Dwabor Kindergarten – a sustainable school

In 2004, recognising the lack of a pre-primary education programme, the Government of Ghana launched a comprehensive early childhood care and development policy aimed at significantly expanding state support for early education initiatives. The Ghanian education authorities recognised that high-quality pre-primary education significantly improves educational achievement and attainment but the newly prioritised central government funds are simply not sufficient to tackle the huge shortage of kindergarten infrastructure and resources nationwide. The need for more education infrastructure is huge. In addition, where facilities do exist, they are not conducive to learning, especially for kindergarten learning which is primarily about learning through play. A typical government school building is a three-classroom linear block built from unsustainable poor-quality concrete masonry units, metal roofing sheets and is not earthquake resistant. The buildings are dark and poorly ventilated and classes are often cancelled during rainfall because of the noise generated from the rain on the metal roof; almost half do not have toilet facilities and 40% lack access to drinking water.

The Sabre Charitable Trust (Sabre) is an education charity working in rural Ghana to improve the future of disadvantaged and marginalised children. Sabre works with the local education authorities there to implement school improvement projects that support the government’s programme of education reforms. Through close links with rural communities in the area and in partnership with the Ghana Education Service (GES), Sabre has identified the need to focus on the kindergarten sector. When Sabre approached Arup in September 2008, we were inspired by their vision and agreed to design and build a kindergarten prototype that was sustainable, maintainable, replicable, and scalable, value for money and child-centred. The project goal is for the prototype to be accepted as a building standard in Ghana and rolled out through the national government school-building programme.

Arup provided, on a pro bono basis, engineering and architectural design services, including sustainability assessment (ASPIRE), construction supervision and strategic advice.

The design process

Prior to Arup’s involvement, Sabre had worked with the GES district office to identify the village in most critical need of a kindergarten school. Dwabor was selected for the first kindergarten school and the site was cleared by the community. A stakeholder analysis was undertaken at the beginning of the design process to understand the impact of relationships on the project (fig. 13.2). We used the results to plan how we would engage with the different stakeholder groups to build relationships and understand the social, political, economic and cultural opportunities arising from them. The key members of the design team undertook an initial research trip to Ghana to gather information to feed into the design, research local resources, and understand the community structure and the patterns of daily life. We progressed the design in its context and aesthetically, identifying different possible implementation processes. We also considered the potential of community construction training programmes. It was paramount that this trip was about understanding the views of the Ghanaians and not imposing western or our personal views on them.

One of the most valuable consultations was with the teachers of the local school. The team had prepared simple massing blocks made from cardboard; each block represented a different accommodation space needed to make up the school. The team and the teachers collaborated in a workshop to understand the best layout for the school and other requirements. As users of the school they were in the best position to communicate the needs. The team came away with two very clear optionsfavouredfavour by the teachers.

A lot of time was spent visiting other schools in the district and in Accra speaking to teachers, students, looking at the architecture to see how different materials had been used and in what
ways, analysing what worked well and what did not and what was considered culturally acceptable. GES were very impressed by the consultative process and recognised that gathering information from a variety of different stakeholders would eliminate the problems of building poor, dysfunctional infrastructure in the future. Achieving buy-in of the GES was critical for the success of the rollout programme. The consultations facilitated a huge amount of knowledge transfer and the team focused on understanding the existing knowledge and built upon it. We also shared our own knowledge and understanding of the design and construction process. As a result the local stakeholders were also empowered by the experience. It is this model of engagement and collaboration that is key to delivering genuinely sustainable projects and in my opinion is hugely important to the future of our profession.

While in Ghana we also researched locally available materials by meeting with material suppliers and local building merchants. We gathered information on costs, including transport, availability, performance and typical sizes. The design and material choice in the kindergarten school were also influenced by these factors, which were helpful in eliminating material waste, making the building more sustainable and arriving at the most economic design. At the beginning of the design process it was important to think about the procurement of materials and the construction process and the possibilities of upskilling and training local labour. We also carried out site investigations while in Dwabor. This included assessing the soil as a possible building material, gathering information for the foundation and the site drainage design. It was important to consider the impact of our new school building on the surrounding area and develop a site design strategy that took into account drainage and future resilience in terms of climate change.

On our return to London we translated all the information gathered into a prototype design for the kindergarten school. We then returned to Ghana to present the final designs. Further iterations based on workshops and consultations followed to ensure that the needs and requirements of all the stakeholders had been fulfilled. The team met again with local consultants (architects

The design approach
Starting with the notion that education is the cornerstone of social and economic advancement, Arup’s approach to planning and designing this kindergarten complex was shaped by local needs, materials, capacity and culture. We optimised the performance and buildability so that the prototype could be replicated and the programme scaled up. The key to this development design approach was to have sustainability at its heart. The sustainable kindergarten school is unique because the design brief was developed through participatory planning consultations with the community, local government, education authority and local consultants. This facilitated an understanding of the local capacity, environment and resources to ensure that we left a workable legacy. The kindergarten project became more than being about producing an engineering product; due to the collaborative approach it ensured knowledge transfer and enriched learning.
The kindergarten design

The design and construction of sustainable kindergarten schools is guided by six key principles:
1. Performance-based design
2. Community participation
3. Local materials
4. Livelihood opportunities
5. Value for money
6. Buildability, replicability and scalability

and engineers) to finalise the construction details. It was important for us and Sabre that Joseph Aggrey, who was the trust’s building projects manager and would be overseeing the construction, was present at these design meetings so that he understood the build process.

The kindergarten complex

We refer to the school as a kindergarten complex, as the classrooms are complemented by external teaching areas, a staff room, toilets and a kitchen to provide a complete educational environment. Educational outcomes have been the overriding imperative in the design process. The child-centred design and layout of the kindergarten complex creates a hub of playful exploration within a safe and contained space. It promotes a learning environment unprecedented among standard government schools in Ghana. The complex is organised around a central spine, which forms the core circulation route extending from the kitchen past the three staggered classrooms to the toilets and provides opportunities for interaction between pupils and teachers throughout the day (fig. 13.1). This design feature came out of the consultation with the teachers. Government schools typically have their circulation areas round the perimeter of the classrooms making it easy for children to abscond during the day. Each classroom module is flanked by two solid walls which provide shade to the strong low-lying morning and evening sun. The main elevations contain colourful pivoting bamboo shutters that create the right amount of light and ventilation internally. Four large pivoting doors in each classroom give access to individual shaded external teaching areas which encourage the use of different learning environments and offers children the chance to investigate their surroundings. The off-centre pitched roof on each classroom forms a large area for rainwater collection and overhangs to reduce glare internally and provide sheltered external walkways. The school is a child-friendly building, ergonomically designed for schoolchildren but also designed to be safe against disasters such as earthquakes. Getting people to accept the real danger of earthquakes to buildings and their users is a challenge in Ghana, where a major quake has not occurred for over 70 years, a lifetime longer than the average life expectancy in the country. Most buildings here are not designed seismically and the country’s building code stems from the provisions of US code UBC90, now superseded. Through the consultation and construction process the team is helping to improve awareness of seismic risks as well as teaching how to build safe buildings. Informed by the extensive consultations we produced a modular classroom designed as a “kit of parts”, with different wall designs to fit within a durable reinforced-concrete frame. Each classroom is made up of a series of bays which can be extended or reduced to accommodate different numbers of children. It should be to noted that concrete was not our initial choice for the frame, preferring cheaper and more sustainable timber, bamboo or soil blocks but it was important to understand and respect the views of the community to encourage ownership of the build. The team found that concrete, used in typical government schools, was seen locally as a sign of development and materials like bamboo and timber were widely viewed as “poor man’s materials”. The consensus was that a model based on a durable concrete frame designed to resist seismic forces and complemented with local and sustainable materials struck the right balance and achieved a design of which everyone could be proud.

The concrete for the frame was designed with locally sourced pozzolana made from clay and palm kernels replacing 30 % of the Portland cement in the mix. The infill walls are made of low-level soil block walls with either bamboo cladding or windows and we worked with the communities and labourers to make these materials more durable. This design reinforced the concept as a durable, strong, sustainable and replicable building. These finishes can be adapted to suit climate, culture, and availability of materials which is potentially interesting in terms of scaling-up and replicating the prototype nationally and else-
Kindergarten in Dwabor

where in Sub-Saharan Africa. Fast-growing, widely available bamboo was also used to clad the ceiling and as a lightweight structure in the external shaded areas. Extensive tests have been and continue to be undertaken to find suitable treatment methods. This project created an excellent opportunity to demonstrate how to produce cheap, sustainable, durable building materials that local community members can reproduce in their village and use for their own houses. The roof was made of metal sheets which are readily available and the preferred option locally. The disadvantage is that the roof gets very hot and radiates heat into the space below and during rainfall the noise can be disruptive to lessons. However, metal roofing has its advantages as the heat burns away any bacteria growing on the roof, making it good for collecting rainwater. To resolve these issues fibre from coconut husks was used as acoustic and thermal insulation to the roof.

The kindergarten construction

One of the core intentions of the project was for the construction process to educate and train those working on it, leaving a lasting legacy in the socio-economic fabric of the community. During the construction of Dwabor kindergarten and the next school at Ayensudo, an Arup structural site engineer was seconded to Sabre to

In rural Ghana, mud and bamboo are commonly used as building materials, but considered “poor man’s materials”. We were able to demonstrate to locals how to make durable soil blocks from the soil on site to minimise the use of expensive concrete. Compressive strength tests carried out in the UK confirmed them to be twice as strong as locally procured sand/cement blocks, and due to their durability and rich appearance they have gained a reputation in the region.
supervise the works and introduce a quality control strategy on site, working alongside Sabre’s site manager, while training a Ghanaian site engineer. Voluntary local labour contributions were agreed with the village elders at the project start. This was excellent in theory but a reliance on voluntary labour to keep to the construction programme became problematic in practice, with people not turning up for a variety of reasons. A good compromise was to have a full-time team of paid skilled and unskilled labour and then organise community participation days to complete large volumes of unskilled work.

Typically, there is little concern for health and safety when working on construction projects in developing countries. One of the roles of the Arup structural engineer was to raise awareness of the risks and teach on-site safety. We were also able to advice local consultants about how to design-out risks prior to construction. Signage to communicate the health and safety issues to the wider community as well as informative display boards explaining the design and its progress were erected.

During the building of Dwabor a local team of skilled labour was supported by local unskilled labour. The local construction team was trained to build the school complex by Arup’s site engineer and through initiatives such as the bamboo training programme. Sabre then selected a core workforce from Dwabor who went on to help lead areas of work on Ayensudo kindergarten. This approach helped speed up the programme and assist in dissemination of knowledge. The benefits to the delivery of the kindergarten school programme are already apparent, for example, the timber roof trusses for the second school were fabricated in a quarter of the time it took in Dwabor. This continuous knowledge transfer is incredibly beneficial for the host country as it develops the skills of the individuals immediately involved, who can then go on to educate others in the population.

**Review**

Once Dwabor was completed it was reviewed in terms of buildability and function through further workshops with teachers, children, the community, local government and labourers. These workshops were tailored to the individual stakeholder groups. For example, many of the labourers were illiterate, so for one workshop we used yellow stickers (easy to build) and red stickers (hard to build) which they then stuck on photographs of each stage and detail of the construction process they had undertaken. All the details with red stickers were then discussed and then adapted with the labourers’ help to make them easier to build.

All feedback was used to optimise and improve the design. Arup also repackaged the construction information into a user-friendly construction manual to speed up progress and reduce building costs, leading to a more efficient roll-out of the kindergarten programme. The manual is divided into chapters and includes a set of rules intended to provide guidance when Sabre itself undertakes the initial needs assessment, community consultations, appropriate site selection, site set-up and site-specific drainage design. The later chapters focus on the construction drawings and contain 2D and 3D images with easy-to-follow construction sequence cartoons augmented by annotated material schedules and specifications designed to make the building process as understandable and accessible as possible.

The kindergarten prototype evaluation and redesign reduced classroom building costs by 5% and the overall build programme costs by 15%. Attendance at both schools has also double since they opened.

The sensitivity of the design team to the needs of the local culture and environment has been key to success of this project, which has proved to be sustainable, functional and of long-term value. It was never about imposing our views of what we assume people want and need; it was always about hearing what their needs are and creating innovative solutions that meet these needs and delivering solutions that are financially and socially sustainable.

Hayley Gryc
Engineering in the developing world

Engineering in the early 21st century is commonly identified with analysis and design applications, CAD drawing production and latterly the drive towards the further management of information through BIM (Building Information Modelling) – all of which, while effective tools, can and do create a deep divide between the business of construction and development and the human purpose and needs of the projects being constructed. In being asked to write a commentary on the Sabre kindergarten school project I have been granted the privilege to reflect on the reasons why we design and build “things” – to change the world, improve the places we live in and the lives of individuals. I believe this project demonstrably delivers against all these aspirations.

The ambitions for the project were extensive: to create a generic, transportable and implementable model for a sustainable kindergarten school development in rural Ghana. It was designed to provide a high-quality learning environment. The project balances the “western” view of sustainability, which focus heavily on energy management and carbon emissions with the views held in the developing world where social sustainability is the key driver and it gains in stature by that balance. In simplistic assessment – does the project fulfil its brief? – without doubt. This project showcases the benefits of gaining a real understanding of the end users’ needs and the local community’s aspirations. It is clearly apparent that the project achieves the obvious success it does as a result of that understanding and the synergies of purpose gained by the dialogue process.

As in the case of all building projects time will reveal whether the end results have achieved the ambitions set out at the project inception. However in developing the design, the experience of a multitude of issues with existing school sites was clearly reflected on and significant confidence can be drawn from the coherent ways in which these issues have been assessed.

Vertical louvres shield low-angle sun during morning and evenings

Diffuse daylighting from roof gives background ambient lighting

Interior surfaces are light in colour and finish

Overhang provide shading from high-angle sun during midday
and then addressed during the design development of the Sabre project. The success of this project is not limited to the simple outcome of providing an accessible and well-considered learning space for young children. It is clear that there has been significant transfer of skills and technology to the local community, which will benefit the whole community as well as individuals. There is an enhanced sense of ownership of the schools by the community which everyone hopes will reduce the risk of them becoming neglected in the future. The use of non-local materials, particularly those produced by industrial (energy-intensive) processes has been critically interrogated and only adopted where their use and benefits align with those of the social sustainability drivers. The use of local materials has been well considered and the development of techniques to offset inherent problems with those materials was very beneficial in achieving the holistic success of the project.

Arguably perhaps one of the major achievements of the project is the production of the construction manual. For this manual to fulfil its ambitions it had by necessity not only to be generic, which always presents risks, but also transportable and implementable. It addresses the challenges of a generic design that has to be implemented admirably in a variety of site-specific locations; the design and construction techniques are clearly transportable to and implementable in different areas – largely due to the benefit of using a “cartoon” style.

I believe this project is an exemplar and “blueprint” for local community projects in the developing world. It showcases the clear advantages of considering and adopting the use of technologies appropriate to wherever these projects are to be constructed. However, and importantly, it also reminds us that communities and individuals are at the heart of the projects we design and construct.

Sarah Fray
When we approached Arup in 2008 to sound out Jo da Silva, the firm’s Director of International Development, we had very little expectation of what might follow. We pitched to Jo our desire to develop a new prototype kindergarten school to support early years education in Ghana, where the government had recently included two years of kindergarten education in the primary school system. Our interest was in creating a new model of school building that would place the child and learning at the heart of the design and would make strong use of local and sustainable materials in a modern context, while using simple building technologies capable of being transferred to local community members.

Fast-forward on four years, and we now have a building that achieves all of these goals and has been recognised by the Ghana Education Service and key donors such as the UK’s Department for International Development, the United Nations Children’s Fund and the Children’s Investment Fund Foundation as providing some of the best kindergarten classrooms in the whole of Ghana. We have built two schools, in the communities of Dwabor and Ayensudo, and have a further three projects planned for the coming year, as well as broader ambitions for a national roll-out programme. Quite simply, none of this would have been possible without the vision and dedication of our colleagues and friends at Arup.

This was a project concept which clearly captured the imagination of Jo and her colleagues, and to date over fifty Arup employees have been involved in the development and refinement of the school design – all of them working in a voluntary capacity as part of Arup’s unique approach to shaping a better world through corporate philanthropy. In addition to the hours spent at the drawing board in the UK, two Arup engineers were seconded to Ghana to work on the first two projects – providing site supervision as well as valuable training for the Sabre Trust’s own site team and project engineer.

As a small organisation, one of the ways we seek to deliver excellence through our projects is by harnessing the skills of expert partners to help us deliver our programmes – in this respect Arup was able to draw on all of its global engineering expertise, and harness it with our local knowledge and understanding to deliver a building that appears very modern and progressive in its context, while making fantastic use of local materials and passive design. Complimentary cost and project management services were also provided by Davis Langdon (now part of the Aecom group) through the firm’s charity partnership with Sabre.

The Arup name also carries a lot of credibility with prospective donors and supporters – to be able to table an Arup-branded comprehensive construction manual, with orthographic and axonometric drawings in two and three dimensions and easy-to-follow site instructions, is an incredible tool when talking about the project to funders (figs. 13.16 and 13.18). Arup is a brand which inspires confidence, and opens doors that would otherwise remain closed to a small but ambitious organisation like ours.

Working with Arup does of course mean working to Arup’s exacting standards – and there have been occasions when our local site team has questioned the need to follow practices that are far more rigorous than the local conventions. However, we were building in a seismic zone and safety is one area where Arup quite rightly refuses to compromise – the school is designed to withstand earthquake forces.

Over and above the team’s enormous contribution to the sustainable kindergarten school project, staff at Arup have also shown an interest in supporting Sabre’s work more broadly – backing our Christmas Appeal campaign, mobilising volunteers to come out on a working holiday to help build the schools, and helping us to develop our longer-term growth strategy for scaling-up the project.

Working with Arup has been an overwhelmingly positive experience, and we look forward to continuing to progress this exciting project over the coming years as we scale up the school design across Ghana and beyond. Dominic Bond