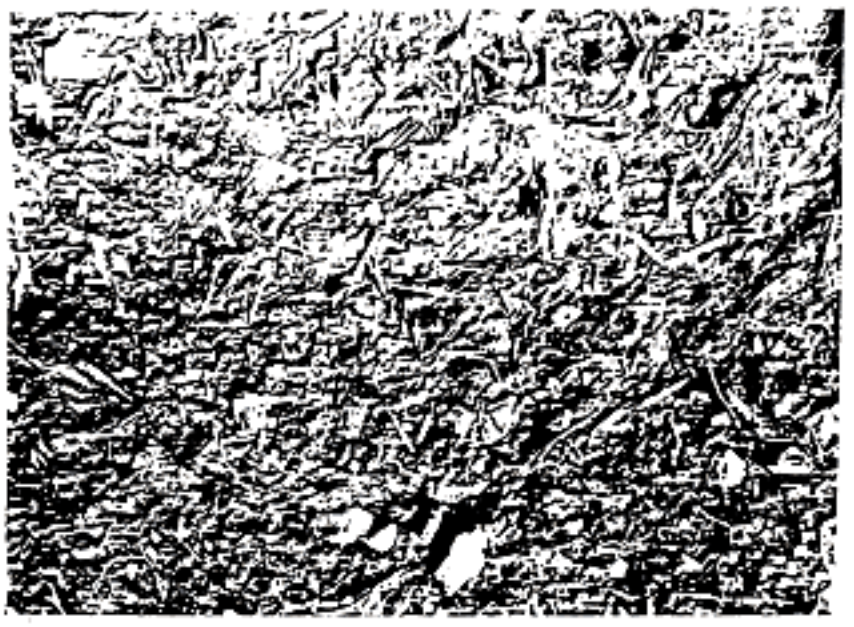
DEVON EARTH BUILDING ASSOCIATION



Newsletter THREE

Research into Cob Construction at the University of Plymouth

Kathryn Coventry , Dept. Civil and Structural Engineering

Research into earthen building construction at the University of Plymouth, has concentrated on 'cob construction'. Cob construction was the traditional method of building throughout rural Devon during the seventeenth and eighteenth centuries, and involves the mixing together of soil, straw and water which is then pitched onto a stone plinth ,in layers, to form a monolithic wall. These layers are then trodden down by the feet of the labourers and finally the wall is 'pared- down' to render its sides smooth.

Unfortunately, increasing efforts to conserve existing cob buildings and adopt this form of construction in new developments, are being hampered by concerns that neither the structural nor thermal performance of cob will satisfy existing building regulations. Furthermore, there is no scientific or research data available to alleviate these fears. Collaborative efforts between the School of Civil and Structural Engineering, the School of Manufacturing Materials and Mechanical Engineering and the School of Architecture at the University of Plymouth, have been instigated to address this need for information, in order to promote and conserve earthen buildings in the UK.

Research into the thermal properties of cob is currently being carried out by Steve Goodhew, and Dr. Dick Griffiths. Using cob walls donated by existing owners, typical thermal conductivities for cob walling will be established by probes developed at Cranfield University. Once representative values for thermal conductivity are obtained, this data, along with the determined moisture content of the sample walls, will be used to asses the overall thermal performance of a range of different designs of cob dwellings by means of some specifically developed dynamic thermal analysis software. Each design is intended to be evaluated with different heating systems, occupancy levels and internal conditions. The assessment of each design considers heat flow, moisture movements (both within the wall and the inside air space) and also evaluates any effects due to alteration.

The software employed, affords a high degree of great flexibility in the approach to this research. Over various tests wall coatings and insulation devices may all be easily assessed for impact on internal conditions, effective radiant and air temperatures. Ultimately these tests will map the thermal properties of monolithic, loadbearing, unbaked earth walling.

Research into the structural capacity of cob has been addressed by two alternative approaches within the university.

Over the past three years Mathew Greer (under the supervision of Mr. David Short, Ms.Linda Watson and Mr.Bob Saxton) has investigated the effect of the composition of earth building materials upon mechanical properties. The focus of this work is the behavioural distinction that can be made between the particles of soil less than 0.002mm ' the binder fraction ' and those greater than 0.002mm ' the aggregate fraction', and the effects of the arrangement of these fractions when mixed together on the compressive strength and rigidity of earthen materials.

Due to the naturally cohesive nature of the binder fraction and the large surface area of the particles within this fraction, it has been shown that its prominence within a earthen building material mix will increase both the rigidity and failure stress of an earthen material. Furthermore, the compressive behaviour and failure mode of the material is dominated by the moisture content of the binder fraction. As the moisture content of the binder fraction

The meeting took place in the small village of Ouzilly-Vignolles, population approximately 250, situation on the reclaimed marshes to the south of Loire, to the north of Poitier. A number of cob buildings exist in the village, including a farmstead which has been recent repaired and converted into a visitors' centre devoted to earth building.

Linda Watson, with the help of Bob Saxton, Rex Harries and Maggie Ford from the University of Plymouth gave a lecture in the local village hall to the community and the Arc representative about cob buildings in Devon and the research at Plymouth. Fortunately one of the locals is English and was able to translate so the talk was given simultaneously in French and English, English being a necessity so the Portuguese could understand the lecture. Displays from the other partners of Terra Atlantica illustrated the cob technique as popular throughout the Arc. Visually there are many similarities with farm building sharing a similar aesthetic.

This should be revealed soon to all as the first task of Terra Atlantica is to compile an exhibition of Earthen Architecture of the Atlantic Arc. Perhaps it could be displayed at Bowhill in Exeter.

CONTEMPORARY DESIGN FROM TRADITIONAL MATERIALS

The third annual conference at Dartington on 8th, 9th and 10th May l996 widened the palette of materials from earth to a number of traditional materials to help create both contemporary and sustainable architecture. Nevertheless a high percentage of the speakers did deliver papers on current earth buildings.

All the members of the European Earthen Architecture Network, representing Finland, Germany, Italy, France and Portugal all gave papers about their latest projects; Bob Vint spoke of the earth buildings of the Southern United States, Thomas Kleespies of Switzerland, Peter Medgyasszay of Hungary and Angel Alonso of Spain. Mark Tichy and Petr Suske drove from Prague to tell the conference of their plans for an earth built suburb in their city and Peter Mold temporarily returned from Australia to show us how earth was already an important contemporary material in the Antipodes. Sumita Sinha spoke of the need to improve the marketing of earth in the U.K.

Other speakers normally associated with earth building including Jeanne-Marie Teutonico, and Fernando Pinto spoke more philosophically on the importance of tradition in design today. All the papers are available.

Like the previous 'Out of Earth' conferences the event provided an excellent opportunity to be updated on recent developments in the earth world. Globally it is apparent that there is a lot of activity and as was agreed at Out of Earth I, as soon as a major earth building is completed in this country the material will 'takeoff'.

Perhaps the Earth Centre at Doncaster will be the flagship. The need to be sustainable as a consequence of Agenda 21 must support this renaissance. Earth has the optimum characteristics to achieve this goal.

Letter from Mike Jefferies, Pitt Farm, Cadbury

With reference to variations in the cob building technique as noted by Barry Honeysett.

I saw the layer technique of building in a cob wall that I demolished in Starcross some years ago. I cannot remember the height of each layer of earth but I do remember that it contained no straw. Between each layer of earth was a distinct band with the long straw laid in line with the wall. Over the years the straw had combined to form a sort of 'cardboard' that could almost be peeled off in a sheet!

I also have my doubts that cob was always mixed and compacted as diligently as we now consider so necessary. When working on old cob I often notice wide colour and texture variations within a small area of cob. From this I would guess that thorough mixing was far from the general rule.

I have also noticed that old cob walls are quite soft at the top and relatively hard lower down. Does this indicate that the majority of compaction was from the weight of wall rather than the human foot? Certainly I find now cob that is thoroughly mixed and compacted to be much harder than early examples.

Finally it is possible that the 'layer' technique of cob building permits each course of earth to act independently? Would shrinkage cracks be distributed rather than confined and often rather dramatic?

I hope that my thoughts are of some interest and look forward to any comments that may result.

Yours sincerely
Mike Jefferies

Suppliers of Cob Blocks

Steve and Shirley Bradford
S & S Cob Blocks
The Old Post Office
Black Dog
Crediton
Devon EX17 4RQ
Tel: 01884 861052

Graham West
Down Farm
Tedburn St Mary
Exeter
Devon
EX6 6ES
01647 24276

M Wye
Glebe House
Buckland Filleigh
Beaworthy
Devon
EX21 5HY
01409 281 644

Kevin McCabe
Lower Tricombe
Northleigh
Colyton
Devon EX13 EDA
Tel: 01404 871487

A Howard
Westleigh
Morchard Road
Crediton
Devon EX17 5LS
01363 84327

J Sharpe
16 Clinton Gardens
Merton
Okehampton
Devon EX20 3DP
01805 603587

The Physical and Constructional Characteristics of Cob Walls Compared with those of Other Forms of Raw Earth Construction. Notes Concerning Suggested Research /Test Programme Designed Specifically to Examine the Behaviour of Cob Walls and their Decay and Failure Mechanisms.

Larry Keefe

1. Leaving aside stabilised soil and composite forms of construction (wattle and daub and mud and stud etc.), neither of which need concern us here, there are three traditional types of load-bearing raw earth construction used internationally. These are: (1) rammed earth or pise de terre (2) adobe or clay lump/mud brick, and (3) cob - known in France as 'bauge'. A fourth type, compressed earth block, is a recent innovation which is now in widespread use, particularly in developing countries.

2. In rammed earth construction cohesion is achieved mainly by mechanical means, through internal friction between the coarser aggregates, with electro-chemical bonding between the clay particles playing a lesser though still significant role. Soils most suitable for ramming are comprised mainly of sands and fine gravels, with a relatively small proportion (30% or less) of 'fines'. They are compacted between heavy duty shuttering at low moisture contents, usually 7 to 10% by weight.

3. Rammed earth is similar to cob in only one respect; it is formed en masse as a homogeneous whole, in a series of horizontal ' lifts' from plinth to eaves level. Being rammed in shallow layers between formwork, the walls are inherently stronger and therefore need not be so thick as those made from cob, about 450 mm being the norm. If the soils used are carefully selected, are placed at optimum moisture content and thoroughly compacted in layers no deeper than 150 mm, then the performance of the material can be predicted with confidence. The only variable, when ramming is carried out manually - using hand tools, is the compactive effort, which might vary according to the individual workman. The use of hydraulic rammers, by largely eliminating the human element, would ensure that optimum compaction is achieved. Contemporary rammed earth may be regarded as an industrialised building system.

4. Adobes, or mud bricks, are, compared with rammed earth, a relatively crude and primitive form of construction. Clay-rich soils are used, mixed with organic fibres - usually some form of straw - and water. The material is mixed in much the same way as cob but is usually used wetter and placed in timber moulds with little or no compaction, turned out and allowed to air-dry. Cohesion is achieved through the clay fraction acting as a binder, 'cementing' the coarser aggregates together.

5. The manufacturing process is fairly crude and, depending on drying conditions, the expansiveness of the soils used, straw and water content, the adobes can vary somewhat in quality. A normal masonry technique is used for wall construction, the adobes being laid in a mortar of sieved sub-soil containing no binder or additives. Because their basic raw materials and mixing processes are very similar, one can draw certain parallels between cob and adobe construction. In fact, cob may be regarded as a form of monolithic adobe. However, the construction process is so entirely different that the two systems are likely to behave, structurally, in rather different ways, so that any tests designed to examine failure mechanisms (assuming I can discover them) may not be appropriate for cob structures.

6. A development of the mud brick system has been used to carry out repairs to historic cob structures in south-west England. Known as cob blocks, these units are fabricated in timber or steel moulds in various sizes using a standard cob mix from which the larger stones, over 25 mm , have been removed by sieving. The material is compacted into the moulds at about the same moisture content as mass cob when placed in order to achieve a density similar to that of the cob wall under repair. The blocks are removed (pushed out) of the moulds and then air-dried in the same way as adobes.

7. The ultimate small-unit raw earth construction system is probably that in which compressed earth blocks are employed. This is a fully industrialised but site-based system where carefully selected soil, in measured batches and at optimum moisture content, is compacted by hydraulic pressure to produce a block of known density and compressive strength. The only variables in this system are (1) the technique used by the mason when constructing the wall and (2) the constituents and moisture content of the mud mortar. A compressed earth block has all the advantages of rammed earth (high density and mechanical cohesion) but with none of the disadvantages of the relatively crude mud brick. Its performance is predictable and can be measured in the same way as that of a fired brick or concrete block.

8. How does cob compare with the other raw earth construction methods described above, in terms of its physical characteristics, construction and structural behaviour? Of the four building methods briefly discussed here, cob is the one whose production process is least subject to 'quality control' and whose structural performance and durability is most difficult to predict or quantify with any degree of accuracy. The reasons for this are set out below.

9. The raw material. Unlike some other parts of Britain where there is a strong local earth building tradition (East Anglia and the chalk downlands of Wessex, for example) the sub-soils of the south-west peninsula show infinite variation, due mainly to the area's geological complexity. Some soils are well-graded, naturally cohesive and structurally stable, and may be used 'as dug' to construct buildings which will perform well over long periods of time. Other soils, however, are far less stable and are extremely susceptible to decay and damage from external sources, mainly in the form of moisture penetration. Buildings constructed from such soils therefore present a conservation problem of significant proportions.

10. The production process. The traditional method of mixing, placing and paring down mass cob has been fully described elsewhere. This basic technique is, or was, common throughout the South West, though some variations have been noted - the use of formwork, for example, and placing the sub-soil in shallow layers, then treading in the straw on the wall head are two of the main ones. The mixing process, the amount of fibrous material added, the moisture content of the material, the method of placing, type of tools employed and degree of compaction achieved, as well as the nature of the sub-soil used, are all factors likely to affect or influence the performance of the completed wall.

11. Construction. So far then, we have seven variables, to which may be added constructional details, which will vary from place to place within the region, and orientation/siting of the building. Builders in Devon and Cornwall were, it would

seem, nothing if not conservative in their approach to building construction. What are now regarded as inherent 'design defects' - too numerous to mention here - continued to be incorporated into cob buildings for century after century. Change came only after the mid- 18th century, with the advent of classicism, 'polite' architecture, the agricultural 'improvers' and architectural pattern books.

12. Now the point of all this is to highlight the need for research which will go some way towards addressing the problem of how best to conserve existing cob buildings by careful and informed survey, analysis and diagnosis. Also to explain the difficulties faced in devising and designing a test programme which would take into account all or most of the variables noted above, mainly in para.10.

13. Constructing five or six sections of large , but not full-scale, cob test wall would, hopefully, achieve several useful objectives. It may be an advantage, for example, for those involved in the research programme to be able to participate in the construction process and thereby gain some insight into how the material works in practice. Building cob walls under controlled conditions would enable the mixing and placing process to be carefully measured and recorded in a way that would not be possible on a building site. Drying out, linear shrinkage and settlement could all be monitored and direct comparisons made with adjoining sections of wall, which would, of course, be subject to identical environmental conditions.

14. Clearly, the test walls would not provide answers to all the problems noted above. Hopefully, the issues raised in para.11, relating to construction, design and on-site environmental factors, could be dealt with through examination of buildings in the field. However, it is hoped that the test walls would also provide an opportunity to carry out tests which would involve the observation, measurement and monitoring of the effects of moisture penetration under load.

15. By carrying out these tests it should be possible to obtain comparative data on failure mechanisms in cob walls identical in all respects other than soil type. It is important, therefore, that the soil types used should be representative of those in most common use for building in the region and that, if possible, their physical characteristics should be similar to those of cob mixes found in traditional buildings in the areas concerned.

UNIVERSITY OF PLYMOUTH
RECENT EARTH BUILDING INITIATIVES

NEW EARTHEN ARCHITECTURE

This two week course was held at the University of Plymouth by the Centre for Earthen Architecture during the last fortnight in July this year. Blessed with glorious weather, the participants were able to spend plenty of time learning the main earth building techniques. Rammed earth, adobe, compressed block and cob were covered with even a little time spent on claystraw.

Experts generously gave their time to lead a series of master classes on these techniques including Julian Keable recent author of 'Rammed Earth Structures: A Code of Practice'. Ali Mesbah expert in earth building from France, David Webb expert in stabilised block and Matthew Vincent and a local cob builder.

Participants were also expertly guided through the science and technology of earth as a building material in the university laboratories by Rex Harries and Bob Saxton. Visits were also made to Tricombe to enjoy the innovatory cob work of Kevin McCabe, and to historic sites including Bowhill and Bushell's cottage to see repairs and alterations to our existing earthen heritage.

Whilst the participants agreed they gained a great deal from the event, the organisers too found developing and delivering the course a great learning experience. This was particularly important with the current interest in using earth as a walling material in British Contemporary Architecture and the University's subsequent involvement as consultants.

TERRA ATLANTICA

On the 15th September 1996 an agreement was signed for collaboration between all the regions on the Atlantic coast of Europe (Atlantic Arc) in the field of earth building.

Representatives of Scotland, Devon, Normandy, Brittany, Loire, Central France, Aquitaine, Algarve and Alentejo (Portugal) were present at the inaugural meeting of this new network. Others including Wales, Dorset, Ireland, Spain, gave their support for this initiative. At the meeting Gildas Lucas (Ouzilly Vignolles) was elected president and Linda Watson (Devon) and Bruce Walker (Scotland) as two

increases from 0 to 12 % by weight, it has been that the rigidity of the binder fraction falls by over 75%.

This work also emphasises the importance of considering earth building materials as a product of a manufacturing process. It is proposed that by understanding the effects of the various processing techniques upon the structure of the material, and why these effects are desirable for manufacture, a greater understanding of the behaviour of all earth building materials will be achieved.

Furthermore Greer has conducted preliminary work on the real time monitoring of the moisture content in an experimental earth wall. This information is important in consideration of the number of earthen building failures which occur through significant moisture penetration.

Greer's work has pinpointed the issues critical to discussion in any dialogue concerning the suitability of earth as a building material, regardless of the earthen technology used.

An alternative approach to this work is currently being adopted by Kathryn Coventry under the supervision of Mr. Bob Saxton, Dr. Rex Harries and Mr. David Short. This research utilises natural soils from areas known to be rich in cob buildings, in order to establish the pertinent characteristics of a variety of soils which, by virtue of their structural endurance, hava been shown to produce earthen building material suited to cob construction.

The preliminary aim in this project is to achieve a rigorous classification of the soils selected. Existing geological and geotechnical classification techniques will be utilised to determine the particle size distribution of these soils, their mineralogy , their plasticity characteristics and their shrinkage characteristics.

After each soil has been classified, it will be manufactured into cylinders to enable compression testing to be carried out. The compressive resistance of natural soil cylinders will then be observed against those obtained from cylinders which have been manufactured from a mix of the natural soil and straw. This mix will simulate the earthen building material used in 'cob construction'.

The compressive performance of these soils will then be analysed against its classification characteristics to determine how optimum compressive resistance may be related to composition. The investigation will also account for the enhanced strength performance of soil-straw- water mixes over those of purely soil and water.

Thin-section microscopy will indicate the degree of adherence of the soil to the straw fraction. It is envisaged that this feature of the investigation will aid the determination of microcracking within the binder fraction which is thought to threaten the structural integrity of cob construction. This work will be further aided by the determination of porosimetry and three-dimensional modelling of pore connectivity.

Further work will be carried out to determine the effects of water content on the natural soil and when mixed to form cob specimens. This work will validate Greer's work on soil matrices and its application to non-processed soils, and extend its discussion to describe the additional effects observed by the inclusion of straw fibres to the matrix.

COB AND THE BUILDING REGULATIONS

Tony Ley, Building Control Manager for North Devon District Council has compiled DEBA's second leaflet on the subject of "Cob and the Building Regulations". This leaflet will be sent free to members and will be available to non-members for £1.00.

MID DEVON SHOW , TIVERTON, 27 JULY 1996

Following the success of two previous appearances at the Devon County Show, this year the Devon Earth Building Association participated in the Mid Devon Show, held near Tiverton.

Although only a one day event and smaller in scale than its Westpoint rival, this popular agricultural trade venue provided an ideal opportunity for exhibiting cob as a contemporary form of construction.

Preparatory work earlier that week had been undertaken by Adrian Hunt (Twyford Lime Products). Concrete blocks and a single lift formed the basis for a demonstration cob wall of 4 metres in length. Throughout the day Kevin McCabe, Larry Keefe and Matthew Vincent (Cob Construction Company) each assisted in the re-wetting, treading, placing and paring of additional pre-mixed cob, drawing a continuous crowd of interested spectators. Whilst time did not permit lime rendering on this occasion, Kevin McCabe manufactured thirty-five cob blocks using a hand operated press. Although this dated from the 1940s it was ideally suited for its new application. In particular it helped remove prejudice towards cob from those who were more accustomed to conventional bricks and mortar.

A limited photographic display of recent examples of earth building in Devon still attracted considerable interest and kept myself and the others busy with general cob enquiries. Almost 70 technical leaflets were sold, generating a modest return for the Association.

Clearly there is both merit and justification for the Association's continued public exhibitions. This is particularly so as the Association was awarded Second Prize by the Mid Devon Show for the quality of its rural craft stand! The success of this day, and its relative ease of organisation mean the Association is now keen to consider similar one day events in the future.

Tristan Peat
Treasurer to DEBA

A Cob Summerhouse

by Jill Smailcombe

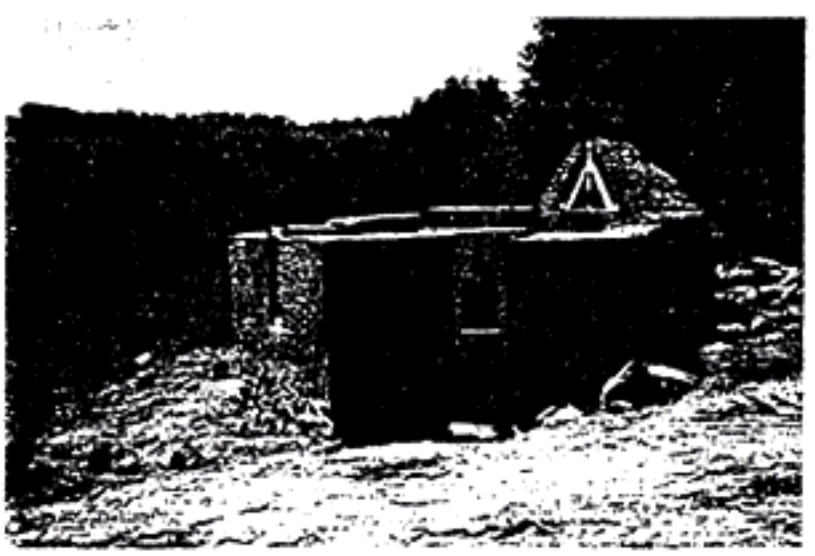
My great grandfather Frederick, built several rather eccentric victorian summerhouses around trees and on mountain tops. And I think this must be why I always wanted to build one. A summerhouse has the advantage of being both small and fairly manageable to build, but also allows for a little unconven - tionality to creep in.

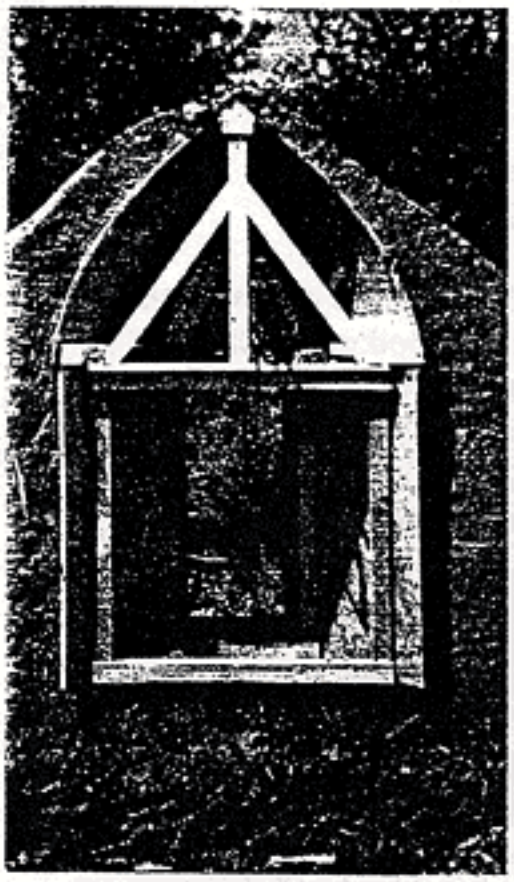
Last year I helped Chris Brookman with his cob construction at Great Burrow.It was a large project and when it was finished we both wanted to continue to work with cob. However we decided on some - thing a little smaller this time! After a few preliminary sketches and inspiration from my husband we decided on an hexagonal design. Everyone asks us - 'Why not round: Cob is so suited to rounded forms?' - this is indeed true, but we thought it was too obvious and opted for something more formal. The designs had to be reasonably conventional as our house and barns are all listed and it was neces - sary to apply for planning permission and listed consent. We carefully chose a site in an old domestic orchard - fairly sheltered and well draining - with beautiful views too and from the building as the pri - mary criteria.

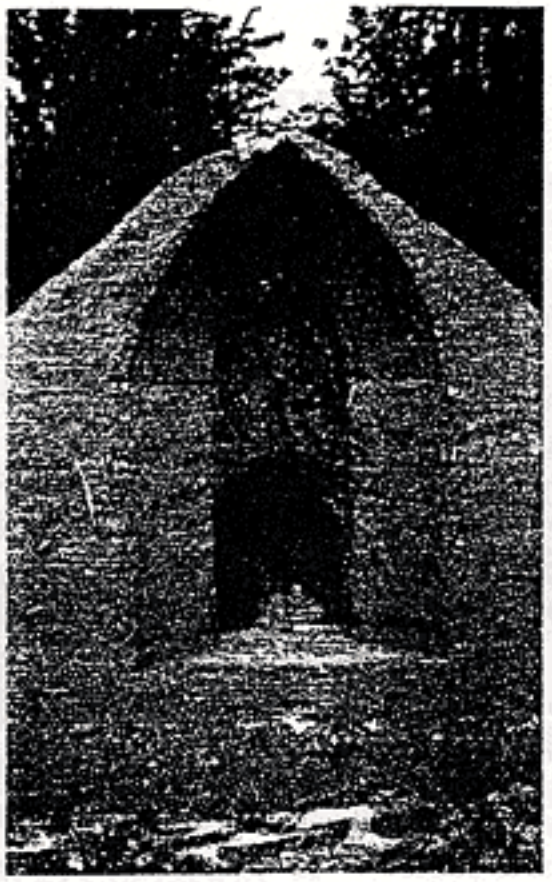
The site was levelled in March. Chris and I then went to Meldon quarry where we picked out 7 tons of stone, including some large flat stones for the base of the foundations. We marked out the site: the building is roughly 4metres in diameter. We dug down to a firm shillet base, approximate - ly 250mm (10 inches). We laid the large stones and then built a 400mm. wide stone plinth, using a lime mortar, to a height of 500mm. (20 ins.).

Subsoil was dug from the bottom of a nearby field, but it proved to have a very high clay con - tent and practically no aggregate. We then dug halfway up the field where we found the perfect mixture: plenty of clay but also a lot of shillet.I took a handful of the subsoil to our nearest cob barn and it was an exact match. We didn't analyse it but guaged it by the feel of the material.

We mixed the subsoil, straw and water with a tractor. Both barley and wheat straw were used. The first lift showed signs of shrinkage, so we decided to add a bucket of sand to every 7 buckets of sub soil. We let the lifts dry without covering them and one or two dried out rather too quickly when the weather was warm and windy. It might have been wise to slow the drying down by covering the wet cob with damp hessian. We pared back the cob the same day and used a mallet to shape it.

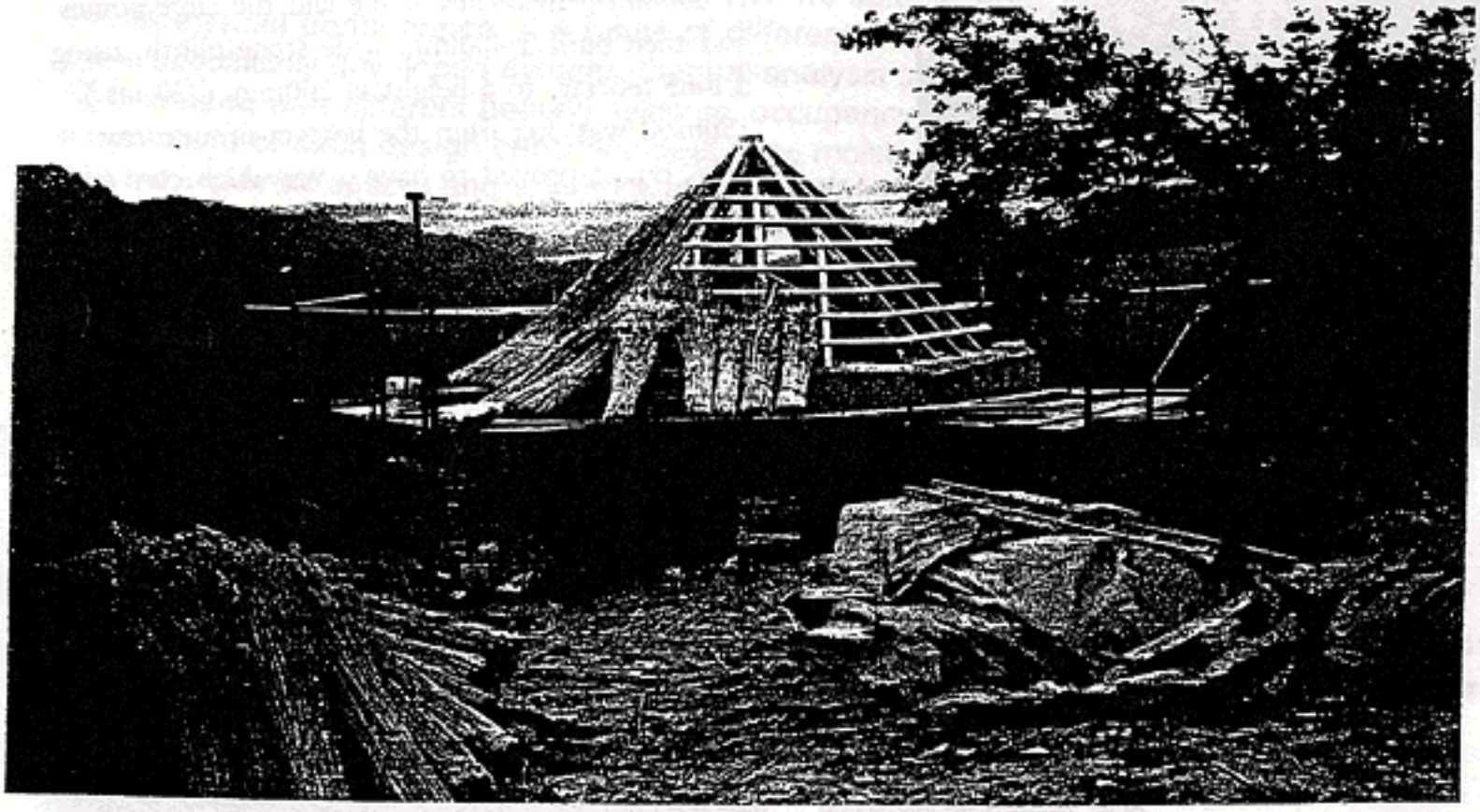






There are 5 gothic windows and a gothic arched door. We had designed a stylised arch so the form work was very complicated but worked surprisingly well. We found that the time spent carefully making strong and robust form work made it easier when it came to building. For the door we left a very roughly shaped opening which we then cut out by hand when the cob was dry. I drew the shape on the wall with chalk and then cut it away with a hammer and cold chisel and my paring tool, actually an African tilling tool .

My husband , Mike, has constructed an impressive roof structure using green oak and pegs. We set timber padstones into each corner and the hammered 400mm. (16 ins.) oak pegs into the cob to fix them. The main rafters are pegged to the padstones and rise through a 45 degree pitch to an hexagonal kingpost. Trusses then run from a lap joint at the bottom of the rafter to a mortise and tenon joint at the lower end of the kingpost.



After discussion with the thatcher (Charles Chalcraft) it was decided to put a softwood ringbeam in, to make a fixing for the secondary timbers and the first course of thatch. The thatch is now virtually complete and the final pitch is approximately 55 degrees. We have reclaimed some cobbles which will be set into the floor (in some, hopefully, interesting pattern). The oak window frames and oak plank door will be fitted at a later date.

We shall be adding a few details! There is a nesting box cut into one of the exterior walls and I would like to borrow some ideas from Africa, the Middle East and our less conventional forebears, when it comes to decorating the interior.