Composite Bamboo Shear Walls

Submitted By: Arup



Organization Profile

Organization Name: Base Bahay

Organization Type: Foundation and philanthropy

Website: https://base-builds.com/

Practice Details

Country(ies): Philippines, Nepal, India, El Salvador, Mexico, Colombia, Ecuador, Peru, Costa Rica

City(ies): Multiple towns and communities across the various countries listed

Start Year: 1990 **Ongoing:** Yes **End Year:** N/A

Main Adequate Housing Components:



Housing Thematic Areas:

Housing & Climate Mitigation

Housing & Climate Adaptation

Technology & Digital Solutions in Housing

Relevant SDGs:



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Problem & Context

There are three major challenges to residential housing in developing countries:

- Globally around 1.6 billion people live in inadequate housing.
- Natural disasters contribute enormously to deaths and house damage.
- Cement contributes towards 8% of global CO2 emissions.

There is therefore an urgent need for affordable and disaster-resilient housing in lower and middle-income countries that is also low-carbon.

There are few technologies which satisfy the above requirements. The majority of walls of permanent and durable affordable housing worldwide are reinforced concrete or masonry. Although these systems can be very resilient, they have a high embodied carbon. Traditional housing systems that use natural materials may satisfy many of the homeowners' criteria, however they also have downsides in terms of resilience, maintenance and durability.

This technology aims to provide a solution towards these challenges.

Solution Developed

Composite bamboo shear walls (CBSWs) are an open-source improved vernacular technology, consisting of a frame made of timber and/or bamboo, with a matrix of flattened/split bamboo or expanded steel mesh. The walls are finished with cement or lime render to form solid structural walls. These panels are an affordable, hazard-resilient (both earthquake and typhoon), low-carbon and durable walling system for affordable housing in tropical countries where bamboo grows.

This technology:

- Maximises the use of bamboo, a renewable resource.
- Has a significantly lower embodied carbon than conventional masonry and concrete housing.
- Has a durability exceeding 50 years without significant maintenance.
- Meets earthquake and typhoon design requirements, even in high hazard zones around the world.
- Provides a modern-looking home, important for communities in lower socio-economic brackets who aspire to have what they perceive to be a better and more durable house.
- Is equal or lower cost compared to other modern masonry and concrete construction.
- As a vernacular-improved system, it is easy and more appropriate for many communities to adopt because of it's existing familiarity.

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Implementation

The CBSW system has developed over time, from a vernacular system into an engineered system. Multiple organisations and initiatives over the past 35 years have developed this technology:

1) Between 1988-1995, the National Bamboo Project of Costa Rica first designed the first properly engineered CBSW homes, and build several thousand CBSW houses.
2) Between 2000-2010, following the 1999 coffee-growing earthquake in Colombia, several NGOs built several thousand CBSW homes. This interest spurred the Colombian Earthquake Engineering Association (AIS) to conduct research into CBSWs, which led to a construction manual and a new chapter in the Colombian design and building code.
3) Between 2012-2014, Arup designed and built several CBSW homes in El Salvador.
4) Since 2014, Base Bahay have designed and built several thousand CBSW homes in the Philippines, India and Nepal.
5) Since 2020, Arup, Base Bahay and Coventry University have been working closely together to improve and scale this technology worldwide, through research, publication of codes and guidance, construction of model housing, and capacity building.

The work above has been financially supported by the UN, governments, NGOs and the private sector.

Enablers & Obstacles

The technology has been enabled through support from the UN, governments, NGOs and the private sector. One of the main drivers behind the technology is that it is so sustainable compared to many other forms of modern permanent housing, especially housing using materials such as masonry and concrete. Various assessments comparing CBSW housing to conventional masonry have demonstrated that CBSWs have 30-60% of the embodied carbon of a conventional house.

The following barriers are typically encountered:

- Perception of natural building materials (bamboo and timber) amongst stakeholders. This can be mitigated by providing stakeholders with clear evidence and successful precedence.
- Regulatory barriers. This can be mitigated by providing clear evidence of its technical performance, and by publishing building codes using this system - this has been done in Colombia, Peru and Ecuador.

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Results & Impact

- Over 10,000 permanent houses have been built using this system since 1990.
- The system has 30-60% of the embodied carbon of conventional masonry and concrete housing.
- The system has a durability exceeding 50 years without significant maintenance.
- The system meets local code earthquake and typhoon design requirements, even in the highest hazard zones around the world.
- Provides a modern-looking home, important for communities in lower socio-economic brackets who aspire to have what they perceive to be a better and more durable house, and one which reflects a higher level of prosperity in comparison to their neighbours.
- Is equal or lower cost compared to other modern masonry and concrete construction.

Replication & Scale Up

The Philippines, Nepal, India, Ecuador, Peru, El Salvador, Mexico, Colombia, Costa Rica.

The technology has been successful in projects where there are adequate supplies of bamboo and timber, there are NGOs interested in construction using bio-based materials, and there is a programme set up to create a value chain.

CBSWs are most appropriate for low-rise housing in rural and peri-urban areas where bamboo grows, and we estimate that currently 180-240 million households worldwide currently live in inadequate housing in such areas.

We believe CBSWs stand out in the market in the following ways:

1) It has the potential to be used in all 4 sectors (self, government, NGO and private client built) of affordable housing.
2) It is one of the few technologies that has been shown to be demonstrably affordable, disaster-resilient, durable and low-carbon, all at the same time, with a proven track record.

Policy Uptake

This housing practice is a new or innovative practice that is not yet adequately or fully integrated into formal policy frameworks.

1) Support the incorporation of this technology into more country codes.
2) The publication of design and construction guidelines using this technology.
3) Continued technical research into this technology, to continue to improve it's performance and sustainability.
4) Improved advertising of this technology worldwide to key stakeholders, including the construction of model housing, presentations, workshops and demonstration tours of existing project case studies.

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Lessons & Takeaways

The technology continues to improve in terms of seismic performance, typhoon performance, durability, buildability and sustainability with time. Some of the earlier designs were less successful, and we have learnt from them, incorporating this research into the latest designs, guidelines and building codes.