Yemen Arab Republic
Executive Office of The Supreme Council for Reconstruction

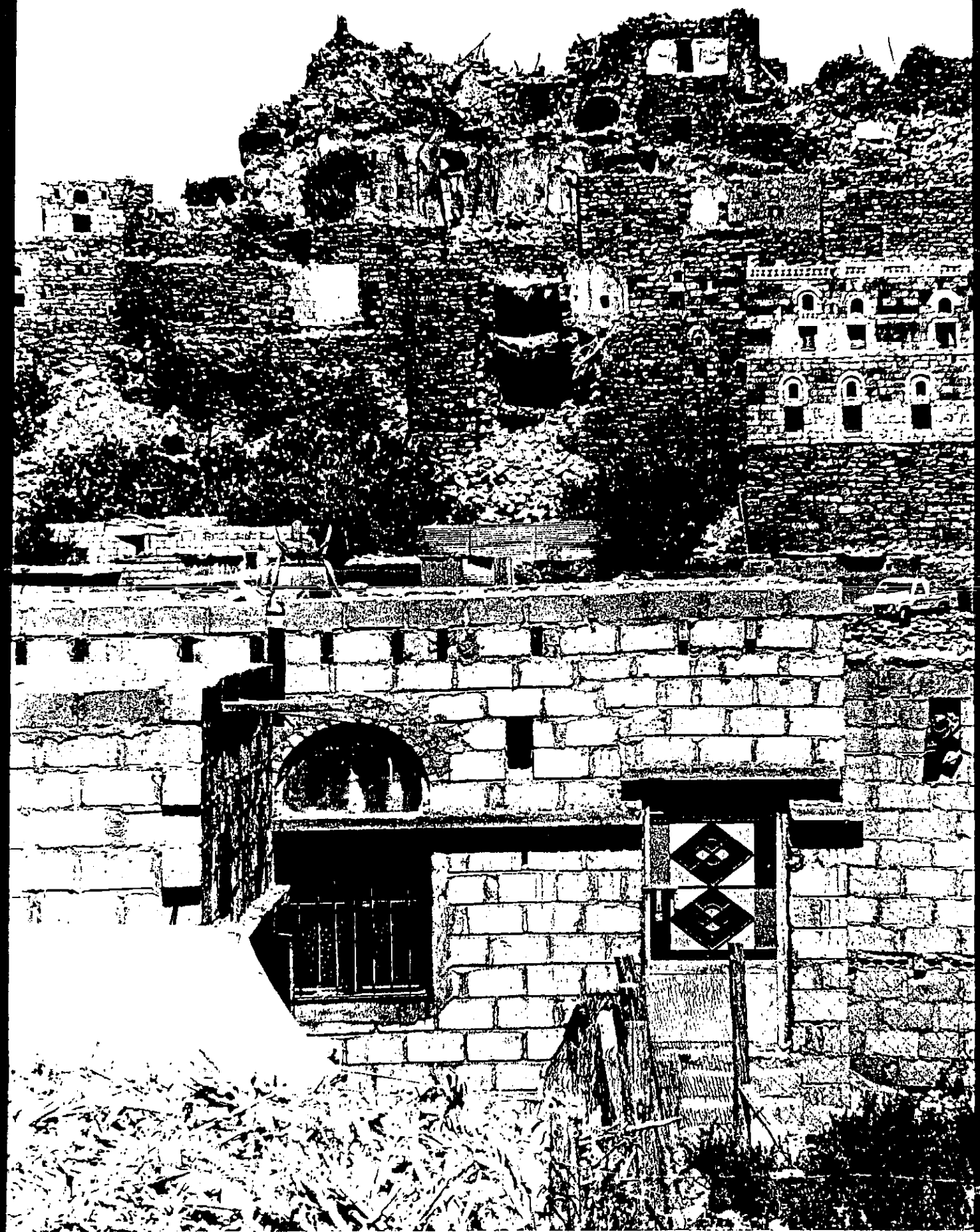
Dhamar Building Education Project

Project Assessment

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Strengthened reconstruction in Manqadah by builder trained on
Dhamar Building Education Project

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1. INTRODUCTION

In March 1983 the Dhamar Building Education Project was set up to encourage self-reliance among local builders faced with the task of reconstruction after the major earthquake of December 1982.

The project has been running for over two and a half years and in October 1985 Oxfam, the coordinating agency on the project, appointed an assessor to examine the work of the project and evaluate its effects within the reconstruction programme. The assessor visited the project from 15th October to 5th November 1985, spending three weeks in the field.

The assessment involved following-up builders who had trained with the project, in order to find out:-

a) the scope of their work since training
b) their ability to remember technical points from the training course.
c) the degree to which ideas from training have been implemented in their subsequent work.

This report sets out the history and background of the project and describes the teaching materials and technical content of the building course. The report sets out to evaluate the extent of coverage by the project in the earthquake affected area and assesses the impact that the education project is likely to have. Conclusions and recommendations are made for the continuation of the project into the final stages of the reconstruction programme and possibly beyond.

2. BACKGROUND TO THE PROJECT

2.1 Earthquake damage and Relief

The earthquake which occurred on 13 December 1982 in Dhamar Province of the Yemen Arab Republic, caused widespread damage and injury, and drew considerable international attention. The earthquake occurred in an area not previously identified with large damaging earthquakes. What was essentially a moderate sized earthquake (5.5 to 6.0 surface wave magnitude) caused extensive damage, over an area of some 6,000 km^2. Estimates of damage in the region were put at 25,000 homes destroyed and some 18,000 damaged. (Supreme Council for Reconstruction, September 1983). See Figures 1 and 2.

Short term relief for the estimated 300,000 homeless was provided in the form of tents, blankets and food. A sizeable number of people left the affected area to seek accommodation elsewhere. The relief effort was co-ordinated by the Joint Relief Committee, comprising members of the Co-ordinating Council of Local Development Associations of Dhamar Governorate, the Central Planning Organisation and other Yemeni institutions together with representatives from foreign missions, bi-lateral and multi-lateral aid agencies and non-governmental organisations.

Soon after the earthquake, many of those living in tents began building more substantial temporary shelter, from corrugated iron or timber framing. This shelter was built largely by the villagers themselves, without help from the relief organisations. The brisk trade in materials for such shelters led to some profiteering and resulted in an extensive distribution network of materials to the affected villages. Those who erected temporary shelter demonstrated their ability to provide for themselves in the short term. Official promises on the media of assistance with reconstruction raised the expectations of longer term help and the issue of re-housing came to be seen in many of the worst damage villages as a government responsibility. Some fifteen months after the earthquake it was estimated that four out of ten villagers in the affected area were still living in some form of temporary shelter. (Leslie (1984)).

2.2 Studies on damage and reconstruction

Within a month of the earthquake, a number of technical studies were begun on damage to buildings and (generally unsolicited) suggestions by technical specialists for reconstruction of housing (Piche and Sirvain for HABITAT, Allard and Godefroy for Architectes sans Frontieres, Arya et al for Rorkee University, Coburnand Hughes for ODA Earthquake Housing Project, and later work by Copenhaver for USAID). At this time there was little idea of the policy that the Yemen government would adopt towards reconstruction. Most of the measures discussed in technical studies (HABITAT, Rorkee, ODA and USAID) assume that re-building would be carried out by the affected population themselves, using predominantly traditional techniques and forms.

A study of the damage and reconstruction options was commissioned by the Central Planning Organisation from a joint mission of specialists representing the World Bank, the Arab Fund and others. Their report dismissed the option of official provision of temporary shelter, in favour of immediate permanent reconstruction, following the architectural tradition of the region in the form of Government funded minimal 'core' units to be built by the villagers themselves with technical assistance. These basic units would form the first stage of homes that would be extended by the owner over a longer period.

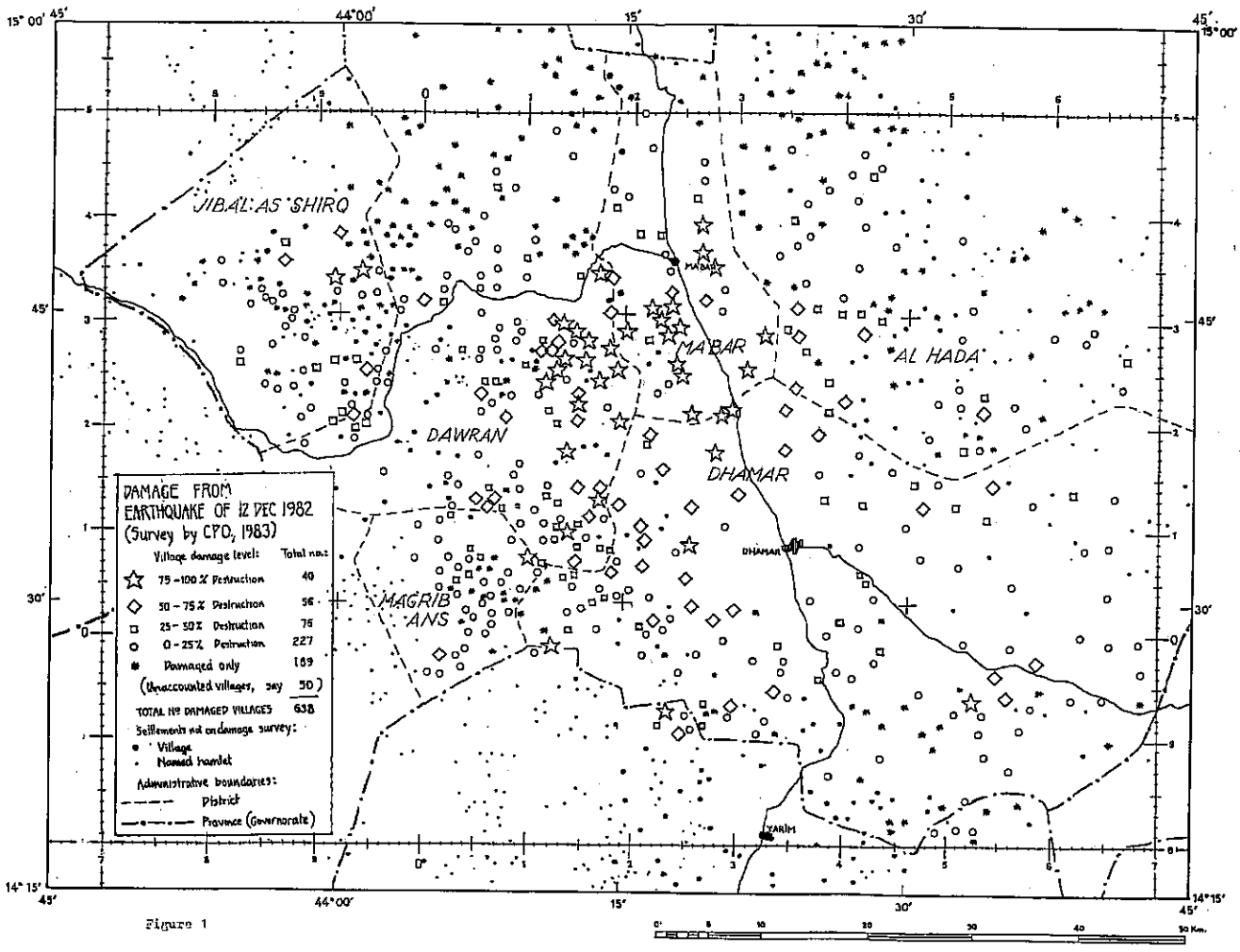

15° 00' 45'
44°00'
15'
30'
45'
15° 00'
JIBAL AS SHIRQ
MA'BAR
AL HADA
DAWRAN
DHAMAR
MAGRIB ANS
DHAMAR
SARIM
45'
30'
0'
14° 15'
14°15'
DAMAGE FROM EARTHQUAKE OF 12 DEC 1982 (Survey by CPO, 1983)
Village damage level: Total no.:
75 - 100 % Destruction 40
50 - 75 % Destruction 56
25 - 50 % Destruction 76
0 - 25 % Destruction 227
Damaged only 189
(Unaccounted villages, say 50)
TOTAL Nº DAMAGED VILLAGES 638
Settlements not on damage survey:
Village
Named hamlet
Administrative boundaries:
District
Province (Governorate)
0 5 10 20 30 40 50 Km.

Figure 1

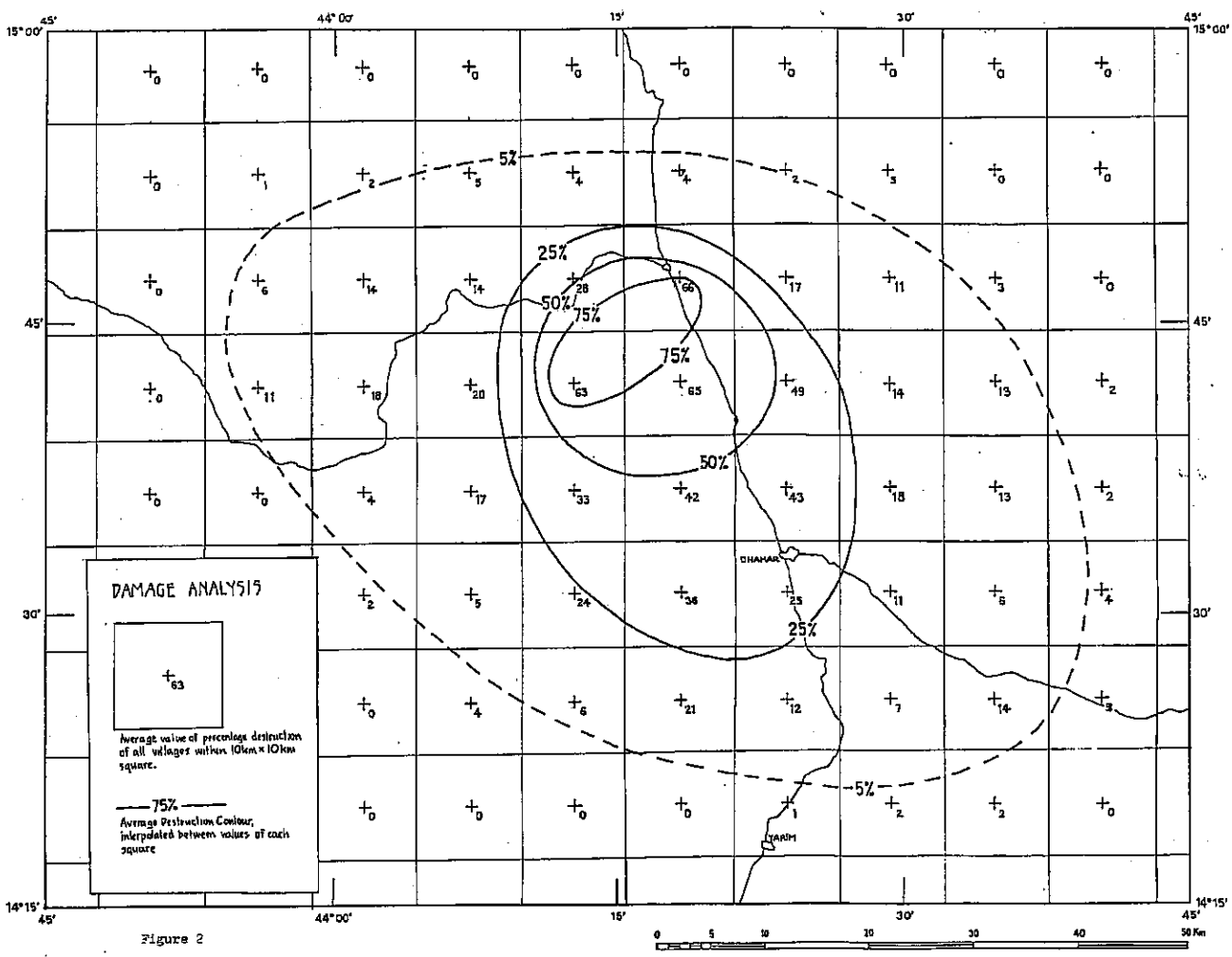

15°00'
45'
44°00'
15'
30'
14°15'
5%
25%
50%
75%
DAMAGE ANALYSIS
Average value of percentage destruction of all villages within 10km x 10km square.
75%
Average Destruction Contour, interpolated between values of each square
DHAHAR
TARIM
0 5 10 20 30 40 50 Km

Figure 2

All technical reports agreed that some priority in the reconstruction should be given to making new buildings less vulnerable to future earthquakes. The occurrence of the earthquake had prompted a re-evaluation of Yemen's seismicity. A history of damaging earthquakes can be found in early texts, and indicate that the 1982 event was not a rare occurrence. Ambraseys and Melville (1983) list 12 damaging earthquakes in the country since 1850, including a series of earthquakes around Dhamar in 1878, which destroyed many houses. From this it can be assumed that many houses built in the reconstruction might well experience another earthquake in their lifetime. The vulnerability of the condition and construction of many buildings was one of the major reasons for the high level of damage sustained. Proposals for the strengthening of traditional construction, to try to achieve a more earthquake resistant housing stock, were included in some of the technical reports (HABITAT, Rorkee Univ., ODA, USAID).

2.3 Establishment of the Education Programme

The initiative for establishing an education programme to promote strengthening measures in traditional construction, was taken by Concern, Redd Barna and Oxfam, all non-governmental agencies with experience of work in Yemen. When the idea was first discussed in February 1983, it was felt that the official reconstruction programme would aim to help villagers rebuild their own houses and that the education programme would be a positive contribution to this process.

Representatives of the agencies involved drew up an outline for a Building Education Project in March 1983. This proposed:-

a) the construction of a strengthened traditional building in Dhamar, to serve as a prototype, and to become a Building Advice and Training Centre (BATC).
b) the preparation of an education programme with a limited set of technical messages to be taught in the form of a short course at the BATC.
c) the establishment of a Mobile Education Unit (MEU) to travel to affected villages, publicise the training and enlist masons on courses.

The broad objectives of the programme were to teach construction techniques that would make traditional houses stronger. Village builders would be able to implement these techniques without supervision, using locally available materials. The education would attempt to encourage self-reliance on the part of builders while reviving confidence in traditional techniques and maintaining a continuity of building practice.

The plan of operation was endorsed in March 1983 by representatives of the Yemen Government, the Co-ordinating Council of Dhamar Local Development Associations, and the agencies. At this stage, responsibilities of the participants were:-

Yemen Government	- site for BATC and labour in its construction, together with training staff.
Concern	- educational specialist, educational material (including video film) and equipment and support for MEU.
Redd Barna	- project co-ordinator, materials for BATC construction.
Oxfam	- construction supervisor for BATC and subsequent training.

Construction of the training centre began on 3rd April 1983. At the same time work began on the educational component of the programme. A video film was provided for Dhamar, dealing with rainproofing of temporary shelter with some general points on building construction in the traditional manner. Photographs of the BATC construction were taken and a booklet to be

used as the basis for the training was prepared in June 1983. Construction of the BATC building was complete by August 1983, when the first project agreement between the Yemeni authorities and the three agencies expired. The opening of the BATC was delayed while the issue of support for the training staff was resolved. A second agreement was signed in September 1983, this time between the Executive Office of the Supreme Council for the Reconstruction of Earthquake Affected Areas (SCR) and Oxfam, who by now were co-ordinating the project. Support from the Canadian Embassy in Jeddah enabled the MEU to begin travel in the affected area. Funding from a number of sources has been received during the project and is illustrated in Figure 3. The present structure of the Dhamar Building Education Project is shown in Figure 4.

2.4 Official Reconstruction Policy

In September 1983 the Executive Office of the Supreme Council issued a document outlining the reconstruction programme that would run up to the end of 1985. While accepting the proposals in the Joint Mission report for self-help, the SCR programme excepted villages with more than 75% or more than 25 dwellings destroyed. In these cases, it was claimed that there was insufficient labour available for villagers to rebuild by their own efforts, and should not have to rely on "self-help" methods. This SCR document also states that the use of salvaged materials from damaged homes is not practical.

The programme proposed building 13,000 homes on 127 sites, using commercial contractors. The remaining 12,000 homes which had been recorded as 'destroyed', and were spread over 1052 villages, were to be rebuilt by self-help methods, with some government financial and technical input, and a guarantee that essential materials would be available in the market at a fixed price. In order to implement this plan, building advice units were to be set up in the affected area. Part of the costs of repairing cracked homes was to be met by the Government, based on surveys of the extent of damage. The total budget for this proposed reconstruction and repair was put at 1.985 YR million (£284 million in 1983). While various funding sources were approached, extra taxes were levied within the country (on imports, qat, industrial and commercial profits) to contribute to the programme.

The timetable for reconstruction was divided into three phases:-

a) Repair (approx 17,000 homes) 5 months survey of repairable homes, and estimation of costs, followed by implementation. To be completed by the end of 1985.

b) Tender programme (approx 13,000 homes). Site selection and planning by government, based on technical and geological criteria. Tenders submitted by October 1983, selection of contractors by November, and construction to be completed by the end of 1985.

c) Self-help construction was to begin after the tender programme was under way, and be completed by the end of 1985.

It is clear from the SCR proposals that greater emphasis was to be put on the contractor-built programme than on the use of local resources and labour to rebuild the earthquake damage. To give priority in reconstruction to those villages with the most severe damage was understandable, and this strategy resulted in the repair and self-help components being relegated to a subsequent phase, if they were to be built at all.

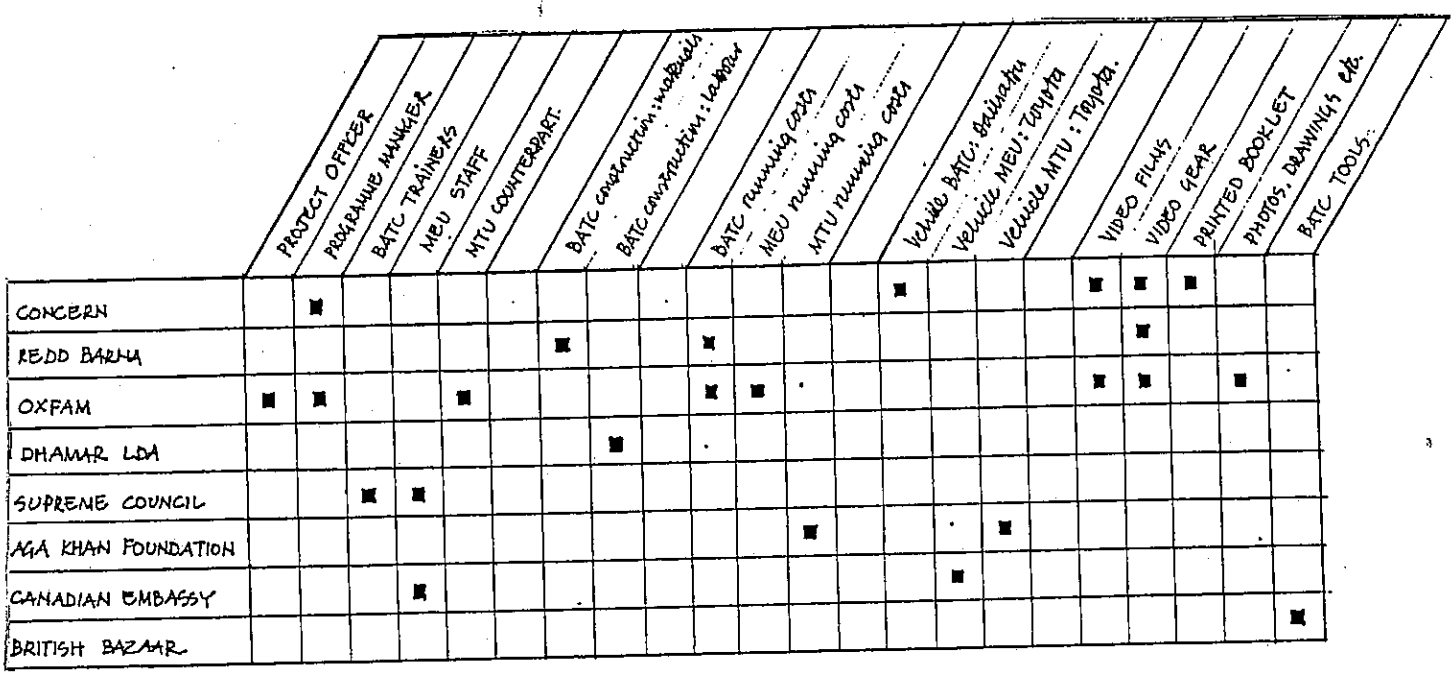


Figure 3 SOURCES OF FUNDING: MAY 1983 - OCTOBER 1985

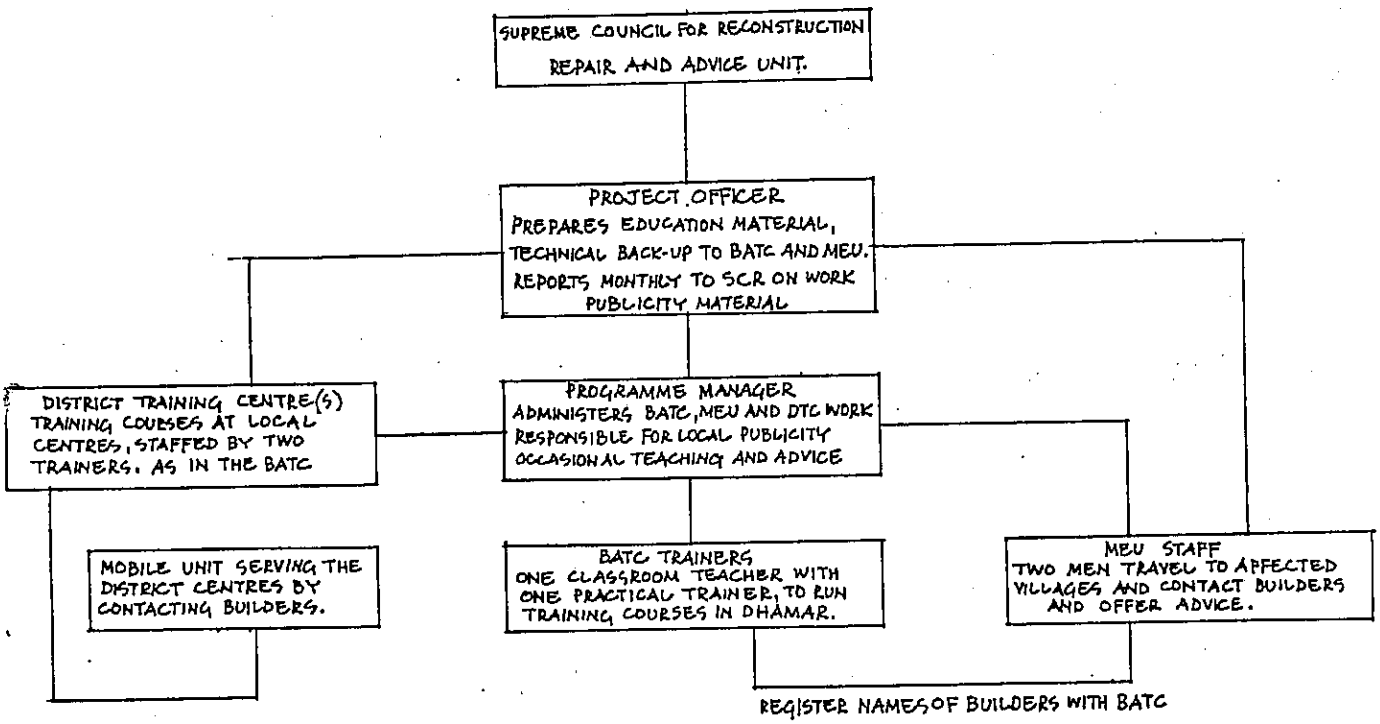


Figure 4 CURRENT STRUCTURE OF THE PROJECT

Further village surveys undertaken by the SCR provided more detailed information on damage which were used to clarify the reconstruction programme. Figures released by the SCR in March 1984 show plans for 14 zones for rebuilding made up of 241 separate village sites (an increase on the September 1983 figures). (Arya et. as 1984). The Final Contract Reconstruction list released later in 1984 shows the contractor programme to have spread to 305 separate villages, with approximately the same number of houses to be constructed as originally estimated. (Figure 5)

Early in 1984, repair techniques were tried out on several buildings in Dhamar, to try to determine an effective method for strengthening damaged traditional buildings. Based on this work, a programme for reinforcing cracked buildings in the city of Dhamar was started, pending the raising of funds for village repair work. By October 1985 some 300 homes and public buildings had been repaired in Dhamar, at an average cost of 23,000 YR per job. Work has not begun on the repair of the estimated 18,000 cracked homes in villages.

2.5 Self-help within the Reconstruction Programme

The SCR programme of September 1983 outlined a self-help reconstruction process that would apply to all those destroyed homes not included in the contractor-built schemes. This implied that 12,000 dwellings would be built by this method. In March 1984 it was proposed that 10,000 homes in 835 villages would fall in to the self-help category (Arya et al, 1984). At this stage, there was some discussions of the specific techniques that might be used in the building, but no detailed proposal for implementing what is essentially a large building programme.

The Dhamar Aided Self-Help Reconstruction Project joined the Dhamar Building Education Project in the self-help activities of the SCR late in 1983. The project, supported by the Netherlands Government and the Commission of European Communities, formed part of the self-help reconstruction effort, through imported building materials, advice on appropriate techniques, and the construction of model homes. (DHV 1983). Based in the Magreb Ans region to the west of Dhamar, the project has received further funding from USAID and plans to construct up to 1000 homes.

A smaller self-help project has been established in the Dawran Ans region, supported by the United Nations Development Programme (UNDP), in co-operation with the SCR. The project plans to build 200 earthquake-resistant houses, with the recipients meeting a proportion of the cost.

Together with the Dhamar Building Education Project, both the self-help initiatives described above, set out to promote the use of reinforcing techniques in rebuilding. Both of the projects aim to provide new houses and to meet a substantial part of the cost of their construction. Both also see the need for building training, as part of a construction programme, if a longer term impact is to be made on village construction techniques. Together, EEC/USAID and UNDP projects will provide hands-on training for up to 850 builders in the Magreb Ans and Dawran Ans regions. Builders involved in the UNDP project are being trained at the Dhamar BATC.

2.6 Building Training during Reconstruction

Training courses at the BATC began in October 1983, by which time the MEU had begun travelling in the affected area to contact builders. There was some evidence at this stage that a sizeable proportion of the affected population were waiting for government assistance for rebuilding. This attitude affected the rate of new construction in the villages, and the MEU found that many of the builders they saw were free to attend training courses at the BATC.

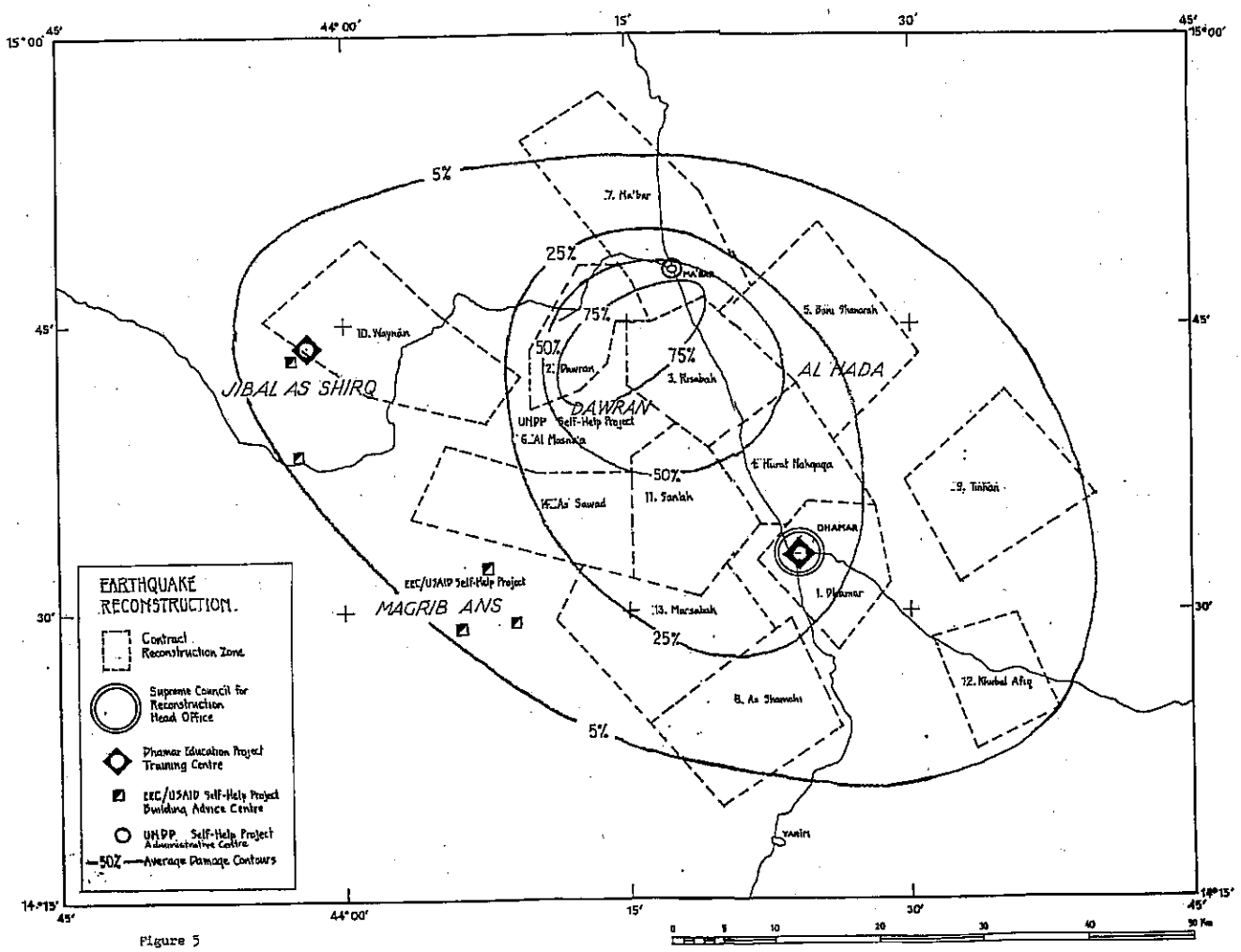

15°00'
45'
44° 00'
15'
30'
45'
5%
25%
75%
50%
75%
50%
7. Ha'bar
10. Waynan
5. Bani Hamarsh
1. Dawran
3. Rasabah
JIBAL AS SHIRQ
AL HADA
DAWRAN
UHPP Self-Help Project
6. Al Masaka
4. Hurat Hahqaqa
9. Tinhan
11. Sanlah
Al As' Sawad
DHAMAR
1. Dhamar
EEC/USAID Self-Help Project
MAGRIB ANS
13. Marsalah
25%
8. As Shamshi
12. Khubal Afiq
5%
YAMIR
EARTHQUAKE RECONSTRUCTION.
Contract Reconstruction Zone
Supreme Council for Reconstruction Head Office
Dhamar Education Project Training Centre
EEC/USAID Self-Help Project Building Advice Centre
UHPP Self-Help Project Administrative Centre
50% Average Damage Contours
14°15'
0 5 10 20 30 40 50 Km

Figure 5

By the end of the second project agreement, in May 1984, some 400 builders had been trained, and received certificates from the project. A further agreement was signed with the Executive Office of the SCR to cover the period up to December 1985. The project was assigned to the Repair and Training Unit of the SCR, which took on a larger share of local salaries. The formation of Mobile Repair Units was proposed in this agreement, when it seemed that advice about repair might be a useful addition to the work of the project. Delays in developing repair techniques, and a change in emphasis away from repair advice to SCR-funded repair work, meant that the Mobile Repair Unit was not set up.

As an extension to the project activities, it was decided to establish a district training centre (DTC) in a remote area which could not be effectively served by the Dhamar BATC. Funds intended for repair work were assigned to the new centre in Al Jum'ah, a market town in the Jebel As Shirq region, which had been designated a self-help area by the SCR. The DTC began training in July 1985, offering a course that had been adapted to the particular conditions of the region. A continuing demand for training has meant that the DTC has remained in the area, when it had been planned to move to another area after three months. Although the project has been discouraged from working in those areas where contractors are now at work, trainees have come from throughout the affected region, and the SCR now seems interested in moving the DTC to an area east of Dhamar which falls inside the contractor zone.

3. THE EDUCATION PROGRAMME

3.1 The Physical Setting

The area affected by the earthquake centres on a highland plain surrounded by mountainous regions which are heavily populated (65 people per kilometre^2 in 1980, Steffen et al (1978)), by Arabian standards. The typical highland home is built of massive stone masonry on several floors. The ground floor is given over to crop storage or the stabling of animals. Rooms on the upper floors are usually of modest size, with spans limited by the lengths of available timber. The use of rooms is rarely specific, with the same space being used for eating, sleeping, conducting business or chewing qat.

The most common building materials for traditional homes are:-

a) cut-face stone, with an inner face of rubble in mud mortar.

b) rough found stone, in mud mortar.

c) sun-dried mud bricks (libn) in mud/straw mortar, and often plastered.

d) kiln-dried clay bricks (yajur) in gypsum or lime mortar.

These materials are often combined in the walls of houses, with stone being the most widespread technique in the earthquake-affected zone. Roofs are built on timber joists laid flat on the walls, with branches as purlins between, topped with dry earth. The process of village construction is additive, and methods might change due to outside influences, altered fortunes or available materials.

3.2 Transformation

The Yemeni countryside is undergoing a process of change that began well before the earthquake of 1982. Migration to the growing cities means that Yemen has a high urban growth rate (Antoniou (1983)) while up to one in three adult men seek employment elsewhere in Arabia. (Sevageldin et al (1983)). Cash earned abroad has transformed aspects of village life, and this is manifest in the changing form of the rural home. Single storey houses are now the most common form under construction. Ground plans are larger, with longer spans made possible by imported materials. But there seems little evidence to suggest that the use of space has changed for the rural highland family.

3.3 Targets and Aims

Most adult men in rural Yemen have a good grasp of basic construction techniques while some aspects of traditional building are regarded as specialist skills. Village communities will normally have one or more men who are considered "builders", who would be employed to plan and organise the construction of new homes. While the primary occupation of the highland builder is construction he will normally also own land and work it for some part of the year. The responsibilities of the builder range from agreeing on a plan with the owner, to estimating costs, employing labour, and ordering materials, which the owner will normally buy and deliver to the site. The distinction between the builder and the labourer rests on experience and ability, and is defined in the wage that each can command for his work. While the builder usually earns 300-350 YR (1985) per day, the labourer is paid 80-100 YR.

The Dhamar Building Education Project set out to address its education to these builders who were in a position to influence the attitudes of their client (the house-owner) and to supervise their labour force. The project has sought out those who are identified as builders by their own community,

as the best means of testing their experience and ability before they train.

The aim of the project is based on a belief that even low levels of strengthening and improvement in construction achieved under the control of the builder himself, will have more effect in the long term on reducing future earthquake loss, than high levels of strengthening achieved under external supervision. Emphasis in training is therefore put on the need for the builder to make appropriate decisions in the role as advisor to the house owner. This aspect of building improvement is as important as the technical means of strengthening.

3.4 Background to the Education Material

The educational component of the original project proposal of March 1983, set out to develop a set of technical messages for local builders, as a basis for materials (booklets, posters, photos and videos) which would be used at the BATC and, through the MEU, in the affected villages. The purpose of this was to:-

a) draw attention to the dangers of unreinforced building, while raising awareness of the hazard of earthquakes.

b) propose simple techniques for strengthening homes, using locally-available materials and skills.

Vulnerable elements of traditional construction were identified by surveying typical damage in the Dhamar area. From this, there emerged a number of principal types of damage, resulting from the separation and disintegration of structural elements, namely:-

i) wall-wall junctions: vertical separations between perpendicular walls, or wedge-shaped corner failure on upper storeys.

ii) roof-wall junctions: timber joists separating from their supporting walls.

iii) disintegration of masonry: splitting between the leaves of a wall, cracking and the loss of wall material, leading to collapse.

In advocating strengthening measures in traditional construction, the general objective is to prevent roof collapse, with damage limitation in any future earthquake aimed at preventing collapse of the structure. For this, the priorities should be:-

1) to strengthen the connections between structural elements.
2) to add ductility to masonry walling.
3) to ensure the integrity of load-bearing masonry.

It is clear that these priorities could be achieved at a number of different levels of strength and cost. The object of training was education in the general principles that were applicable to all construction, with demonstration of a number of different methods of strengthening. A decision on the level of expenditure on strengthening was to be left to the builder and his client.

Verbal instruction by trainers was chosen as the principle means of education, together with practical demonstrations of construction. Teaching aids such as films, photos and booklets were developed to assist the trainers in person-to-person explanations of specific points. Except in the case of general display, none of the media described below are presented to trainees without commentary from the trainer.

3.5 The Training Course

The content of the course has developed since training started at the BATC, and new issues have emerged from contact with builders from throughout the affected area. The two day course typically consists of:-

Day 1

- introduction to the centre and scope of the training
- page by page explanation of the booklet
- slide show covering typical damage, and the means of preventing it.
- video films illustrating:- the construction of a reinforced building
  - the need to persuade house owners to incorporate strengthening in new houses.
- demonstration on training building under construction, of strengthening practices.

Day 2

- practical training, instruction on site, involving construction of part of a demonstration building, the setting-out of a small plan in cement blocks. This work is intended to test a builders' ability to implement some of the earlier theoretical training in both stone and blocks.
- examination by the course trainers of the builders' grasp of a range of issues related to reinforced construction.

3.6 Educational Material

3.6.1 Booklets

In consultation with the SCR, a printed booklet was prepared to illustrate techniques of strengthening, included as Appendix I. The result was a document dealing with:-

1) the importance of level, stable foundations
2) advantages of using properly mixed cement mortar
3) the benefits of good stone bonding
4) the need to consider the size and position of openings in walls.
5) the advantages of continuous horizontal reinforcement in masonry.
6) the need for strong connections between wall-head and roof.

The booklet was illustrated with line drawings, intended to be comprehensive to those with little familiarity with printed images. The evaluation of the impact of this material was not possible at this stage. A compromise had to be reached between the requirements of the SCR for a document for literate builders, and the reality of a low adult literacy rate. (11% in 1975, Steffen et al (1978)).

The booklet was intended to serve both as a basis for the training course at the BATC, and also to provide builders with some reference in their future work. Follow up work seems to show that nearly all builders have kept their booklets, and use them to explain techniques to others, especially house owners. The booklet has also played a useful role in the link between the MEU and potential trainees. The staff of the MEU use booklets to show village builders the scope of the training, and register the number of interested builders on it, together with the date they they are to attend for training. When they come to the BATC, they are expected to produce this list when registering for training, so that any absentees might be followed up.

3.6.2 Posters

An early decision was made not to attempt to use posters as an educational medium. It was anticipated that all technical messages would be best explained verbally to builders, which ruled out the use of posters, other

than for general publicity.

In September 1983 a batch of silk-screened posters were produced by the project staff, in order to publicise the training on offer at the BATC. A simple written message about how and where to train, was accompanied by the image of a cracked building. These posters were distributed through the local offices of the Local Development Associations, by the Co-ordinating Council of LDA's based in Dhamar. The posters were handed out to local representatives at council meetings, so that each would be in a position to explain them to builders in their areas. They were displayed in a public place in the village, usually on the wall of the school, over a short period.

A handwritten announcement, reproduced by photocopying, has been used by the DTC in Jebel as Shirq, and the mobile team have distributed them.

3.6.3 Line drawings

Faced with a substantially different form of construction in the Jebel as Shirq area, it was decided in April 1985 to develop a set of drawn images for the DTC teaching, to supplement the printed booklet.

The intention was to cover issues that had emerged from several field trips to the area, and also draw on experience from the use of the booklet in the Dhamar area. The establishment of the DTC provided a change for the project to expand the scope of its education. It also was an opportunity to try out various types of educational material on a population that was less familiar with visual images, because of its relative isolation.

The set of drawings for the DTC (Appendix II) were generally presented in a format that contrasted the correct with the 'incorrect' technique, in terms of the specific point that was being made. This was a format that had been tested, and proved widely understandable. Each image was limited to describing one step in the construction of a house, from siting to the fixing of the roof.

An attempt was made, wherever possible, to make the images recognisably local. (for example using recognisable architectural styles in buildings or clothing on human figures). The initial set of drawings was tested on builders during the survey period, and changes made at their suggestions. These changes dealt mainly with the degree of stylization of the image, and in several cases involved the addition of tools, to assist in recognition of a building stage. Changes in scale between images were minimised, although it was impossible to cover all aspects at the same scale. Building elements, such as walls, viewed from an unfamiliar angle (ie axonometric or section) seemed harder for builders to grasp, because of the distortions involved. Sequential drawings, usually comprising four or more images showing stages in a process (for example, clearing and filling foundations) proved more difficult to grasp than the simpler correct/incorrect format. A single image depicting several men at various stages of the same job (for example, mixing concrete and casting a ring beam) were the easiest for most builders to recognise. Although cut-away sections of walls were identifiable, a drawing of a section through a foundation (which would never be seen in actuality) was inevitably misunderstood. Arrows, used to indicate relative spacing between elements, were generally recognised, despite the expectation that they were an abstract notion. Wherever possible, the emphasis of parts of the drawing in red was an aid to its understanding.

Out of a total of 22 images produced for use by the DTC, 15 are in regular use for training, with other media. New drawings have been developed as further issues about building emerge. A process of self-selection has emerged, by which the trainers themselves use those images that they find most effective.

3.6.4 Photographs

These are used for display in the BATC, and also as a teaching tool in the training course. For display purposes, colour prints have been used to contrast damaged buildings with the strengthening techniques devised to resist such damage. This small exhibition is intended for casual visitors to the BATC, and is supplemented by black and white pictures of different aspects of damage, which trainees are shown as part of the course.

Black and white photographs have been used extensively by the MEU in its early stages, as a means of introducing builders to the work of the project. On the whole, it might be said that colour photographs attract more attention than black and white, and in cases are better understood. There seems some difficulty in discerning the tones of the monochrome image. Construction details in black and white are not successful, and the follow-up of trainees has borne this out, when more general shots aremore easily recognisable, especially when including a figure. For this reason, many of the photographs in use by the DTC are of a single builder clearly demonstrating some aspect of reinforcement.

Large colour prints of damage have been used to some effect, principally as a backdrop in the training room, to remind builders of the effects of earthquakes.

Limited work has been done on "blocked out" black and white photographs, where part of the photo is obscured, and a drawing used to emphasise a particular technique. In the opinion of the trainees, this was a very perplexing mixture of media.

3.6.5 Slides

Slide lectures have been in use from the start of the training, illustrating the construction of the BATC, and interspersed with examples of typical damage. When UNICEF provided the project with a slide/tape machine, in Nov. 1983, a text was devised to accompany the slides. It soon became clear that the fascination with the automatic machine was a distraction, and the trainers resumed a live commentary on the slides. The manual operation of slides also allows particular points to be emphasised or repeated and encourages discussion. The slide collection has been supplemented to show the building of a small room for demonstration and training by the DTC.

It can be said that techniques on slides are, on the whole, more easily grasped than those printed on paper. Back projection onto a screen similar to a television attracted more attention than projecting onto a wall.

3.6.6 Video Films

The video covering temporary shelter and simple reinforcement, made by Concern in early 1983, was the first education component of the project, and has been included in our training since then. At the time of its making, the notion prevailed that video films should form the backbone of the BATC training. Time and production difficulties have resulted in a shift of emphasis away from video, although it is still an important part of the education.

From footage taken during construction of the BATC, and of village damage, a second film was transferred and edited in London. This took considerable time, and the results were technically limited by the original filming on VHS format. The edited copy was dubbed into Arabic in country, and the film is now in use in the training.

A third film was shot in Dhamar, involving trainee masons discussing good and poor construction in the form of a drama, with elaborate rehearsal: this work required no editing. This has proved to be the most successful of the films, involving comic acting as well as more serious discussion of the responsibilities of the builder.

The lessons from the video productions clearly show that amateur filming is a severe constraint on the scope of the results. Anything but the very simplest short films should be undertaken professionally. The cost of this work is hardly justifiable, in terms of the impact of video films in training, unless such films are to be more widely used, or else broadcast on television. There are now editing facilities available in Sana'a but costs are high.

Several short dialogues have been filmed at the DTC, each dealing with one specific aspect of reinforcement. Once edited, these will be used for training, while the SCR has expressed some interest in getting them broadcast.

The value of video in training lies in its role in raising awareness rather than as a medium with which to communicate building techniques. Most masons surveyed in follow-up visits remembered some of what they saw on screen, but spoken instructions were much better understood.

3.6.7 Models

Several simple wooden models have been in use at the BATC and DTC, illustrating the mechanics of building failure. They are hinged to "fail" until some reinforcement is used (wire as steel bars, for example) and have proved a useful tool by which the trainers can demonstrate basic principles. Their use is neccessarily limited to those aspects of failure that can be simply described, without too great an abstraction. A scale model of a complete roof, connected to a timber ring beam, is also used in the training course. The problem of scale, and the need for builders to visualise a wooden object as a building, does not seem to affect their understanding of the principles illustrated.

3.6.8 Demonstration Building

The BATC itself was built as a demonstration of strengthened traditional construction. By using dressed stone with timber ring beams the center is identifiably local. Although there was some discussion of the use of prototype dwellings, to suggest 'improved' house plans it was decided at an early stage to leave the planning of homes to builders themselves, unless they asked for advice. There were few technical difficulties in constructing the BATC, and the unfamiliar aspects of the design (such as steel in a masonry wall) were quckly grasped by those involved. As a costing exercise, the BATC building was to provide an idea of the increase in costs through reinforcement. By estimating the costs of the same building without reinforcement, it was established that the BATC costs were up to a third more than those for ahome using no reinforcement or cement mortar.

(See Table 1 over)

Construction type masonry	Costs (material and labour) YR Building Stage						
	EXCAV	FOUNDS	WALL	ROOF	FINISH	TOTAL	%
a) unreinforced no cement	3150	9100	51,295	5660	1500	70,705	100
b) with cement mortar	3150	9975	55,795	8510	4960	82,390	116
c) with timber ring beam	3150	9975	63,049	8510	4960	86,224	121
d) with horizontal steel	3150	9975	62,943	8510	4960	89,538	126
e) horizontal and vertical steel	3150	12,345	65,993	8510	4960	94,958	134

Table 1: Costs of strengthening traditional construction (from BATC 1983)

Foundations for a second building were built at the same time as the BATC, based on a plan suggested by the World Bank Mission for a reconstruction 'core' house. Block work walls were built up using trainee labour, to serve as a demonstration of reinforcement in another material. Horizontal reinforcement and roof corrections were left exposed, to serve as built examples for the training programme.

A third building, of sun-dried mud blocks was built in 1984, to investigate reinforcement techniques with this material, and to widen the scope of the methods on display at the BATC. A system of timber ties was used in this building, with exposed connections for demonstration purposes.

A further demonstration, built by BATC staff and funded by SCR/Overseas Development Administration (UK) and Oxfam, was started in late 1984. The intention was to demonstrate cement stabilised soil blocks in use, and investigate reinforcement. The half-completed structure was demolished by the Dhamar Municipality to make way for a proposed road, in May 1985. There has been no further work on the stabilised soil techniques since then, pending some agreement with the SCR on their interest in material development work.

A small demonstration building is under construction in Al Jum'ah and serves as practical training for builders attending the DTC. Simple horizontal reinforcement has been incorporated in local stone masonry (which is predominantly coursed rubble), and trainees will be required to build a fully-braced roof as part of their training.

3.7 Practical Training

By relying on the identification of builders by the community itself, the MEU has been able to ensure that those invited for training have some degree of experience, and a recognised ability. Builders have been encouraged to improve their skills at the BATC, but project staff insist on a basic minimum of construction experience as a condition of registration for training courses. While the basic training course lasts for two days, trainees who are slower to grasp the principles of earthquake-resistant building are required to undergo longer courses, during which the trainers attempt to clarify specific points.

On the second day of the training course, builders are given a practical building exercise. Trainees set out and build a small (2m x 2m) 'house plan' in cement block or stone, paying attention to bonding through stones, incorporation of horizontal steel and mesh reinforcement. At the end of the training there is a verbal test on some aspects of the techniques that are advocated in the training and stone masons are required to build a stone arch. Those unable to complete the test are required to continue training and are examined again before they receive a certificate of attendance.

3.8 Certificates

The certificate presented to successful trainees at the end of their course states the particular techniques that have been covered by training. The purpose of the certificate is to act as an incentive to builders to train, to enable them to show the skills they have gained, and to create a sense that builders "ought to know" about strengthening in the affected area. There seems little doubt that the certificate has helped attract builders to the BATC. In following up visits it emerged that most builders did not find the certificate directly useful in getting work, but that people could easily identify those who had qualified from the training course.

3.9 Staff

The training staff at the BATC are local men with experience in construction techniques, who have been involved in the work of the project from its' early stages. Their familiarity with traditional construction and participation in the building of the BATC, enables them to understand the problems that trainee builders might face with reinforcement.

The MEU and DTC each include one man who is a local member of the community and has a good local knowledge. This man introduces the work of the project to village builders. This link was seen as an important means of gaining acceptance for the work in the rural community.

Given the simple nature of the technical messages of the training, it was decided that local men with a proven ability to build, would be of more use than those with more sophisticated training (engineers, for example) and would be in a better position to communicate with their fellow-builders.

4. ASSESSMENT

4.1 Technical Assessment of Training

The specific methods of increasing the earthquake resistance of traditional buildings were originally drawn up from a compilation of the recommendations of the technical earthquake damage reports and some additional general manuals on earthquake-resistant design and construction. The improvements advocated can be categorised as:-

a) planning of a safer building form
b) use of construction methods less likely to develop structural defects which would weaken the structure
c) the addition of strengthening the resist dynamic loads.

a) Recommendation for planning a safer building form are quite limited in teaching at the Centre, principally because layouts of traditional houses are well established and not intrinsically weak. The importance of planning the position of structural openings is stressed, and is particularly important with current construction favouring large windows. The most important principle of structural form for reducing earthquake vulnerability of weak masonry structures is to limit the height of the building. Current construction is nearly all single storey, but it is evident that in the future these buildings will be extended vertically. The technical messages of the centre show the dangers of building too high by illustrating damage to the older three and four storey buildings, but the explicit rule of not adding a third storey to a house is not part of the teaching material, booklet or other checklists that the builder is given. It may be that this is an inappropriate technical message for the moment. Although it may be a long time before many buildings are extended that far, there may be some value in adding some guidance for the proper bonding of a second storey onto an existing lower one (as some of the present new construction is upper storey). Recommendations on siting a new building are fairly superfluous as few builders are given a choice of site or asked for advice on siting. Messages on siting are mainly concerned with preparing the site that is provided, to get good, level foundations.

b) The emphasis of construction methods which are less likely to develop defects is an important part of the training course. Better building practice does not add a great deal to the cost of construction, but may significantly improve the earthquake performance of a building. Emphasis is placed on proper foundations, which is extremely important in reducing problems of settlement (settlement cracks were identified as a major source of weakness in the earthquake damage) and in tying walls together. Good bonding and the construction of integral walls, both in stonework and in block is stressed. The connection of internal walls with the external walls is also emphasised, although this requires a significant change in the sequence of construction. The use of cement mortar can be an important improvement to the integrity of stone masonry. It is however expensive, and may add a further 30% to the cost of a village house. The training should recognise that builders might not always use cement mortar with stone masonry, and that weak mixes and partial use of cement can also be effective. In terms of cost and the reduction of damage, the use of horizontal reinforcement is more effective than the exclusive use of cement mortar. The use of soil mortar in masonry, with the addition of a timber or concrete ring beam will be more resistant to earthquake forces than masonry with cement mortar alone.

Good construction is vital in earthquake resistance and the encouragement of pride in the quality of building that the course encourages ("a building is only as strong as its weakest element") is a valuable aspect of the training.

c) The addition of strengthening is the main emphasis of the training course. A number of different methods and details of strengthening are advocated, any or all of which can be incorporated at different levels of cost. The function of strengthening is to resist the separation of structural elements that is the first stage towards building collapse. Proposed methods of strengthening range from the addition of light steel mesh in cement mortar courses, through timber wall beams, to the casting of full reinforced concrete ringbeams. All of these methods, if tied throughout the building will give considerable improvement to its ability to resist disintegration under lateral forces. Even the minimal use of small lengths of steel to reinforce corner bonding, demonstrated in some detail on the course, is likely to have a significant effect on reducing wall separations. The role of the roof in acting as a diaphragm, tying together the walls below it, is dealt with in some detail. The notion of the diaphragm is a difficult concept for builders to grasp, and a scale model was built to show its effectiveness. The course emphasised the careful construction of a monolithic roof (use of plywood sheeting) and its bonding to all of the walls. The monolithic roof is also critical to the prevention of roof collapse and avoidance of casualties which is the principal objective in the reduction of future earthquake damage.

The use of vertical steel as a reinforcing element through the masonry was tried in the construction of the training building in Dhamar but problems with anchorage in the foundations and complications in construction outweigh its structural advantages (resisting shear by putting masonry into compression) and it was decided not to incorporate it in the training course.

Altogether the technical messages given on the training course form an integrated approach to more earthquake-resistant and generally higher quality construction than would be built without them. A very approximate indicator of the improvement in earthquake performance that would result from following the training is the classification of building types in the MSK-76 earthquake intensity scale. (Medvedev (1968)). The traditional buildings that made up most of those affected by the earthquake would be classified as building type A (rural structures, random stone masonry, mud mortar) which for example are likely to have 50% destruction at Intensity VII and 75% destruction at Intensity VIII. Buildings built according to the training course would be classified as building type B (shaped stone masonry with moderate horizontal reinforcement) which by comparison would suffer 5% destruction at Intensity VII and 50% destruction at Intensity VIII. In terms of total earthquake damage, if the buildings in Dhamar Province had all been of type B instead of type A, then the total number of houses destroyed would have been in the order of 8,000 rather than the 25,000 that were estimated destroyed in the December 1982 earthquake. (Assuming reassigned level of destruction for all villages in Figure 1).

However, the implementation of the teaching messages into building construction can only be expected to have partial success. It is clear from the follow-up study that a minority of trainees have not implemented techniques that they have been taught, even when cost has not be a restraint.

In general, the concepts of strengthening seem to have been grasped more easily than specific details. For example, a builder might understand the need for a concrete ring beam, but might not include the correct number of steel stirrups. Although it is not always neccesary for details to be followed exactly, there are crucial points whose omission might affect the strength of the building. For example, trainees are taught to lap joint and nail timber ring beams, but the survey showed that some trainees, while understanding the need for a beam, had not joined it properly.

To get across construction details that are critical, it would appear that

the practical part of the training course should be more extensive, involving more repetition of several tasks. Critical details should include a) jointing timber ring beams
b) lapping and fixing reinforcing steel
c) connection within the roof, and from roof to wall.

4.2 Coverage of affected areas by the Project

Figure 6 shows the villages visited by the Mobile Education Unit. Some 294 villages were visited out of an estimated 638 damaged villages; almost half of the affected settlements. The MEU operated from September 1983 to December 1984 recruiting trainees and from December 1984 to July 1985 carrying out follow-up visits and surveys of new buildings. Villages visited were limited by accessibility and the need for the MEU to return to the training centre the same day. More villages could be reached if the MEU were to continue longer and to operate from regional bases. The MEU stopped operating in Dhamar district when it transferred to the Jebel as' Shirq district to operate from the District Training Centre there. With the cessation of village visits the number of builders coming to the Dhamar training centre decreased considerably. Continued presence in the villages appears to be necessary to maintain a constant supply of trainees.

The trainee survey showed that in villages that had been already covered by the MEU, there were still builders who were willing to train. This follow-up work might be an important step in increasing the numbers trained in the affected area.

By October 1985, 820 masons had been trained, coming from 190 different villages - nearly a third of those damaged. From Figure 6 it can be seen that villages from which masons responded to the MEU visit, are clustered together and this may be a result of word of mouth between villages. Some masons from villages which the MEU did not visit also came for training, usually from the neighbourhood of other MEU visits. Future MEU work should concentrate on re-visiting expanding areas where builders are already responding to calls for training.

An estimate of the total number of masons in the earthquake-affected area can be found from the surveys made by the MEU in 80 of the affected villages. Although there is large variation, on average there are about 6 builders for every 100 households. With average household sizes of 5.3 people (Steffen ibid), this means approximately one builder for every 88 people or one builder for every 20 working men. The estimated total population of the earthquake affected districts of Dhamar, Al Hada, Dawran Anis, Jibal as Shirq and Ma'bar in 1985 is 292,663 (assuming 2.4% annual growth from 1980 population) i.e. the 300,000 people affected as quoted in initial relief estimates. For 300,000 people the ratio of persons per builder from the surveyed villages would suggest that there are 3,400 builders in the earthquake affected areas. The 820 builders trained at the Centre is therefore 24%, or nearly one quarter of the available builders in the reconstruction area.

From Figure 6 there are three main areas which have been left out of MEU visits, and from whose villages there are no trainees. The first is west of Dhamar in Magreb Ans and extending upwards into Dawran, an area where self-help projects are operating (and which are training builders on the job). The second is the area to the north-east of Al Jum'ah in the mountainous northern areas of Dawran district, and the third is east of Ma'bar in the large area of Al Hada. To service the Al Hada area sufficiently another district training centre would probably have to be established there.

Current rates of training builders are averaging around 50 a month. With sustained activity by MEU's and the possible establishing of other regional training centres to service areas not yet covered, it may be possible to

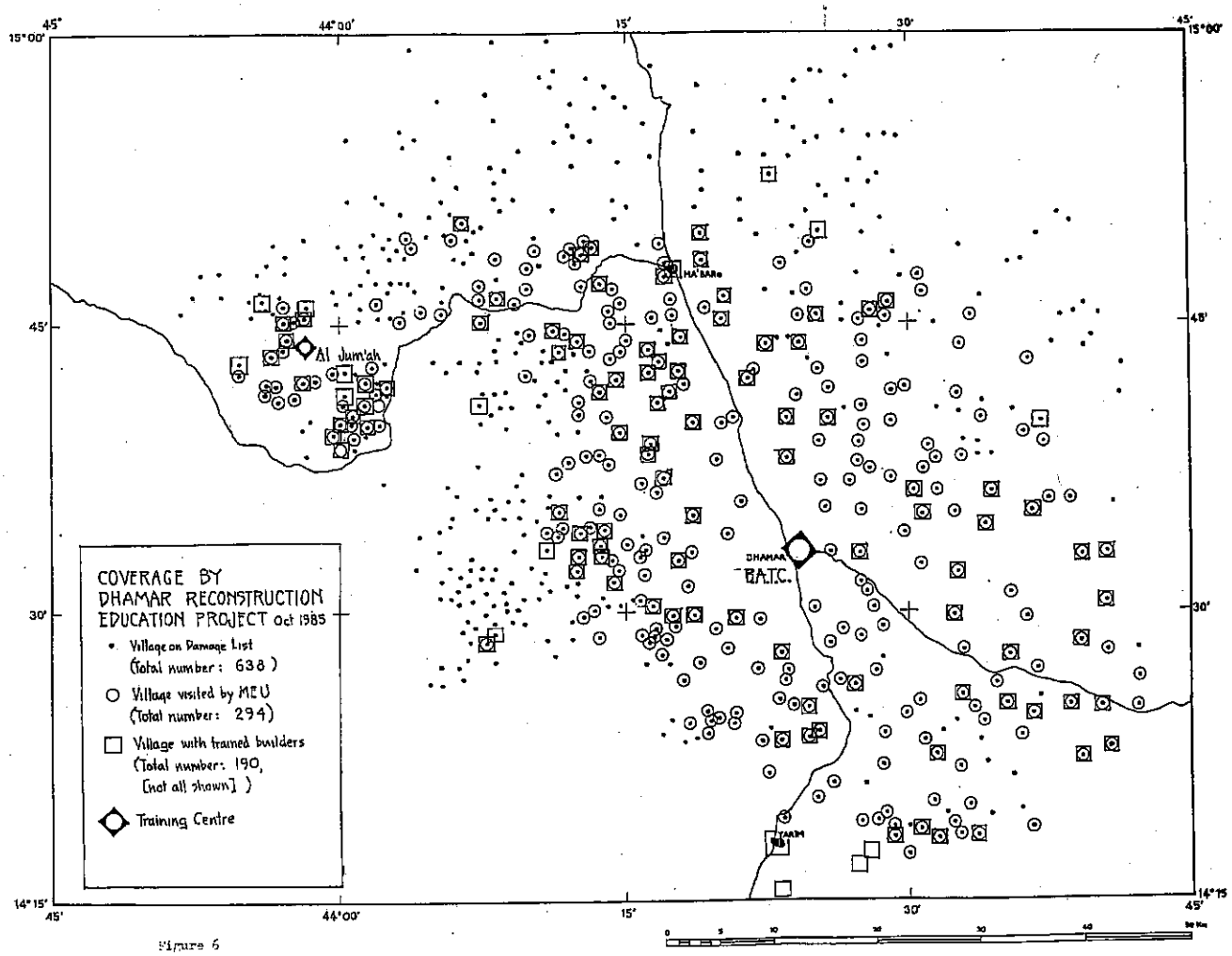

45°
44°00'
15'
30'
45'
15°00'
45'
30'
14°15'
Al Jum'ah
HA'BAR
DHAMAR
T.T.C.
YARM
COVERAGE BY
DHAMAR RECONSTRUCTION
EDUCATION PROJECT oct 1985
Village on Damage List
(Total number: 638)
Village visited by MEU
(Total number: 294)
Village with trained builders
(Total number: 190,
[not all shown])
Training Centre

Figure 6

train another 900 builders in the remaining 14 months of the SCR reconstruction programme (63 per month), which would be about 50% of the total estimated number of builders in the earthquake affected area. This would be a very respectable achievement for the building education project.

4.3 Effectiveness of training

In order to assess the effectiveness of the training, a number of villages were visited, to trace the builders who had come for training. 15 villages in the Dhamar district and 5 villages in Jebel as Shirq district, were visited, and the whereabouts of 74 trainees were ascertained. From the 74 trainees, 11 (15%) had left the country to work abroad, mainly to Saudi Arabia, 24 (32%) had left their village and were working for contractors in the reconstruction areas or the repair unit in Dhamar, 12 (16%) were still in their village but were unable to get building work and 27 (36%) were working as builders in their own village. Thus, just over a third of the builders in this sample of trainees had returned to their village and were involved in new house construction there. 11 of the interviewed were from Dhamar, they could get work with the repair unit more easily. The proportion of trainees getting work with contractors elsewhere is probably lower, and if Dhamar builders are excluded from the sample, the proportion of village builders employed by contractors is 24%.

Of the 74 trainees traced, 20 were interviewed (both unemployed builders and those engaged in construction) and 33houses built by trainees were inspected. Nearly all of the houses built by the trainees were in concrete blockwork. For comparison, a similar survey was made of houses built since the earthquake by builders who had not attended the training course, in 6 of the villages in Dhamar district. 107 buildings built by non-trainees were surveyed, 85 of which were concrete block, and 22 stone masonry. For comparison of houses built by trainees and those built by others, it is only possible from this sample to compare construction in blockwork.

This is shown in Table 2.

From this it can be seen that good and bad quality construction, reinforced and unreinforced buildings are built by both groups of builders. However, a significantly larger proportion of the buildings built by trainees (84% as compared to 40% by non-trainees) were built with horizontal reinforcement, which is the main emphasis of the training course. There is some evidence that quality of construction is better in the trainee buildings; 33% are good quality and 90% medium or better, compared with 12% and 73% for other buildings. This may be due to emphasis on good quality concrete block masonry on the training course.

This sample of buildings is relatively small, but is considered fairly representative of the new building 'stock'. It is possible that some smaller concrete block construction may not be regarded by owners as long-term building, and so not worth reinforcing, which would make a survey of concrete block buildings unrepresentative of longer-term building stock. However, the sample does demonstrate that a significant number of builders are putting the principles of their training into practice. It would appear that about 44% of houses built by trainees have additional strengthening, that might not have been included without the training course.

	Buildings built by builders having completed training					Buildings built by builders without attending training				
	Poor Qlty Blockwk[1]	Med. Qlty Blockwk[2]	Good Qlty Blockwk[3]	Total		Poor Qlty Blockwk[1]	Med. Qlty Block[2]	Good Qlty Block[3]	Total	
Unstrengthened	-	13%	3%	16%		19%	35%	6%	60%	
Strengthened with horizontal timber courses	-	3%	-	3%	Buildings with horizontal strengthening 84%	1%	4%	-	5%	Buildings w/o horizontal strengthening 40%
Strengthened with single concrete beam	3%	7%	7%	17%		5%	15%	4%	24%	
Strengthened with more than one concrete beam	7%	35%	23%	65%		2%	7%	2%	12%	
Total	10%	58%	33%	100%		27%	61%	12%	100%	
	Sample size : 31					Sample size : 85				

1. Poor Quality Blockwork: Concrete blockwork with cement (or occasionally soil) mortar, poor quality blocks, crumbling corners, gaps in wall, broken blocks or fillers used, vertical unstaggered joints.

2. Medium Quality Blockwork: Concrete blockwork with cement mortar. Solid wall, full blocks, some undulation of horizontal courses, large joints, messy pointing.

3. Good Quality Blockwork: Concrete blockwork with cement mortar. Level courses, neat jointing, corner and internal wall bonding.

Table 2. Comparison of buildings built by trainees and other builders (Concrete block construction only)

4.4 Issues from Interviewing Trainees

20 builders were interviewed, using a standard questionnaire form, as shown in Figure 7. This was to find out in more detail the problems and issues facing builders who had been trained. The questionnaire included a test of how well each trainee remembered his training, in the form of a series of detailed questions from the curriculum of the course. It also involved the testing of a number of different educational images (photographs and drawings), to see what builders understood from each.

In general, the trainees remembered the theory of what they were taught extremely well. 7 questions were asked, 2 points scored for a response exactly as taught, 1 point for the general principle and 0 for having no idea. Out of the 20 builders none scored less than 9 out of a possible 14. Some of the builders who had been trained over two years ago, still remembered their training as well as more recent trainees, but it would be expected that over a longer time period, details of the training would be forgotten.

There was some consensus on the issues raised in interviews with builders in discussing their activities since training. These can be summarised as:-

a) difficulties in getting building employment

b) problems persuading owners to pay for additional strengthening in construction.

a) Many of the builders in the villages in Dhamar district claim to have found it difficult to find sustained building work. These villages are having many of their destroyed houses replaced by contractors and although some people are building new houses, most are adequately housed and waiting for the new housing allocation. Contractors generally appear to prefer employing labourers from outside their construction zone. Builders not willing to travel to a different area have not found contracted work locally. In Jebel As Shirq, (outside the contractor areas), a region of relatively low earthquake damage, builders are continuing with business much as before the earthquake, and apparently very little of their present work involves replacing damaged houses.

Training at the BATC generally has not improved the chances of a builder finding work. Dhamar Municipality however has announced that they will only employ builders with a training certificate from BATC, and this should improve the chances of some trainees getting work.

It is difficult to estimate the amount of new construction being built by villagers independently of the contractor programme. In 6 medium sized villages, 100-300 households, (with moderately heavy damage; 5-30% destruction) at least 100 buildings could be identified as built since the earthquake. This represents about one new building per 10 households. Some of these buildings may be built as an interim measure until the full reconstruction is completed, but a considerable number are large and represent a significant investment in permanent housing. Without knowing the rate of new building before the earthquake it is difficult to judge the impact of the earthquake, and reconstruction programme on the normal building industry. It may be the case that most owners who are willing to rebuild for themselves have now done so, and any further building work will wait until after contractor-built houses are allocated.

b) Builders from all areas discussed the problem of persuading owners to finance the strengthening that they recommended should be included in the construction. It appeared that owners' priorities with their available finance were mainly to maximise the built floor area, rather than to increase the quality and strength of construction.

YEM 49 Trainee survey October/Novemeber 1985 Form no. 6 Date, 27/10/85

1 Name. M'med Saleh Muhamed. Ghanja Home village. Hyat Mougadam.
Date of training. 10/1/84. Years experience. 15 Apprenticeship.
Skills: Waqqis Usta'hajja ~~Mobathin~~
Work since training: a) several small rooms in village
b) this school.
c)

3 Current building.
Location. HIJRAT MANQADAH. Owner. School.
Area (approx). Rooms. 3 classrooms. Cost. 10,000 YR comes from pupils. labour free.
X Who planned the house? school teacher.
Did you persuade the owner to reinforce? Cost.
Construction.
Foundations. stone/soil (stone/cement) block/cement concrete
Walling. stone/soil stone/cement (block/cement) mud bricks mud blocks
Openings. X window from corner.
Roof. traditional (plywood on sawn timber) fixings
Reinforcement.
Foundations. ✓
Horizontal reinf. in walls. ×
Window head beam/lintels. × timber lintels concrete/(timber) continuous?
Wall head beam ✓ concrete/timber continuous?

2 House owners comments on reinforcement, cost, need etc.
mason says it's important to persuade the owner.

How did you hear of the training? MEU/(other trainees)/ from village
Did others attend from your village? Yes. Number. 13
Has your certificate helped you get work? no. little work With whom. didn't go to seek work after training
Where would you go for advice now? (BATC)/engineer/friends/
Do you still have your training book? no. doesn't know
How have you used it? ~~no~~ yes, a little.
Do you remember seeing a video at the BATC? Yes. what did it say? complete. beam.
Have you ever seen such films on television?
What were the photographs you saw at the BATC? (damage)/reinforcement no bonding
What does this photograph show? a) ✓ correct. A
b) unsure idea B/C.
c) ✓ correct A.
What does this drawing show? a) correctly with identifying / took prompting to see wood → then easy A/B.
b) ✓ correct. numbers helped him to see the point.
c) ✓× elements B.
classify : correct/distinguishes elements/no idea.

How deep would you dig the foundations for a stone wall?	✓			1
How many buckets of sand would you use with one of cement?	✓			2
How would you make the corner of the house stronger?	✓			3
How would you prevent a stone wall splitting apart?	✓			4
Is it good to join the internal with the external walls?	✓			5
How would you connect the roof to the wall-head?	✓			6
Which is the weakest point in the traditional building?				7
no thro'stones, splitting walls. stones higher than their width.	2 as taught	1 principle	0 no idea	

Other observations:
Children helping to build school.
mason worked 3 year in Sana'a / 4 year in S.A.
People are forgetting the earthquake.
Older mason built the foundation of the school.
Companies are hiring from south / Hujeria and Taiz

Figure 7

Although trained builders saw it as their responsibility to persuade owners to include strengthening, some had found this impossible. A few claimed to have got the initial agreement of the owner, who then failed to deliver the required materials to the site.

The builders who had included strengthening in new building were often those who had a good relationship with their client. A good deal of the potential impact from training lies in the calibre of the builder himself, and his ability to communicate general points about building strength to the house-owner.

5. SUMMARY OF CONCLUSIONS

5.1 In the two and a half years that the Dhamar Building Education Project has been operating, 820 village builders have been trained. This represents about 25% of the estimated total number of builders in the earthquake affected areas.

5.2 Builders have been drawn for training widely across the earthquake affected areas. Notable gaps where builders have not been trained are in Magreb Ans (where the CEC/USAID self-help project is training builders), northern areas of Dawran district and in Al Hada district. It is evident that even within areas already covered by Mobile Education Units there are still builders willing to come for training.

5.3 Of the builders who have come for training, about a third are employed on building work in their own village. Others have left the area for work outside or are unemployed. A certificate from the Training Centre has not directly improved the chances of a builder in finding work in the villages.

5.4 More buildings by trainees tend to incorporate strengthening than those by other builders. It would appear that about 44% of houses built by trainees have additional strengthening that might not have been included without the training course.

5.5 Lack of sustained employment and the need to persuade house owners to pay for strengthening, were the main issues emerging from interviews with trained builders. Although there has been considerable building activity in the area since the earthquake, the contractor programme seems to have more recently affected the number of villagers building for themselves.

5.6 The training course appears well suited to the present circumstances of the area. The costs of strengthening measures advocated on the course seem to be within the means of most villagers. Technical messages are well within the capabilities of the local builders and are based on the materials available. A house built following the training course would be significantly stronger than the typical traditional house.

5.7 Builders trained on the course at BATC have a good grasp of the principles of strengthening. Details of strengthening have not always been implemented in accordance with training . Trainees would probably have a better understanding of the importance of detailing if they received more practical training.

5.8 Training that is followed relatively quickly by work in building construction is likely to be the most successful. It is probable that after the contractor housing is allocated there will be another period of building activity as demand for housing returns to normal and those people not allocated a house begin to build for themselves. It is important that the building education project maintains a presence in these areas during the final phases of the reconstruction programme and offers training on extending existing buildings and other advice relevant to the expected construction work. By maintaining the current level of influence while the building industry returns to normal, the Building Education Project can make a long term improvement on the strength and quality of building stock in the region.

6. RECOMMENDATIONS

On the basis of this assessment of the project activities it is clear that a positive contribution has been made to the reconstruction process in the earthquake-affected area. By improving the quality of new construction, a start has been made on the building of a safer housing stock. This process is still under way and the current circumstances provide a good opportunity to continue the training of builders and expand the long-term impact that this has on local construction.

Altitudes of the Executive Office of the SCR towards the project are positive and it can expect continued support from the Repair and Advice Unit.

Recommendations for the future of the project are:

1. The project is continued until the end of the official reconstruction programme in December 1986.

2. A second district training centre is established and Mobile Education Unit visits should be made to the villages which have not yet had builders trained. A target for total number of builders trained by December 1986 might be 1700, about half the builders estimated to be in the earthquake-affecte areas. This would require training around 60 builders a month, only a moderate increase on the present rate.

3. Training of builders should be coupled with a publicity programme aimed at house owners to encourage them to support the strengthening of buildings as recommended by their builder. The MEUs should take on a role of contacting owners of new buildings early in their construction to make them aware of strengthening issues.

4. The training of builders should be extended to give more practical training practice on critical strengthening details.

5. It would be preferable if a Technical Officer could continue to oversee the project in its final year. His responsibilities should include the broadening of the project activities, preparation of new material and continued advice in villages. If this is not possible the project will have to continue at its present level of training activity and place less emphasis on offering technical advice.

6. During the last year of the project some effort should be made to explore the possibility of a Yemeni Ministry, Institute of Engineers or other official body taking over the building education project for application in other earthquake-prone areas. The application of the experience learnt in the reconstruction should be applied to the long-term mitigation of earthquake risk in other parts of the country and would be most appropriate in areas of high seismicity, with a vulnerable building stock and a large, expanding population.

8. DOCUMENTATION

8.1 Project Documentation

6 March 1983	'Education Programme for Building Reconstruction in Dhamar Governorate' Joint Concern/Oxfam Project.
19 March 1983	'Earthquake Reconstruction Project, Y.A.R., Preliminary Draft Specifications and Costings.'
29 March 1983	'Dhamar Domestic Reconstruction Education Project, Plan of Operations.' Project Agreement between SCR, LDA, Oxfam, Concern, Redd Barna, March - September 1983.
29 April 1983	Project Progress Report (Delaney, Oxfam)
16 May 1983	Project Progress Report (Hogan, Delaney, Concern)
9 June 1983	Project Progress Report (Leslie, Oxfam)
12 June 1983	Project Progress Report (Feeney, Oxfam/Concern)
Sept 1983	Project Progress Report (Leslie, Oxfam)
10 Sept 1983	Project Agreement, Domestic Reconstruction Education Project Executive Office of SCR, Oxfam, Sept 1983-May 1984
Dec 1983	Project Progress Report (Leslie, Oxfam)
23 May 1984	Project Agreement, Domestic Reconstruction Education Project Executive Office of SCR, Oxfam, June 1984-Dec 1985
Dec 1984	Project Progress Report (Leslie, Oxfam)
May 1985	Project Progress Report (Leslie, Oxfam)
Sept 1985	Project Progress Report (Leslie, Oxfam)

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8.2 Documentation on Reconstruction

Jan 1983	Text of Press Conference by Dr. Abdulkarim El-Eryani, Prime Minister of Yemen Arab Republic.
March 1983	Joint Mission Report to the Supreme Council for Reconstruction (Summarised in 'The Reconstruction Programme')
Sept 1983	'The Reconstruction Programme The Executive Office, Supreme Council for Reconstruction of the Earthquake A ected Areas, Yemen Arab Republic.
	Earthquake Damage Map (1:500,000 series maps) Survey Authority, Ministry of Public Works, Sana'a.
	Contract Reconstruction List, Supreme Council for Reconstruction of Earthquake Affecetd Areas, Yemen Arab Republic.
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October 1983	Dhamar Aided Self Help Reconstruction Project Document, Yemen Arab Republic/Kingdom of the Netherlands/Commission of European Communities, DHV Consulting Engineers, Anersfoort, Netherlands.
February 1984	Post Earthquake Rural Housing Self Help Reconstruction Project Formulation Report. YEM/84/COI, G. Lemarchands, United Nations Capital Development Fund.
March 1984	Post Earthquake Rural Housing Reconstruction Project Document. Government of the Yemen Arab Republic/United Nations Development Programme, Sana'a.

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A.S.Arya, M.K.Ataher, A.S.Sanabani,G. Sho'ulan. (1984) 'Rehabilitation and Reconstruction of Earthquake Affecetd Areas of Dhamar Province in Yemen Arab Republic. Paper submitted to International Symposium on Earthquake Relief in Less-industrialised Areas, Zurich, on behalf of the Supreme Council for Reconstruction of Earthquake Affected Areas, Executive Office Technical Office, Sana'a.

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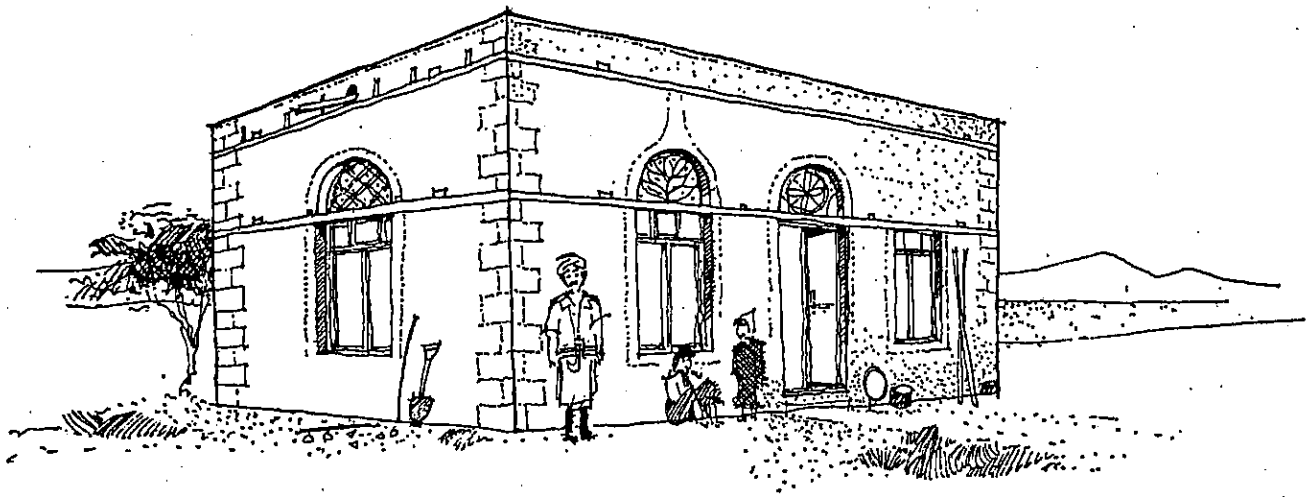
M.Piche, J.Sirvain (1983,Jan) Preliminary Report on the Human Settlements Sector after the Dhamar Earthquake, 13th December 1982, United Nations Centre for Human Settlements.(HABITAT)

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APPENDIX I

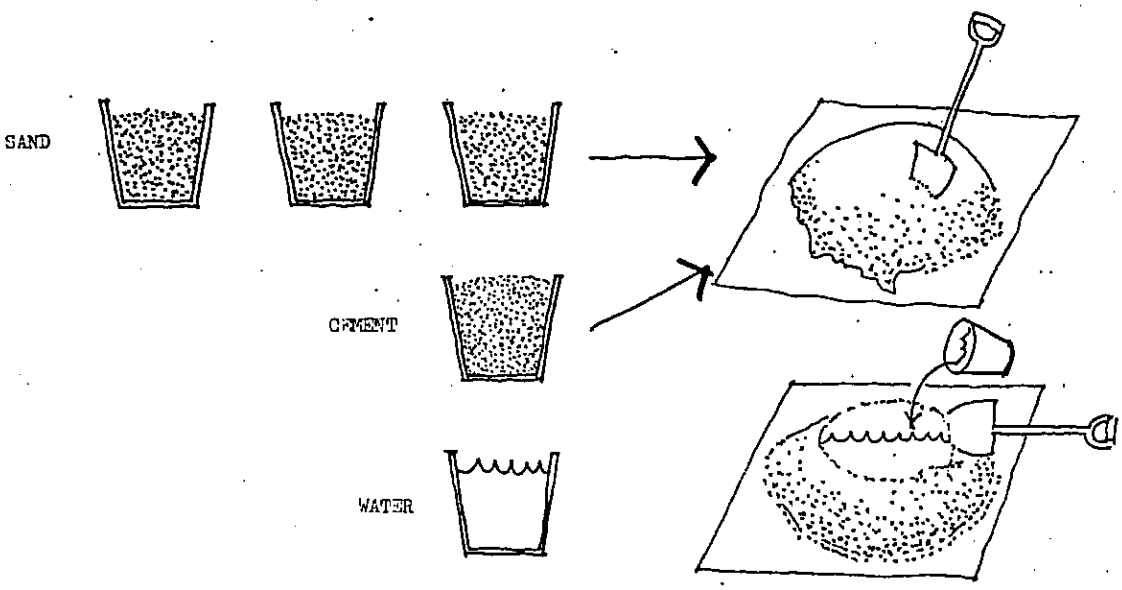
'Think Before You Build'.
Training Booklet issued on Dhamar Building Education Project.
English Translation.



THINK BEFORE YOU BUILD

HOW TO MAKE CEMENT MORTAR

Mix together 3 buckets of dry sand with 1 bucket of cement. Heap the mixture together, and make a hole in the middle of it with a spade.
Pour one bucket of water in to this hole.
Scoop the dry mixture from the edges of the pile in to the centre, until there is no water left in the middle.
Mix it all together so that the mortar all has the same wetness

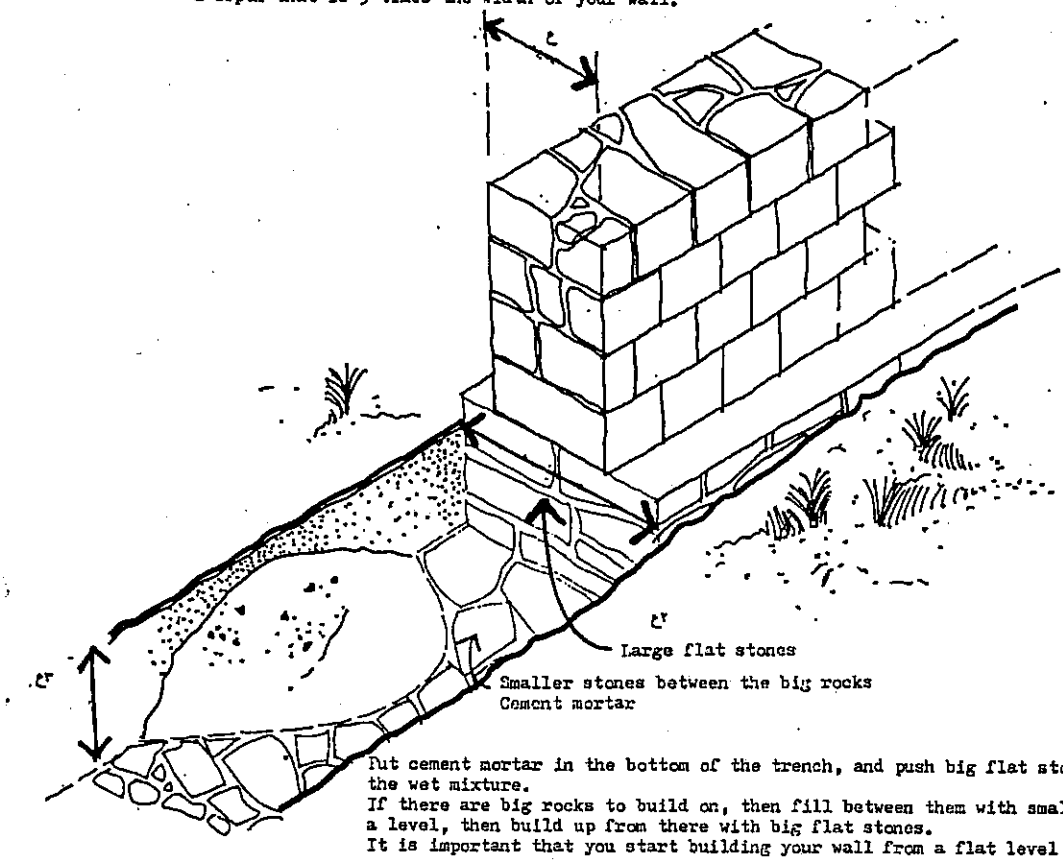


You should mix the mortar on clean dry earth that is hard, or else use a sheet of plastic or plywood.

You can use this cement mortar in the walls or foundations of your house.

THE FOUNDATIONS OF YOUR HOUSE

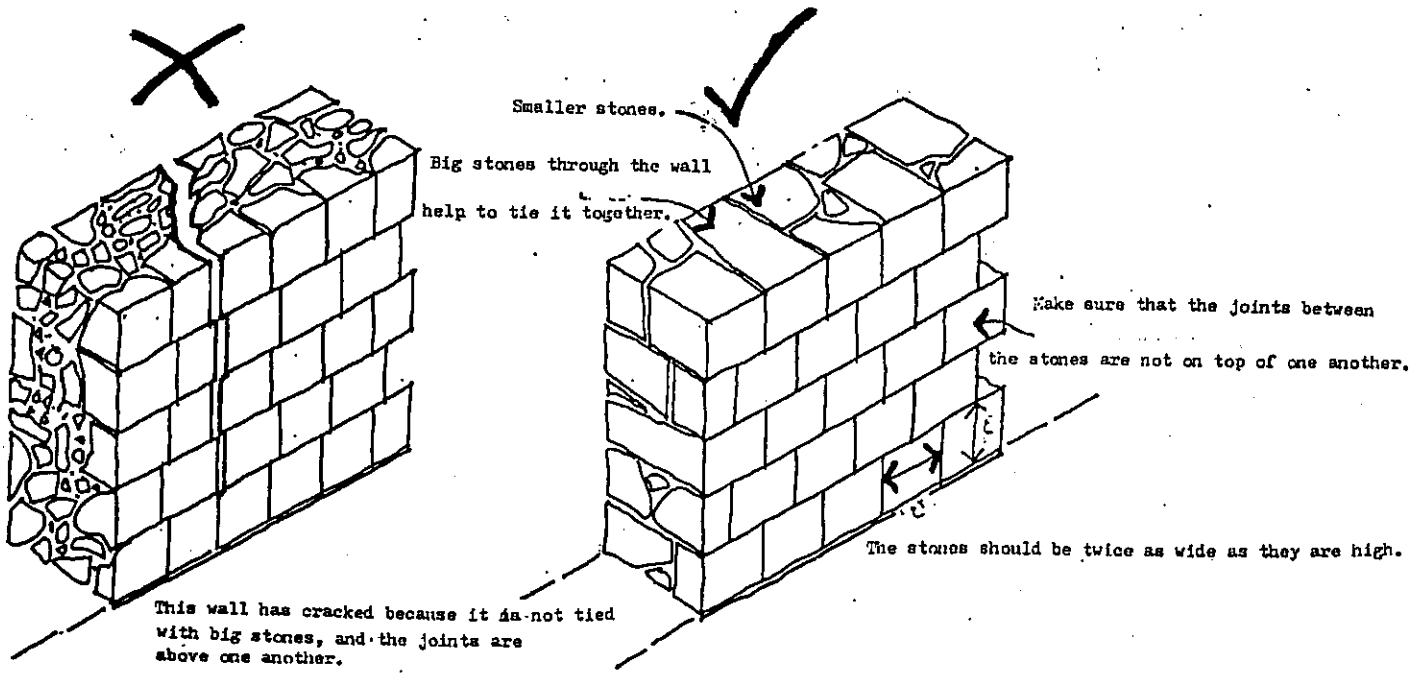
Dig a trench that is twice as wide as the wall of your house will be.
If your house is on rocky soil, dig down until you reach the big rocks, removing all the smaller stones and earth between them.
If your house is on sandy soil, then dig down until you reach firm ground, or to a depth that is 3 times the width of your wall.



Put cement mortar in the bottom of the trench, and push big flat stones on top of the wet mixture.
If there are big rocks to build on, then fill between them with smaller stones to a level, then build up from there with big flat stones.
It is important that you start building your wall from a flat level surface.

THE STONES IN YOUR WALL

You should use the biggest stones possible in your walls, and bed them well in cement mortar.

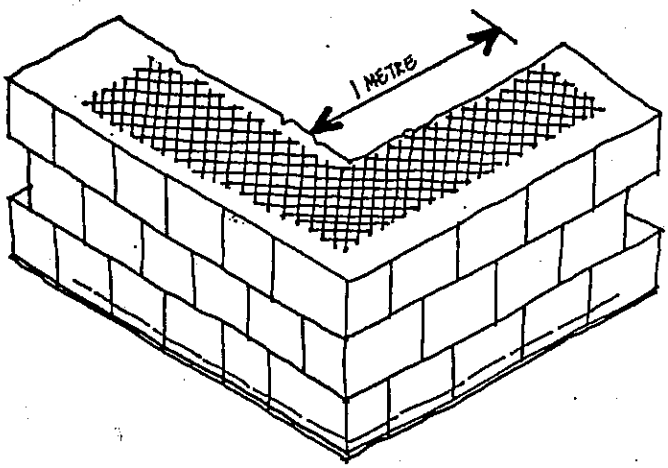


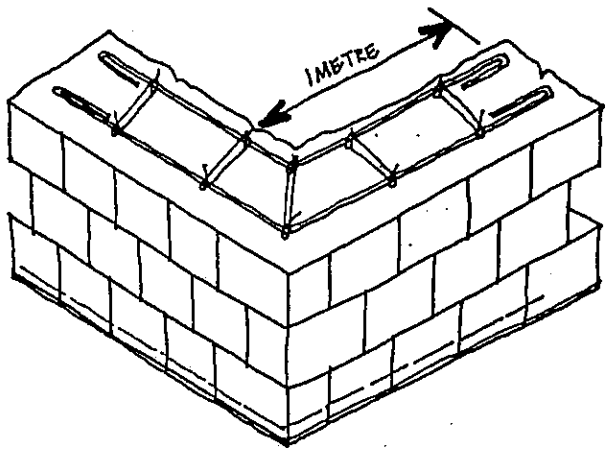
THE CORNERS OF YOUR HOUSE

You can make the corners of your house stronger by putting steel bars or wire mesh between the stones. Cover the steel wall with cement mortar before you lay the stones on top.

Put this reinforcement in the wall every 3 courses of stone.

Use the biggest stones available for the corners of your house.



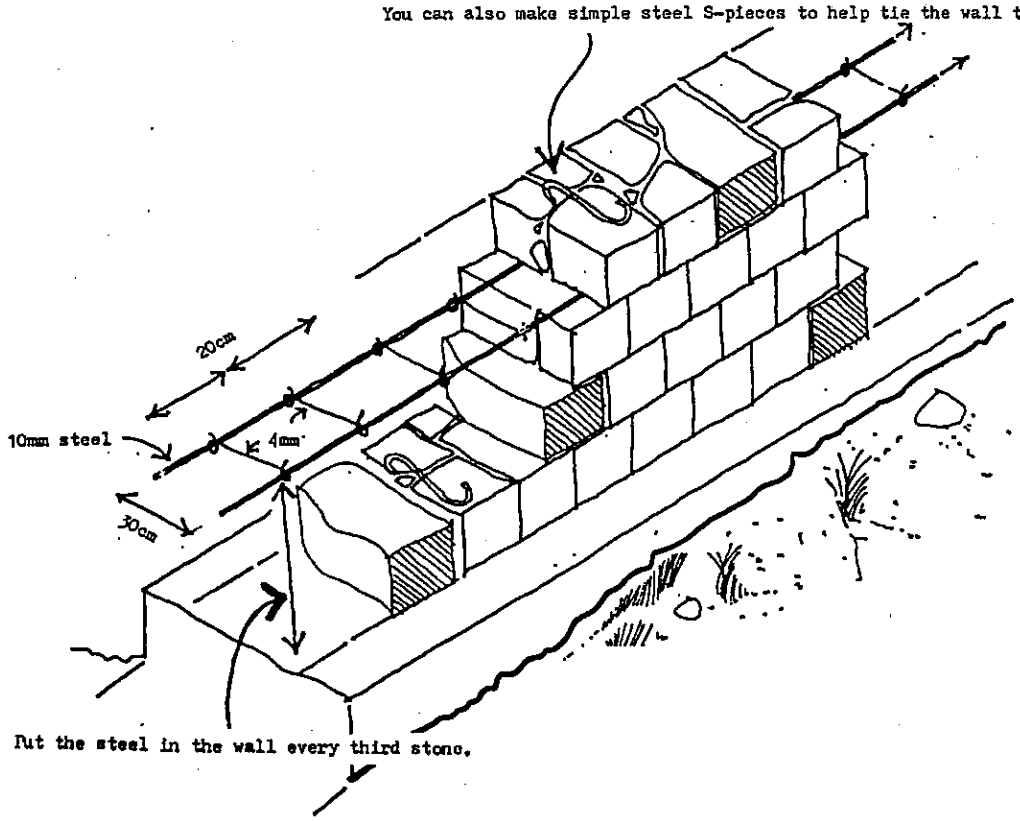


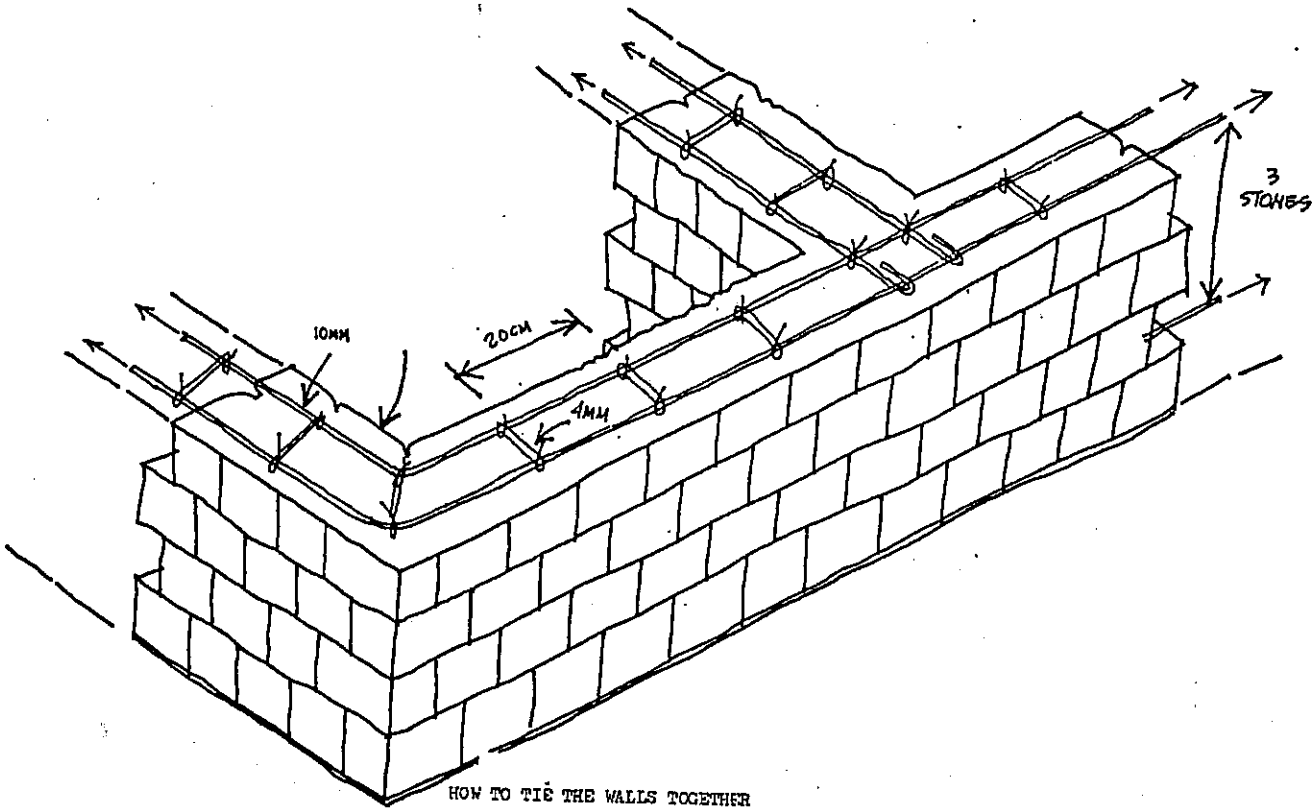
MAKING THE WALLS STRONGER

Big stones that run right through the wall will help to tie it together.

Steel running right around the walls of the house will also strengthen it. Cover the steel with cement mortar

You can also make simple steel S-pieces to help tie the wall together.





HOW TO TIE THE WALLS TOGETHER

The steel that you put in your walls should run all the way around the house. The inside walls should also be tied to it, by bending the steel bars over each other.

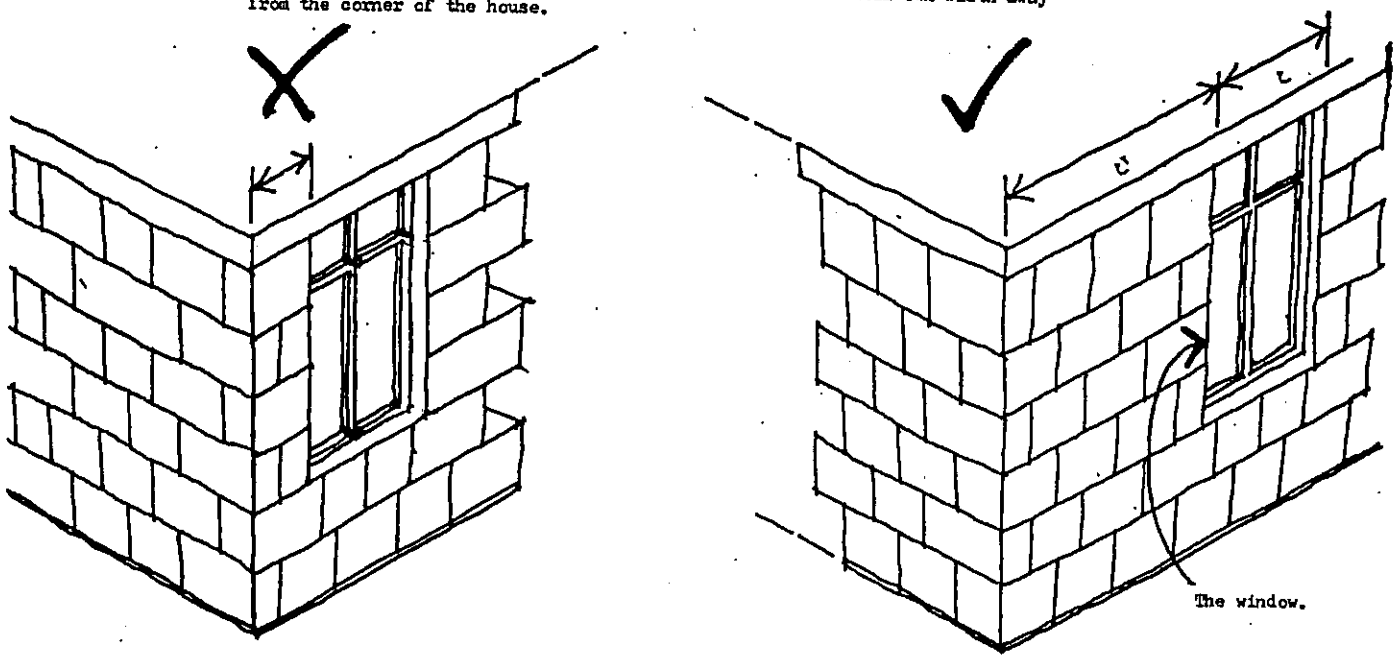
Make sure that the 2 steel bars are wired together well all the way along the wall.

Tie the internal walls with steel too,

Put the steel in the wall every 3 stones.

MAKING WINDOWS AND DOORS IN THE WALL

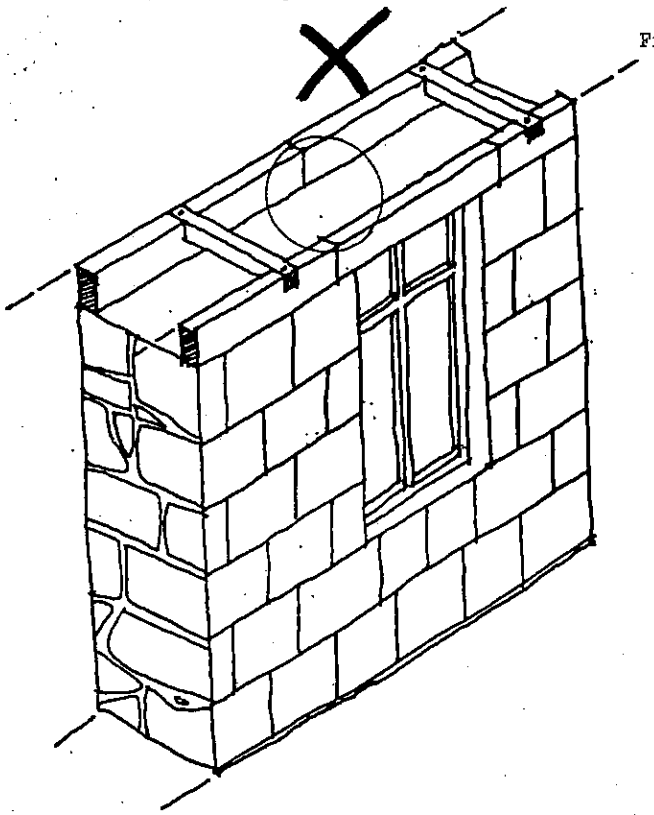
Windows and doors make the wall weak, so you must be careful where you put them. Make sure that both windows and doors are at least twice their own width away from the corner of the house.



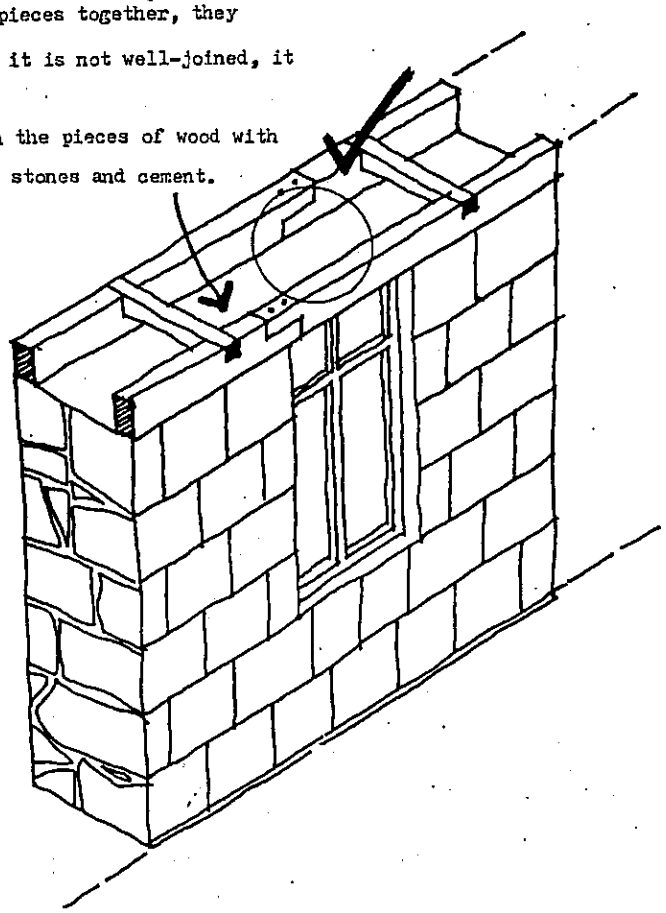
If you put your windows or doors too close to the corner, the wall will crack.

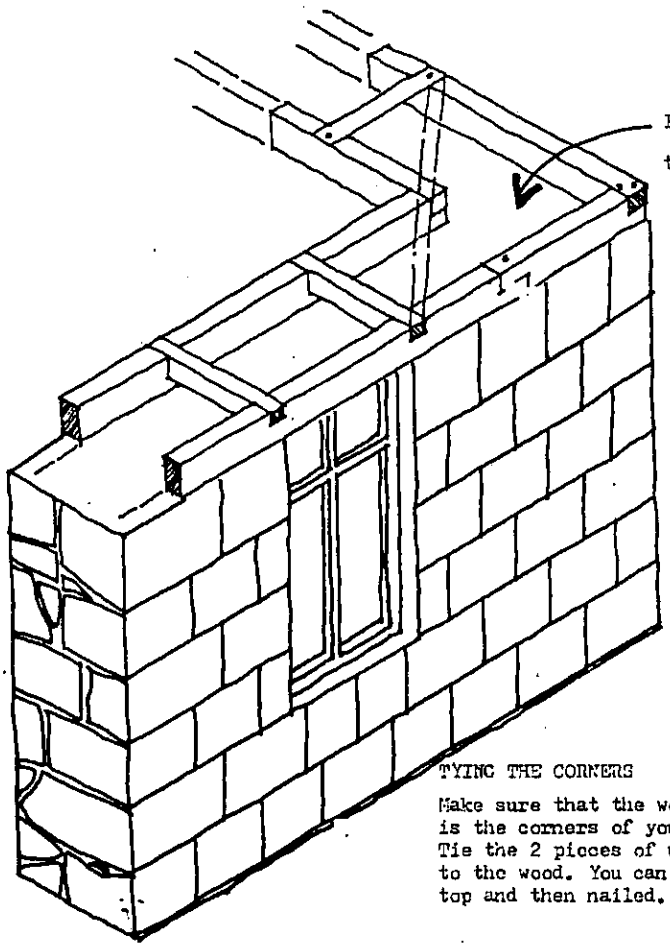
TYING THE TOP OF THE WALL TOGETHER

You can see how many houses were cracked by the earthquake at the top of the wall, If you put wood on top of the stone wall, and nail the pieces together, they will help to stop the wall cracking.
Make sure that you notbh the wood, and then nail it. If it is not well-joined, it will not help the wall.



Fill between the pieces of wood with small stones and cement.





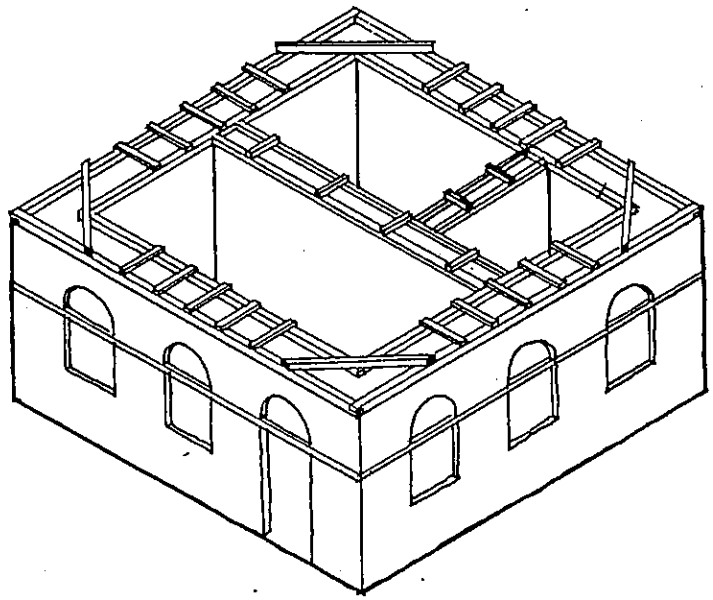
Put a daigonal piece of wood across the corner to make it stronger, and nail it well.

TYING THE CORNERS

Make sure that the wood is also nailed together at the corners. Remember that it is the corners of your house that will crack first, if they are not strong.
Tie the 2 pieces of wood together with steel, bent at the ends and then nailed to the wood. You can also tie the pieces with shorter lengths of wood laid on top and then nailed.

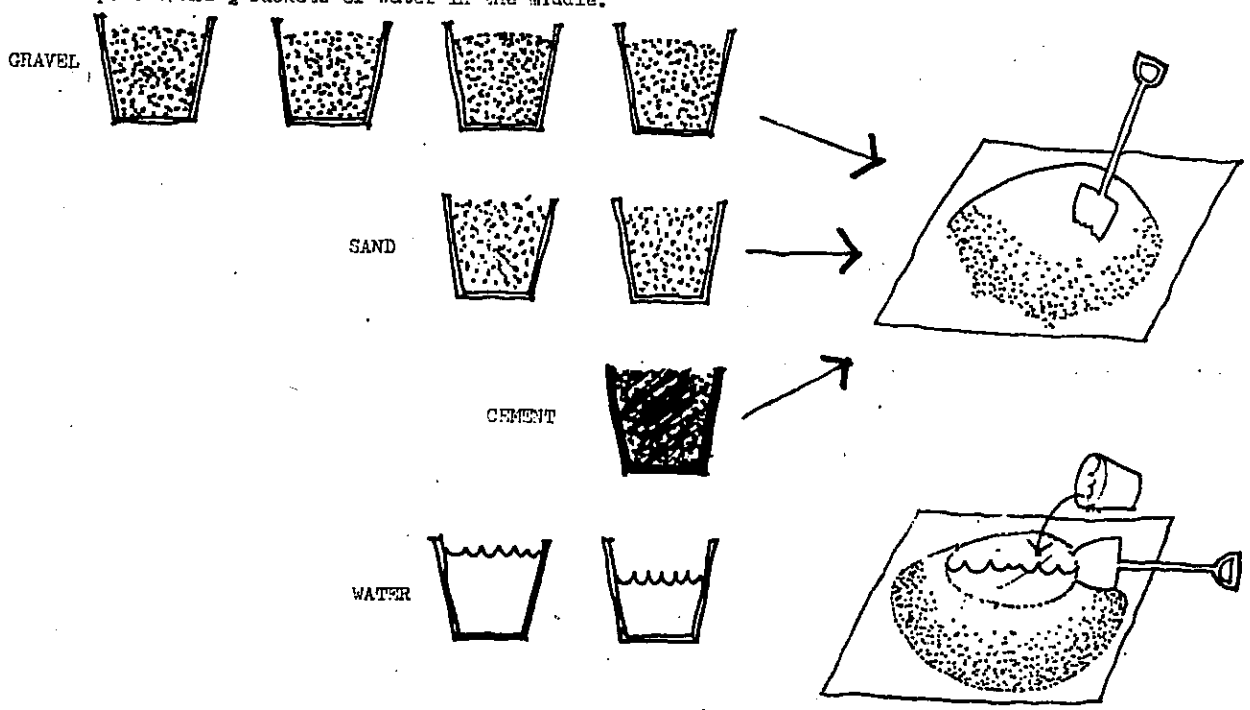
TIE THE WHOLE HOUSE TOGETHER

Make sure that this wood is on top of all the walls of the house, both inside and outside. This will tie the whole house together.



MIXING CONCRETE

Another way to use cement in your house is by making the foundations or beams with concrete.
This is similar to cement mortar, but you also use gravel in the mixture.
To make concrete, mix 4 buckets of gravel with 2 of sand on a dry flat surface.
Add 1 bucket of cement, and mix this all together. Make a pile as before, and pour 1 and $\frac{1}{2}$ buckets of water in the middle.



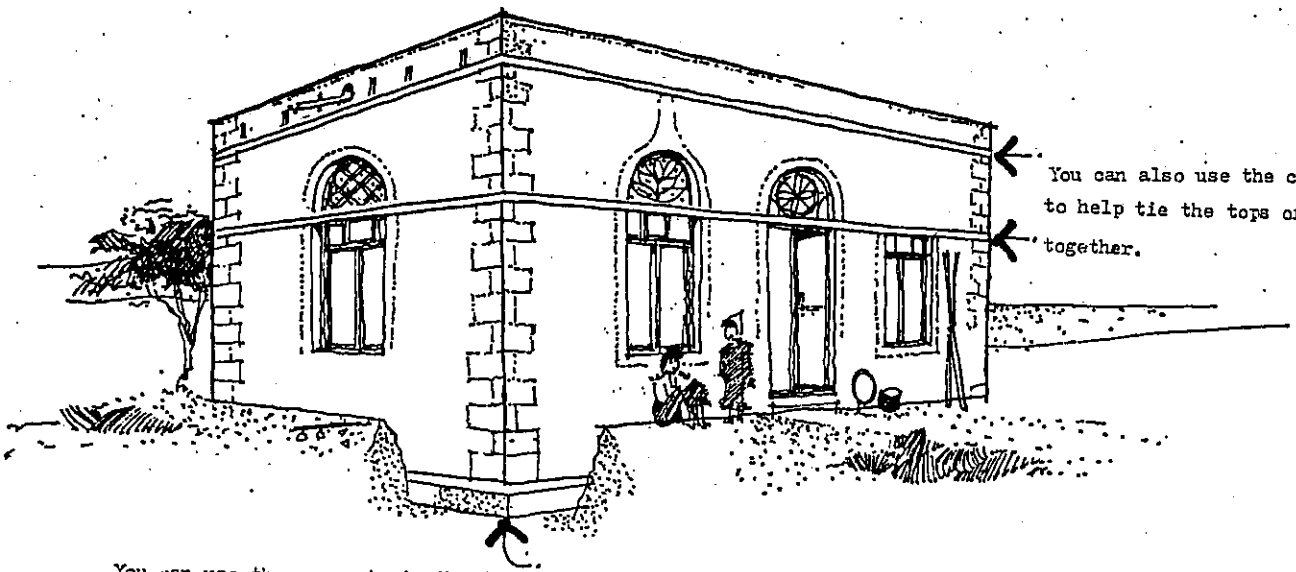
Mix this together until there is no water in the pile, and the mixture all has the same wetness.

Do not mix too much concrete at a time, as if it becomes too dry it will lose strength.

APPENDIX II

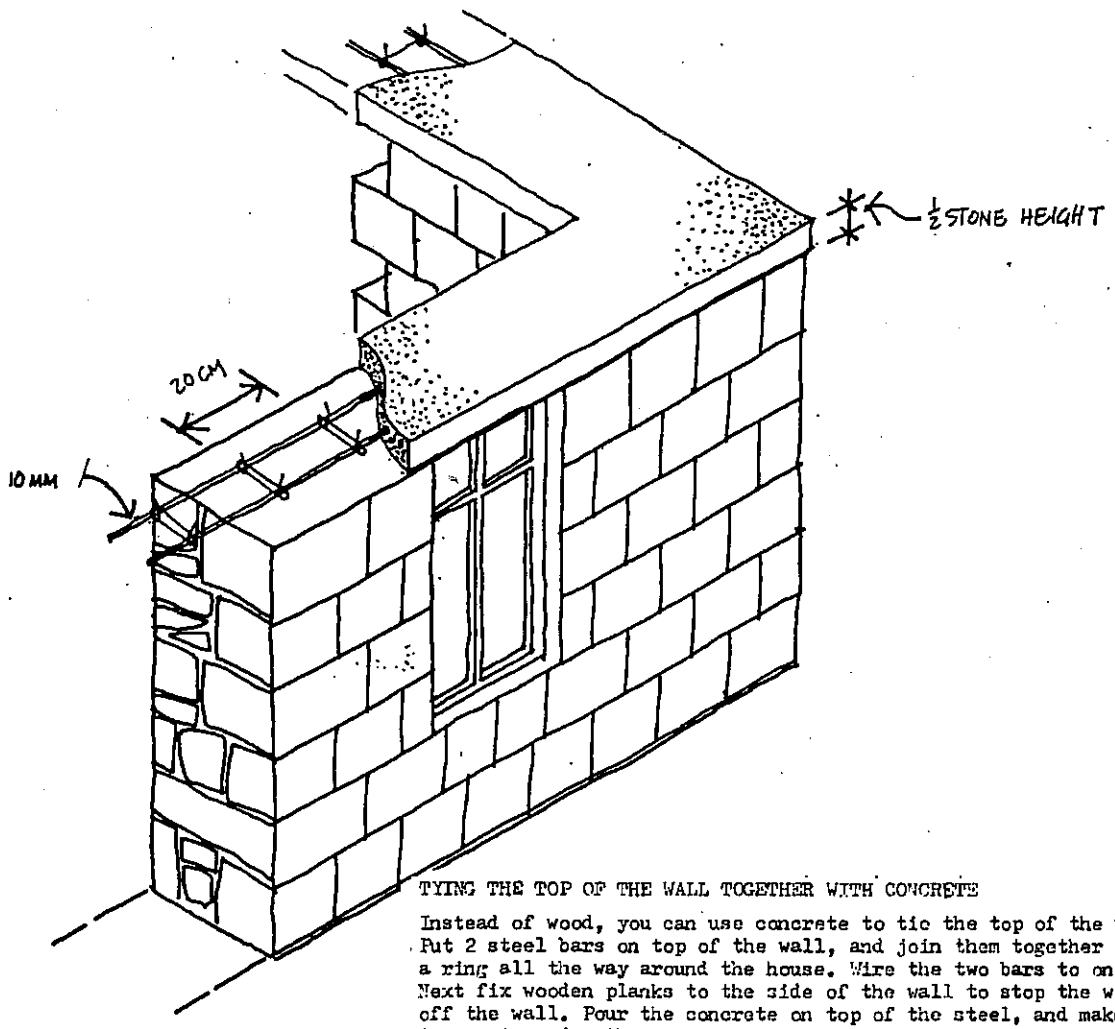
Selection of Educational Material drawn up for District Training Centre.

WHERE TO USE THE CONCRETE



You can also use the concrete to help tie the tops of the walls together.

You can use the concrete in the foundations of your house instead of stone. The foundation will need to be as deep as the width of the wall above it. Follow the same method as for stone foundations when you excavate. To make the concrete even stronger, you can put 2 steel bars of 10mm in the trench before you pour the concrete. Make sure the steel runs all the way around the trench and is joined at the ends.

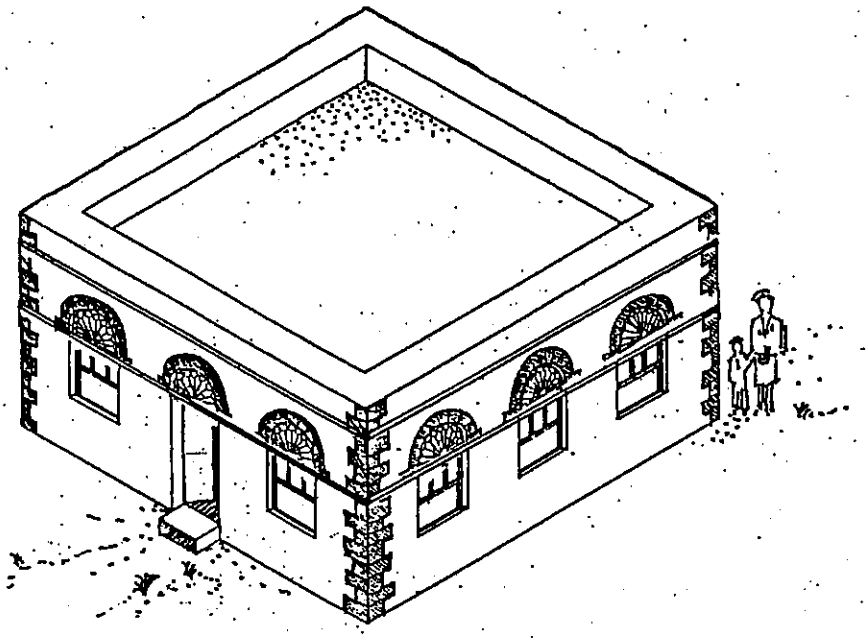


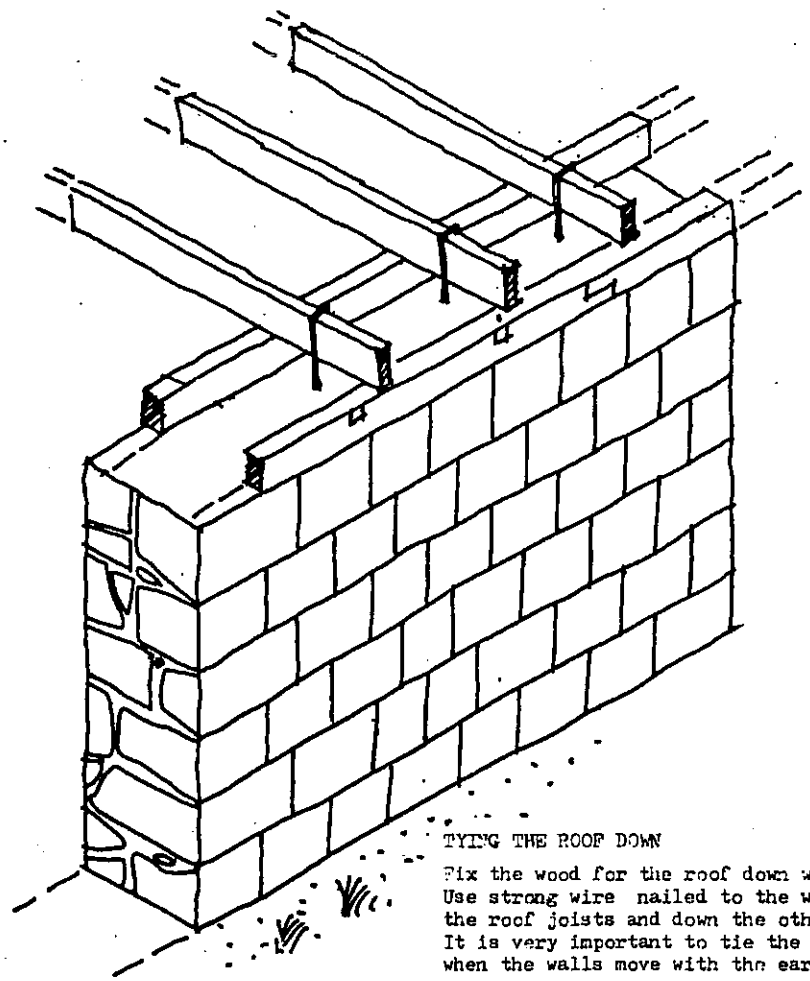
TYING THE TOP OF THE WALL TOGETHER WITH CONCRETE

Instead of wood, you can use concrete to tie the top of the wall together. Put 2 steel bars on top of the wall, and join them together so that they make a ring all the way around the house. Wire the two bars to one another. Next fix wooden planks to the side of the wall to stop the wet concrete running off the wall. Pour the concrete on top of the steel, and make sure that there is no air under the wet mixture by pushing it down with a spade. Let the concrete dry for a day before you remove the wood. Splash water on top of the concrete for the next 3 days to stop it drying too fast, or it will crack.

TIE THE WHOLE HOUSE TOGETHER

Make sure that the steel and the concrete is on top of all the walls of the house. This will help to tie the whole house together.



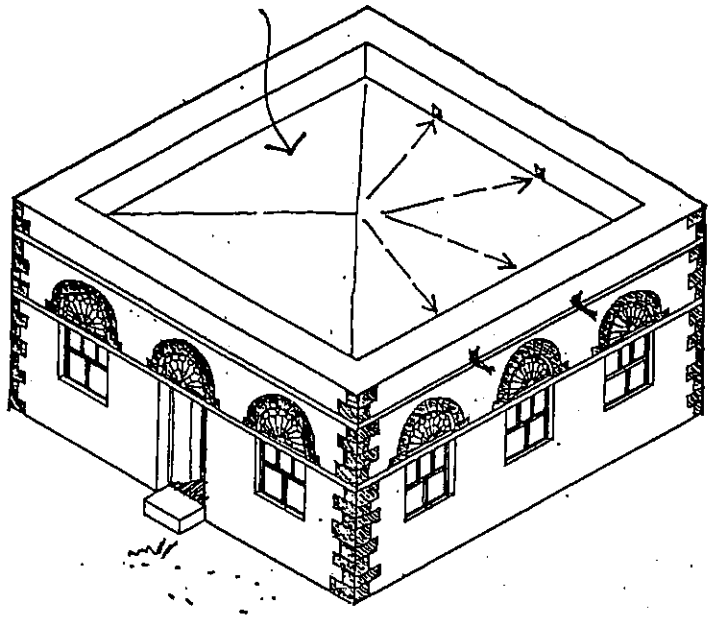


TYING THE ROOF DOWN

Fix the wood for the roof down well to the walls below.
Use strong wire nailed to the wooden beam in the wall, and twist it up over the roof joists and down the other side. Then nail it down so that it is tight.
It is very important to tie the roof to the walls, to stop it falling down when the walls move with the earthquake.

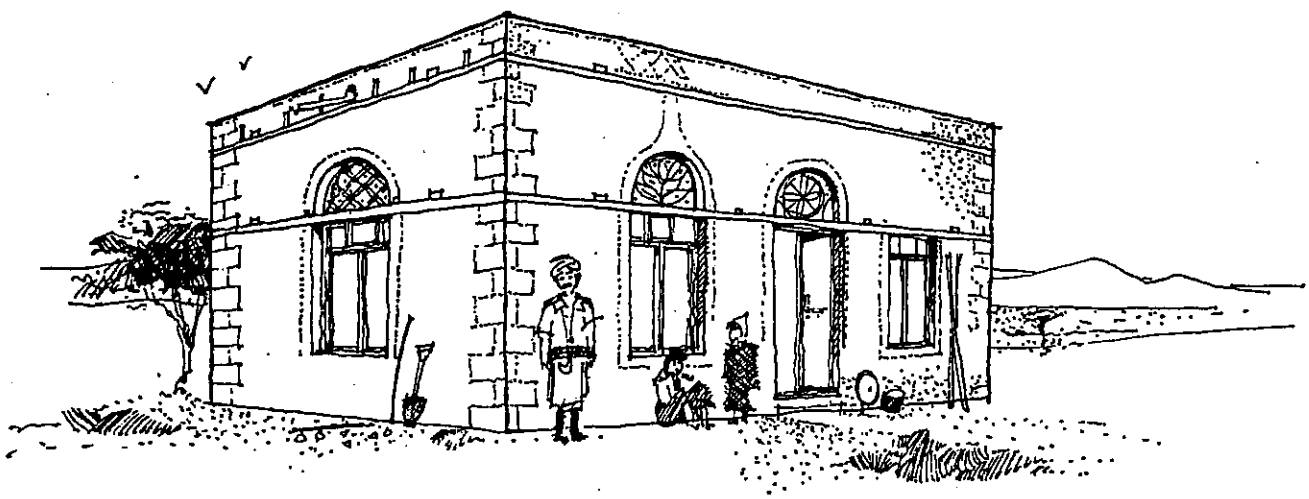
KEEPING YOUR ROOF DRY

Make sure that your roof slopes enough, so that the rain runs off it quickly.
If not, the rain will soak down through the roof and make it very heavy.
If the wood under the roof gets wet, it will become weak in time.



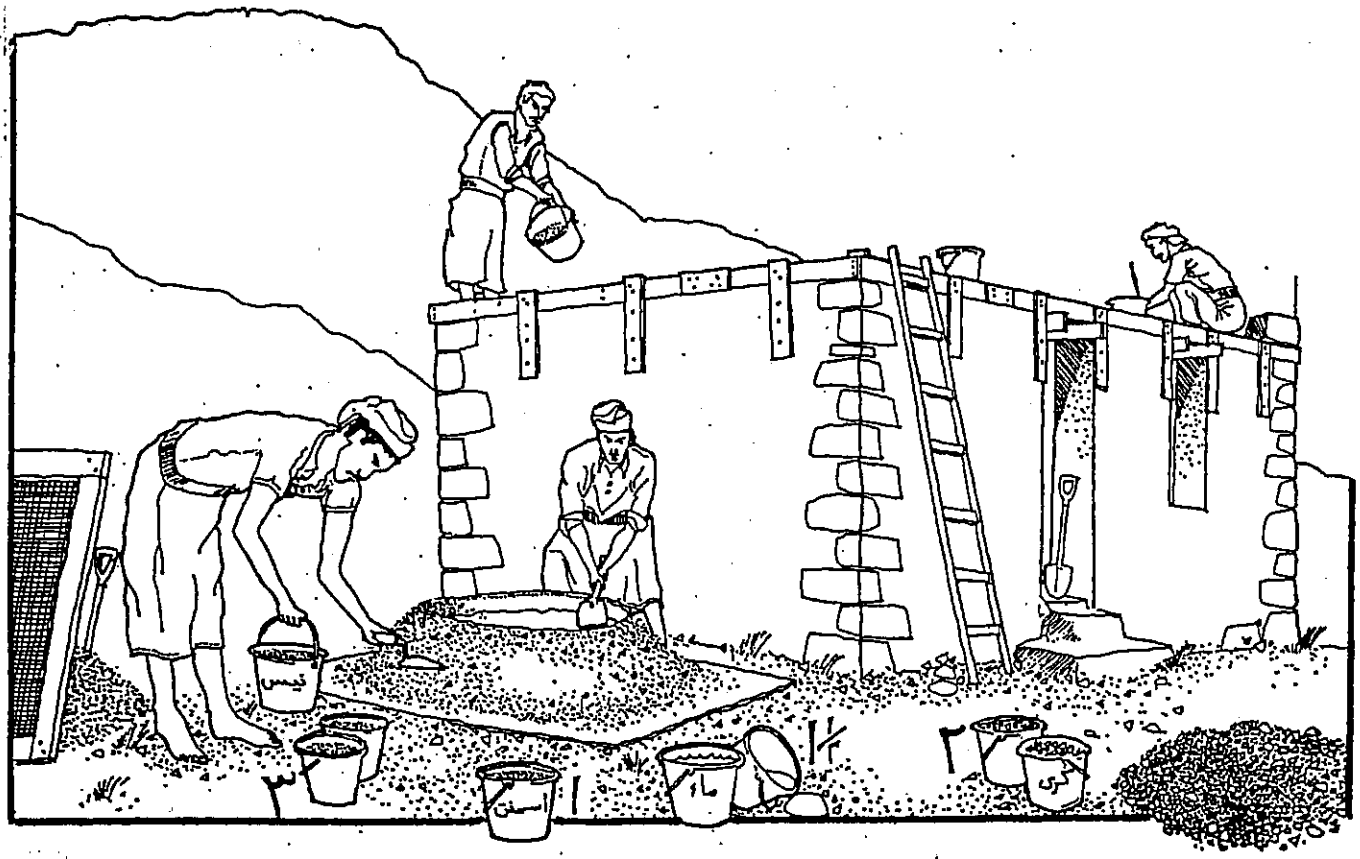
REMEMBER

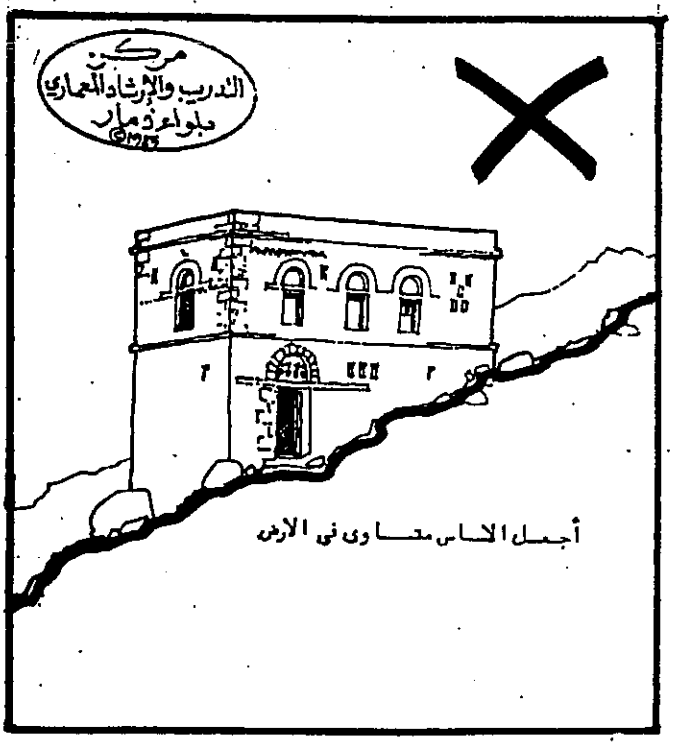
Mix the cement mortar well.
Use big stones in the walls and foundations of your house.
Put steel in the corners to make them strong.
Tie the walls together at the top with wood or steel and concrete.
Tie the roof on to the wall.



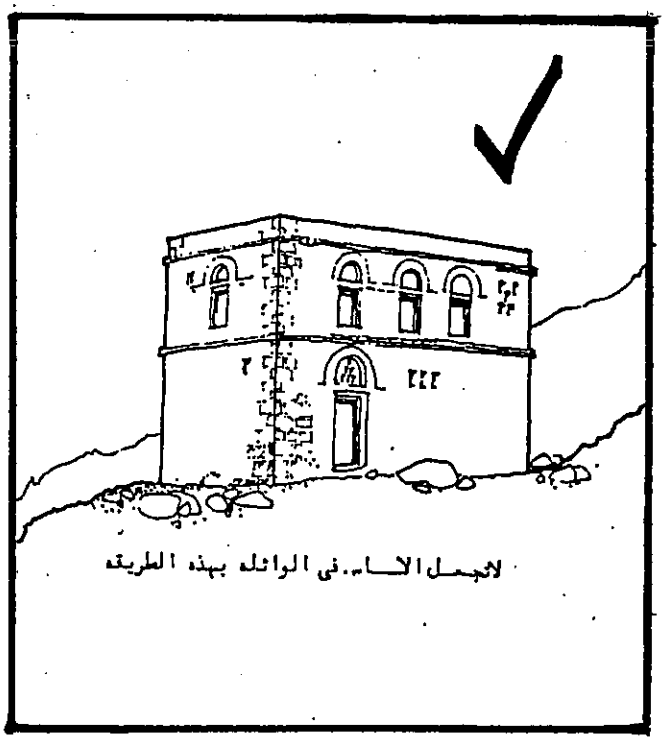
THINK BEFORE YOU BUILD
Produced jointly by:
Concern (Ireland)
Oxfam (United Kingdom)
Redd Barna (Norway)
In collaboration with the Executive Office of the
Supreme Council for Reconstruction of Earthquake
Affected Areas.

كيفية عمل خلطة الخرسانة العادية

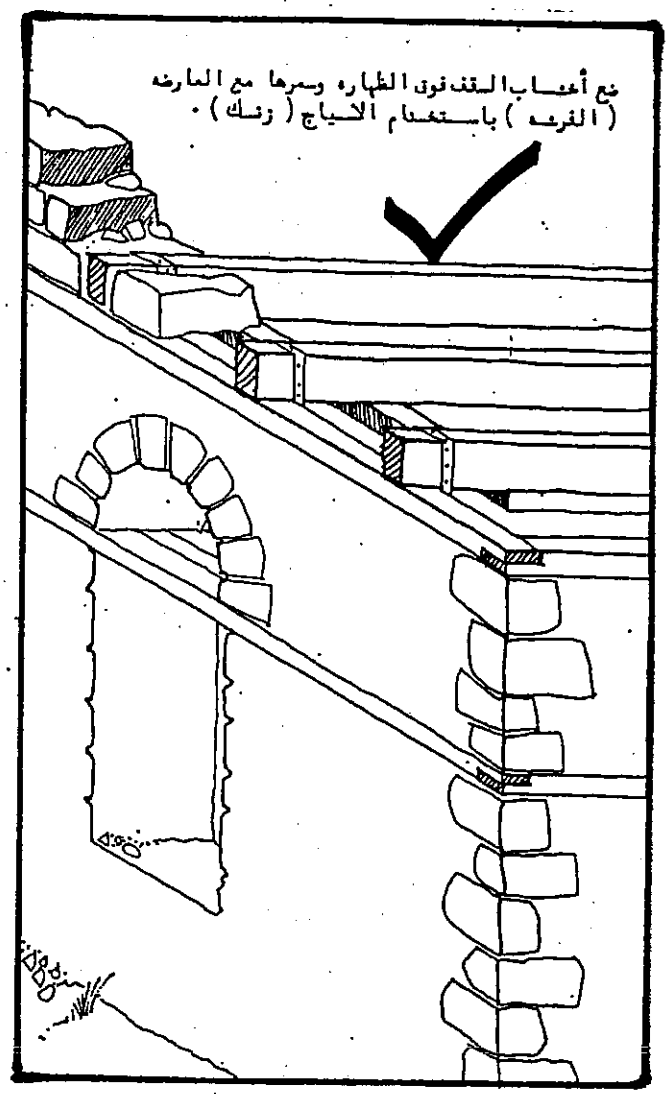


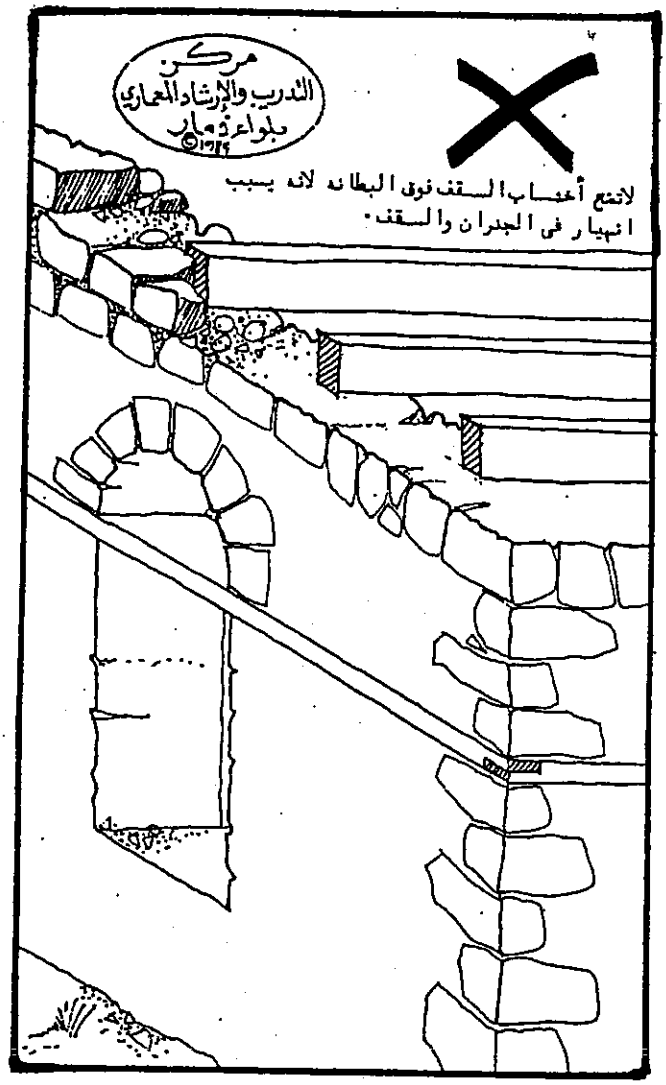


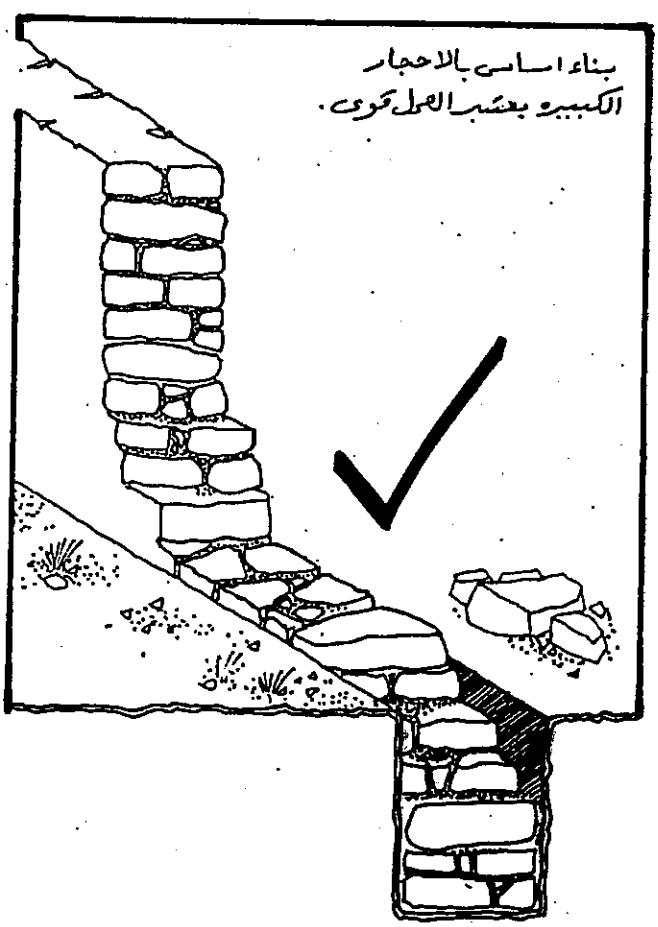
أجعل الأساس محتوى في الأرض



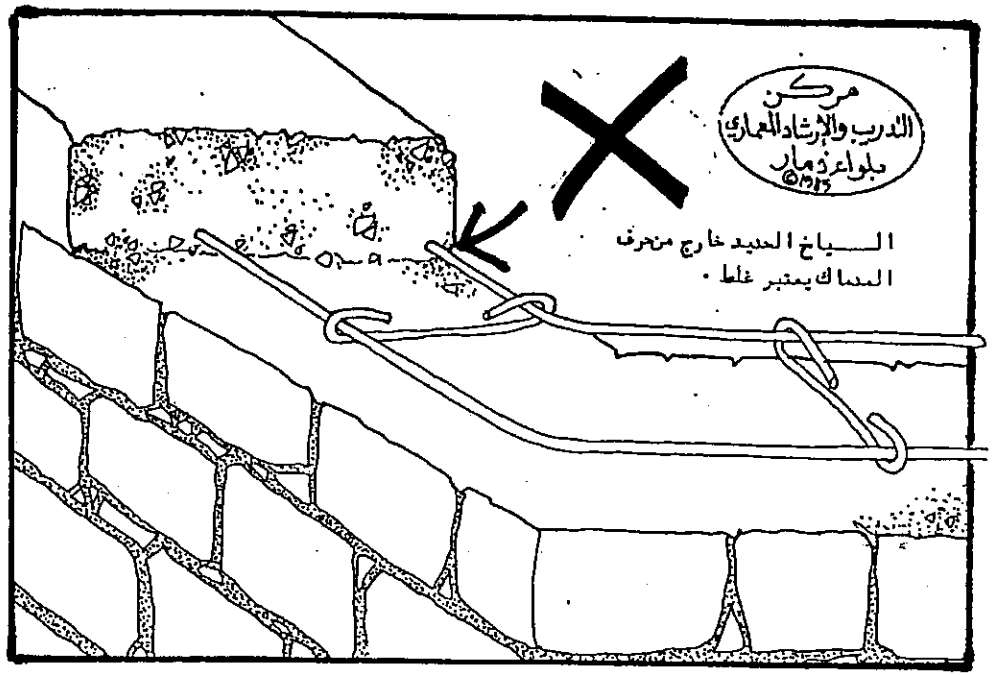
لاتجعل الأساس في الوائله بهذه الطريقه

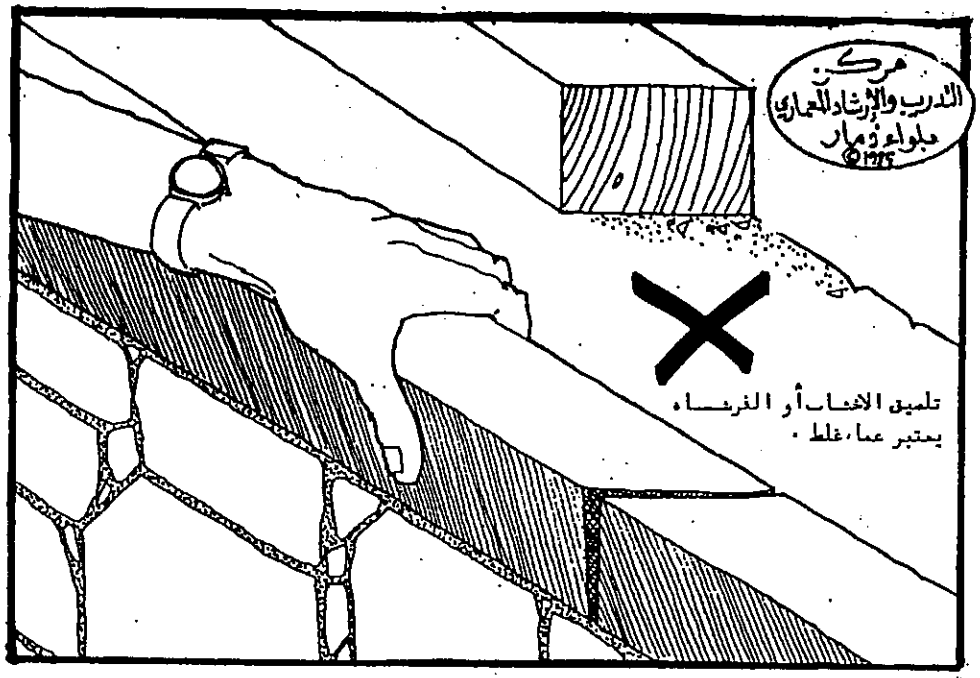

ضع أعتاب السقف فوق الطاره وسمرها مع العارضه
(الفرشه) باستخدام السياج (زنك) .

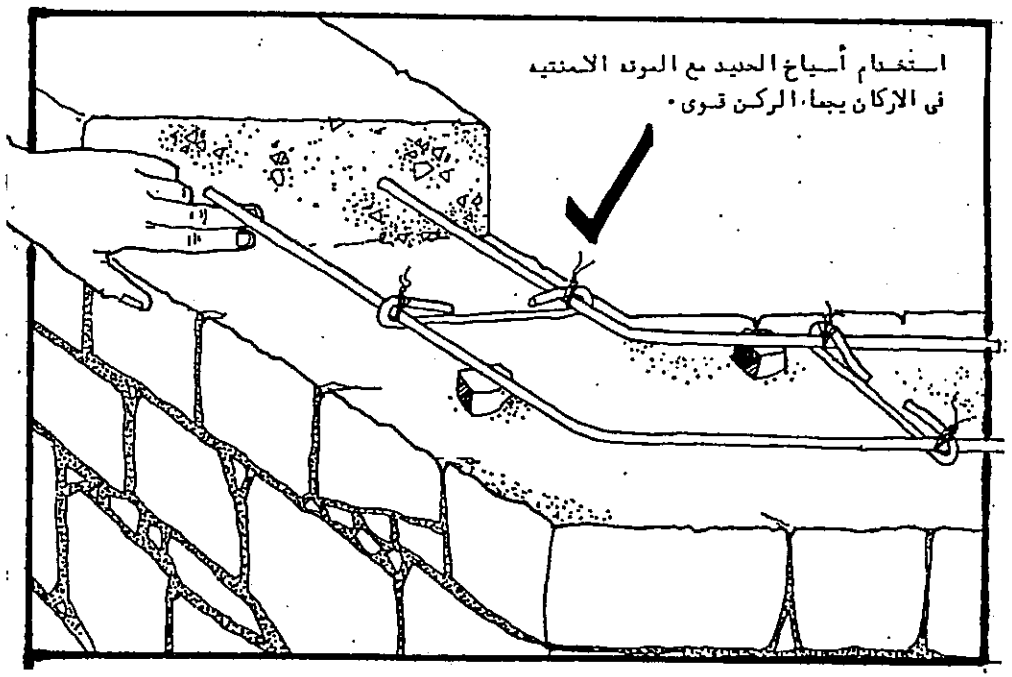

مركز
التدريب والإرشاد المعماري
بلواء ذمار
لاتضع أعتاب السقف فوق البطانه لانه يسبب
انهيار فى الجدران والسقف .

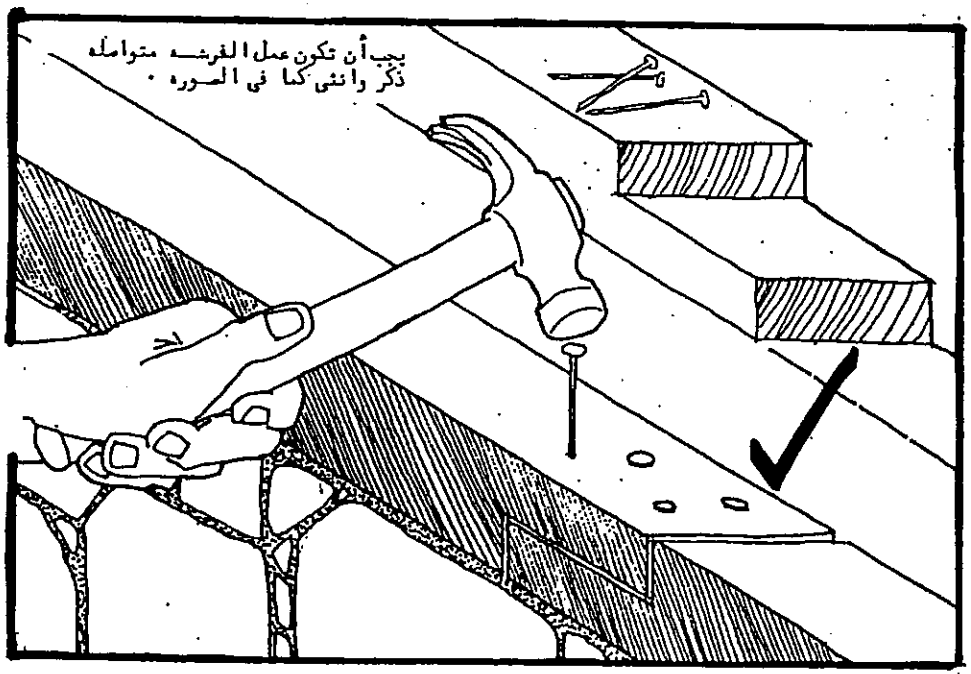

بناء اساس بالاحجار
الكبيره يعتبر العمل قوى .


مركز
التدريب والإرشاد المعماري
بلواء ذمار
بناء الاساس بالاحجار
الصغيرة يعتبر غلط .


مركز
التدريب والإرشاد المعماري
بلواء زمار
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السباخ الحديد خارج منحرف
المدماك يعتبر غلط .


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تلميس الاقشاب أو الفرشاه
يعتبر عمل غلط .


استخدام أسياخ الحديد مع الوتد الاسمنتيه
فى الاركان يجعل الركن قوى .


يجب أن تكون عمل الفرشه متوازيه
ذكر وانثى كما فى الصوره .



1. The Buiding Advice and Training Centre in Dhamar.



2. Practical training of builders.



3. Video films form part of the training course.



4. Discussion of the training booklet.



5. Practical demonstration of skills forms part of the course.



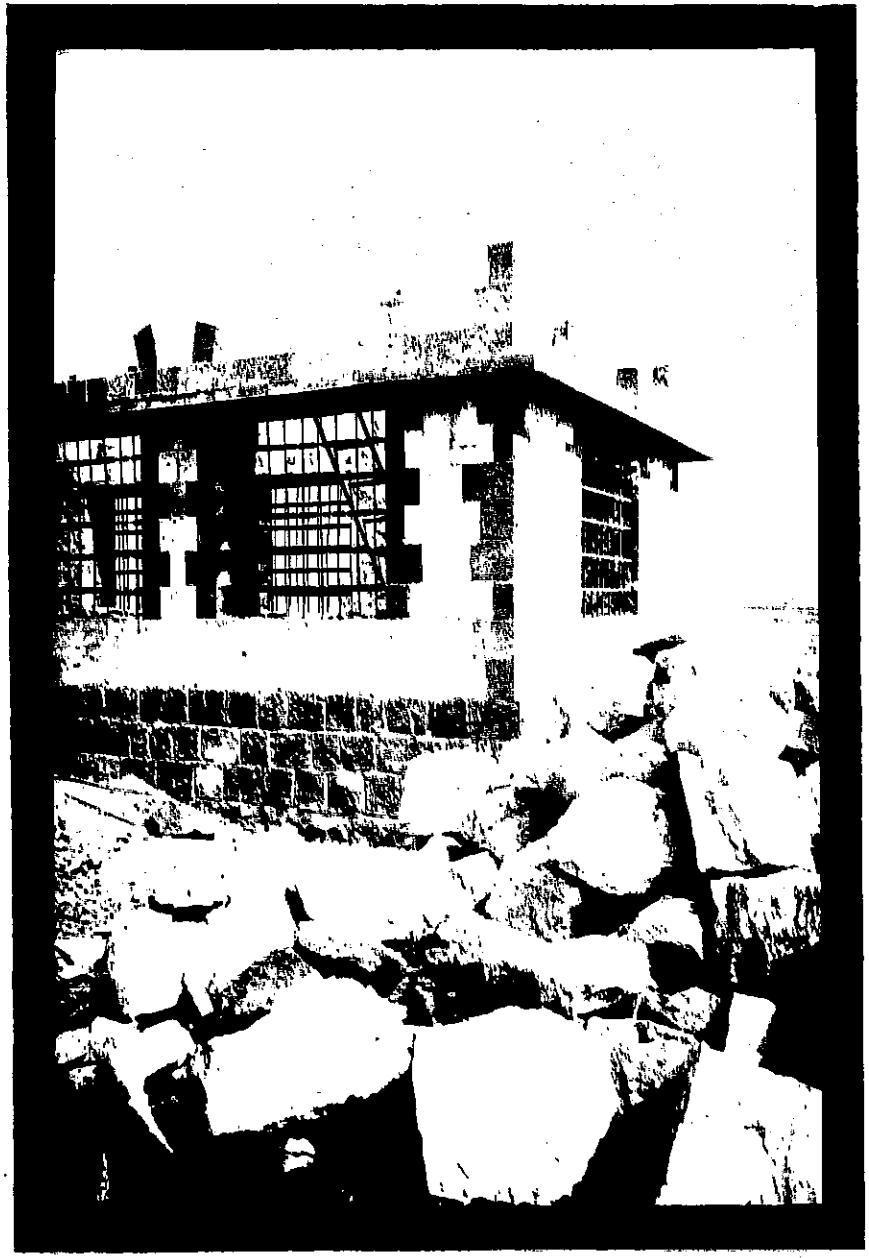
6. A demonstration building at the Dhamar Training Centre.



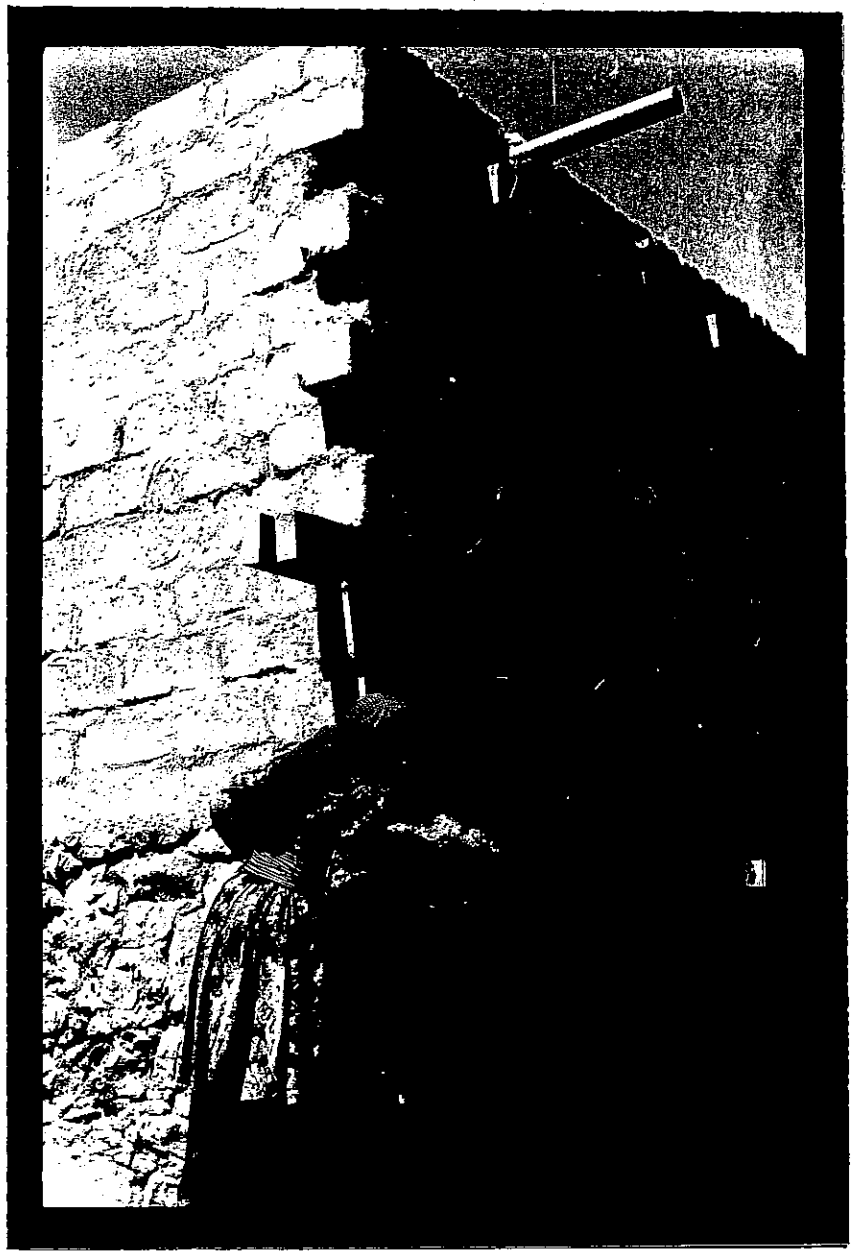
7. Consultation with village builders about new construction.



8. Good quality blockwork construction with reinforcement by a trainee in Dhamar.



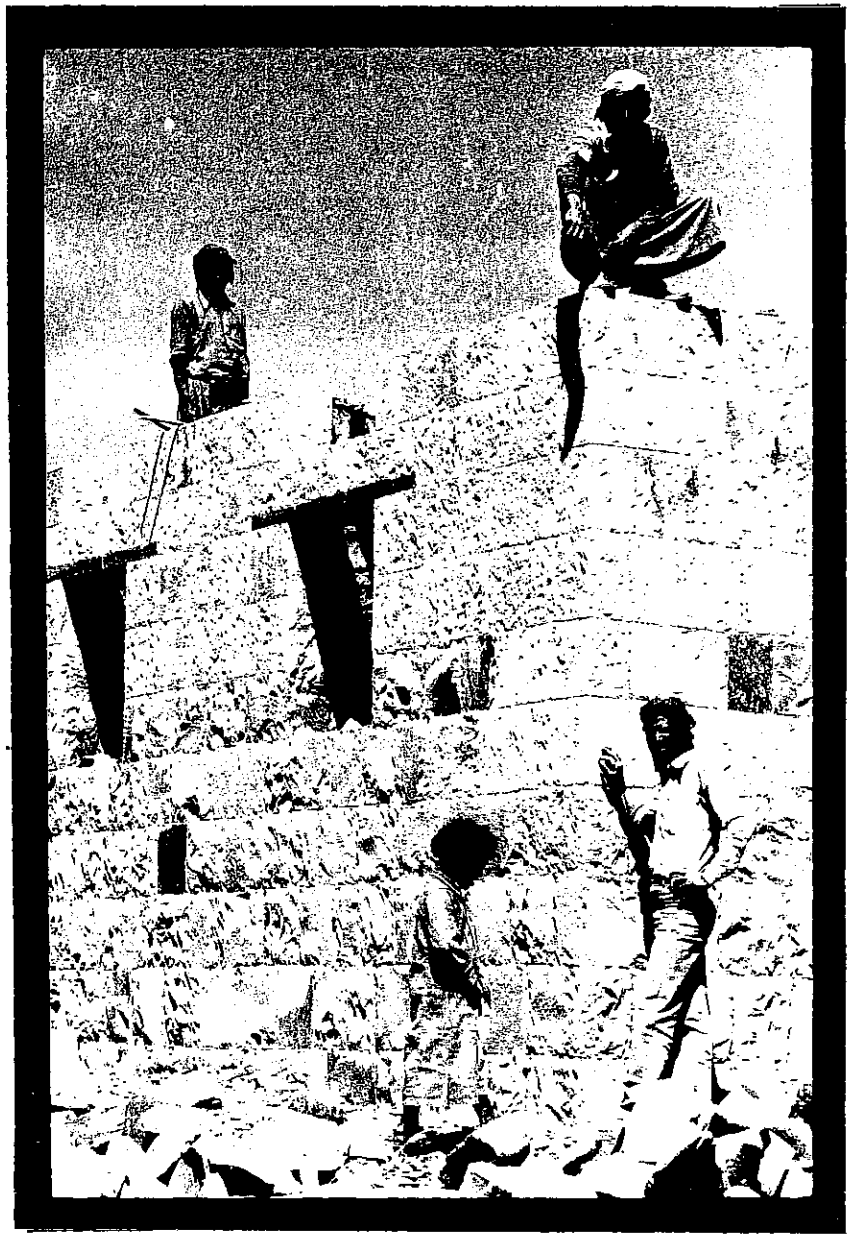
10. Good quality stone construction with reinforcement built by a trainee in Dhamar.



9. Some details of reinforcement have been misunderstood by trainees in their subsequent buildings.



12. Practical training with blockwork.



11. In some cases traditional construction is of good quality, although unreinforced.