2004 On Site Review Report 2920.BOU

by Fernando Varanda

Primary School

Gando, Burkina Faso



Architect
Diébédo Francis Kéré

Client
Village Community of Gando

Design
1999

Completed
2001

Primary School

Gando, Burkina Faso

I. Introduction

This school, in a remote settlement in the south of Burkina Faso, is the expression of one man's commitment to improve conditions in his village. It also represents the involvement of a whole community in the construction of a building that symbolizes the first step towards this improvement. The designer, who was studying architecture in Berlin when he conceived the project, was heavily involved in raising funds in Germany. In his home country of Burkina Faso, meanwhile, he helped mobilize the local population and secure the support of a government institution that could train people in using improved techniques to construct with local materials. The final building combines passive solar design and cross-ventilation with the use of earth as the basic construction material; the use of concrete is minimized, and there is no wood. The roof was made in a light metal structure, an ingenious solution requiring little skill and only simple tools to execute. The school is an object of pride to the local community. It now serves children not only from the village of Gando but also from the surrounding area.

II. Contextual Information

A. Historical background

Gando, with a population of 3,000, lies on the southern plains of Burkina Faso, some 20 kilometres west of Tenkodogo and almost 200 kilometres from Ouagadougou, the capital. Before the French conquest in the nineteenth century, Tenkodogo was the seat of a local ruler whose authority was recognized by the oldest Mossi dynasties and whose territory was crossed by one of the major trade routes that converged on Djénne, in Mali. Nowadays, Tenkodogo is a provincial capital with a population of about 40,000, on the road to Lomé, Togo. In 1990 it was one of the towns included in the Burkina Faso government's Secondary Towns Development Programme (PDVM – Programme de Développement des Villes Moyennes), which aimed to create local economic centres that would reduce the migratory flow to the country's two major cities, Ouagadougou and Bobo-Dioulasso. At that time, as part of governmental development measures, Gando was provided with a primary school, a modest building made in concrete blocks and roofed with corrugated metal sheeting. In spite of the cultural success of the initiative – at first regarded with distrust, the school eventually became a 'symbol of hope' for the village – the building's low quality, combined with the lack of government funding for its maintenance, soon brought it to an advanced state of deterioration. Without extensive repair work it would have had to be abandoned – which would have meant the end of a school in the village.

Diébédo Francis Kéré was the first person from the village to have access to higher education abroad. An architectural student in Berlin, he was convinced that education was the cornerstone of his people's advancement. Not only did he take upon himself the cause of ensuring that his village was not deprived of a school, but he was also determined that the

new school would exemplify the building quality that could be achieved by designing in sympathy with the local climate, resources and materials.

Local financing was out of the question: neither the community as a whole nor any of its individuals had the financial means. Therefore, while in Germany, Francis Kéré and a group of friends set up a fundraising association, Schulbausteine für Gando (Bricks for the Gando School); the idea of building a school in the middle of Africa met with a very positive response. Having secured finance through the association, he obtained, in Burkina Faso, the support of LOCOMAT, a government agency engaged in the promotion of local building materials, to train brick makers in the technique of working with compressed stabilized earth. Construction could now take place, and began in October 2000. There was a large amount of help from the local population – men, women and children – all of whom offered labour to the best of their capabilities. The building was ready in July 2001, and was occupied from October that year. After the school was completed, construction began of the buildings to house resident teachers. These applied similar principles but went a little further in experimenting with new techniques, namely the use of vaulted brick roofs.

B. Topography, climate

Burkina Faso is a flat country and Gando is situated in one of its flattest regions, with altitudes averaging 200 metres. This area is contained within the Sudano-Sahelian climate zone, representing about half of the country's surface area and characterized by the alternation of a dry and a rainy season. The rainy season here lasts four or five months between April and October, with mean annual rainfall between 60 and 100 centimetres and strong showers beaten by the eastern wind, especially in the beginning and the end of the season. Average annual temperature is 25ºC, but the lowest recorded temperature is 15ºC, in January 1975, and the highest 41ºC, in April 1983. Winds are relatively gentle, except at the beginning and end of the rainy season when they can reach speeds of up to 120 kilometres per hour.

The vegetation is mostly wooded and arboraceous savannah, turning into scrubby savannah or steppe in the area around Gando. The country is suffering a climate crisis, expressed as 'desertification' or 'aridification' and characterized by a significant drop in rainfall and an increase in extreme temperatures. Although this is part of a global context, local conditions are exacerbated by large-scale destruction of plant cover, overexploitation of land, overgrazing and repeated and uncontrolled bushfires.

C. Settlement patterns and local architectural character

The rural dwellings of this region, as elsewhere in central Burkina Faso (where the Mossi ethnic group predominates), consist of round compounds closed in by walls. Circular and quadrangular one-room structures are built within each compound and open on to the central open space. The central space can be subdivided into courtyards, house forecourts and circulation alleys. The volumetric and spatial relations of these elements are sometimes so complex that the compound's interior can be more evocative of a whole settlement than a single household. Each compound shelters an extended family and may be expanded as necessary, though past a certain limit a new compound will be built.

Granaries are included within each compound, and cattle are sheltered in the compound after sunset. Additional granaries may be placed outside the compound, by the main entrance. In this same place will also be found an arbour (known locally as a *zandi*), comprising wooden poles supporting a cover made of stacked millet or sorghum stalks. If the interior of the compound is the women's realm then this is the privileged space of the household's senior man, where he receives and talks with his male guests. This role, incidentally, is also performed by a large tree, often designated as the 'palaver tree', under the shade of which men meet to discuss matters of common interest, or simply chat. Villages and hamlets comprise several compounds of this type, interspersed with trees and often so scattered that a settlement pattern is difficult to recognize except from the air. There is usually an associated mosque and market place, situated a certain distance from the settlement's nucleus.

D. Forms and materials

The compound walls are built of sun-dried mud blocks (*banco*), although concrete blocks are increasing used for the quadrangular constructions. The latter were traditionally covered with flat mud roofs, supported on wooden structures, but single-slope low-pitch tin roofs are now current both in mud and concrete wall buildings. The round-plan rooms have conical thatch roofs, as do, in general, the granaries; but these can also appear as large ovoid forms made entirely from straw mats. Granaries are systematically raised above the ground for protection against moisture and pests. Mud block construction, in the rudimentary techniques used here, does seem vulnerable to erosion by rain, particularly when, carried by the strong east wind, it hits the walls almost horizontally. Some measure of waterproofing is obtained by adding shea butter to a mud rendering or interposing a coat of asphalt between rendering and blocks in the eastern walls, but this is not a widespread technique. This is usually one of the reasons given for using concrete blocks when they can be afforded, in spite of their higher cost and poorer climatic performance. Concrete was the dominant material used for colonial buildings, and this has set a few formal stereotypes, particularly concerning the abundant use of surfaces made with pre-cast ventilation blocks or grilles. In Tenkodogo, the region's main town, concrete construction is now ubiquitous, one the reasons apparently being the proximity to the border with Togo and the easy accessibility to concrete imported from there.

E. Topography

Gando closely follows the typical settlement pattern described above. The village consists of some forty compounds spread over an area of roughly 150 hectares, in an expanse of scrubby savannah with patches of poorly developed agricultural land and thickets of trees, often badly affected by termites. Two outcrops of rock form landmarks in the village: one on the eastern edge, setting a nominal natural barrier, and a smaller one at the northern end. The bulk of the settlement – including the chief's complex and the 'palaver tree', marking the village core – is situated at the foot of the northern outcrop. The southern extreme of the village comprises a few scattered compounds and the school site. The mosque and the market are halfway between the school and the village core, and mark the geometric centre of the nominal village site. A straight dirt track connects all these parts and then meanders from the settlement's limits to the tarmac road a few kilometres to the south.

III. Programme

The programme was informed by the principles of designing for climatic comfort with low-cost construction; making the most of local materials and the labour potential of the local community; and adapting in a simple way technological contributions from the industrialized world. Underlying the project was a strong didactic component: it was designed as an exemplar that would help the local community appreciate the value of traditional materials, updated with simple techniques that would need few new skills.

The functional programme designated a school complex for 360 pupils, with ancillary buildings for toilets and kitchen, a vegetable garden, a sports field and housing for six teachers and their families. This was to be implemented in stages. The first stage consisted of the construction of a school building for 120 pupils (although in 2003/4 it was actually serving 182 students). The second stage, being concluded at the time of writing, was the construction of the teachers' houses. Ancillary services have been built between the school and the teachers' houses. These consist of a toilet block, made in concrete by the DANIDA (the Danish Agency for Development Assistance), and a kitchen, which started out as the training prototype for the vaults used in the housing complex. A well, partially sponsored by DANIDA, and the fencing of the vegetable garden, between the school and an informal sports field, completed the first stage.

IV. Description

A. Project data

The ground allocated for the school and any future expansion was 30,000 square metres, including the sports field and garden. The school building itself occupies 526 square metres. It is a long rectangular volume, set on a platform raised 50 centimetres from the ground and oriented along an east–west axis, meaning that the main exposures are towards the north and the south. The roof overhang provides the necessary shade, particularly needed on the south side. The walls are built in compressed stabilized earth blocks. These are 'ribbed' with pilasters for further structural soundness and to provide solar protection from the east and the west; they also enhance the three-dimensional quality of the walls. In the interior the pilasters create niches on the end walls of the classrooms. The niches have been made into cupboards by recycling the wooden formwork employed when pouring the reinforced concrete.

Climatic comfort is ensured by the building's orientation, by the nature of the wall materials and by a design that allows the unimpeded flow of air between the roof structure and the ceiling. Cross-ventilation is further enhanced by abundant use of shutters on the northern and southern walls.

The teachers' houses are disposed along a wide arch segment which more or less marks the southern limits of the school site. Six units were built, to a total of 300 square metres of covered area.

B. Evolution of design concepts

In the architect's words, the project is intended to be 'adapted to the needs and the economic situation of the people in the region and responsive to the prevalent climatic conditions, and thus capable of achieving sustainability'. He adds that this involves, 'on the one hand, informing the village community and raising their awareness of the merits of traditional construction materials and, on the other, evolving high-grade planning concepts and constructive architectural solutions using local construction materials and the skills of the local community. The school was conceived as a line of three 7 x 9 metre volumes, each containing a fifty-pupil classroom, separated by patios, on a platform raised 50 centimetres from the ground, and covered by a single roof. Climatic considerations largely determined of the building's form, orientation and materials, but the designer is also keen to underline the symbolic meanings of its spaces. Thus, the school is on a platform raised from the ground like the traditional granaries; the covered patios between the classrooms evoke the *zandi*, the men's arbour; and the roof's steel truss is to recall the filigree effect of treetops.

The form of the roof was also designed to direct rain water into a channel that would run along the building's northern elevation into a pond, where it could be used to irrigate the adjoining vegetable garden. The water channel and pond have not yet been constructed, since they were not designated a priority in the ensemble of constructions built with the available funds. In fact, the deep well built next to the garden, with the help of later bilateral aid, has made less urgent the need to find alternative forms of water supply for irrigation. The teachers' houses were planned to demonstrate the advantages of building with local materials and using local skills, combined with quality planning and architectural design. They were intended to be sufficiently comfortable and formally attractive to convince teachers that they could live here in the same conditions as those found in any larger town.

It was envisaged that the houses would be built as evolving units, with one-room modules constructed in phases until a dwelling unit was complete. In practice all the basic rooms of each unit were built at the same time, and the phasing of construction consisted only of leaving for later the erection of yard walls, the construction of outside bathrooms and the paving with rammed earth of the area around the complex. The barrel roofs of connecting modules were designed to be of different heights, thus leaving a sickle-shaped opening between them to allow top-lighting and ventilation. After construction, however, it was found that these openings were vulnerable to penetration by wind and dust. Therefore consideration was being given to closing these gaps with some kind of industrial transparent material, such as Plexiglas. This, of course, would defeat their original ventilation purpose.

Landscaping consisted basically of defining a vegetable garden plot and planting trees and shrubs along the side of the school. An existing cluster of trees between the school and the teachers' houses – which functions as a particular landmark of the site – has been visibly attacked by termites. The trees are damaged to such an extent that it is feared that they will need to be cut down and the area replanted with less vulnerable species. Apparently mango trees are more resistant.

C. *Structure, materials, technology*

The basic structure of the school comprises load-bearing walls made from compressed earth blocks stabilized with 8% industrial cement, cast in hand presses on the construction site and jointed by an earth mortar. The foundations are of stone and poured concrete; reinforced concrete was used only for the beams that support the ceilings. Stabilized compressed earth was also used for the hexagonal pavement slabs. In the classrooms, the floors are of rammed earth stabilized with cement. Dilatation joints were made by the simple device of embedding small I-beams into the adjoining concrete lintels so that the end of one beam simply lies on top of the end of another. This permits free movement when the material contracts or dilates.

The roof is of corrugated metal sheeting. The sheets are laid over a space frame made of common 16 millimetre reinforcing steel bars tied to the steel or concrete beams that are set in parallel to the width of the building. Air circulates freely between the roof and ceiling. The ceiling is made of compressed earth blocks supported by 12 millimetre steel bars, set some 15 centimetres apart and perpendicular to the concrete beams. At the end each classroom, as well as above the platform for the blackboard and teacher's desk, there is a 10 centimetre gap between the ceiling blocks, running from wall to wall. This allows light and air to enter, although shutters running the length of the opposite wall also provide ample natural lighting and ventilation control. Other details, such as the rounded edges of the pillars, show concern for the children's safety. However, it was not foreseen that children – being what they are – would use the louvered shutters as ladders and climb into the space between the roof and the ceiling. This creates an additional load on the ceilings, for which they are not designed.

Structural use of wood was rejected for two reasons: first, there is no local tradition of building in wood and so little expertise in carpentry; and second, native hardwood is scarce, and varieties imported from neighbouring countries are of unreliable quality, often not properly dried and susceptible to warping. Perhaps for these reasons, or perhaps because it is less demanding in terms of tools and work precision, metal has long replaced wood for construction in this part of the world. Steel was therefore used for shutters and doors, thus utilizing a technology with which the local craftsmen were familiar. Another reason for avoiding wood is that termites are a real threat, to the point that reportedly there is no straw in the local mud blocks because termites feed on them – eventually they nest in the mud walls themselves. Efficient wood treatment was beyond the means of this enterprise, which required a simple, immediate approach.

Besides these reservations as regards the use of wood, the choice of a space frame for the roof can be explained for other reasons. First, a conventional I-beam structure would have entailed high transportation costs: at the time of construction the national road was not tarmac, and the track from there to the village was difficult to negotiate. Second, because of their sheer weight the elements involved in this kind of structure would have required machinery, such as cranes, which, once again, would have been beyond the means of this project. Instead, the designer devised a process whereby common construction steel bars were cut to predetermined lengths, bent at the middle to form an inverted V (or two legs set apart to sustain the body, as the architect emphatically illustrated) and welded in long modules that could easily be carried to the top of the building and tied to the transverse concrete or steel beams. Steel bars running lengthways were welded to these modules in order to tie them

together. All that was necessary was to teach people how to use a hand saw and a small welding machine.

In the teachers' houses, the walls are made from traditional *banco* blocks, 40 centimetres thick, on a foundation of cyclopean stone aggregated with concrete. Barrel vaults of stabilized earth brick were used for roofs. The vaults were set in place with the help of wooden forms, each 1.2 metres wide. Only two such forms were necessary for the whole construction. Reinforced concrete curved beams were used to form the vaults' borders. The walls and the extrados of the vaults were waterproofed by being rendered with a plaster made of earth, some concrete and asphalt, an adaptation of a technique already used in more traditional construction. Contemplated in the project, but not applied at the time of the technical reviewer's visit, was an 'over-roof' made of corrugated metal sheeting, which would provide further protection against heavy rains. The floors are of rammed earth, those in the interior being later finished with earth with a percentage of grease. Women did a large part of this task, using short-handed tools and working in groups to the rhythm of drums played by young men.

To ensure quick drainage, concrete gutters run along the valley between contiguous vaults and on top of the side walls, descending along the wall ends as a kind of hollow buttresses. Later on a roof comb made of one course of concrete blocks was added to protect the gutters against strong wind. The openings in the top walls, facing east and west, consist largely of brick grilles and are mainly for ventilation. The yard walls of these houses use concrete blocks braced by light reinforced concrete pillars. At the time of the technical reviewer's visit, toilets had not yet been installed and personal washing was done in a straw mat enclosure, as often occurs in traditional dwellings. There is no electricity or telephone. Water was originally carried by women from a source some seven kilometres away, but later on, as mentioned above, a well was dug in the vicinity of the school, which enormously simplified their task. The school's toilet block was made in concrete and is of the 'cesspool' type, a model used in other parts of the region and offered by DANIDA.

D. Origin of technology, materials, labour force, professionals

Training of brick makers and masons was undertaken by Projet LOCOMAT, in Ouagadougou, an agency of the Ministère de l'Infrastructure, Habitat et Transports (Ministry of Infrastructure, Housing and Transportation) created to promote the use of local materials in improved techniques. Earth for the blocks came from the village itself, and was taken 500 metres from the site. Bricks and floor slabs were cast in hand presses imported from Belgium. Concrete and steel were imported from neighbouring countries. Metal sheeting for roofs was manufactured in Burkina Faso; doors and shutters were the work of blacksmiths in Tenkodogo. The space frame for the roof was mounted *in situ*, under the instructions of the architect, who also supervised and actively participated in the construction and training of local personnel. Apart from the training staff from LOCOMAT and the blacksmiths from Tenkodogo, all the people involved in the construction and project management (including the architect) were native to the village. The first group of volunteer labour numbered 150 people, mostly young men aged fifteen to twenty, but also women and children.

V. Construction Schedule and Costs

The decision to carry out this project was made in 1998; the design in 1999 and construction lasted from October 2000 to July 2001. The school began activity in October 2001.

The initial estimated budget was 19,175,000 CFA Francs (USD 28,954) and the actual cost came to 22,750.000 CFA Francs (USD 29,830).This comprised 4,850,000 CFA Francs (USD 6,551) for infrastructure; 1,800,000 CFA Francs (USD 2,431) for labour; 10,725,000 CFA Francs (USD 14,486) for materials; 450,000 CFA Francs (USD 608) for landscaping; 1,650,000 CFA Francs (USD 2,229) for professional fees; and 3,275,000 CFA Francs (USD 4,424) in unspecified costs. This brings the cost per square metre to 43,250 CFA Francs (USD 58). No value was put on the land or on the community's volunteer work.

Since the land and voluntary labour was not valued, it is difficult to make a comparative assessment of costs. The architect considers that the cost is high, although it is three times less than buildings of the same quality made in different conditions. As a measure of comparison, the cost per square metre of the market at Ouahigouya, where land cost was also not a consideration, was about 2.5 times higher than that of this school.

VI. Technical Assessment

The school performs very well both in terms of spatial organization – having the classrooms separated by patios has the further advantage of sound insulation – and climatic comfort, where the results obtained are indeed remarkable. The mark it sets in the overall landscape is strong but consistent.

The emphasis put on extremely simple – almost primitive – methods is founded on sound structural knowledge, best represented by the roof frame. In some places, however, risks seem to have been taken that in other contexts would probably have not been contemplated, such as the slim (20 x 15 centimetre) concrete beams spanning the 7-metre width of the classrooms, which are rather insubstantial in view of the weight of the ceiling. Likewise, it is now obvious that the steel bars set across these beams to support the ceiling bricks should have been thicker, since they are already beginning to sag. Some signs of wear are visible in the corrosion of wall bricks and floor tiles. This seems to be a common condition of the material since it can be seen in other buildings elsewhere in the country. As for the teachers' houses, the choice of their siting and the curvilinear site plan work well in the ensemble and, at a distance, this may be seen as evoking the contour of the compounds nearby. The tenants seem satisfied with the space and climatic conditions. The concrete-block roof combs, added later but not yet rendered, may create problems where they join the rest of the wall.

VII. Users

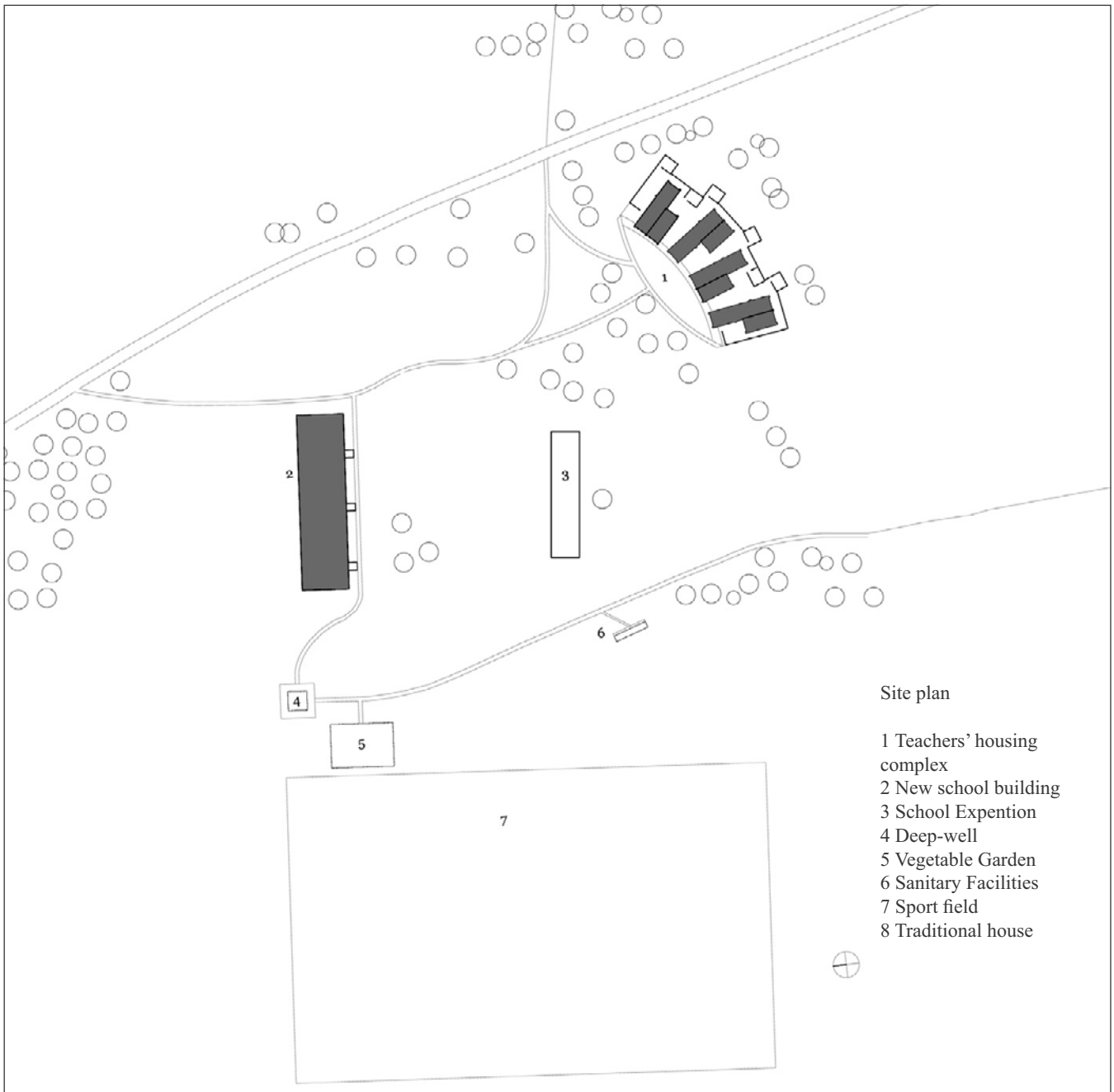
The school was originally intended to serve only the children of Gando, but use by children of the neighbouring villages is increasing. It has been reported that even the Peul, nomadic herders traditionally reluctant to let their children go to school, have let their children attend.

This appears as an additional reason for the community's pride. One of the teachers affirmed that he has a better success rate here than in the schools he was in before; possibly because children are more comfortable, they are more attentive.

VIII. Persons Involved

Architect and Principal Designer: Diébédo Francis Kéré
Fund raising and Financing: Schulbausteine für Gando e. V. (D. Francis Kéré)
Coordination and Management: Wénéyda Kéré
Supervision / Training in brick production: Issa Moné, Technical Officer, Projet LOCOMAT
Master Masons: Sanfo Saidou ('Baba') and Ousmane Moné
Welder: Minoungou Saidou
Labour: The population of Gando

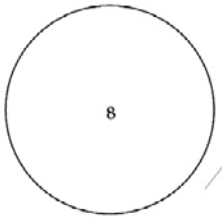
Fernando Varanda
May 2004

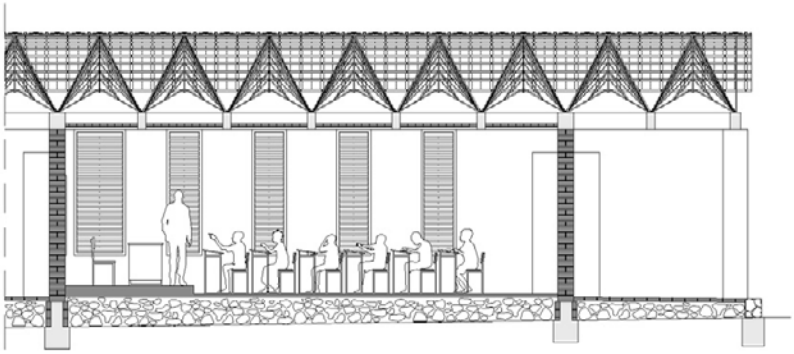


Site plan

1 Teachers' housing complex
2 New school building
3 School Expention
4 Deep-well
5 Vegetable Garden
6 Sanitary Facilities
7 Sport field
8 Traditional house

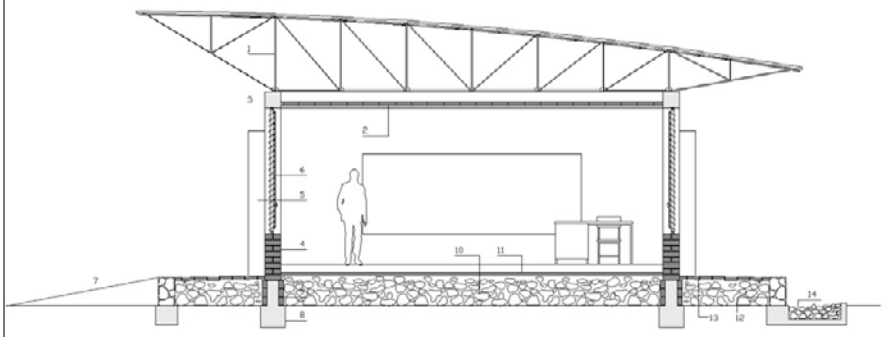




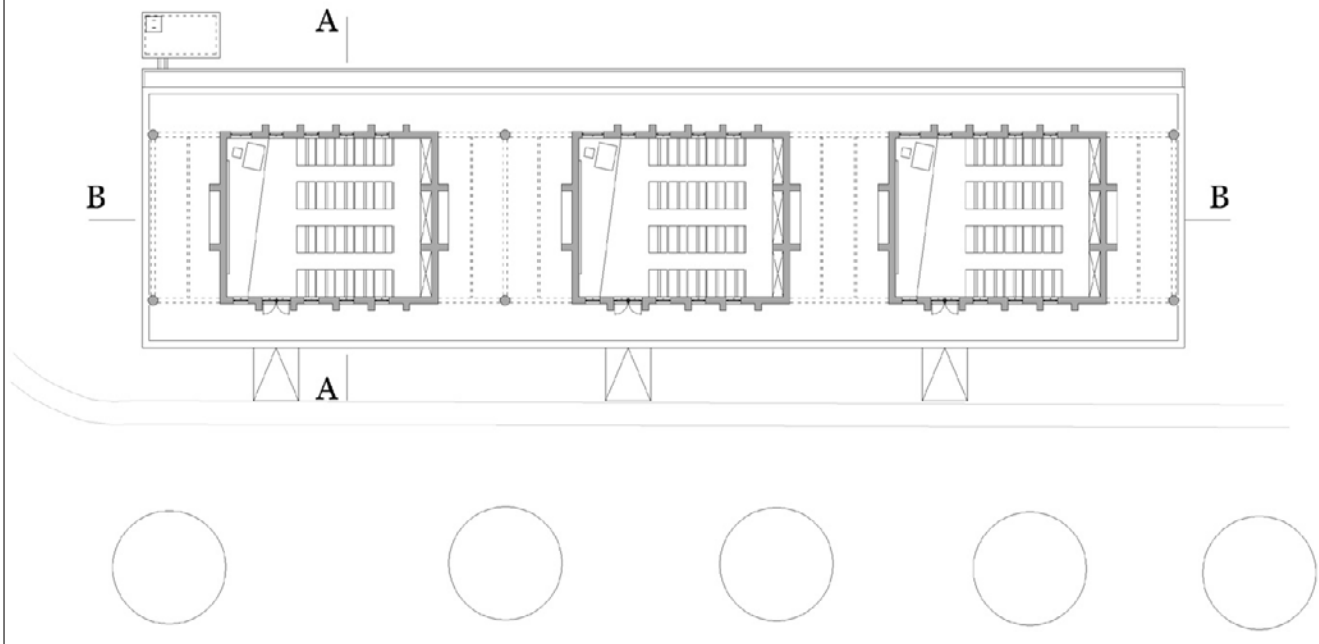


Section B-B

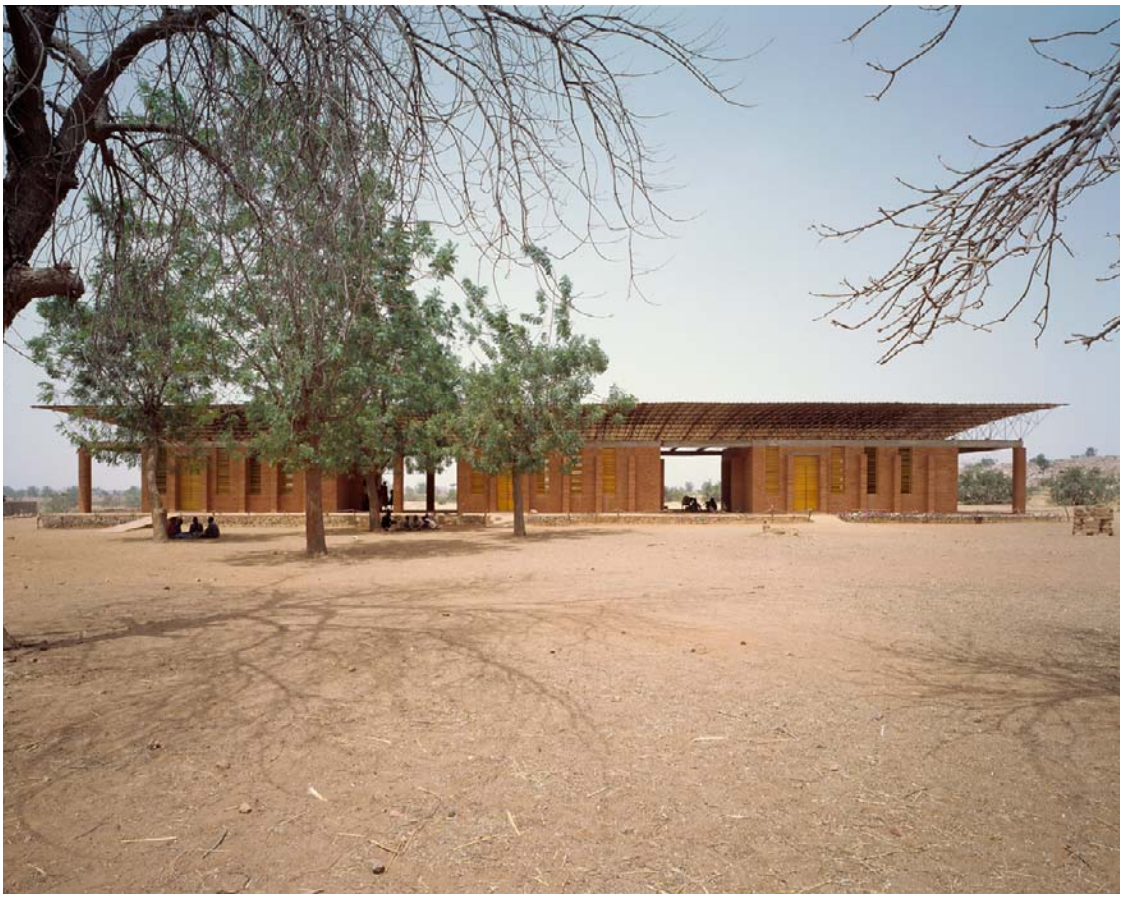
1 Roof (roof membrane of trapezoid metal sheet, girders of welded reinforcing steel)
2 Suspended ceiling (adobe seiling)
3 Circular beam (reinforced concrete)
4 Supporting clay walls
5 Reinforcing elements (adobe brickwork)
6 Steel lamella elements
7 Rampe (natural stone & cast-in-place concrete
8 Continuous foundation (non-reinforced concrete)
9 Permanent shuttering (edgewise bricked up adobe)
10 Clay & stone filling
11 Compressed clay (traditionally stamped clay
12 Edge strips terrace (natural stone masonery)
13 Terrace covering (hexagonal adobe)
14 Rain water conductor



Section A-A



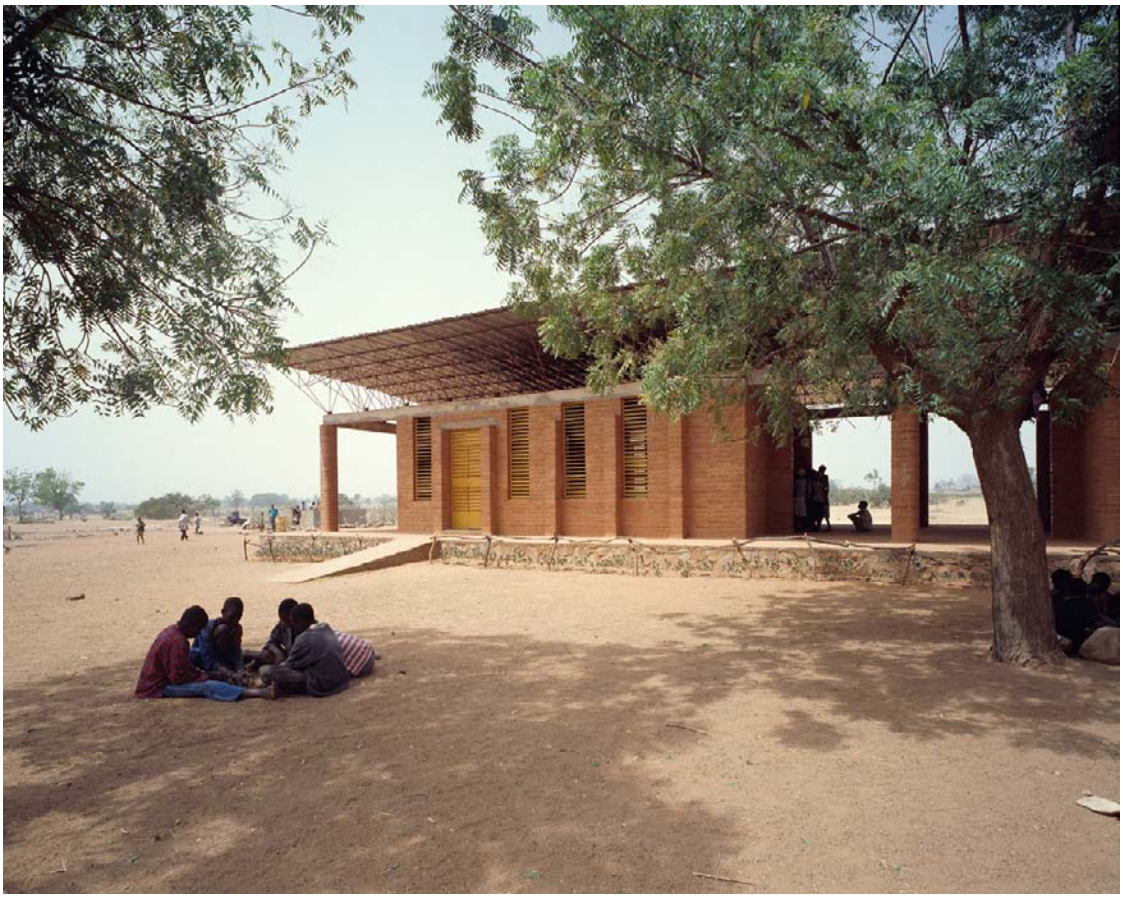
Ground floor plan



South view of the school in Gando, on the southern plains of Burkina Faso, some 20 kilometres west of Tenkodogo and almost 200 kilometres from Ouagadougou.



View of the old school on the left and the new school on the right.



Climatic comfort is ensured by solar orientation, the nature of the wall materials and the unimpeded airflow between the roof structure and the ceiling. Cross ventilation is emphasised by the abundant use of shutters on the northern and southern walls.



West view of the school.



Each 50-pupil classroom is separated by patios, on a platform raised 50 cm from the ground and contains a blackboard on one side. This patio space can be used for children's workshops.



The rounded corners of pillars show concern for children's safety. Reinforced concrete was used only for the beams that support the ceiling.



Ceilings were made of compressed earth blocks supported by 12 mm steel bars, set 15 cm apart and perpendicular to the concrete beams.



Steel was used for shutters and doors, applying a technology with which the local craftsmen were familiar.

Above the platform for the blackboard and teacher's desk, there is a 10 cm gap between the ceiling bricks, running from wall to wall, to allow entrance of top light and air. Shutters amply provide for natural light and ventilation control.



The school was originally to serve the children of Gando alone, but use by children of the neighbouring villages is increasing.





The roof is of corrugated metal sheets over a space frame made of common 16 mm reinforcing steel bars tied to the steel or concrete beams set in parallel to the width of the building. Air circulates freely between roof and ceilings.



The basic structure of the school comprises load-bearing walls made from compressed earth blocks stabilized with 8% industrial cement, cast in hand presses on the construction site and jointed by an earth mortar.