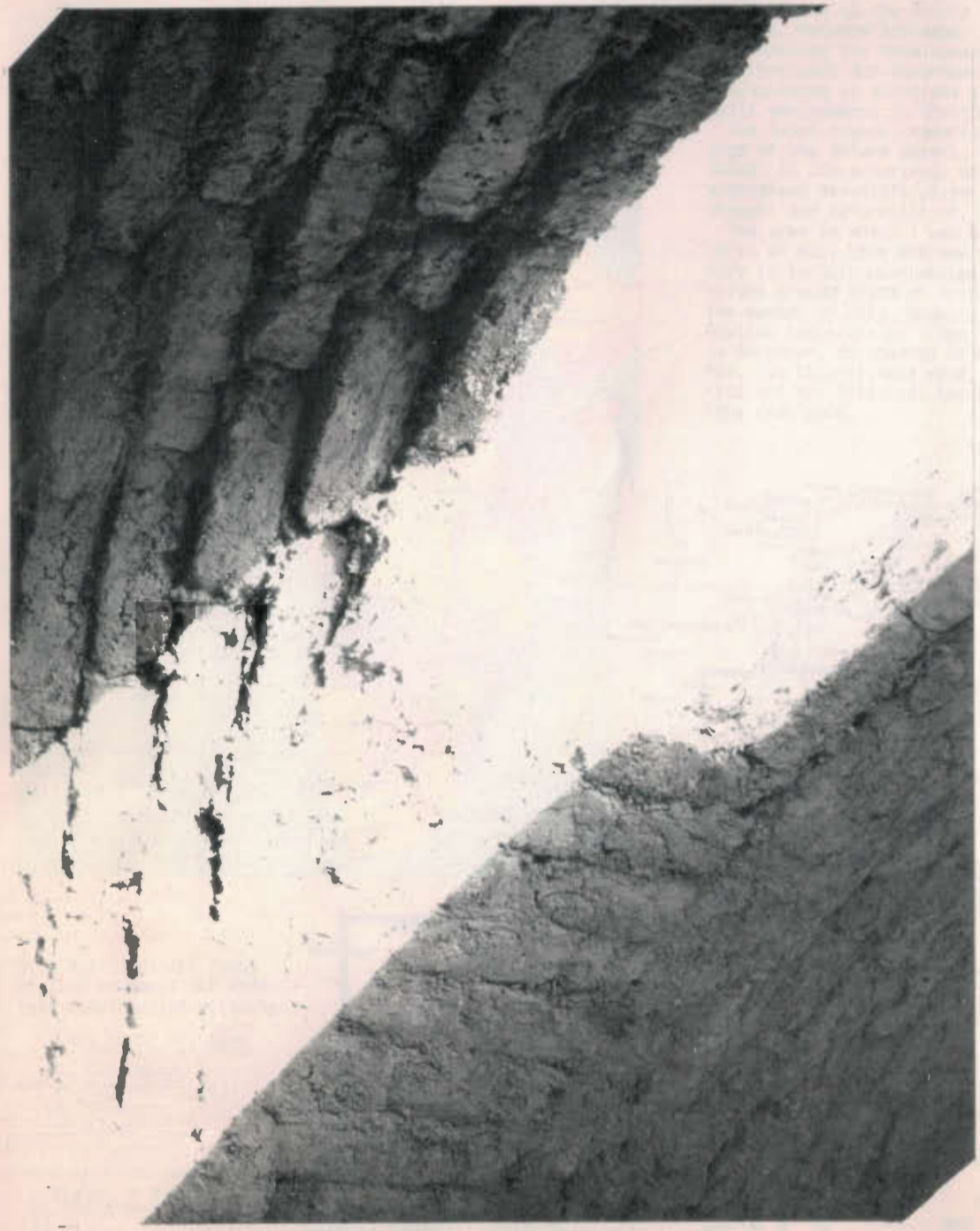


photograph showing the underside
of a nubian vault under construction.

WOODLESS CONSTRUCTION

Michael Jardine
January 1997

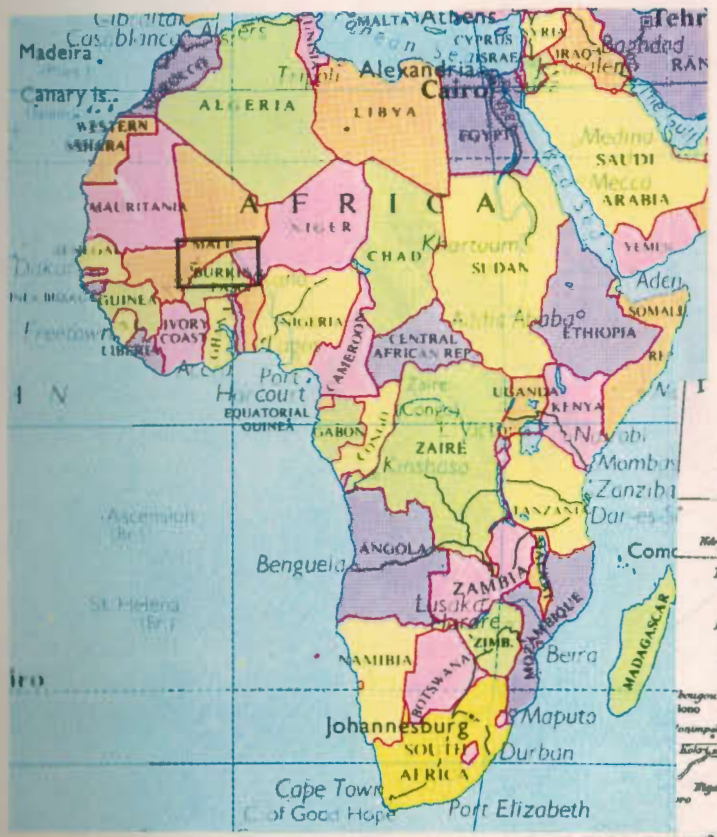
1: Introduction

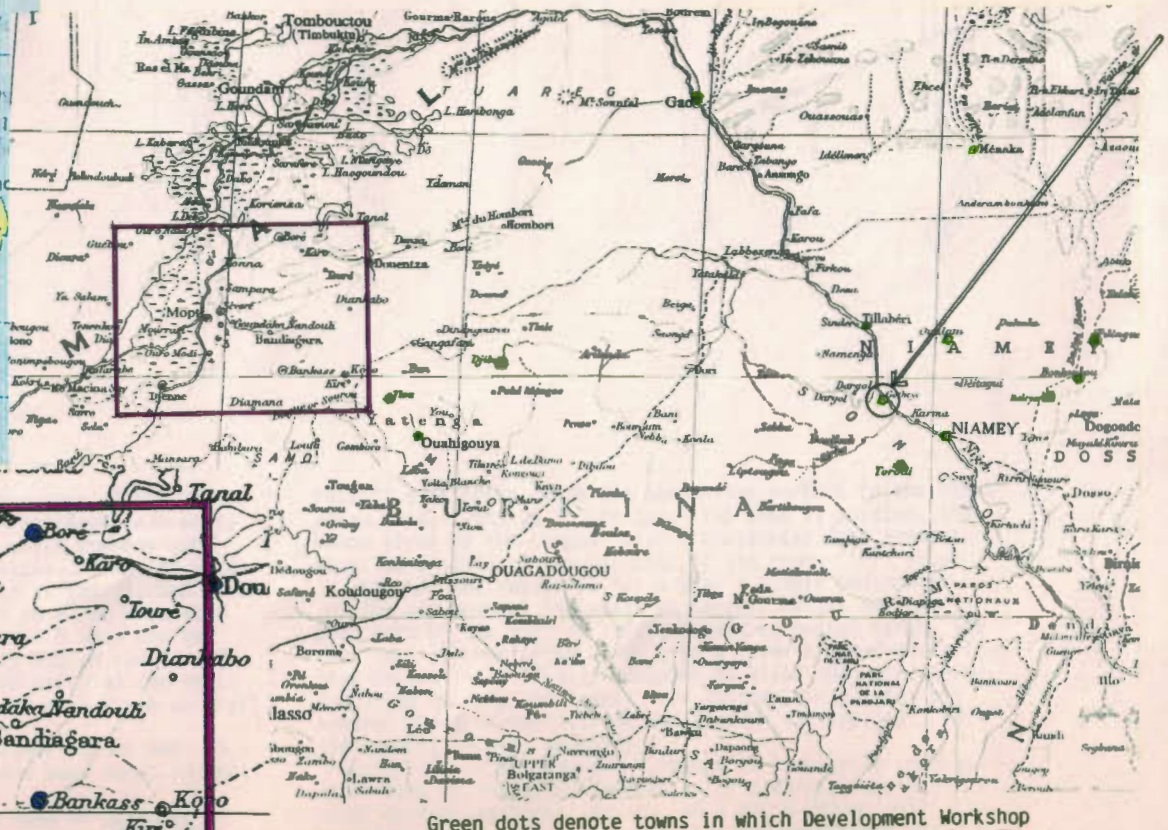
This document is intended to explain, and to show some of the fruits of, the time that I spent, between September 1994 and October 1996 working for Development Workshop, an international Non-Governmental Organisation specialising in solutions to problems in the built environment in developing countries.

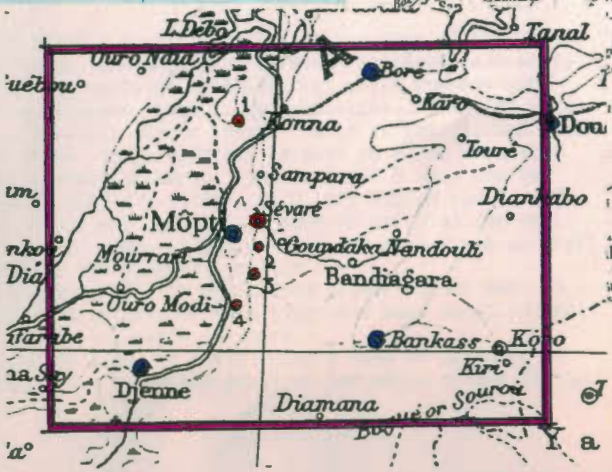
The Sahel region, comprising the southern edge of the Sahara desert, from Senegal to Sudan, is characterised, unfortunately, by widespread desertification, brought on by drought and deforestation.

The area in which I was based is in the north of Mali (the extreme north of the country is largely uninhabited desert), and receives around 500mm of rain annually, in the months of July, August, and September. Daytime temperatures range from around 25°C in December, to upwards of 40°C in April and May. In this climate wood, for preparing food and for building, has become more precious than gold.

Above: A typical townscape of the area. This shows the flat, timber-framed roofs of local, traditional buildings. (Gotheye, Niger)







Blue dots indicate towns serving as bases for Woodless Construction activity.

Red Cross Villages

1. Diambakrou
2. Soufourallaye
3. Sirakoro
4. Kouna

Red dots indicate target villages of the Red Cross Environmental Education project.

Green dots denote towns in which Development Workshop has trained masons and/or supervised building works. There are many more off the map, from Mauritania to the east of Niger.

The project was born in the north of the Ni Republic in 1980, when Development Workshop w brought in to look at feasibility of introdu Middle-Eastern vernacu dome, arch, and vault- building techniques to help protect diminishi natural resources in t Aïr/Ténéré region.

The techniques were soon modified to simpl the training of local ns, and to make the bu dings more acceptable local communities, an evolution which contin to this day.

2: The Techniques of Woodless Construction

figure 1

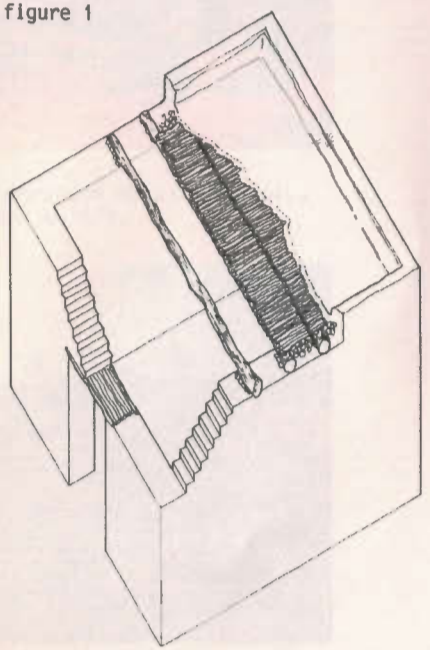


figure 2

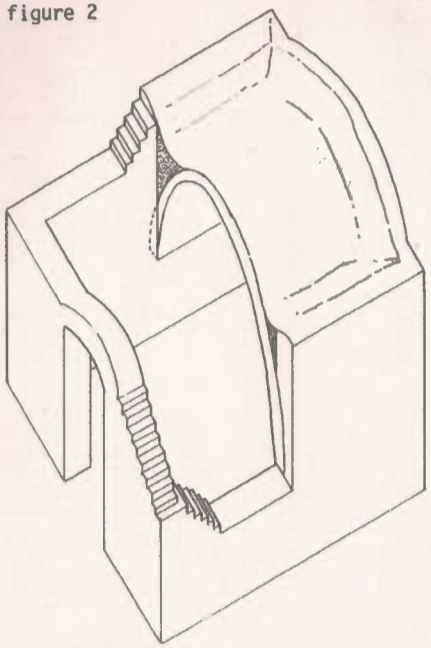


figure 3

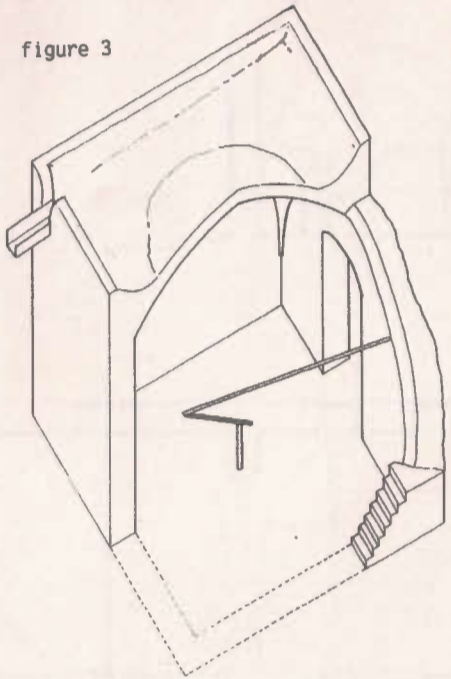


Figure 1 shows a traditional structural type of the Sahel, Principal beams, preferably of termite-resistant palm-wood, are laid across walls of earth-bricks, which possess good compressive strength, then large quantities of smaller wooden laths are placed across these. Earth is then packed down onto this frame, and a gradient is made to allow rainwater to run off through gutters. Figures 2 and 3 show the two techniques of woodless construction, the Nubian vault, and the dome. These are made of the same material as the walls of Figure 1, sun-baked clayey earth mixed with straw or chaff, but the bricks are slightly smaller.

Figure 2, the vault, is built from either end to meet in the middle. Structures of this type have been built in what is now Iran for thousands of years.

Figure 3, the dome, is built using a kind of compass, as shown here. This gives the position and angle of the inside face of each brick, from the pendentive corners to the rings above them, right up to the top. The dome is pointed, the shape given by the compass with a horizontal displacement equal to a sixth of the diagonal of the room. This shape is stronger and easier to build than a simple hemisphere.

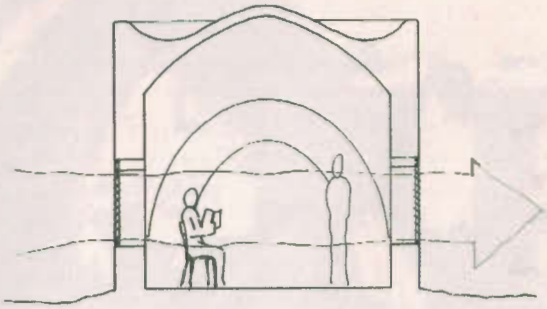
The gap between the walls at parapet height and the structure of the roof is infilled with compacted earth. The roof area is then often paved with a layer of roofbricks laid flat before it is finally sculpted to allow rainwater to be evacuated quickly and evenly, the gutters are placed, and several coats of sacrificial mud-plaster are applied. This are usually renewed annually.

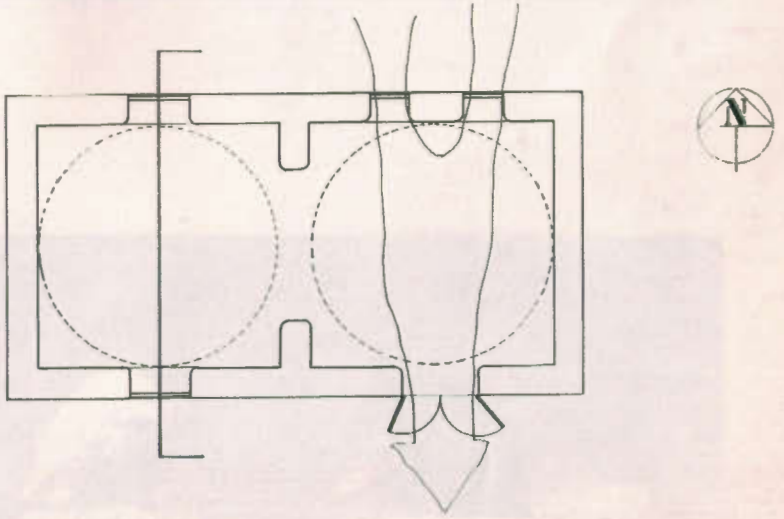
Costly and wood-consuming formwork is completely unnecessary owing to the gluey properties of clay-rich earth. This means that a roofbrick (approx. 60 x 200 x 140mm) will stick by plaster alone until the rest of a row or ring of masonry is there to support it.

Above: the first prototype structure, built at Chikal, in Niger, in 1979.

Above: at the end of the day, small roofbricks are left to dry. (Sevare, Apr '95)

Above: a training-structure, on which the end-walls have been removed, shows the section of the Nubian vault. (Sevare, May '95)





Climatically, there is much to be gained by orienting the building correctly, in order to make the most of the excellent thermal properties of sun-baked mud, or 'banco' as it is generally known.

Looking at the plan above, the building is aligned east-west, so that the heat of the evening sun from the west, and the brunt of the destructive force of rain, from the east, are directed against the smallest possible surface. This orientation also allows air to pass north-south. It is also preferable to place the major openings (doors) on the south, thus avoiding the hot-season midday sun, which attacks from the north.

The section, at top, shows the windows at a fairly low level to allow the benefits of moving air to extend to those seated or lying-down.

3: Training

These photos were taken at a 'training of trainers' that took place at Filingue,. in Niger, in October 1994.

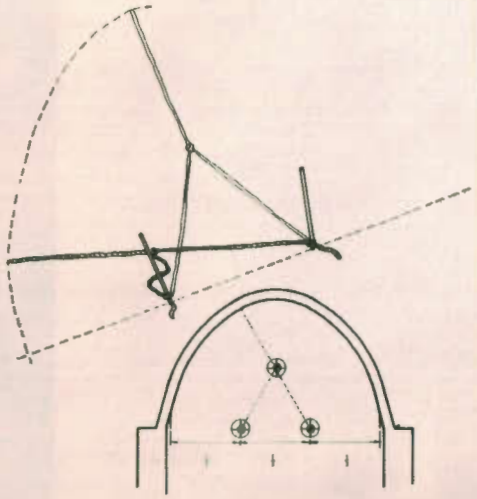
Above right: the third full curve of bricks has just been completed. Note how they start at an incline, and also how the strings have been placed to guide the progress of the vault.

Left: a row of training structures, the furthest of which has the two ends almost meeting in the middle.

Bottom right: when these two halves finally meet, rows of bricks are built up laterally, then more curves as before, until then last brick can just be tapped in to close the vault. Here two senior trainers sit poised to control the work.

Above: senior trainers demonstrate, from left; a) the structural principles of a wooden roof, b) those of a vault, and c) the perils of springing a vault too high

Below: diagram showing how the vault is traced on the end walls. In practise, the ends are often straightened by eye, to make for a more stable 'shape'.



The training programme, run by Development Workshop in partnership with IUCN in Niger, ran two eight-week camps based in Sevare, in Mali, from December to January '95/'95 and from February through to April 1995, on which I was progressively more involved as I myself learned about the techniques involved.

For each training, about forty masons were selected, mostly from Sevare/Mopti, and a target-town, first Bankass and then Djenne. Some came from other countries, such as Burkina Faso. We also found eight client-partners, who would contribute unskilled labour, scaffolding, and materials to eventually receive the shell of a small two- or three-roomed building.

The trainee masons, already required to be expert in building with unfired earth, underwent two weeks of intensive training on a special site, both practical, on specific training structures, and theoretical. They were then split into eight groups, each with a trainer to oversee the work, and spent five weeks on the building site, with another weeks revision, and training.

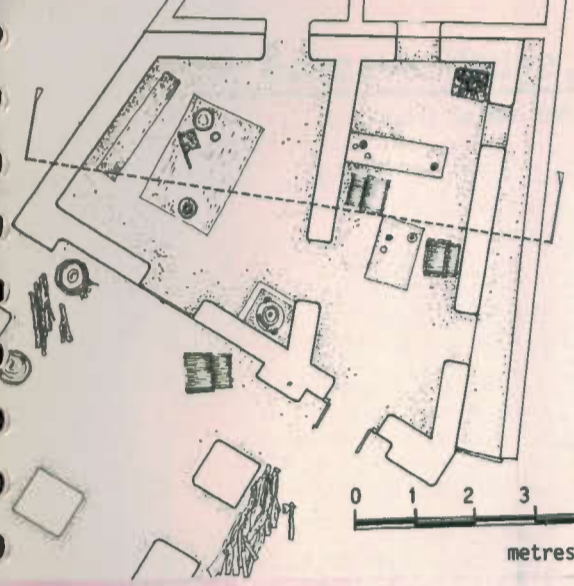
At the end of the training, each mason would receive a certificate according to his competence, and performance, and all were encouraged to go home, and try it out for themselves and their families.

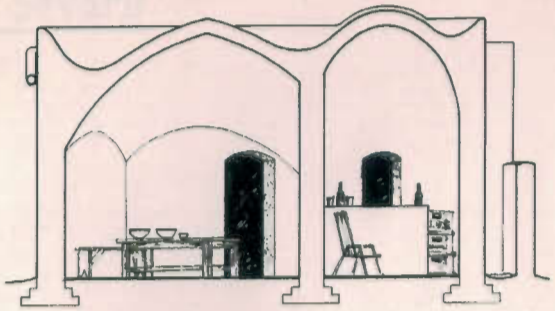
During this period, I was seconded to Development Workshop as a volunteer of the Overseas Training Programme, an initiative of VSO.

Above: exterior, and below: interior of a 'stage' building in Sevare, a one-room study for a local school-teacher. The trainees were encouraged to apply the decorative style of their home-town, Djenne, famous for its architectural artistry.

4: A Restaurant

in the Rue du Marche, Sevare.





The irregular shape of the plan derives from the shape of the plot in relation to the street facade; the line required by the vestigial local planning law for the limit of permanent building.

The restaurant is on one of the principal streets in the town, adjoining the huge and chaotic market area. The man behind the motorcycle is Léonard Togo, the client-partner, who contributed materials and unskilled labour towards the restaurant, which is run by his wife.

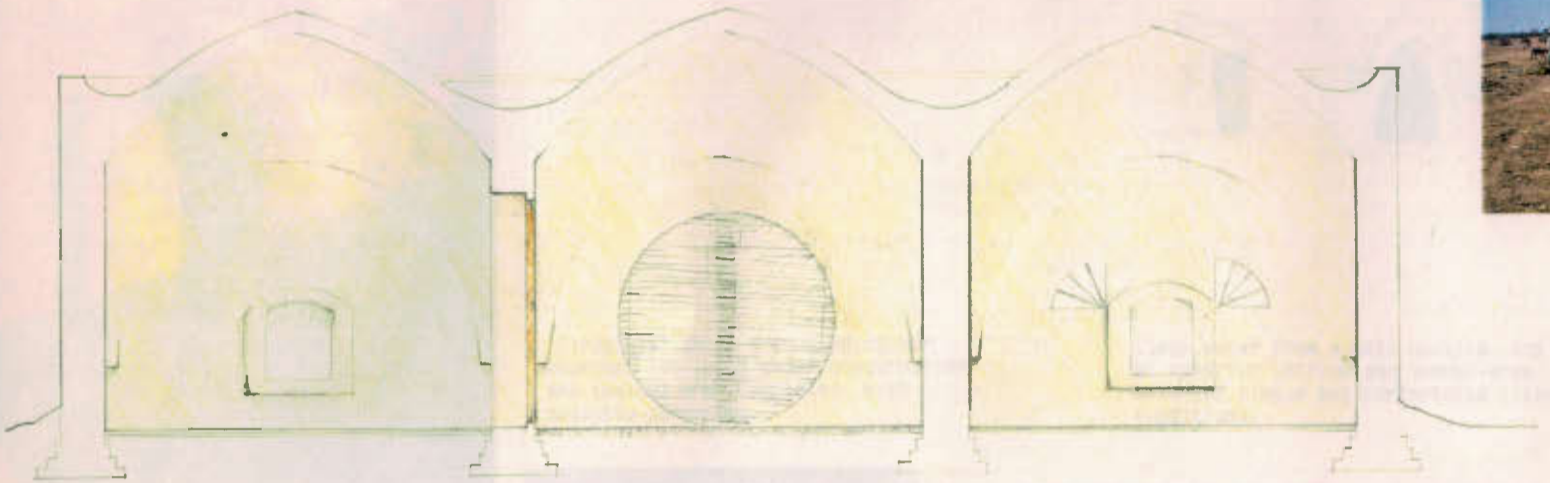
porch, or 'hangar' in local French
built entirely of scavenged and
rials, a year or so after the main

ng confused many when proposed in
. When built it showed how a
built over any plan-form, however

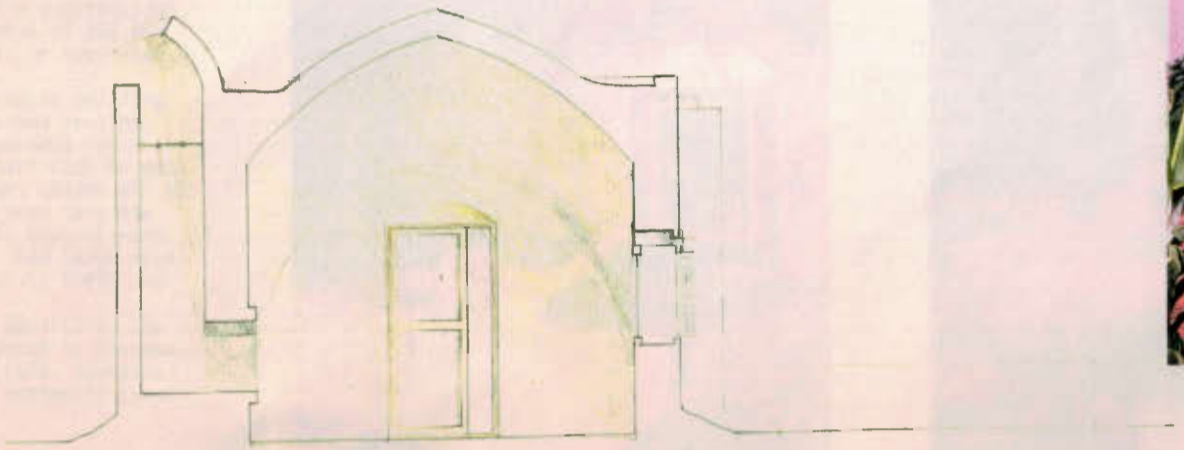
5: The Batcave House, Sevare

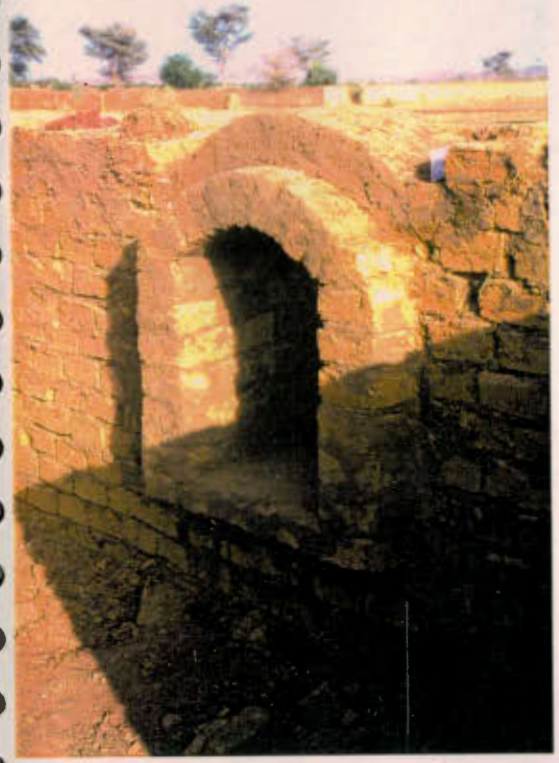
built in May 1995

Above: The house under construction. Once the pendentives of the domes have been built up to the first full circle, the walls on the corners must be built up.
Below: North front.



Above: long section
Below: cross section clearly showing chimney-aided ventilation system. Both drawings at 1:50





'Fireplace' inlet from windcatcher chimneys (at left) under construction and (below) when completed, with mosquito-screening.

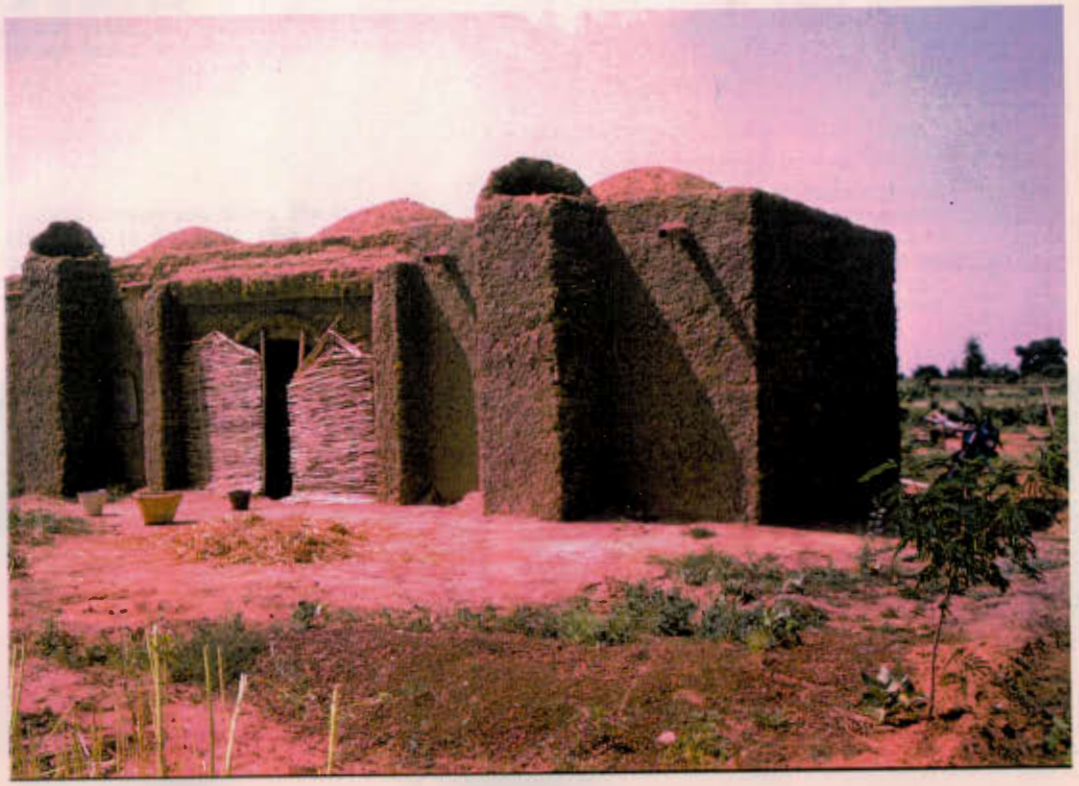
Clean water from a well on-site, and an exterior latrine and shower-area make for simple but comfortable living conditions.

Above: freehand sketch
Below: South ('rear') face, with chimney inlets.

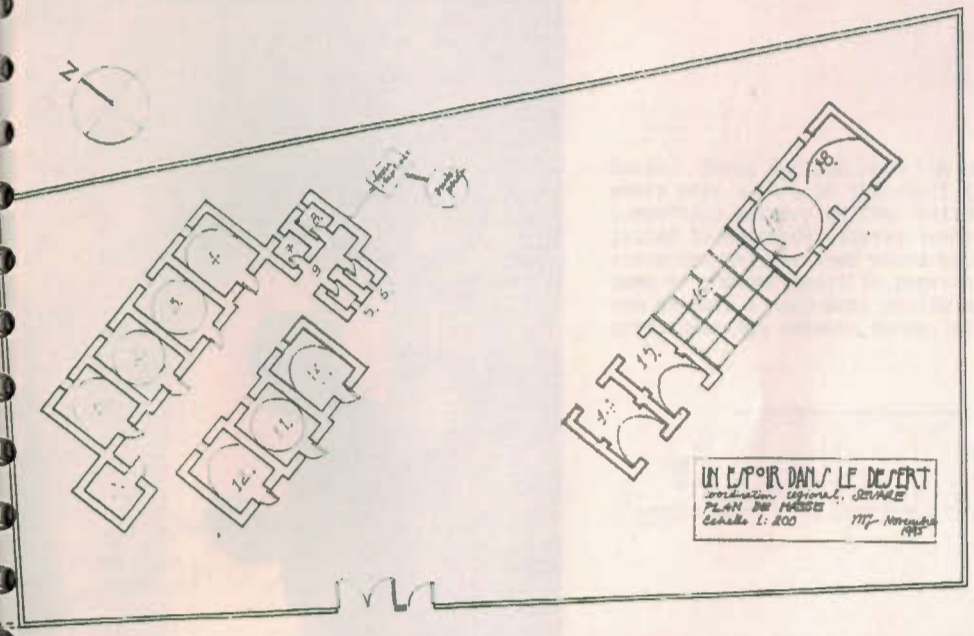
The house was built for myself and a friend, on land belonging to a third party, all contributing a third of the construction cost- a total of 500,000 CFA francs, or approximately £600.

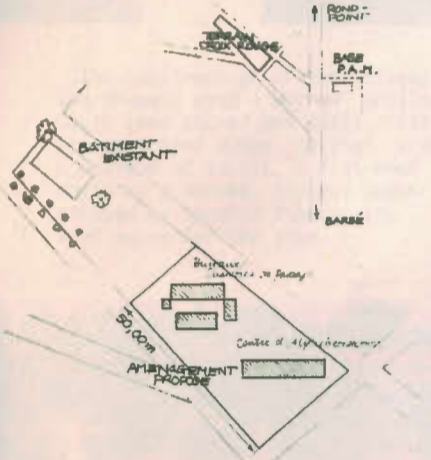
A very simple building of three domes in-line, the two bedrooms had a 'windcatcher' each to pull the cleaner, colder air at rooflevel down into the rooms. The central room, a 'salon', had large arched openings to north and south.

Upon my departure, the house reverted to the owner of the land, Boureima Togo, who currently lives there.



6: 'Un Espoir dans le Desert': Regional HQ





CHAMBRES de PASSAGE	
1	chambre
2	chambre
3	chambre
4	chambre
5	WC
6	WC
7	douche
8	douche
9	comptoir
10	cuisine

BUREAUX	
11	magasin
12	bureau
13	bureau

ANIMATION/ALPHABETISAT.	
14	hangar
15	hangar
16	hangar
17	salle d'Alphabétisation
18	

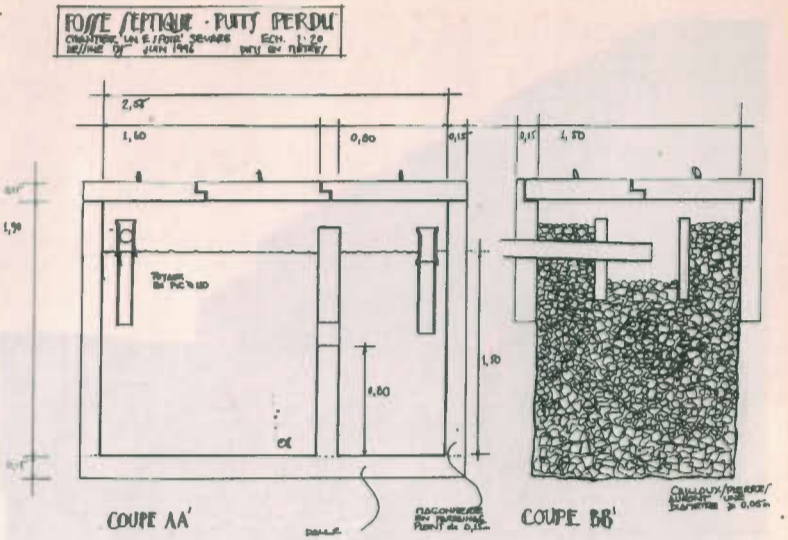
PROJET pour la construction d'une Coordination Régionale pour le projet UN ESPOIR DANS LE DÉSERT de la [illegible] avec, Mopti.
Dessiné par [illegible] Workshop · Nov 95

In October 1995, work started on a contract with the Danish Red Cross, to execute a woodless construction programme for the Danish-funded Malian Red Cross environmental education project entitled 'Un Espoir dans le Désert'.

This was to train a number of masons from the project's target villages, and to construct centres in the villages (see following pages), and also to build the project's regional headquarters.

The 'gros-oeuvre' or shell was built as part of the training between November 1995 and January 1996.

The finishing work (electrics, plumbing, etc.) continued up until the onset of the rains in June of that year.

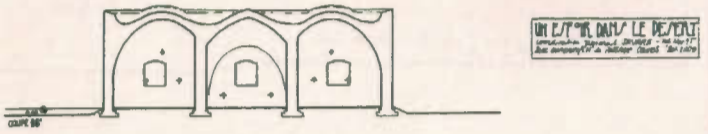


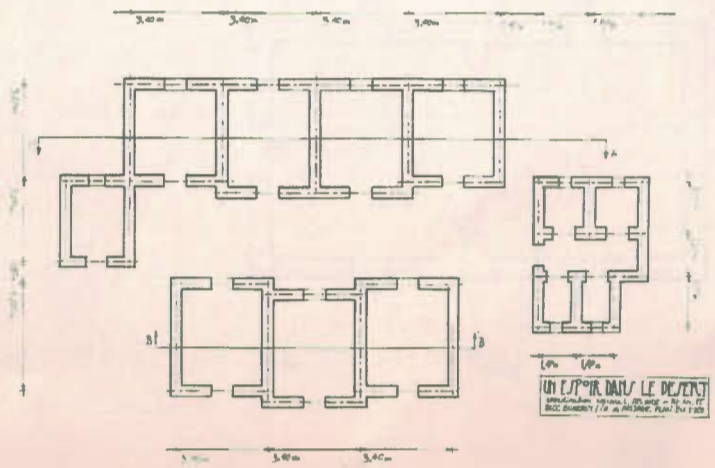
This photograph shows the building site in December 1995. The two small structures in the foreground are for training, teaching how to start off a dome-pendentive, and were later demolished.

The main block is here shown showing signs of 'first-season' weathering. Although the tops of the walls are somewhat eroded by a healthy season's worth of rain, none of these buildings suffered any leaks.

The construction of the toilets and showers used a narrow, shallow vault (see above) and small, flat, string-traced domes, so that with a minimum of infill, a flat roof could be acheived, (below) demonstrated by Ibrahim Tomota, the head mason for the site.

Below: These section show the use of an 'eccentric' vault where only a part of the vault is used. Obviously the supporting masonry on the 'inside' of such a vault is subjected to enormous lateral loading, so this type of structure can only be used where this side is abutted by a dome or another vault to provide a counterthrust. This can produce a much more usable space in terms of flat wall-area, openings between rooms, etc.





It is generally very important to evaluate the performance of a building during the first rainy season after its construction, in terms of water run-off, erosability, etc. In the case of the interior courtyard (shown above), we noted the mess created as the mud-plaster was washed off and deposited on the paving, and had the walls replastered in a ferro-cement render .

7: 'Un Espoir dans le Desert'
Village Centres

The view at right shows us the interior finish created by earth render, followed with a sandy (to prevent cracks) clay plaster, mixed with insecticide (to prevent termites) and finally whitewashed.

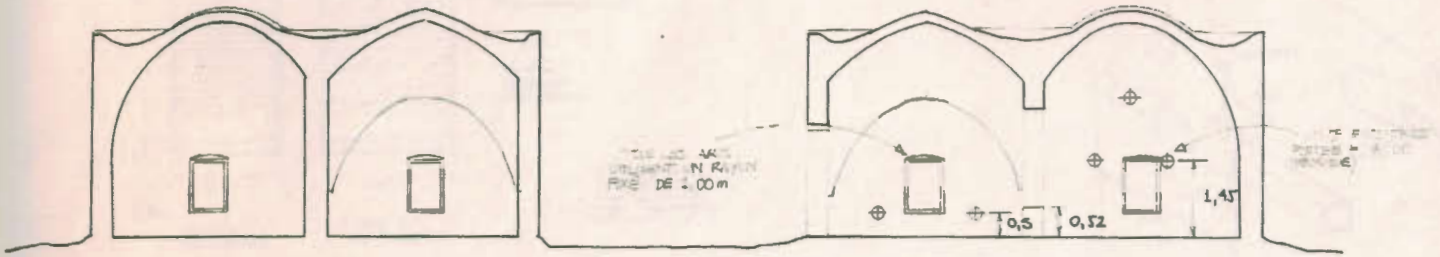
On the doorway the masonry is rounded off, which makes the plasterwork less prone to scuffing, and thus more durable.

Outside the door is the makeshift basin in which the 'crép-issage', a sacrificial mud-plaster made with rotten rice-husks, manure, or sump-oil, is mixed and allowed to brew.

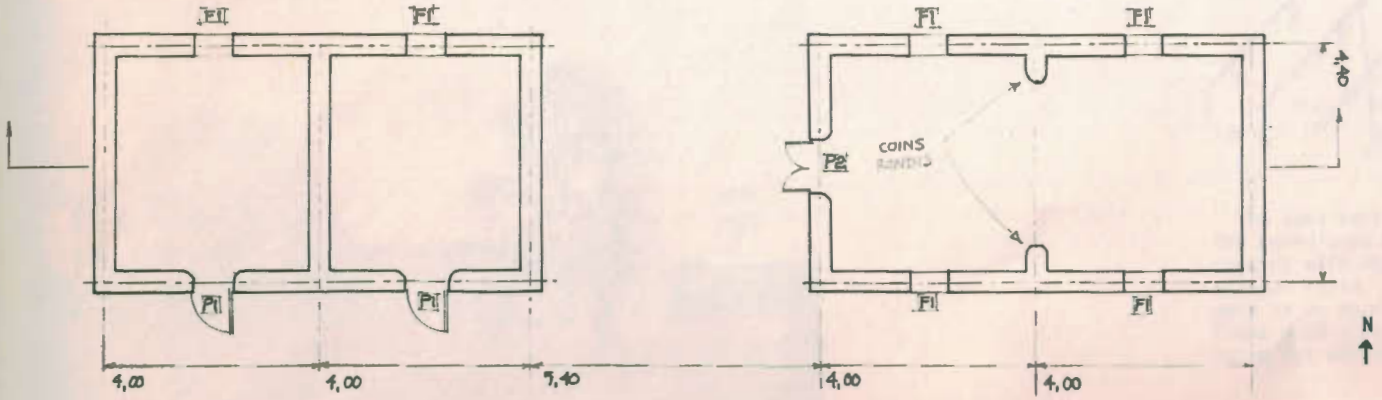
The photo is of the centre at Kouna.

Above: Kouna, north face
Below: Sirakoro, interior

CENTRE MULTIFONCTIONNEL
'UN ESPOIR DANS LE DESERT'
PT & ITY ECHELLE 1:100
DIMENSIONS EN MÈTRES

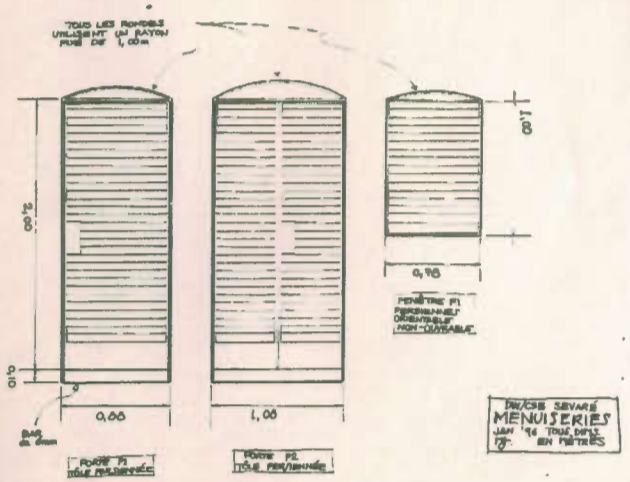


Below: Kouna, interior



The interiors, and the area between the two buildings, are paved with small concrete slabs fabricated by village teams on-site. This required very little specialised knowledge, such as that of control joints, and was easy to control, discouraging local practises, such as the 'concrete' floor consisting of 5mm of sand mixed with a quarter of a bag of cement!

The doors and windows were made in Sevare, consisting mostly of louvres (movable for the windows) in steel sheet.

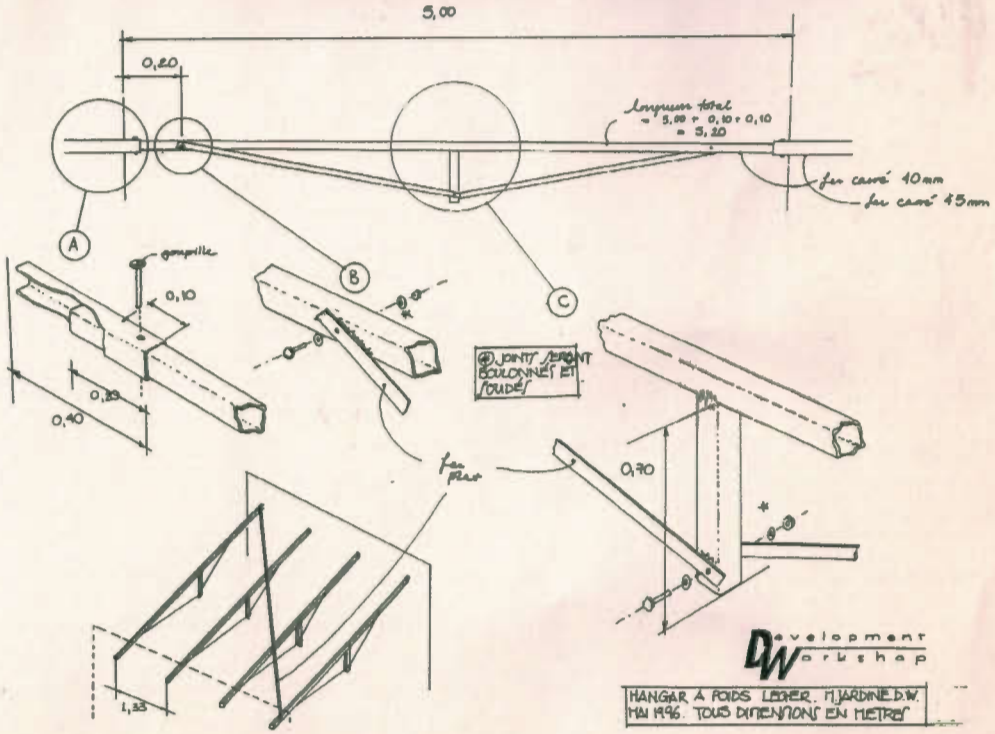


Below: Kouna, general view

Dates of construction

Village	
Kouna	24/2-21/3
Sirakoro	24/3-19/4
Soufourallaye	30/3-24/4
Diambakrou	8/5- 3/6

Right:
'hangar'-frame being erected at Soufourallaye- October '96



The idea behind the design of a steel-framed sunshade over the paved area between the buildings was that it could be covered with whatever material was available, on a village-by-village basis. In Soufourallaye, stalks of the right length were to be kept over from the millet harvest and bound to the frame with wire. An alternative might be to use the straw mats woven for market-day by women in many villages.

Hertford
21st January

Dear John,

I hope all is well. Here is, as promised, a copy of my 'folio on the DW work. It is very much a first version, and has been laid out so that it can be added to. So any suggestions that you have for changes and/or additions would be most welcome.

regards

Mike Jardine