CASE STUDY

Sustainable design: Building from the ground up

Country: Republic of Ghana

Organisation: Sabre Charitable Trust, Arup International Development

Hazards: High winds, earthquakes, extreme temperature

Keywords: environmental sustainability, functionality, research, building trust, Ghana

Summary: Sabre Charitable Trust and Arup International Development incorporated local building materials and design preferences into kindergartens for Central and Western Ghana, paying special attention to sustainability principles. Through prolonged research and community interaction, the team created a design that used both modern preferences for concrete and local materials to create safer schools.

Country and hazard overview

With a rapidly growing population, Ghana's education sector has struggled to keep pace with demand. Nearly 30,000 public sector classrooms are in need of major repair and the country has a shortage of nearly 10,000 kindergarten classrooms.

In the country's decentralised system, the process of constructing schools often begins with a community parent teacher association (PTA) or elder petitioning the district assembly or district line ministry. The government body will then seek funds for construction, either from their own coffers or by identifying a development actor willing to fund or even oversee a school construction project.

Communities typically contribute to the building of public schools, providing in-kind labour, materials, or cash to support a hired contractor. Community elders may also attempt to monitor construction to ensure contractors meet contractual obligations, but safety remains a concern given the technical nature of construction.

One common problem is when the contractor fails to properly attach roof trusses to the building frame. Many schools have lost their roofs when high winds blow across the region; similar damage can result from seismic tremors present in the south of the country.

School construction: Incorporating sustainability principles into design

In 2008, Sabre Charitable Trust teamed up with technical experts from Arup to design and construct safe, affordable, replicable, maintainable and environmentally sustainable kindergarten buildings that met the needs of communities living in the central and western regions of Ghana.

In the design process, the first step was in-depth research about vernacular design and the local construction skills.

The design team ensured the materials were not just local, but also readily available, even checking in the local markets to see first-hand what was for sale. They also aspired to 'build from the ground up', meaning they were literally attempting to pull resources from the earth and incorporate them into the school building.

When local building practices and conventional materials were not likely to produce a safe building, the team turned

Innovative façade made using pivoting bamboo shutters to allow optimum amount of natural light and ventilation. Photos: Arup & Sabre Trust.

to research. They tested local building materials, focusing on the strength and durability of local soil-based materials. Some communities used soil to produce bricks but the quality of the soil and fabrication process varied. These and other local practices needed to be informed by tested engineering options that increased safety and durability.

Challenges: Perceptions of local materials

Convincing communities to build with soil and other local materials proved challenging. In Ghana, communities wanted to use concrete and other materials they associated with development. Building school buildings completely out of natural and local materials, and following vernacular practices, put the school at risk of being seen as undesirable. Rather than disregarding the community's notion of progress and pushing local materials for the sake of environmental sustainability, the team had to build trust over time.

The community saw some value in vernacular design but also wanted modern materials. The team opted for a compromise in material choice consisting of a concrete frame, with traditional materials like bamboo and stabilised soil blocks used as infill walls.

At first, the prospect of building with mud seemed dismal to community members. But after being trained on how to manufacture the blocks properly, which included sifting the soil and mixing it with locally available stabilising agents like portland cement and pozzalana, the community members saw the outcome as an improvement. The improved soil blocks became more desirable and proved stronger than the local concrete blocks. In addition, going through the entire process of design and fabrication gave the community a vital sense of ownership.

By using a concrete structural skeleton designed to resist seismic loads, infill walls could be made from renewable and locally sourced materials. This design feature and the concrete frame's modular form ensured the design was scalable and replicable. Locals were already erecting concrete frames, but the construction quality was poor. This provided an opportunity to increase local skills in creating vital structural components for future infrastructure.

The concrete was made from using locally sourced pozzolana – a mix of clay and palm kernels – as a 30 percent substitute for portland cement. Using locally available materials for the infill walls also increased the sustainability of the building and made it easier for communities to contribute to the construction process and do routine maintenance. The durable concrete frame is designed to bear the force of shaking, high winds or other hazards. This provided the team with an opportunity to use different or new materials for the works without fear of compromising safety.

Design specifications did not only focus on sustainable material choices. The design team went to great lengths to design the building for functionality. They created classroom layouts to meet performance-based criteria for daylight, temperature and acoustics. This provided a high-quality learning environment without the need for external energy. Every building element had at least two functions so that no materials were wasted and add-ons were unnecessary.

Key takeaways

- Be sure the design team has done in-depth research into local building materials, processes and aesthetics.
- Understand the gaps in safety that may exist in traditional building techniques or current practices.
- Develop sufficient trust to show communities they can improve and refine traditional building techniques.
- When appropriate, draw materials from the natural environment. Be sure to extract at a sustainable rate.