco-earth sandwich system to depict their endogenous and vernacular coherence.

Keywords: Communal construction, Local materials, Replicable systems, Actual necessity.

1 INTRODUCTION TO ENVIRONMENTAL AND VERNACULAR BUILDINGS

In the last 40 years, the increase in energy consumption has been more significant than the growth of the human population (Jorgensen and Fath *et al.* 2008). The construction industry is the largest consumer of natural resources (Alavedra *et al.* 1997) and directly impacts climate change. Globally, 45% of world energy and 50% of water is consumed by buildings (Dixon 2010).

One of the mitigation strategies would be to increase endogenous constructions according to the site and vernacular architecture, for it decreases the ecological footprint of the buildings, which is the biologically productive area needed to absorb the waste generated (Jorgensen and Fath *et al.* 2008). Endogenous development is understood as "local development produced mainly by local impulses and grounded largely on local resources" (Picchi 1994). Vernacular architecture in terms of Hidalgo Arellano (2018), as we now see them, discovering the history and the past contained in them. Through the images studied, we can understand that architecture does not explain its past but instead contains it. Regarding Ghisleni (2020), vernacular architecture is a local or regional construction that uses traditional materials and resources from the area where the building is located (Ghisleni 2020). Consequently, vernacular and endogenous

buildings are directly connected; this architecture is related to its context and is aware of its specific geographic features and cultural aspects (Ghisleni 2020).

This study compares two similar construction systems, distant in time and space. We choose to evaluate these systems because both consist of confined earth with a non-removable mold, one a Machu Picchu's wall (Peru 15th AC) and the eco earth sandwich (Ensusitio 2019). These systems will be evaluated through the concepts of endogenous and vernacular.

2 HOW IS VERNACULAR CONSTRUCTION ENDOGENOUS?

Vernacular techniques have offered a great variety of architectural solutions used for many generations, coherent with the environmental care of the planet, and also are an important piece for the cultural heritage from the communities all over the world, that through understanding its territories, were able to adapt and satisfy its basics life necessities (Rojas 2019)—

A vernacular building is endogenous due to its close relationship with the local culture, environment, and society (Flores 1979). The endogenous nature of vernacular architecture is further emphasized by its reliance on local resources and the adaptation of building techniques to the community's specific needs (Piesik 2017). This architecture embodies a sustainable approach, utilizing materials readily available in the area and encouraging a harmonious relationship with the location being environmentally and socially responsible.

In the book *Arquitectura Popular española*, Carlos Flores (1979) unveils the multifaceted nature of architecture without architects, and in *Arquitectura vernácula y Patrimonio*, Arrellano and Ángel (2018) shows parameters for vernacular construction from Flores's investigation and embodies both endogenous and vernacular approaches to building. The parameters are as follows:

- “1. *The construction does not contain the presence of architects.*
2. *Expresses itself without the necessity of explanation.*
3. *Coherent, original, and synthetic solutions.*
4. *Topography adaptations.*
5. *Responds to the weather, constructive tradition, the function, human scale, material nature, and the social economy.*
6. *Born from the habitat and the time.*
7. *Responds in its fullness to the necessities of the human in a rational way.”*
(Arrellano and Ángel 2018)

Following Arrellano and Ángel parameters, we consider the current context:

Points 1, 2 and 3 refer to the construction system. With no need for professionals, these are approachable, simple, accessible, and replicable systems. Points 4 and 5 relate to site resources, bioclimatic comfort, cost, and local circular economy. Point 6 interacts with local culture, time, and symbolism. Point 7 is functional and responds to local essential needs and solutions.

2.1 Machu Picchu (Peru)

In Machu Picchu (mid-15th to the early or mid-16th century), by incorporating stone facades, the earth walls were fortified against adverse weather conditions, ensuring their durability and longevity. The base structure of dry stone walls is filled with earth. The stone was taken from the nearest rivers and canyons, and the interior was filled with earth from the site. Traditionally, stone and earth are used in the foundations of buildings, two layers of stone, known as "molón." with earth working as the mortar and interior filling. Historically, the walls were thought of as being only made of stone, but the stone was used as a mold that was not meant to be removed and protected the earth wall from the elements.

Table 1. Parameters for vernacular-endogenous construction in Machu Picchu buildings. (Modified from Arrellano and Ángel 2018).

Table of parameters for vernacular construction.	YES	NO	WHY
1. The construction does not contain the presence of architects.		X	It is unknown, unverifiable
2. Expresses itself without the necessity of explanation.	X		The materials and system are explicit. replicable
3. Coherent, original, and synthetic solutions.	X		Accessible materials and workforce
4. Topography adaptation	X		Works with the site.
5. Responds to the weather, constructive tradition, Function, human scale, material nature, and the social economy.	X		Durable available materials.
6. Born from the habitat and the time.	X		Control and subsistence.
7. It responds in its entirety to the necessities of the human in a rational way.	X		Secure strategic point.

Reviewing the parameters in Table 1, the Machu Picchu reference most parameters answered as yes; thus, it can be categorized as mainly vernacular-endogenous architecture. It is unverified how the system was implemented, from the complexity of the site, specialized or professional guidance may have been present. The wall structures evidence the use of the stone walls as the containers of the earth filling, all materials readily available.

2.2 Eco Earth Sandwich Systems

The eco earth sandwich, developed in the community of Guápulo-Ecuador by the Con Lo Que Hay 14 (CLQH 14) workshop, which translates to With What is Available edition 14 workshop, together with Ensusitio, seeks to be an alternative construction structure based on local site and culture (Ensusitio 2019). The eco earth sandwich is a reinforced earth wall construction system with a non-removable steel mold with spatial and structural applications, being structurally safe, self-supporting, acoustic, and thermally comfortable.

The system is designed to be accessible and adaptable, allowing communities to construct their own buildings without needing architects. It empowers residents to participate actively in the construction process. Its construction technique is intuitive and straightforward, allowing users to understand, implement, replicate, and adapt it. See Figure 1.



Figure 1. Community and students during the construction process.

The system can adapt to different terrains and topographical conditions. It reflects the knowledge, practices, and resources available in the local environment. Also, it considers the local weather conditions and utilizes materials and construction techniques that have proven effective in the region and applied by the local workforce. As per Con Lo Que Hay 14 design, the elements conforming the eco earth sandwich system are detailed in Figure 2 and bulleted below (Ensusitio 2019).

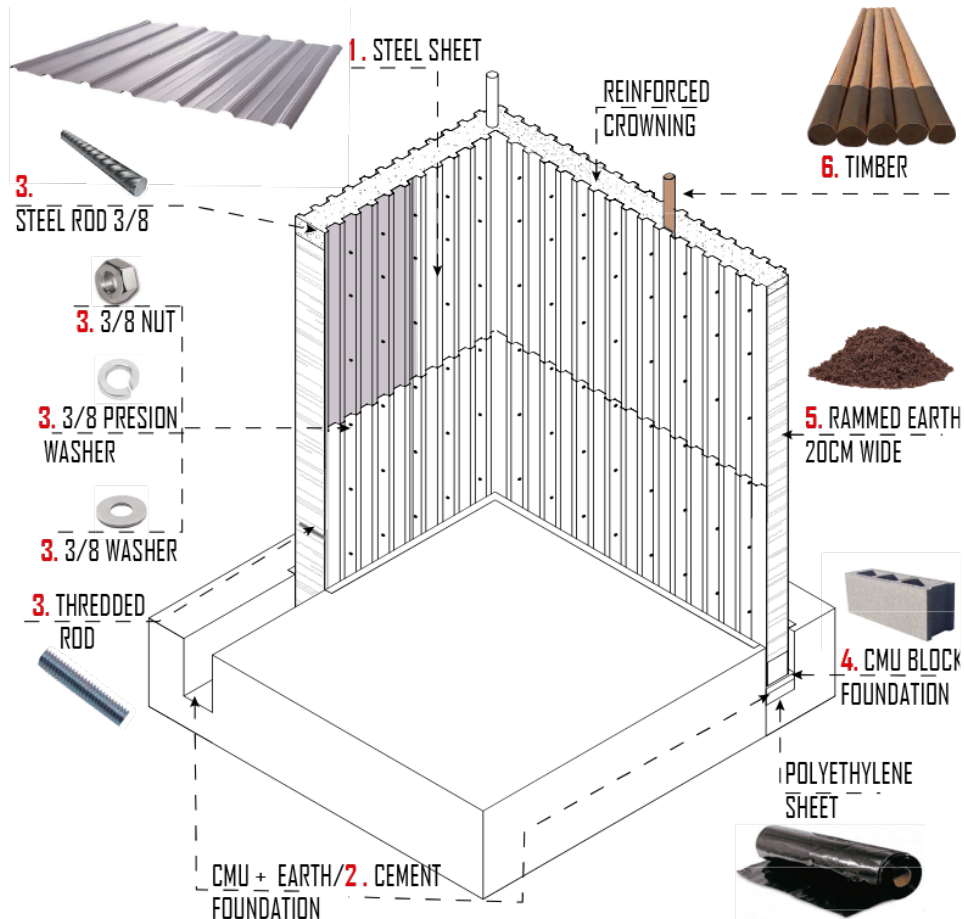


Figure 2. Eco earth sandwich system materials. (Modified from (Ensusitio 2019)).

- (1) Galvanized steel panel – reused roofing from site.
- (2) Cement. Readily available, brought to site.
- (3) Galvanized steel accessories, nuts, washers, and rods, brought to site.
- (4) Mass produced CMU block partially reused from site.
- (5) Rammed earth using soil from the site; and
- (6) Timber from site.

The eco earth sandwich system is a reinforced earth wall that has spatial and structural applications as shown in figures above. The parameters for vernacular construction eco earth sandwich system are given in Table 2. .

Table 2. Parameters for vernacular construction *eco earth sandwich* system. (Modified from (Arrellano and Ángel 2018)).

Parameters for vernacular construction. <i>eco earth sandwich</i> system	YES	NO	WHY
1. The vernacular architecture does not contain the presence of architects.		X	Developed by students together with the community
2. Expresses itself without the necessity of explication.	X		Built with the community and their feedback. Local input. Replicable.
3. Coherent, original, and synthetic solution.	X		Accessible materials and workforce
4. Topography adaptation	X		Works with the site.
5. Responds to the weather, constructive tradition, function, human scale, material nature, and the social economy.	X		<i>Minga</i> -collaborative work with community. Re-use of available steel sheets.
6. Born from the habitat and the time.		X	Students approached and found a true necessity
7. It responds in its entirety to the necessities of the human in a rational way.	X		Need of a safe zone and community gathering

Note: The constructive system *eco earth sandwich* fulfills parameters such as vernacular-endogenous architecture at contemporary times, self-expression, coherence, originality, and synthesis.

3 RESULTS

Both Machu Picchu and the CLQH 14 workshop exemplify a resourceful construction approach, utilizing materials readily accessible in their respective contexts. Machu Picchu vernacular construction uses local stone on-site and in nearby rivers and canyons. This abundant endogenous material served as a sturdy foundation for the structures.

CLQH 14 workshop, with a contemporary perspective, adopts a similar Machu Picchu approach by working with what is available. However, with advancements in technology and the availability of modern materials, the use of metal has become more prevalent. Metal offers advantages such as strength, flexibility, and ease of use in construction processes. It has become a cost-effective resource due to its contemporary relevance and widespread availability. The use of metal also holds a visual reference and cultural significance because metal elements can be incorporated into the design to provide a contemporary local aesthetic. This blending of modern materials with cultural references creates a dialogue between the past and the present, maintaining a connection to the local cultural identity.

4 CONCLUSIONS

Although energetically it would be ideal to have an utterly endogenous building, it is not practical in praxis due to local economies in urban contexts. That is why some construction systems tend to incorporate materials that, although not endogenous, have become vernacular in their own terms, in this case, the CMU and the steel panel. The goal could be to bring significance and relevance to these materials to apply them to the best of their capacities.

The endogenous and vernacular materials change over time along with technology development and, therefore, adapt accordingly. Machu Picchu and CLQH 14 embrace working with available materials and workforce. While Machu Picchu primarily relied on local stone (the technology of the time), the second one incorporates metal due to its contemporary convenience and cultural relevance. This adaptation demonstrates how construction practices can evolve over time, embracing new materials and technologies while preserving the essence of the local culture and heritage.

The steel panel is not an endogenous material, but it can be considered vernacular due to its widespread use in all informal constructions.

Both constructions appeal to responsible uses of resources, being vernacular and endogenous in their own terms, therefore being environmentally responsible in the long term.

References

- Alavedra, P., Domínguez, J., Gonzalo, E., and Serra, J., *The Sustainable Construction: The State of the Issue*, Informes De La Construcción, 49(451), 41-47, 1997.
- Arrellano, Hidalgo, and Ángel, J., *Arquitectura Vernácula y Patrimonio. La Arquitectura sin Arquitectos, la Memoria y la Identidad*, Anáhuac, México: Universidad Anáhuac, 2018.
- Dixon, W. *The Impacts of Construction and the Built Environment*, Briefing Notes, Willmott-Dixon Group, 2010.
- Ensusio Arquitectura, *CLQH 14, Con lo Que Hay PUCE 14*, Ensusioarq.com, May 12, 2019. Retrieved from <http://ensusioarq.com/clqh-puce-14.html> on May 15, 2021.
- Flores, Carlos., *La España Popular, Raíces de una Arquitectura Vernácula*, Madrid, Aguilar, 1979.
- Ghisleni, C., *What is Vernacular Architecture?*, Archdaily.com, November 25, 2020. Retrieved from <https://www.archdaily.com/951667/what-is-vernacular-architecture> on November 12, 2023.
- Hidalgo Arellano, J. A., *Arquitectura Vernácula y Patrimonio*, La Arquitectura Sin Arquitectos, La Memoria y la Identidad, 2018.
- Jorgensen, S. E., and Fath, B. D., *Encyclopedia of Ecology*, Elsevier, 2008.
- Picchi, A., *Born from Within, Practice and Perspective of Endogenous Rural Development*, The Netherlands, Van Grocum Assem, 1994.
- Piesik, S., *Hábitat: Arquitectura Vernácula para un Mundo Cambiante*, Barcelona, BLUME, 2017.
- Rojas Parada, S. C., *Laboratorio de Técnicas Vernáculas para Soluciones Arquitectónicas Contemporáneas*, Bogotá D.C., Colombia, Pontificia Universidad Javeriana, 2019.