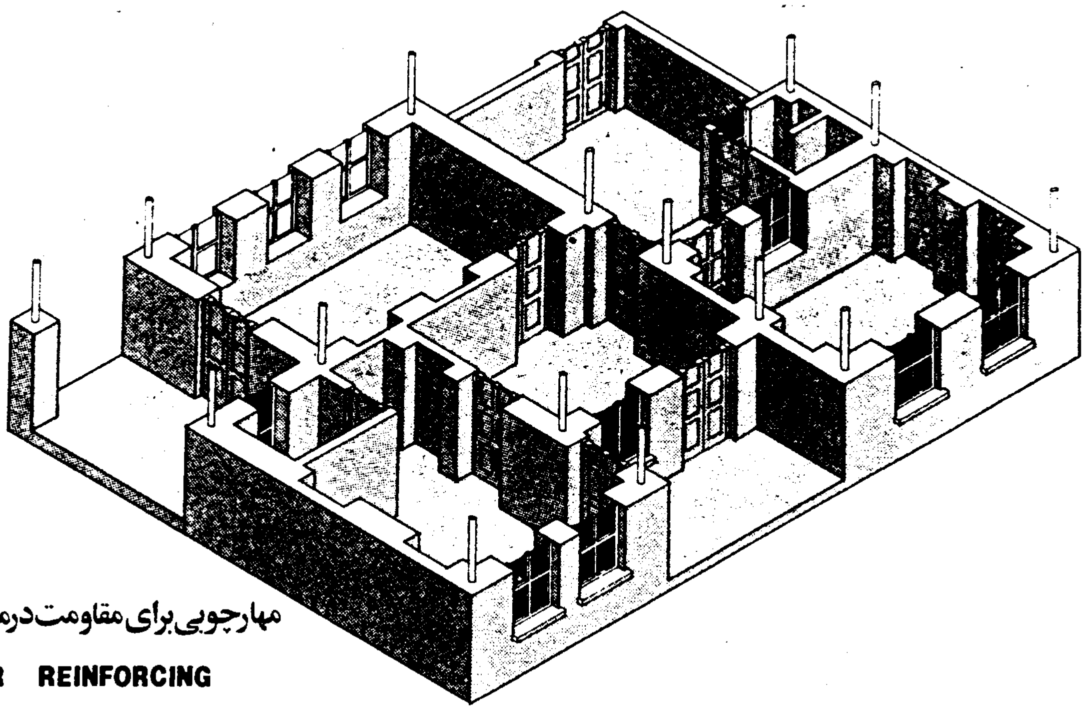
A STRATEGY FOR DEVELOPING INDIGENOUS BUILDING IN EARTHQUAKE REGIONS



مهارچوبی برای مقاومت درمقابل زلزله

TIMBER REINFORCING FOR EARTHQUAKE RESISTANCE

CASE STUDIES OF THE BANDAR ABBAS (1977) AND THE ZARAND (1978) EARTHQUAKES

Development Workshop

A STRATEGY FOR DEVELOPING INDIGENOUS BUILDING IN EARTHQUAKE REGIONS

CASE STUDIES OF THE BANDAR ABBAS 1977 EARTHQUAKE AND THE ZARAND 1978 EARTHQUAKE

BY

DEVELOPMENT WORKSHOP

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These case studies are based on a working paper prepared on behalf of the Centre for Endogenous Development Studies, Teheran.

CONTENTS

1.0 INTRODUCTION

This report discusses indigenous village building methods in earthquake regions. It proposes a methodology for the upgrading of village building - to better withstand earthquakes - involving local people themselves and materials and technologies which remain in their hands. The report is prepared in light of surveys carried out in the areas of the Bandar Abbas earthquake in March 1977 and the Zarand earthquake of December 1977.

The conventional approach to earthquake construction has two common features: developing earthquake resistant structures in technical institutions, and introducing these structures into a region usually through a resettlement programme after an earthquake has occurred.

The people of the region are neither involved in the development nor implementation of the structures, and these structures, although they may meet earthquake resistance requirements, often ignore other needs. In several cases the conventional approach has failed when people have left their newly provided houses and have repaired and moved back into their old homes.

In areas of earthquake destruction, such as the rural Siah Ho region north of Bandar Abbas, whilst a certain amount of reconstruction work can be done with the help of external government aid, using the services of contractors and materials imported into the region, much of the reconstruction work and certainly most of the future building will be done by local people themselves. In a remote mountain area, a combination of extremely poor or non-existent road connections and local poverty make the large-scale importation of building materials and equipment impractical over a long term. Through the development of indigenous building methods, solutions can be reached which are economically, socially and environmentally suited to the region and remain within the control of local people. Simple improvements in local building methods in the Siah Ho and Zarand areas would have prevented much of the damage and loss of life which did occur.

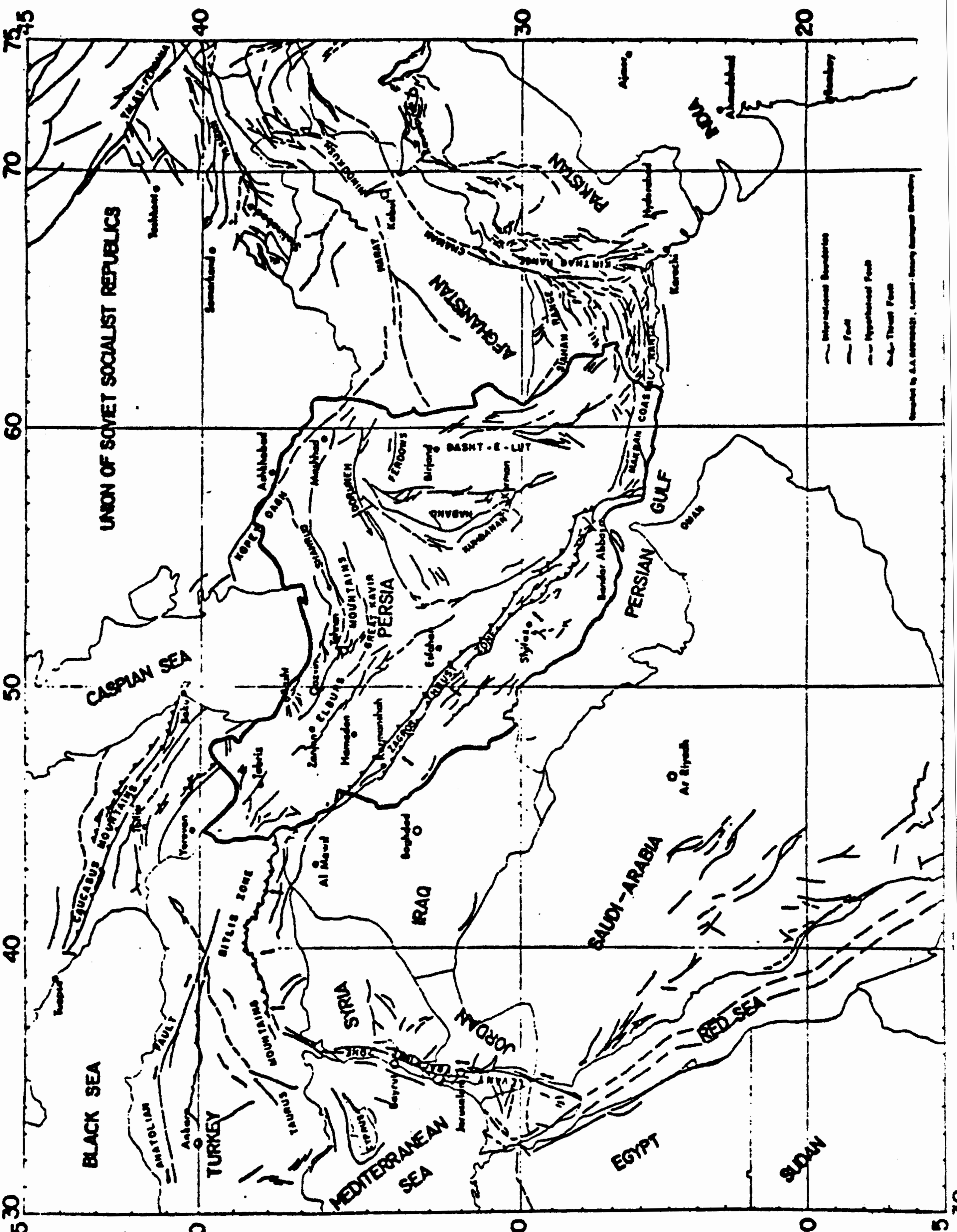
This paper has two main parts: the first part assesses the effect of earthquakes on the indigenous building types in the two areas surveyed, and the second part proposes a methodology for the introduction of improved building techniques into earthquake areas. A programme of short training workshops held in rural areas, in which village builders participate is proposed as a way of upgrading indigenous building techniques. A case-study is used to illustrate this.

MAPS

FIELD STUDY AREAS

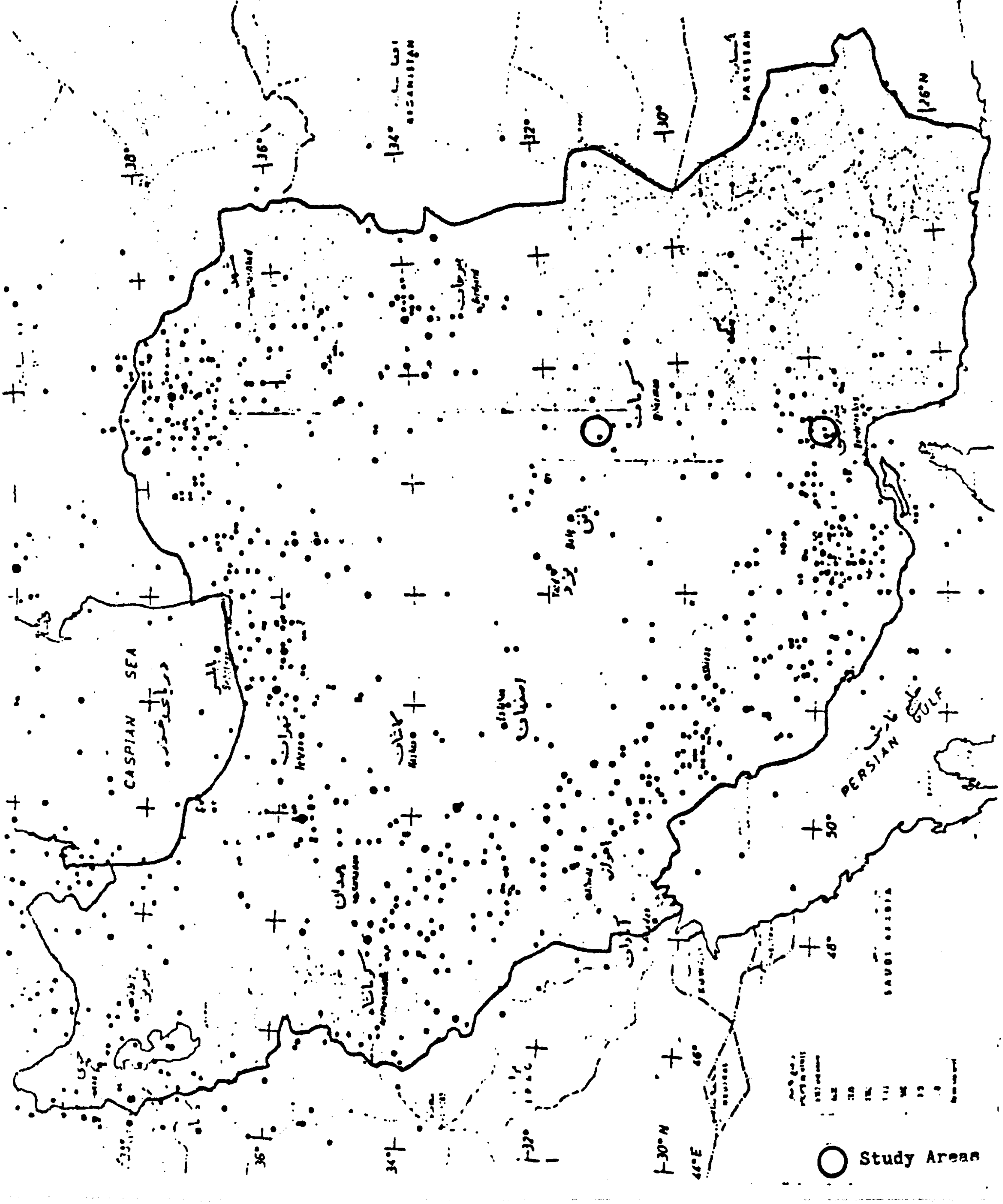
MAJOR FAULTS IN MIDDLE EAST REGION

Ref. Building and Housing Research Centre. Tehran, Iran.

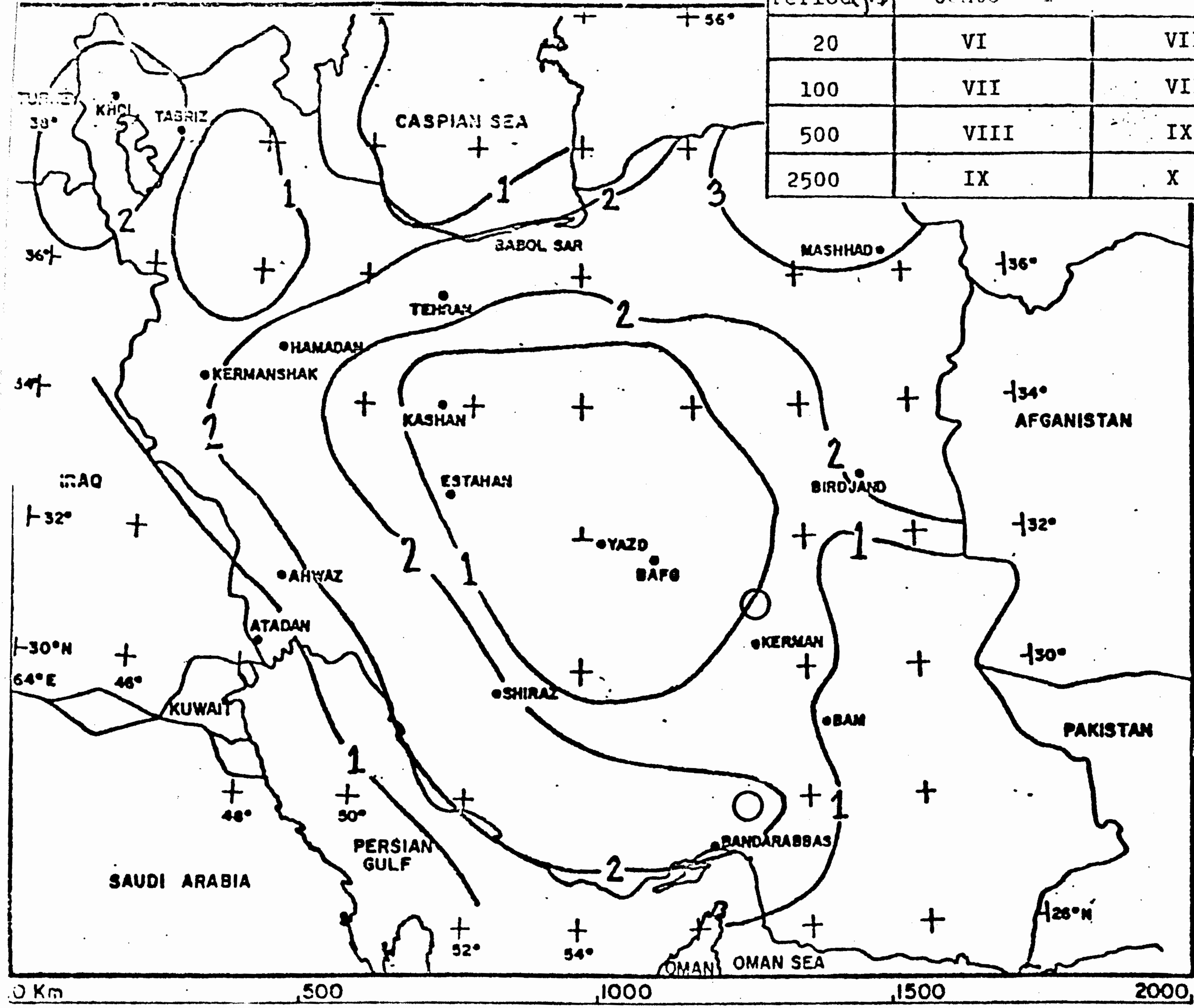


EPICENTERS FOR IRAN

Ref. Building and Housing Research Centre, Tehran. Iran.



Period(yrs)	Conto… 1		
20	VI	VII	VIII
100	VII	VIII	IX
500	VIII	IX	X
2500	IX	X	XI



EARTHQUAKE INTENSITY CONTOUR MAP

Ref. Building and Housing Research Centre, Tehran. Iran.

○ Study Areas

2.0 SURVEY OF EARTHQUAKE AREAS

2.1 Bandar Abbas

The Bandar Abbas area was visited by members of the Development Workshop in March 1977 (Farvardin 2536), a few days after the major earthquake shocks occurred. The Siah Ho area, about 60 kms to the northeast of Bandar Abbas, was one of two areas that suffered the worst damage from the earthquake. The villages of Khoorgar, Sarkhah and Gi shan were visited. In all three villages there were no buildings that were undamaged by the earthquake. An extremely high proportion of the buildings had either partially or totally collapsed. Of the range of buildings seen in the area, no one type appeared to have escaped earthquake damage, although certain elements and techniques had offered greater resistance to damage.

Three main local types of construction are used in the region: palm frond stem shelters; mud brick walls with flat timber and mud roofs; and stone walls with flat timber and mud roofs. In addition, a few buildings have been built using techniques and materials imported from outside the area.

2.1.1 Palm Frond Stem Shelters - "Kapar":

Shelters using a timber framework - usually palm tree trunks - and using palm frond stem matting for covering the roof and sides, are used for summer houses and for animal shelters as well. Because of their framed construction and lightweight panel cladding, these shelters remained largely intact and provided valuable emergency shelter after the earthquake. There were some examples where part of the support for the matting roof had collapsed, usually where part of the shelter was supported by a mud or stone wall which had collapsed. However, these shelters indicated some important points in earthquake protected construction: firstly, that a framed construction that can move intact is less damaged; and secondly, that lightweight roofing, even in the event of collapse, causes less damage and injury.

The other two types of construction (mud brick and stone) both had flat roofs using timber beams, matting and mud.

2.1.2 <u>Mud Brick Walls - "Divaar Kheshti":</u>

The failure of these walls was facilitated by the lack of bonding through the width of the wall. Walls were built with an outer and inner course of bricks, with only the mortar to hold the two halves together. These two halves tended to separate during the tremors, so that neither half consequently was strong enough or thick enough to stand up on its own or to support its load, leading to collapse. In the absence of observing the actual collapse of these buildings, it is not possible to state accurately which part collapsed first or exactly how; however, the lack of bonding would facilitate the total disintegration of the wall. There was also evidence that the strength of the walls had been reduced by termite bore holes, which seemed particularly the case for the mud mortar used between the bricks, which may have been prepared with less care than the mud bricks themselves. Similarly, where timber had been embedded into the walls (basically a good practice in reinforcing and framing the walls of a building for earthquake protection), it had been attacked by subterranean termites and substantially weakened. There were some instances where walls had fallen intact as a result of the movement. Examples of this were particularly apparent where existing openings had been filled in at a later date with no bond to the sides of the opening and with nothing to resist the collapse of the added wall, which in several cases was seen lying almost intact on the ground.

In all these cases, the instability of the wall was increased by sub-standard foundations, or none at all.

2.1.3 <u>Stone Walls, Rubble and Mud Mortar:</u>

Stone walls were most commonly built using mud mortar which provided practically no adhesive bond between the stones, and therefore little to stop the whole wall collapsing into a heap of rubble when shaken.

Additionally, stone walls were built with no bonding - small round stones placed on top of each other formed the two sides of the wall, with general rubble and earth filling in the gap between. In many cases the outer surface had simply peeled off. Elsewhere the two sides had separated and had both fallen away. If walls are load bearing, any s uch failure will cause the roof to collapse.

There were very few examples of stones being laid in such a way as to bond one side of the wall to the other. Where stone had been properly laid with a bond, and good mortar used, the building had suffered far less damage.

2.1.4 Corners:

In both stone and mud wall constructions, the corners were the weakest points, and even where the building had not totally collapsed, there were severe cracks at or collapse of the corner. This is due to the weakness resulting from the two different orientations of the walls in relation to the movement of the ground, causing conflicting movement in the walls. Once again, the absence of proper bonding had increased this effect.

2.1.5 Openings:

Nearly all the openings had been spanned with timber lintels. Because in most cases the lintels projected only a small amount into the wall on either side, the timber pulled out and the structure above collapsed. Even where the projection was sufficient, severe cracking on either side of the opening occurred.

The position of the opening was also important. Where openings occurred close to the corners, the combined effect of the corner and the opening resulted in greater cracking and more often collapse.

2.1.6 Roofs:

Clearly the collapse of walls supporting a roof will cause the roof to collapse as well. However, it was noted that walls carrying a roof load were more likely to fail than those carrying only their own weight. Where the timber beams did not project far enough over the wall, the outward movement of the wall resulted in the beams slipping off and pushing the wall over as the roof fell. Thus the roof itself can increase the likelihood of the wall collapsing where the junction between the two is not properly built. This situation was also seen with steel I beam construction.

Timber roofs using a large number of thin beams (of approximately 10 cm diameter) tended to remain in place better than roofs using fewer but larger beams. The load on the former type is more evenly distributed along the length of the wall, so that no one point is under too much pressure. The palm matting used over the timber beams was also helpful, since being flexible and in large sheets it could take up some of the movement.

2.1.7 New Materials:

Only one building, a school, was seen during the visit that used materials and techniques not readily available in the area. The walls were of concrete block and the roof made of steel I beams with brick jack arches. There was a sheet of chicken wire mesh under the roof structure onto which the plaster had been applied. All the walls were cracked and one of the loadbearing walls had totally collapsed. The roof had collapsed.

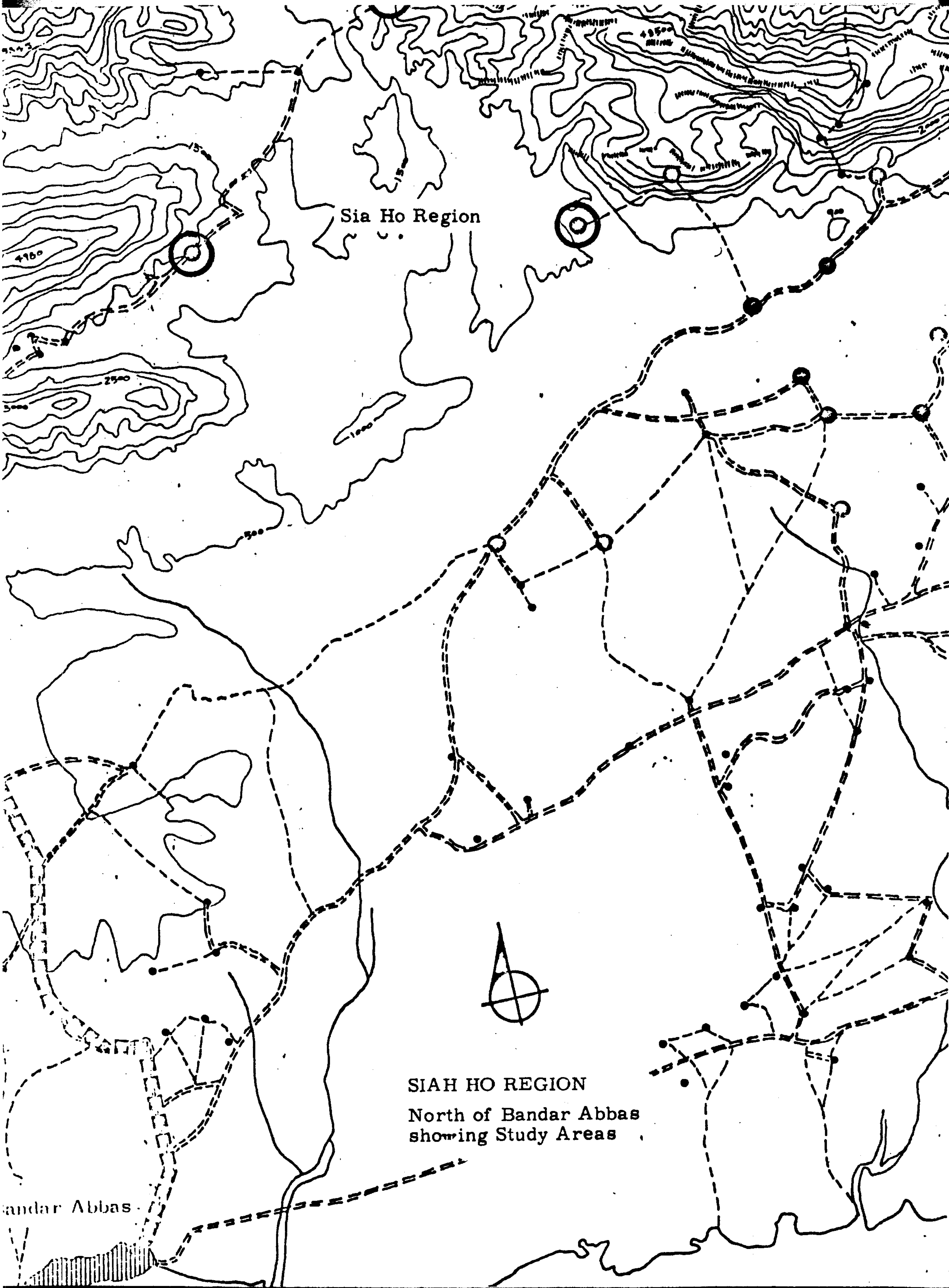
The steel I beams had not been tied together and overall the building had suffered from insufficient, and in parts non-existent framing. With the movement of the steel, the jack arches had also collapsed.

As a general comment, the standard of building was extremely poor, with very little technical ability. Much of the damage could have been avoided if the materials had been used properly and carefully.

BANDAR ABAS

SIA HO EARTHQUAKE REGION

<u>ILLUSTRATIONS</u>

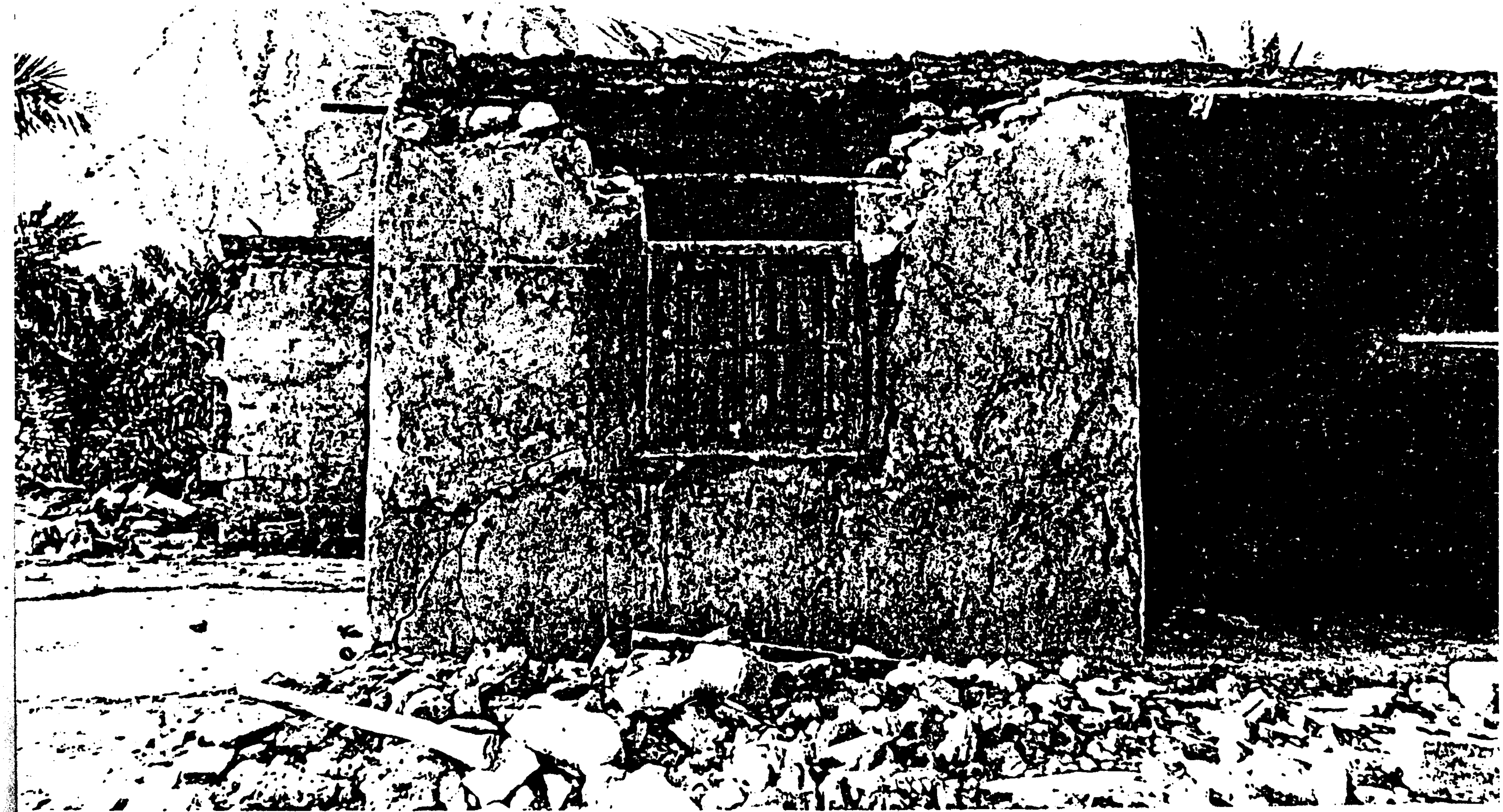

Sia Ho Region
SIAH HO REGION
North of Bandar Abbas
showing Study Areas
andar Abbas

Examples of wall failure due to lack of internal bondin

No bonding between
wall and external surfac

Examples of corner failures - due to stress concentratio
poor bonding and lack of reinforcement

Corner failure
and collapse of concrete



Lintels over doors and windows were not embedded deep enough into wall.

2.2 Zarand Earthquake

At 3.40 a.m. on 30th Azar 2536 (20th December 1977) an earthquake with a reported magnitude of 6.2 R. devastated three villages and damaged to varying degrees approximately seventy others in the Zarand region of Kerman. The loss of life was estimated at over 500 persons by the Red Lion and Sun Society. This area was visited by members of the Development Workshop on the 10th Bahman (30th January) in order to assess the nature of the damage to the local buildings.

The villages of Sar Bagh, Dartangle and Gisk, situated between six to ten kilometres north-east of Zarand, were the areas most damaged by the earthquake. Buildings had collapsed in other villages as well as the town of Zarand, but the extent of the damage in these areas was comparatively low. Almost all the buildings in the three main villages had partially or totally collapsed and very few structures could be considered rehabitable.

The great extent of this damage we attribute to the poor construction techniques used in the buildings rather than the magnitude of the earthquake. The majority of the buildings were constructed with rubble stone walls with vault and dome roofs. In the village of Dartangle, the old quarter was mainly mud-brick construction with rubble masonry buildings situated on the outskirts. Fired brick and steel I beams were used in a few buildings in the three main villages. Vaults were constructed mainly of rubble stone masonry, but some were of fired brick and mud-brick was also used.

2.2.1 Wall Construction:

Rubble Stone Masonry Walls - Stone walls were most commonly built using mud mortar, which provided practically no adhesive bond between the stones, and therefore little to stop the whole wall collapsing into a heap of rubble when shaken.

Additionally, stone walls were built with no bonding - small round stones placed on top of each other formed the two sides of the wall with general rubble and earth filling in the gap between. In many cases the outer surface had simply peeled off. Elsewhere, the two sides had separated and had both fallen away. If walls are load bearing, any such failure will cause the roof to collapse.

There were very few examples of stones being laid in such a way as to bond one side of the wall to the other. Where stone had been properly laid with a bond, and good mortar used, the building had suffered far less damage.

Mud-Brick Walls - The failure of these walls was facilitated by the lack of bonding through the width of the wall. Walls were built with an outer and inner course of bricks, with only the mortar to hold the two halves together. These two halves tended to separate during the tremors, so that neither half consequently was strong enough or thick enough to stand up on its own or to support its load, leading to collapse. It was also observed that the majority of the badly damaged mud-brick buildings were those poorly maintained. Thorough and regular maintenance of mud-brick buildings, especially against water damage, is essential to perpetuate their strength.

However, mud-brick buildings had shown greater resistance to collapse than the common stone structures. Even where they were badly damaged they had not collapsed totally and thus caused fewer deaths. The local people reported that the time lag between the tremors and the collapse of the buildings was greater in the mud-brick buildings than those constructed with stone and thus the inhabitants of the mud-brick buildings were able to escape. This is probably due to the greater adhesiveness and homogeneity between mud-brick and mud mortar.

2.2.2 Roof Construction:

Rubble Stone Vaults - This rather unusual technique of vault building consists of narrow arched "ribs" constructed from gypsym reinforced with thin branches. The arches are positioned at approximately one metre centres.

in between which rubble stone is placed in gypsum mortar.

This system of construction creates a very heavy roof, undesirable in earthquake areas. The stones are held together merely by the mortar, and the lack of bonding between them causes collapse in the event of earthquake movement. Hence the structure of the roof depends solely on the strength of the gypsum. The smooth edge of the arched ribs are not tied to the stone infill and therefore, as it was often the case, the vaults had sheared and collapsed at the junction of the ribs and the stone infill.

Mud-Brick Vaults and Domes - As in the case of the walls, mud-brick roofs performed better than the stone vaults. The homogenous nature of mud-brick roofs built with mud mortar enables them to behave similar to a shell structure, thus holding together in the event of earthquakes better than masonry structures. Another important factor is the lighter weight of the roof which has a lower moment of inertia, thus being more stable in case of movement. The mud-brick units which are considerably lighter than the stone are likely to cause much less injury to occupants in case of collapse.

It was observed that mud-brick domes withstood the earthquake better than the vaults. This is due to the double curvature of the domes distributing the thrusts in all directions. The vaults which were tied with reinforcing bars sufficiently anchored into the side walls proved to be much safer structures. In a series of vaults built side by side, the end vaults, if not properly tied, had collapsed and the internal vaults showed progressively less damage. In the internal vaults the opposing thrusts balance each other, while stresses are concentrated toward the end vaults, causing their collapse; thus, if the end vaults are strengthened, it would improve the resistance of the whole series of vaults.

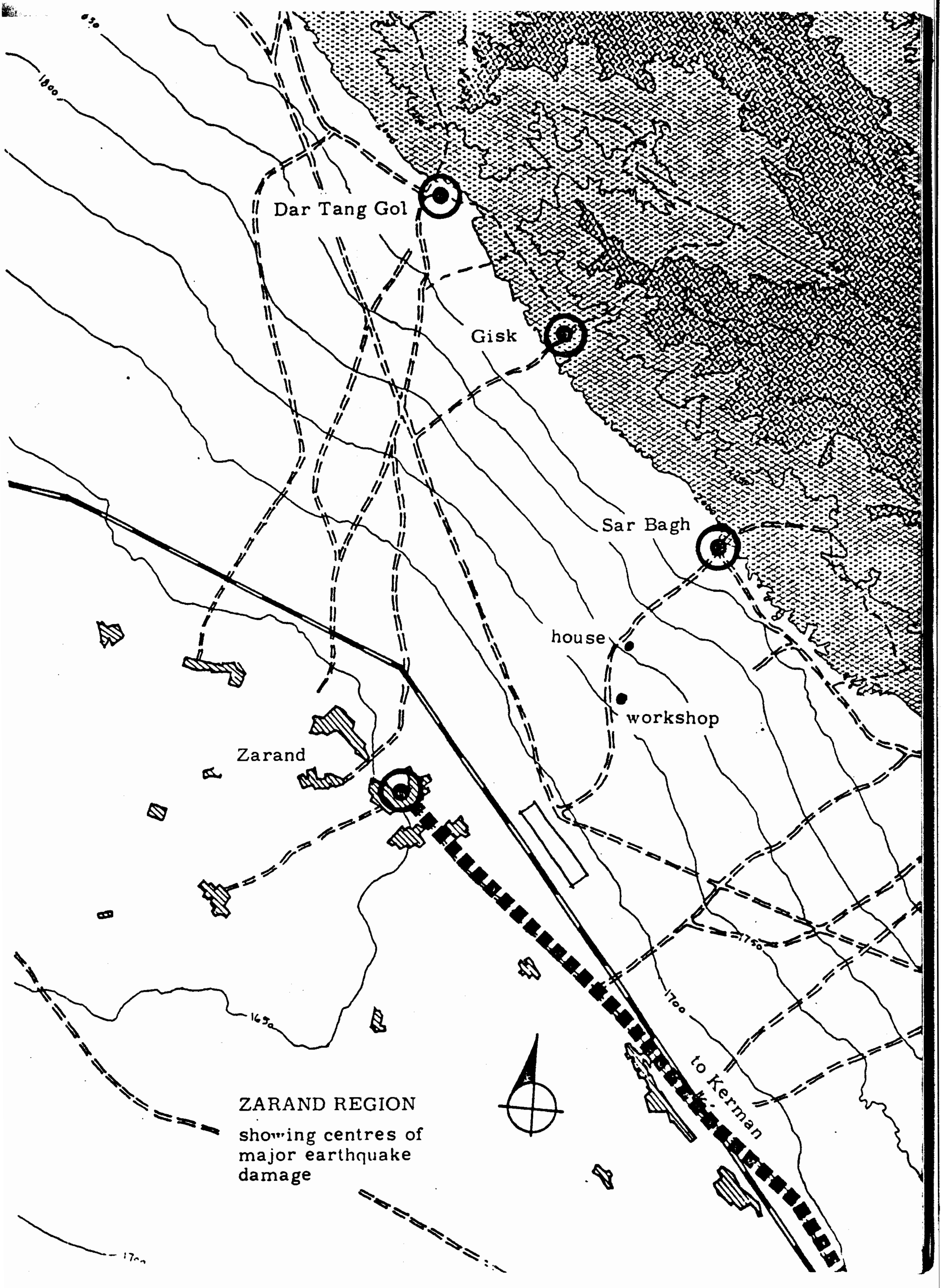
2.2.3 <u>Brick and Steel Construction:</u>

Very few such structures existed in the three villages of Sar Bagh, Dartangle and Gisk, but in Zarand, as in most Iranian towns, steel and brick jack arch construction is quite common. Generally, this form of construction could withstand earthquakes of such magnitude, provided the structure is framed and well tied together. In cases where the steel was not a framed structure, which we found to be frequent, it had caused collapse or partial damage.

In general, the buildings were of a very poor standard of construction. Apart from special precautions that need to be taken in seismic areas, correct and thorough construction and maintenance techniques is essential to ensure safety in the event of an earthquake. In the villages visited, sufficient consideration was not given to bonding, horizontal and vertical reinforcement and regular maintenance, especially of public buildings.

ZARAND EARTHQUAKE REGION

ILLUSTRATIONS



Dar Tang Gol
Gisk
Sar Bagh
house
workshop
Zarand
to Kerman
1800
1750
1700
1650
ZARAND REGION
showing centres of
major earthquake
damage

Gisk Village:

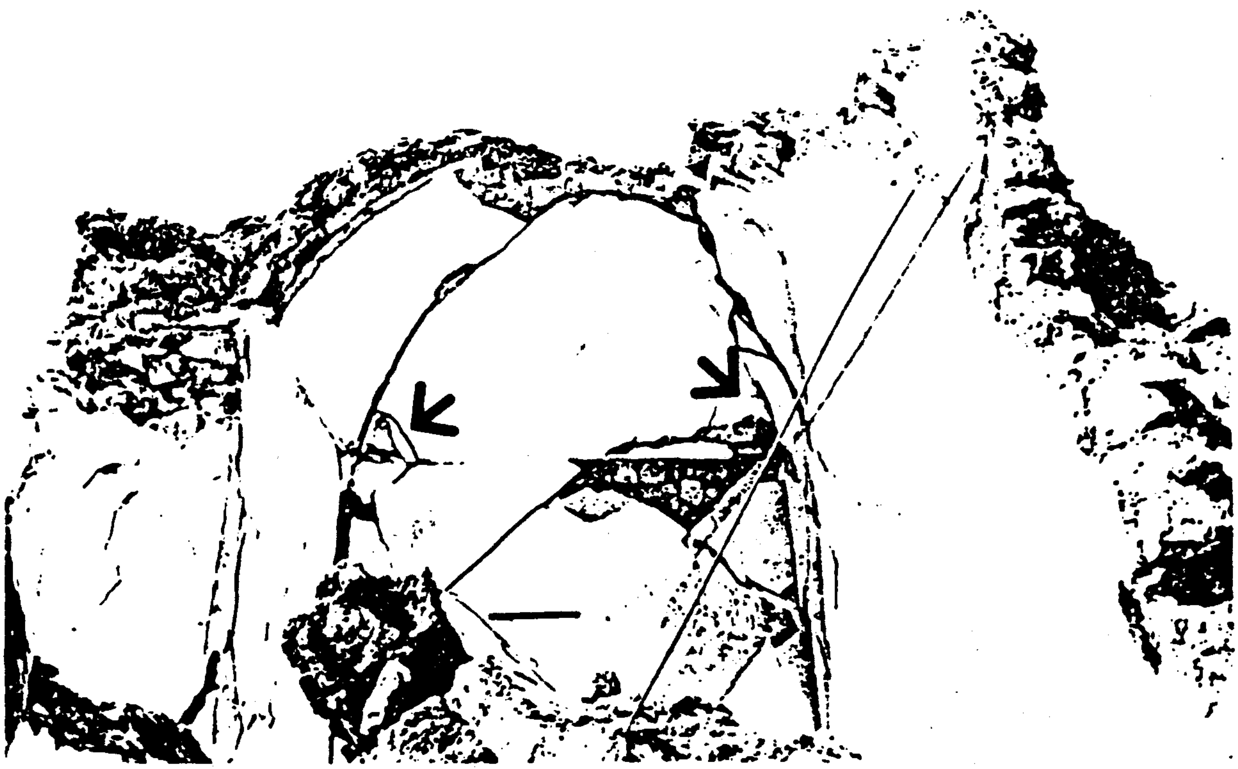
Metal tie rods anchored into reinforced horizontal beam at top of wall have prevented vault collapse. Horizontal timber beam set in cement mortar.

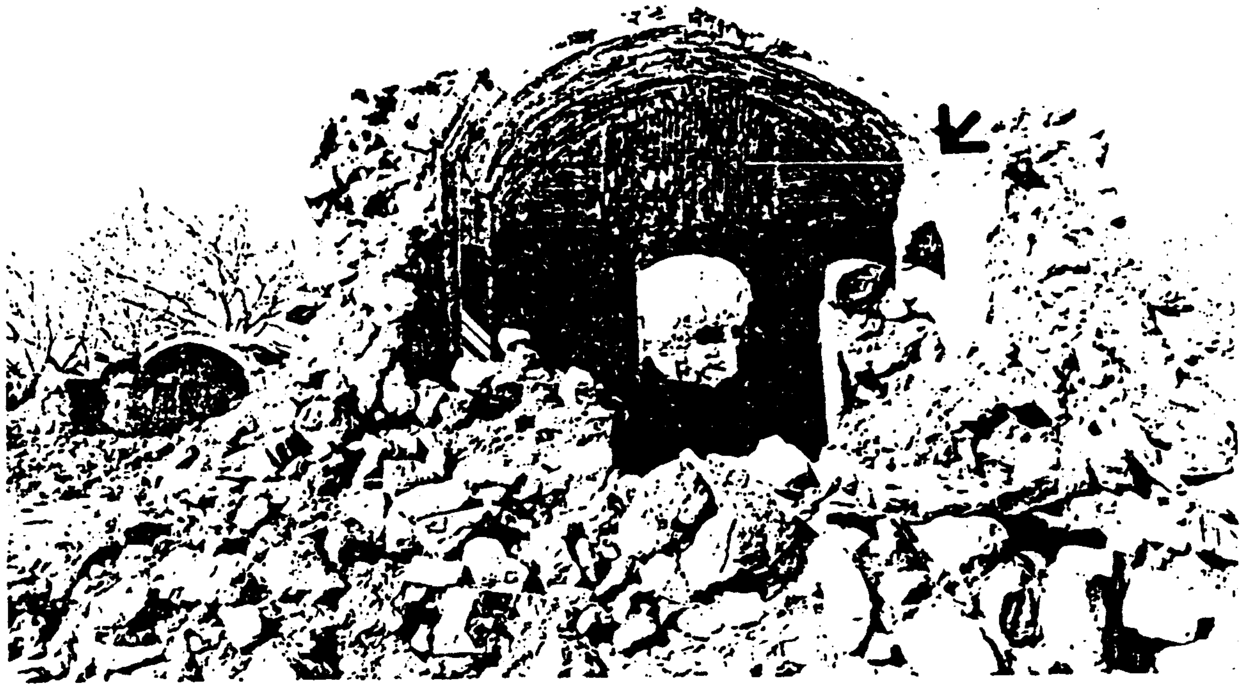
Gisk:

Detail showing timber wall reinforcing set in cement mortar.

Dar Tang Gol:
Rubble wall failure due to lack of internal bonding.

Sar Bagh:
Corner failure due to stress concentration.





Sar Bagh Village:

Brick vault collapse. Note metal tie rods are not anchored by continuous horizontal wall ties.

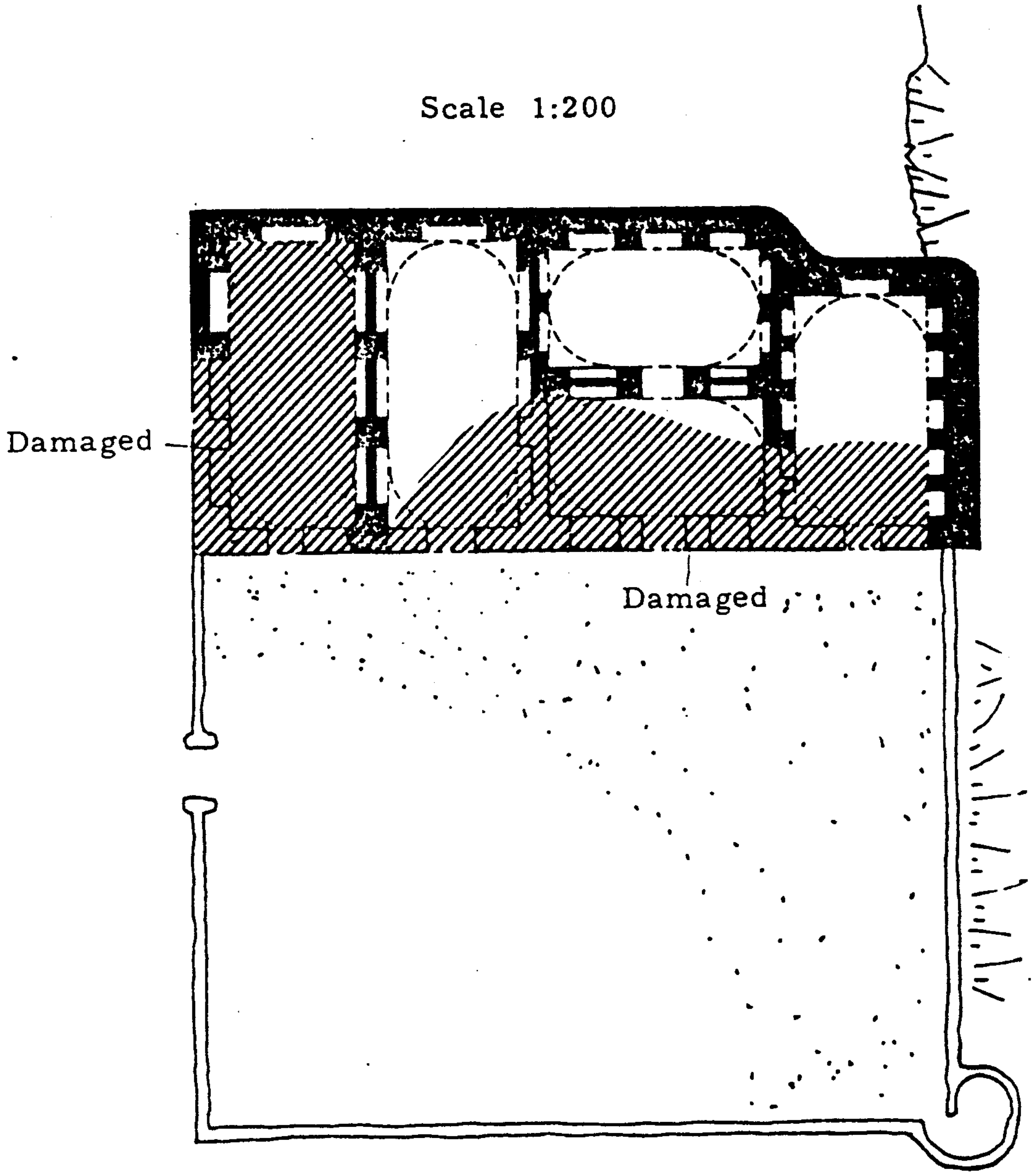
Sar Bagh:

Stone vaults with gypsym ribs at approximately 1 metre centres

HOUSE AT SAR B/ GH VILLAGE

Built of rubble stone walls with mud mortar and stone roof vaults with gypsum mortar. Total collapse of end room and major damage to other rooms

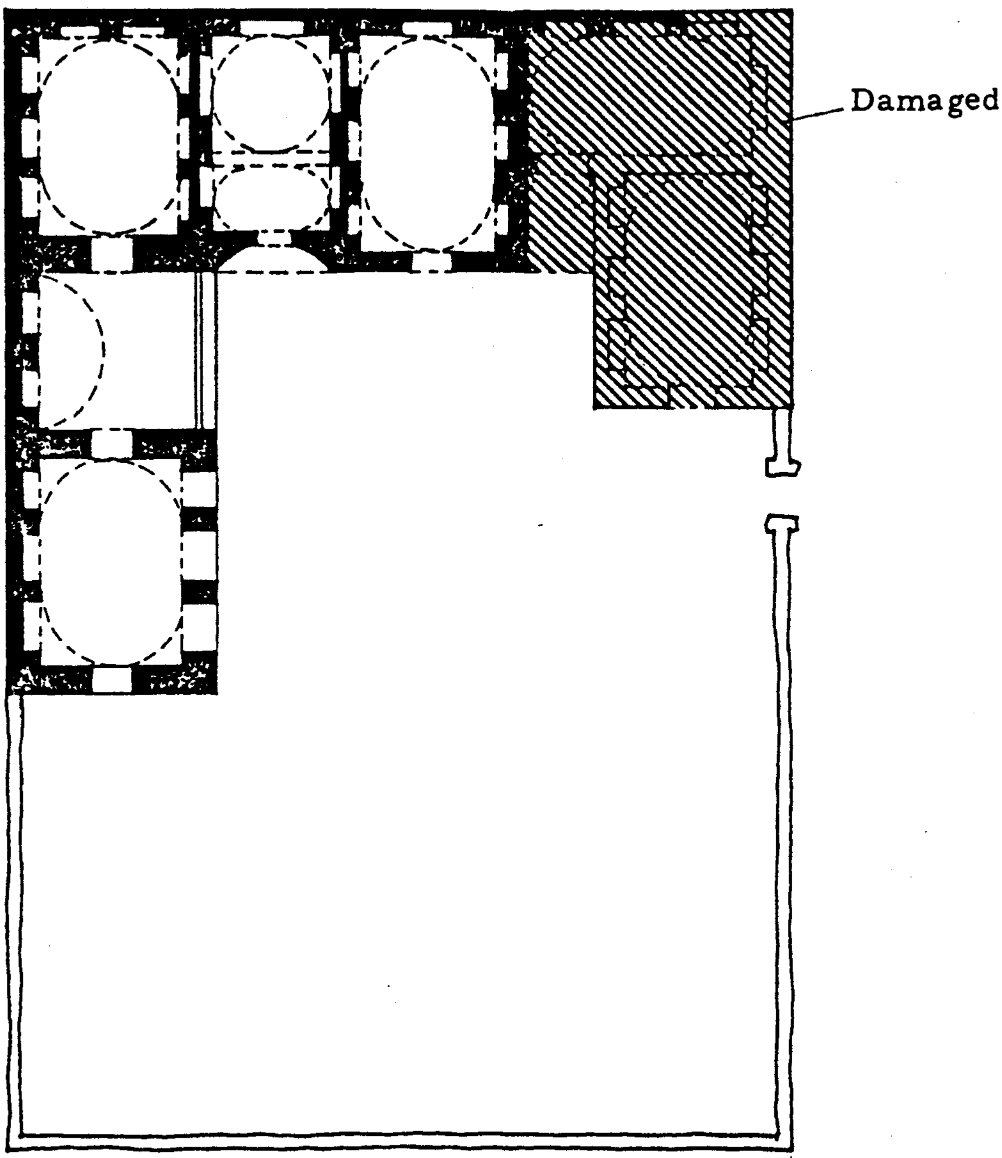
Scale 1:200

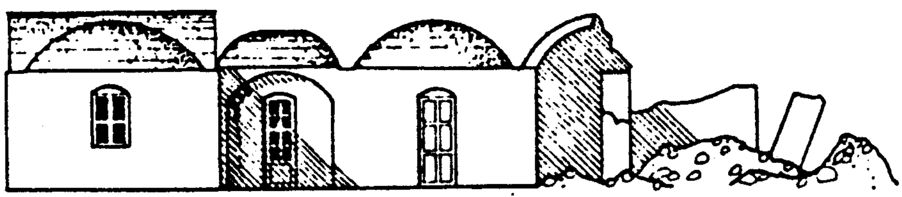


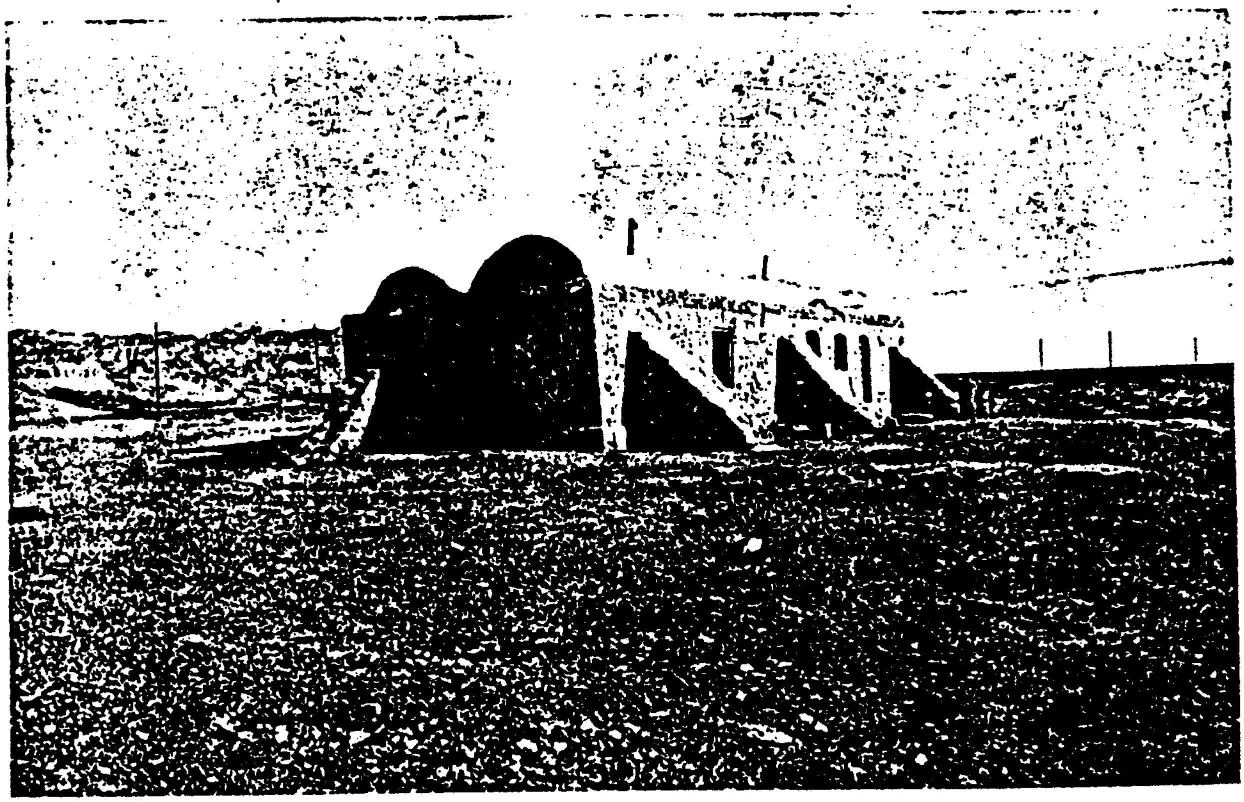
HOUSE AT S\R BAGH VILLAGE

Stone and mud construction.
Stress conce itration in end rooms caused collapse.

Scale 1:200

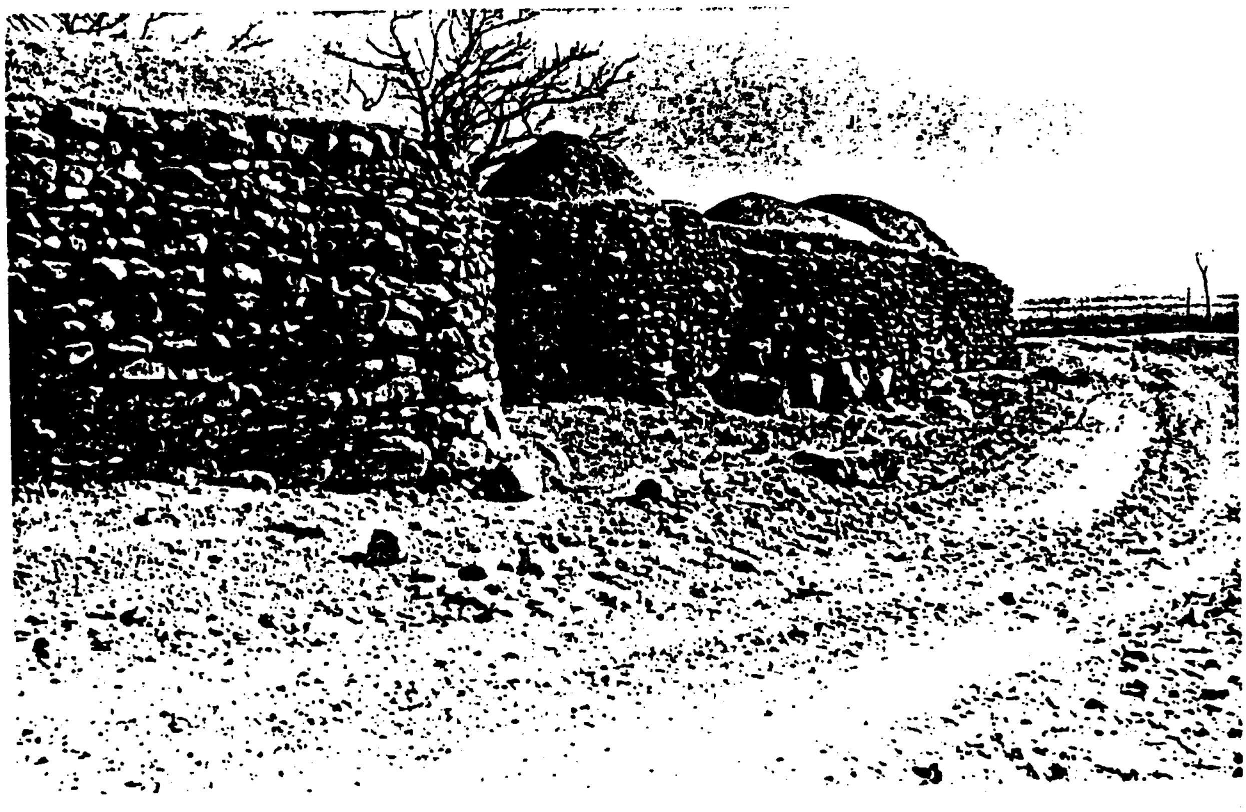


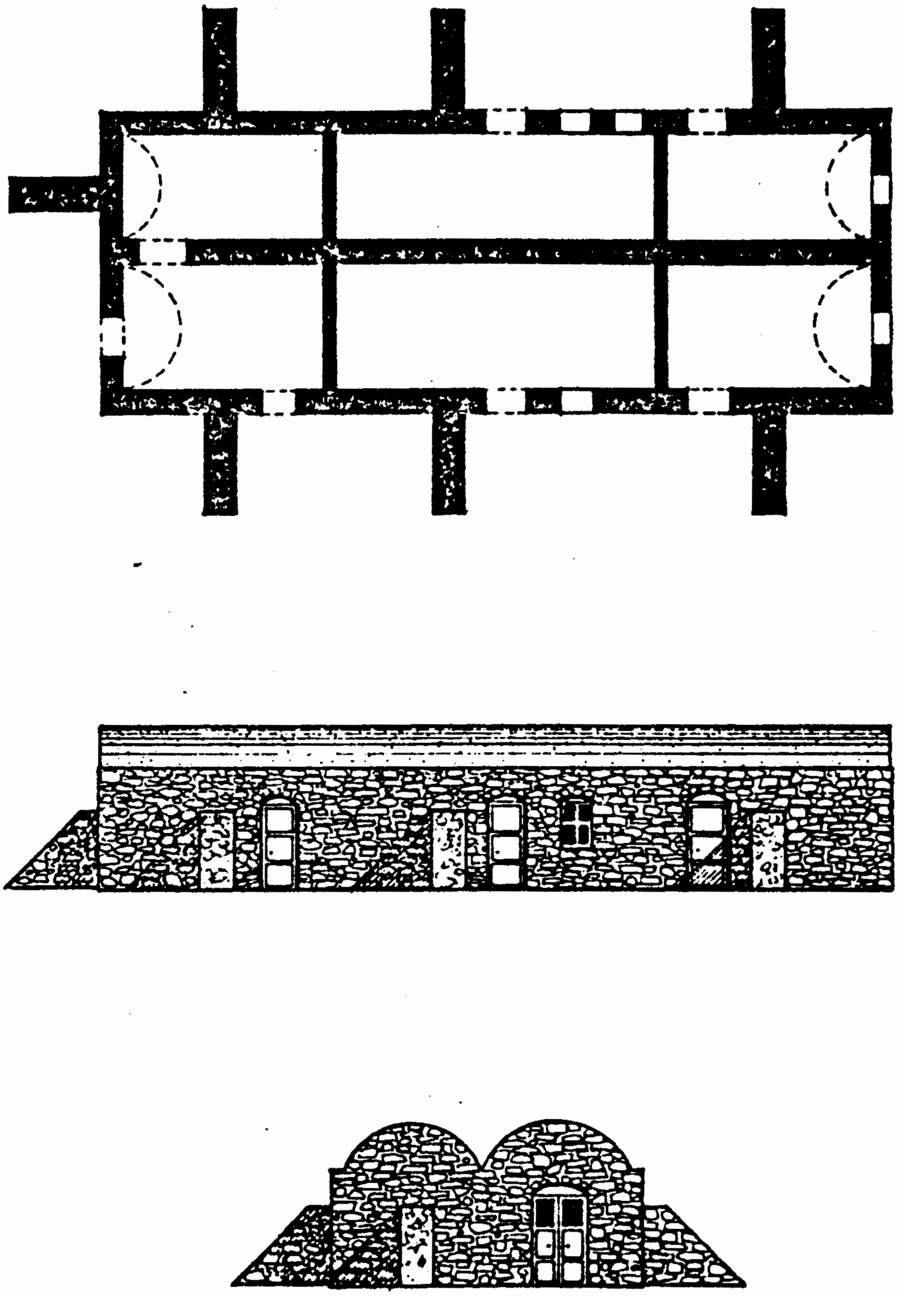




Workshop building south of Sar Bagh.
(See accompanying drawing).

House south of Sar Bagh:
Rounded corners tend to disperse load which would otherwise be concentrated and cause damage.





Scale 1:200

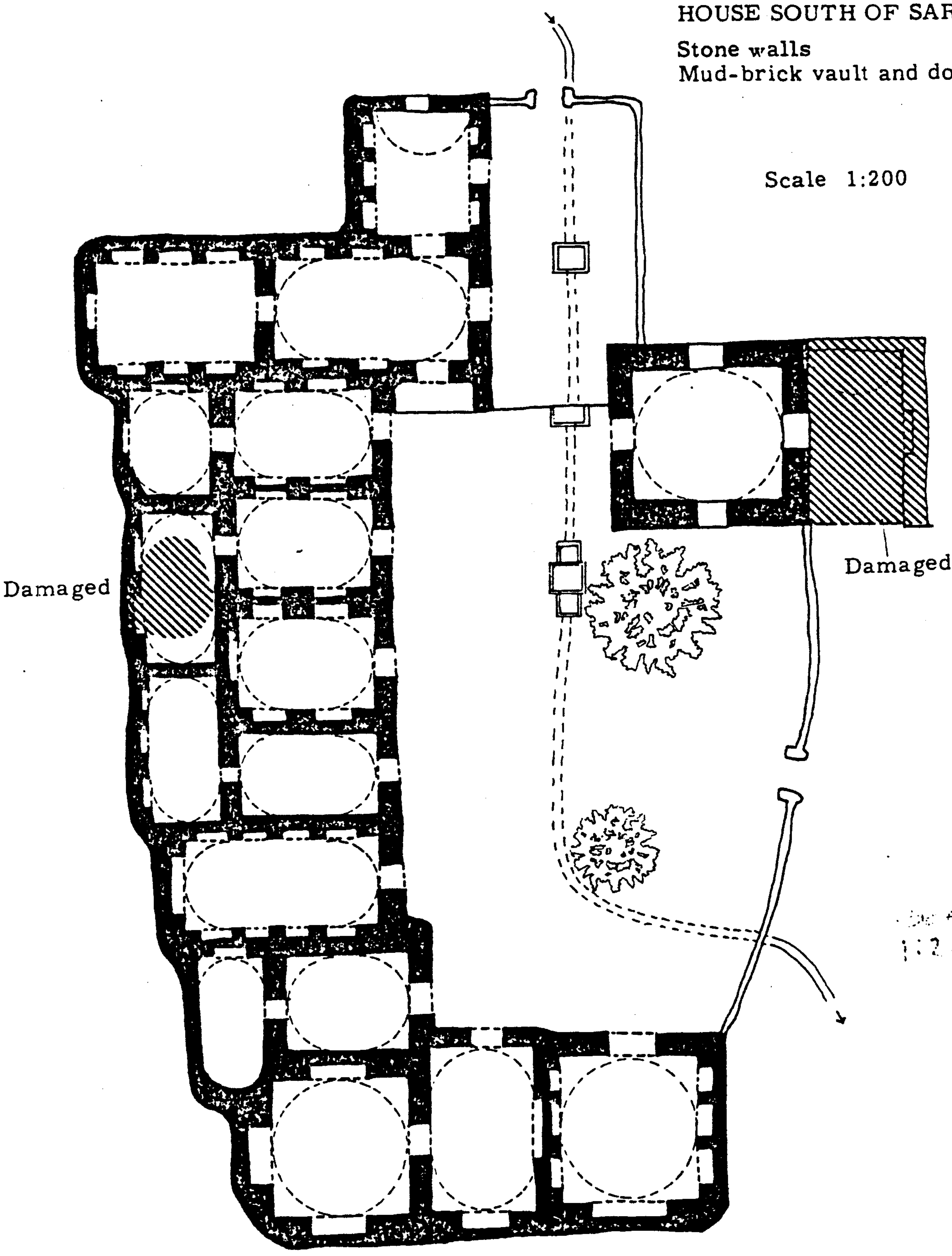
WORKSHOP BUILDING SOUTH OF SAR BAGH

Stone walls in lime mortar and fired brick vaults. External buttresses assisted building to withstand major earthquake damage.

HOUSE SOUTH OF SAR BAGH

Stone walls
Mud-brick vault and dome roofs.

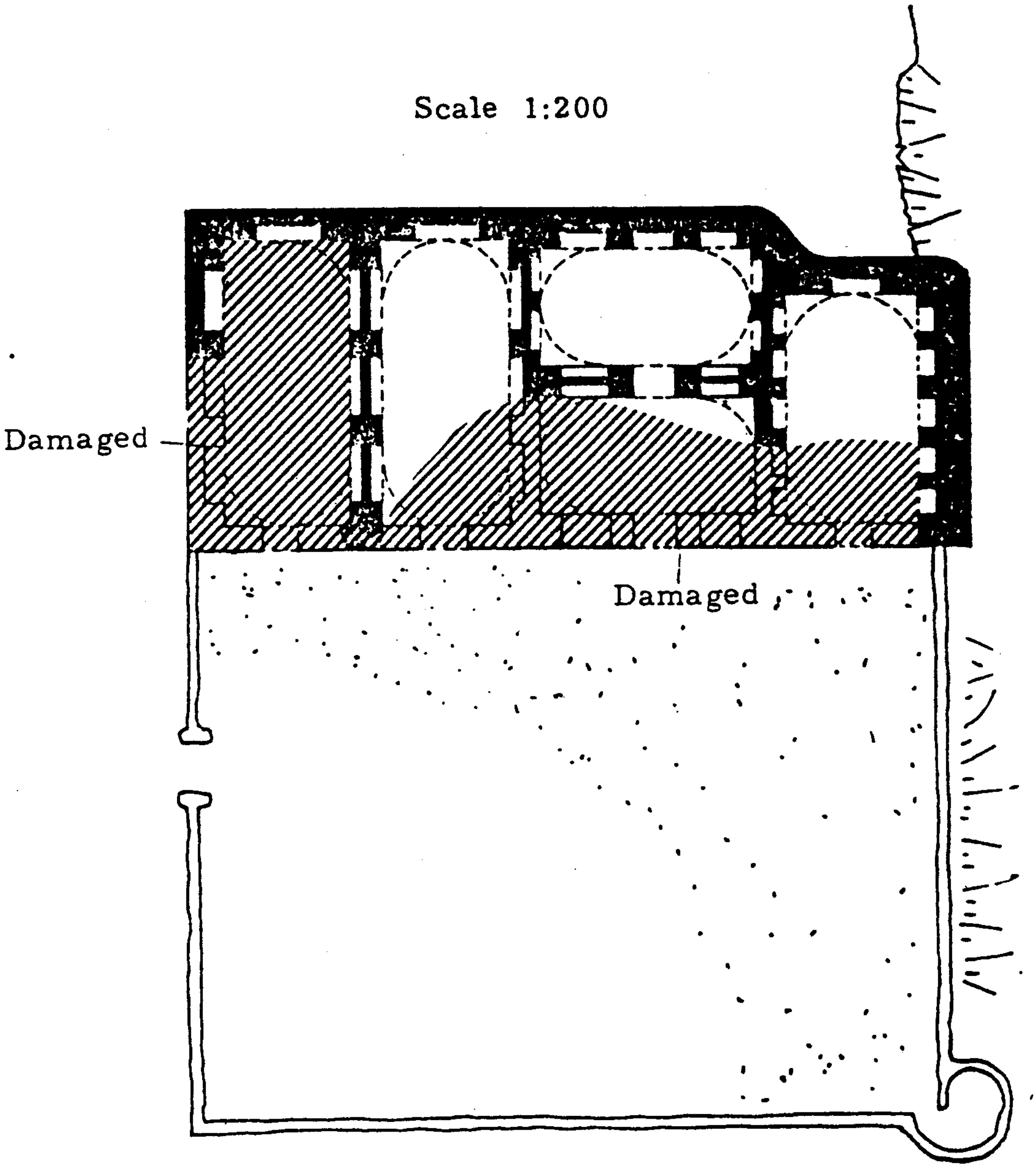
Scale 1:200

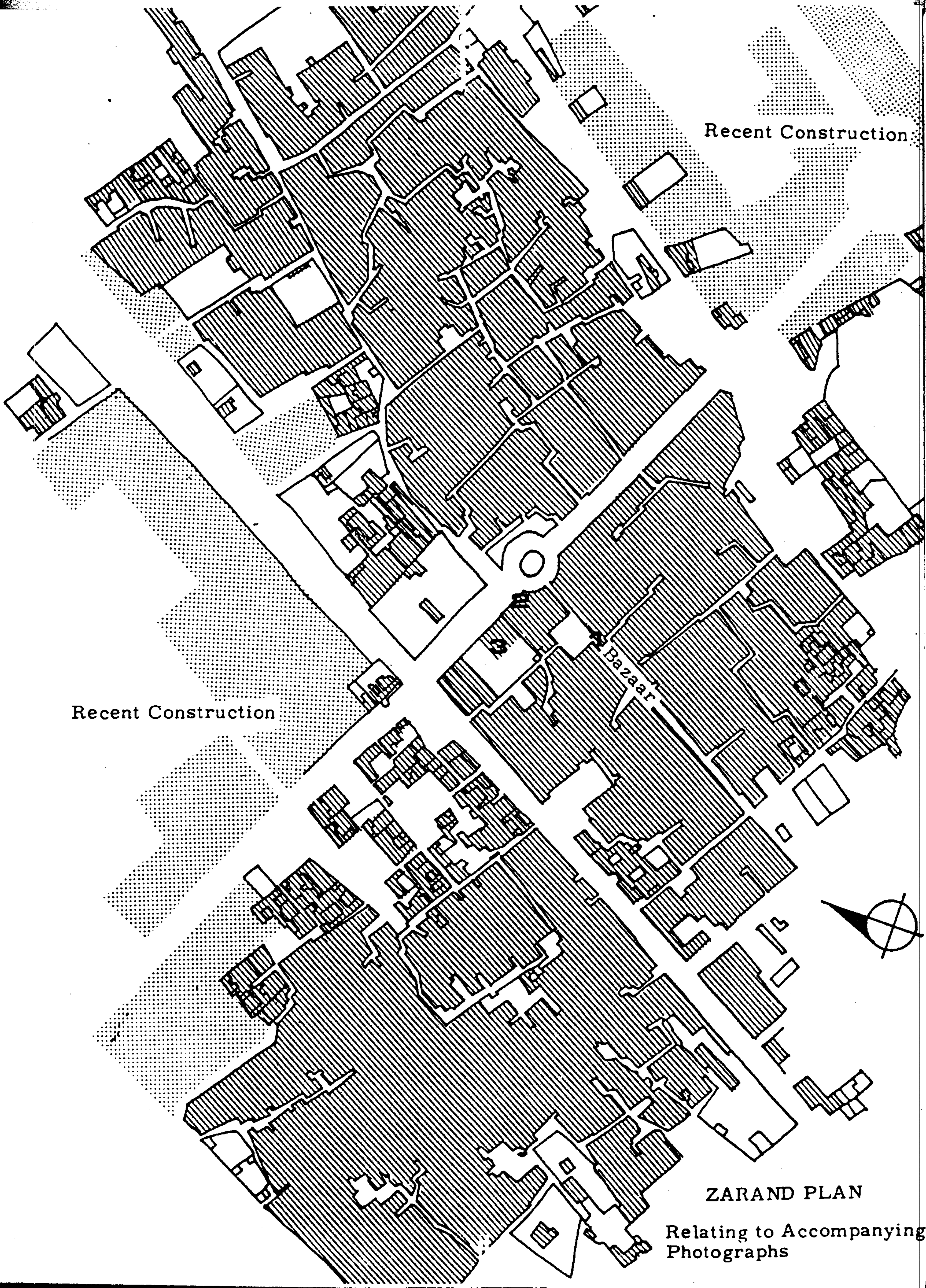


HOUSE AT SAR B/ GH VILLAGE

Built of rubble stone walls with mud mortar and stone roof vaults with gypsum mortar. Total collapse of end room and major damage to other rooms

Scale 1:200





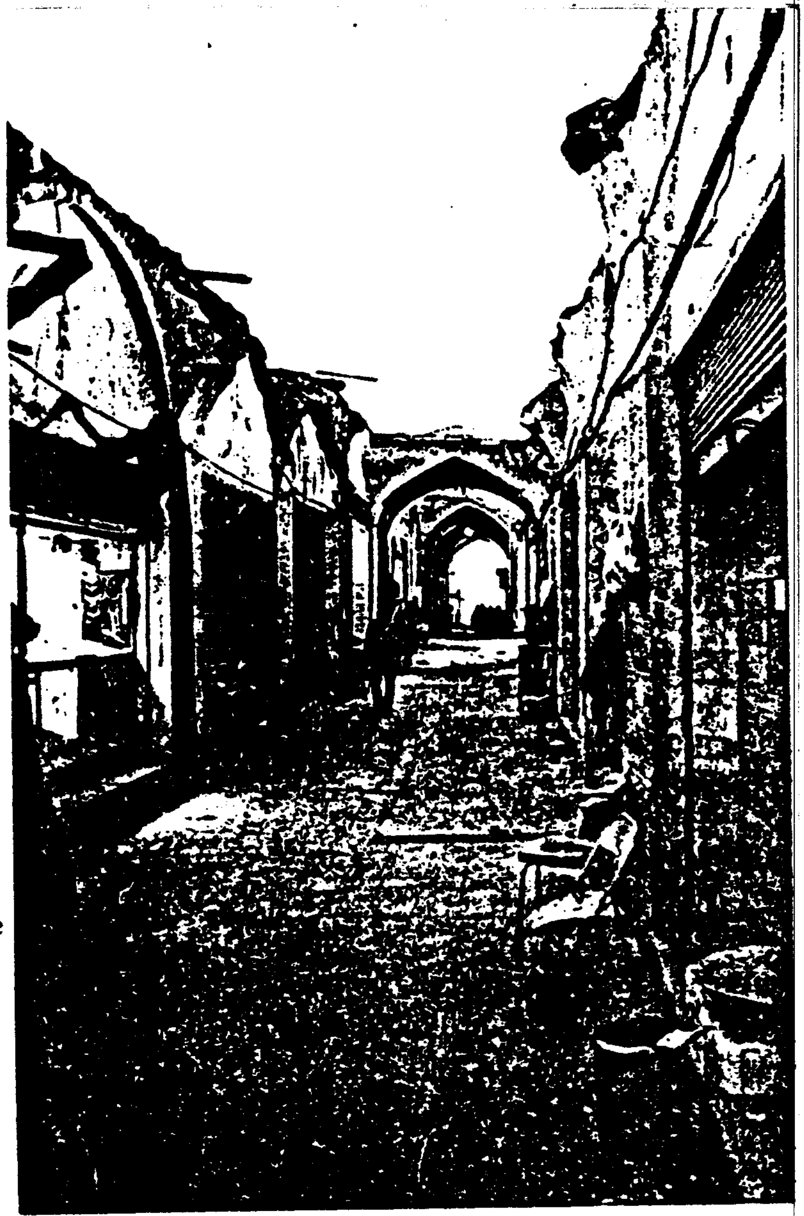
ZARAND PLAN

Relating to Accompanying Photographs

1

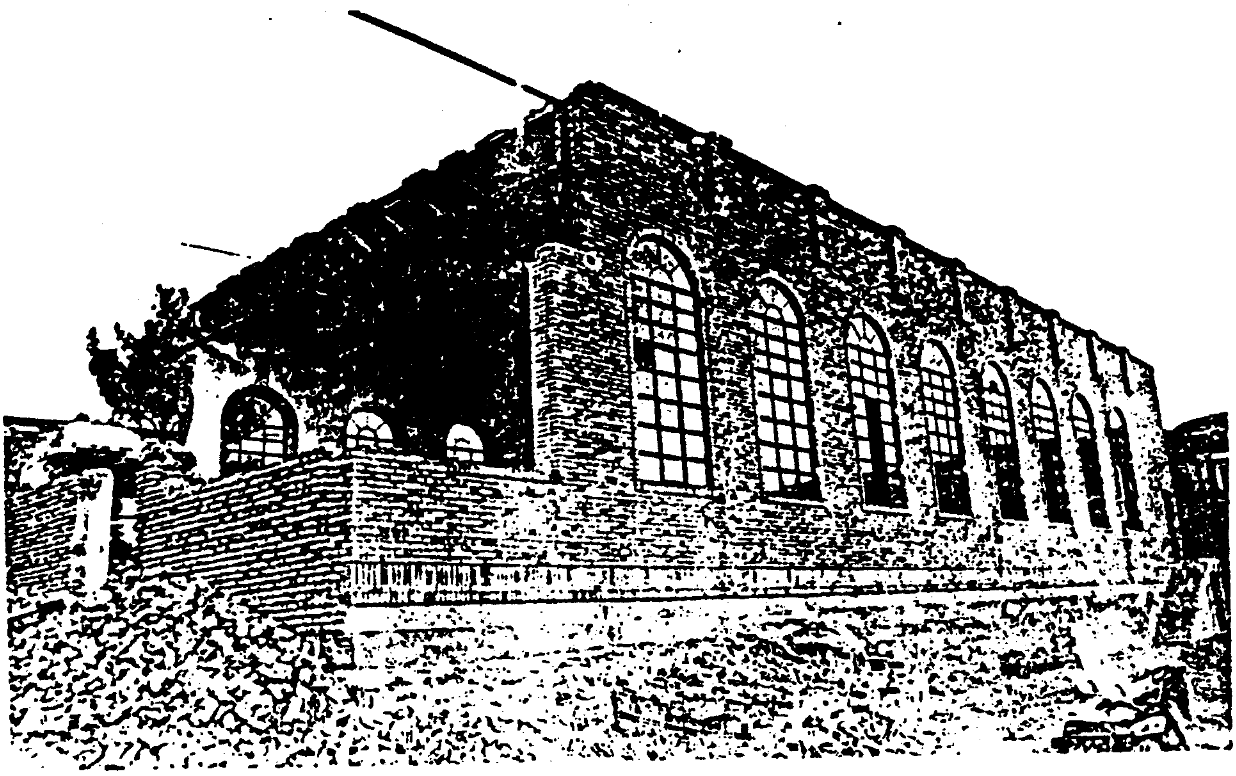
Zarand - Bazaar:

Collapse of bazaar roof probably due to poor repair.



2 Zarand -

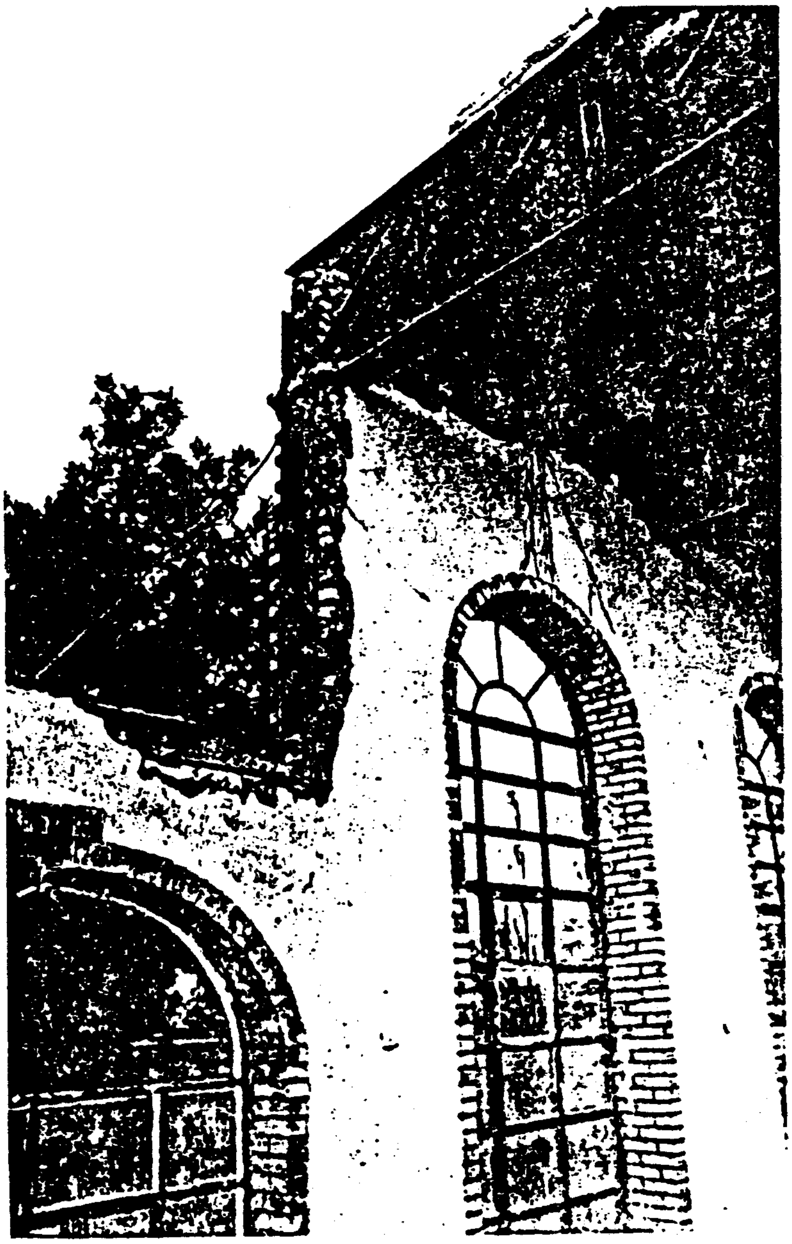
Vaults built side by side show progressively greater damage toward ends.



3 Zarand:

Recently built school failure due to improper steel framing, especially at corners.

Roof constructed of steel I beams and brick, supported by trusses.



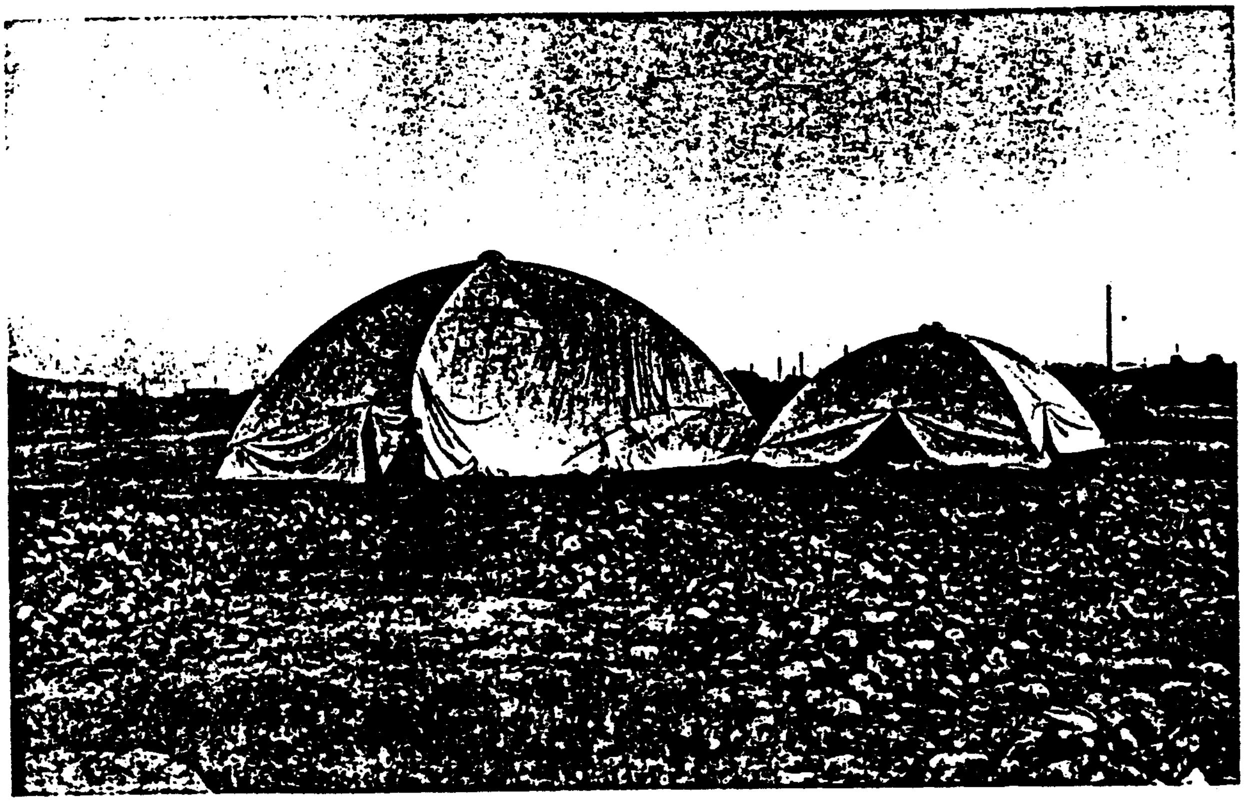
Detail of corners showing lack of steel framing.

Sar Bagh:

Government provided emergency shelter for homeless.

Zarand:

Government provided emergency shelter for public services.



3.0 BUILDERS' TRAINING WORKSHOP (A CASE STUDY)

The local rural builder, who is traditionally responsible in each village for most of the construction, both public and private, offers an appropriate channel for the introduction of improved building techniques and solutions to rural shelter problems. It is with these people that research should be carried out into more appropriate building in earthquake prone regions. Short workshop training programmes for local builders in post-disaster situations could equip them to meet reconstruction needs with improved building techniques .

The following is a case study of a builders' training workshop which dealt with building in earthquake areas as just one subject among many building problems. The Workshop methodology could easily be adapted to focus more particularly on building for earthquake protection.

A workshop for upgrading the skills of rural builders was organised by the Development Workshop in conjunction with the Selseleh Integrated Development Project in the spring of 1977. The workshop was carried out in Yazd in south central Iran, an area of advanced indigenous building techniques. Builders from villages in Luristan Province, Iran, participated in the two month programme. They were involved in experimenting with improvement to their local materials and building technologies. Experience was shared between workshop participants, which included village builders, architects and master builders from other regions of Iran. Solutions to village settlement problems were arrived at through discussion, then tested in the field.

3.1 Aims:

To develop the practical and organisational skills of village builders so that they are equipped to meet most rural shelter needs without dependence on city based contractors, engineers and building materials. This also means that capital invested in rural building remains in rural areas.

3.2 Methodology:

The workshop methodology adopted was: learning through discussion, through practice and through experimentation.

For example, discussion on building methods, design and drawing principles was introduced by asking each participant to draw their own house and discuss its advantages and disadvantages. From these discussions village housing and detailed building problems were identified and drawing skills were developed.

Each aspect of building construction, from different types of soils and foundations to walls and roofs were discussed in turn. On each subject the participants contributed their experiences and optimum solutions were agreed upon. Each building solution was tried out in practice in a yard set aside for such testing. At the same time, experiments were carried out on local materials like timber, stone and mud-brick. Soils were tested using simple sedimentation techniques that could be mastered by any local builder. Stabilisers for mud-brick and renders for improving earth walls against rain and wind weathering were developed for local soil types.

In the evening, literacy classes were conducted for the largely illiterate village builders. The workshop demonstrated the importance of basic literacy to the builders by relating it to their work. By gearing a literacy programme directly to the problems of reading plans and keeping their own building records, builders developed a keen interest in becoming literate.

3.3 Subjects Covered:

3.3.1 Problems and potentials of Indigenous Building and general village development:

- problems of rural underdevelopment
- potentials for small-scale village industrialisation using local resources
- rural shelter and village settlement problems
- the role of the village builder as a development cadre.

3.3.2 Basic Design Principles:

- site planning and orientation
- relationship of spaces and elements within a building.

3.3.3 Reading Drawings and Laying Out Buildings.

3.3.4 Foundations:

- for differing soil and site conditions
- differing building requirements

3.3.5 Walls:

Mud, mud-brick, fired-brick, stone and mud-brick and fired-brick combinations. For each type of wall the costs, structural, physical and climatic properties were compared. Builders learned the best methods for compacting mud, making mud-brick, fired-brick, types of mortar, required wall thicknesses, brick laying methods, etc.

3.3.6 Timber Roofs:

Timber roof types in Iran and other countries, new alternative timber roof types and timber trusses. Through construction and experimentation each type was evaluated.

3.3.7 Vault and Dome Roofs:

The most widely applicable vault and dome types were selected. Builders learned how to construct these types, the variations of wall thicknesses according to roof span, arch construction, roof span to vault and dome curve ratios, the physical, structural and climatic properties of vault and dome.

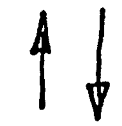
3.3.8 Building in Earthquake Areas:

The following are illustrations and notes from some of the workshop's discussions and experiments on earthquake construction. Earthquake considerations were discussed at each of the stages of building, i.e. foundations, walls, roofs, etc. and were also dealt with in specific workshop discussions on this problem.

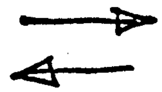
3.4 Workshop Notes on Improving Indigenous Buildings' Earthquake Resistance

Motion at the focus of the earthquake is normally vertical and is actually less damaging to heavy structures than the sideways horizontal motion of the earthquake's periphery.

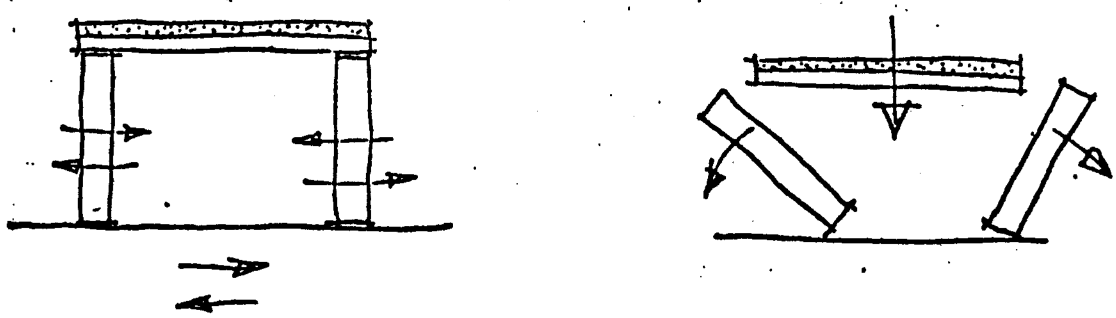
Centre of Quake –



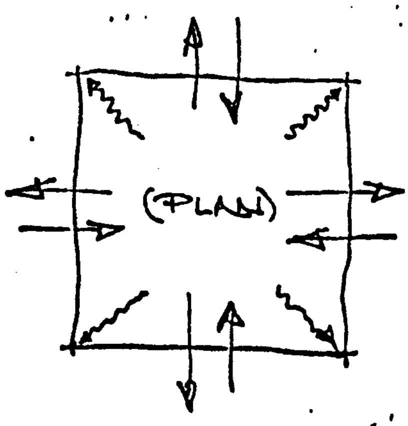
Periphery (most common)

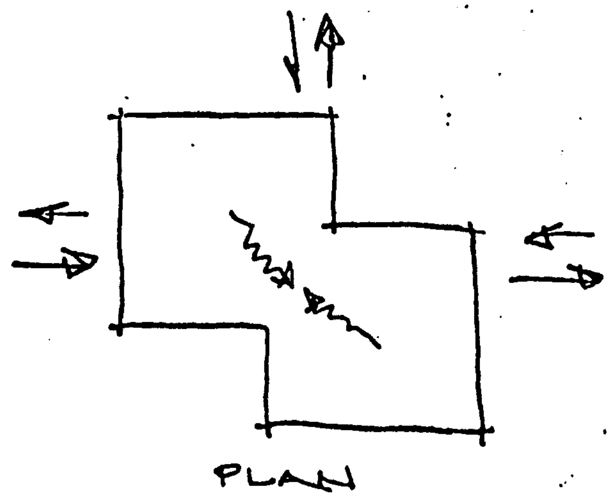


If walls are supporting heavy roofs, the sideways sway gathers momentum and walls fall outward causing the roof to collapse.



Stress due to earthquake movement is known to concentrate at the corners of a building or at joints between building elements. These areas need special design and construction attention.



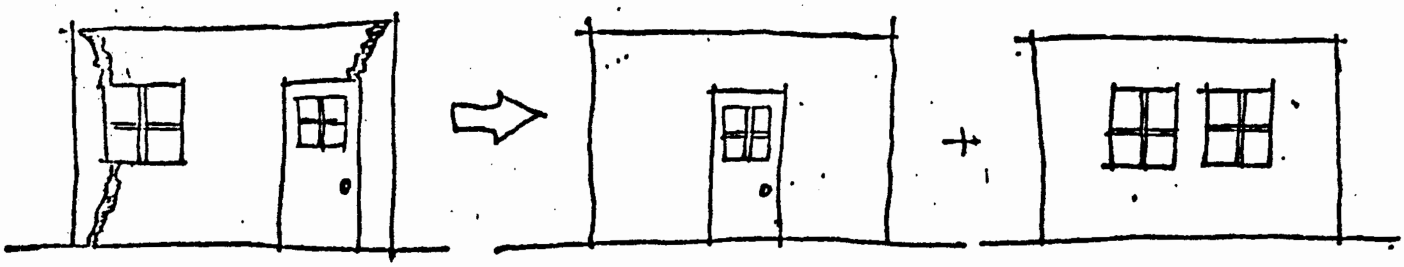


stress at corners

stress at joints

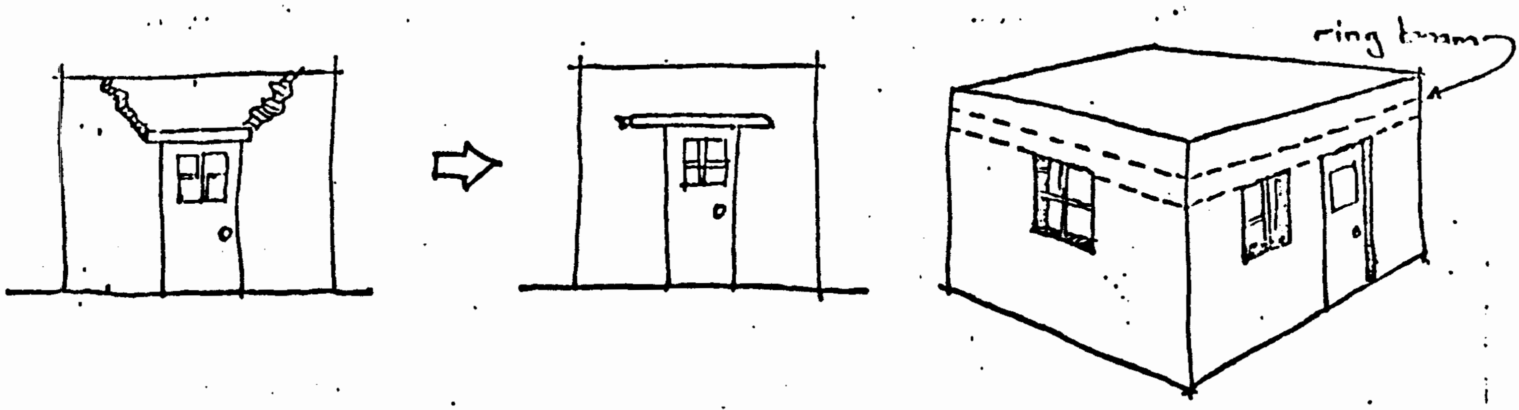
3.4.1 Design and Positioning of Openings

Because of stress concentration, openings should be avoided near corners of buildings.



Therefore it is better to position openings centrally on the walls.

Cracking and failure often occurs above door and window openings. These areas can be strengthened by extending lintels deep into walls or by using continuous reinforced ring beams as a common lintel above all openings, with extra reinforcing at corners.

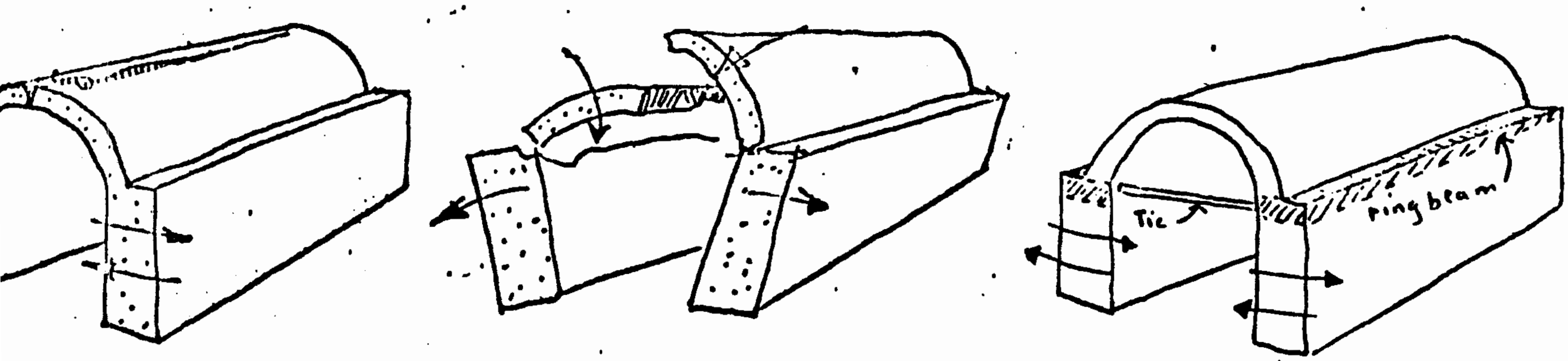


Such ring beams serve a double function in tying walls together to prevent movement which could cause roof collapse.

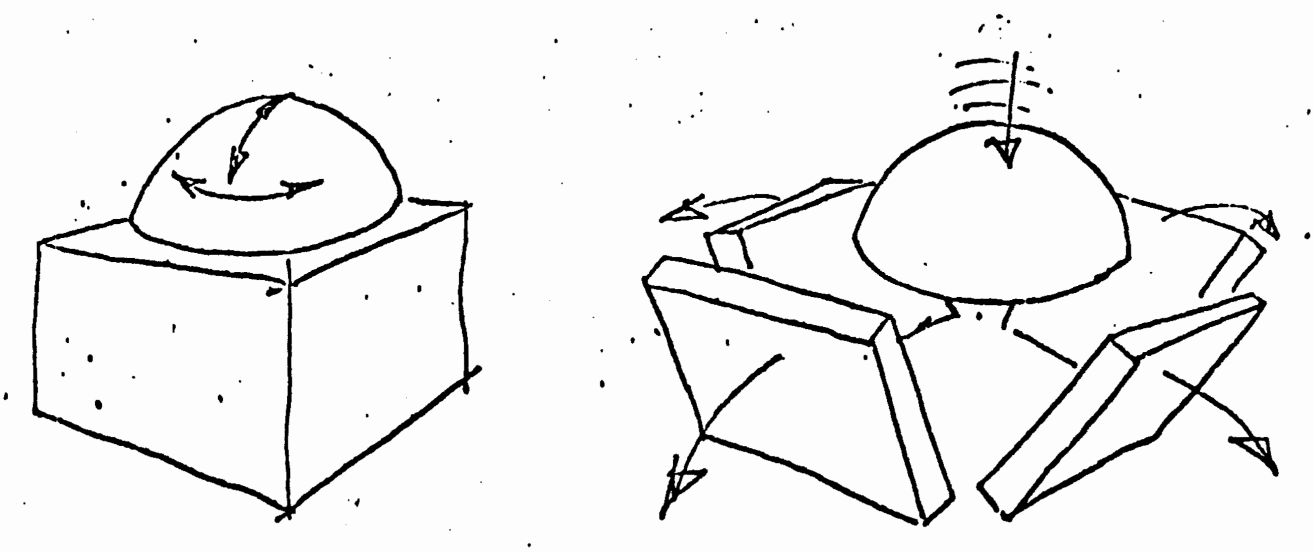
3.4.2 Vault and Domes

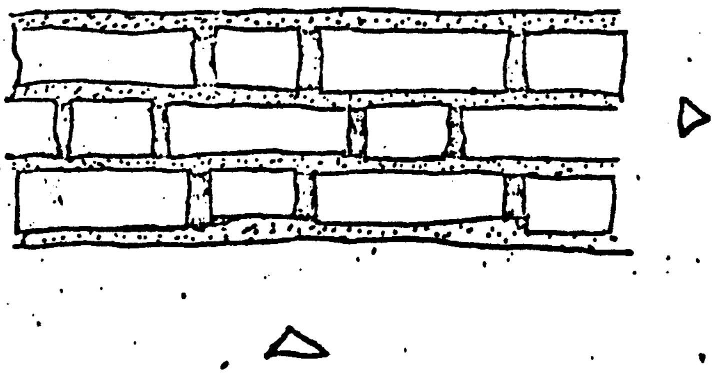
Vaults are much more susceptible to earthquake damage than domes. Any movement of walls upon which the vault rests will cause cracking in and failure of the roof.

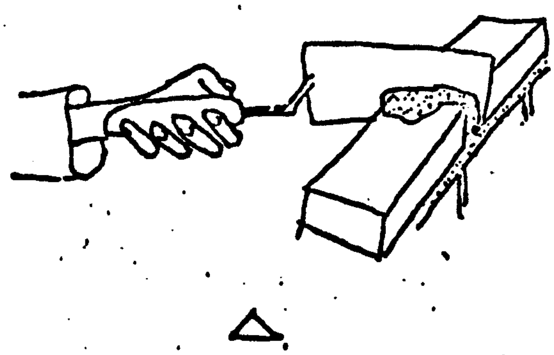
A tie rod connecting the two side walls, which should have a continuous ring beam at the base of the vaults, will resist earthquake damage.



Domes, unlike vaults, have a double curvature and are able to withstand forces and movement much more easily. In many cases where walls have collapsed due to earthquakes, domed roofs have simply fallen intact.

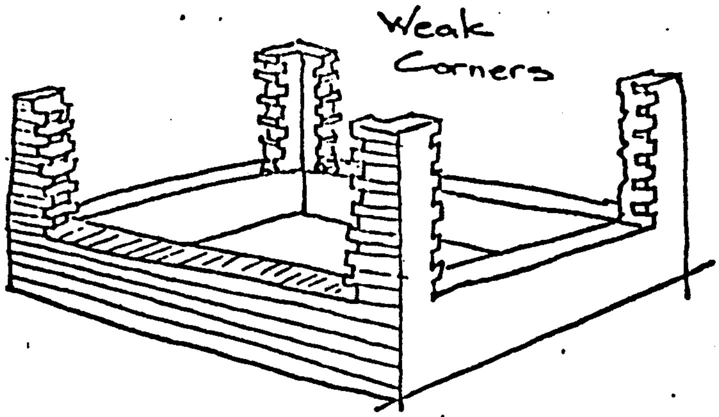






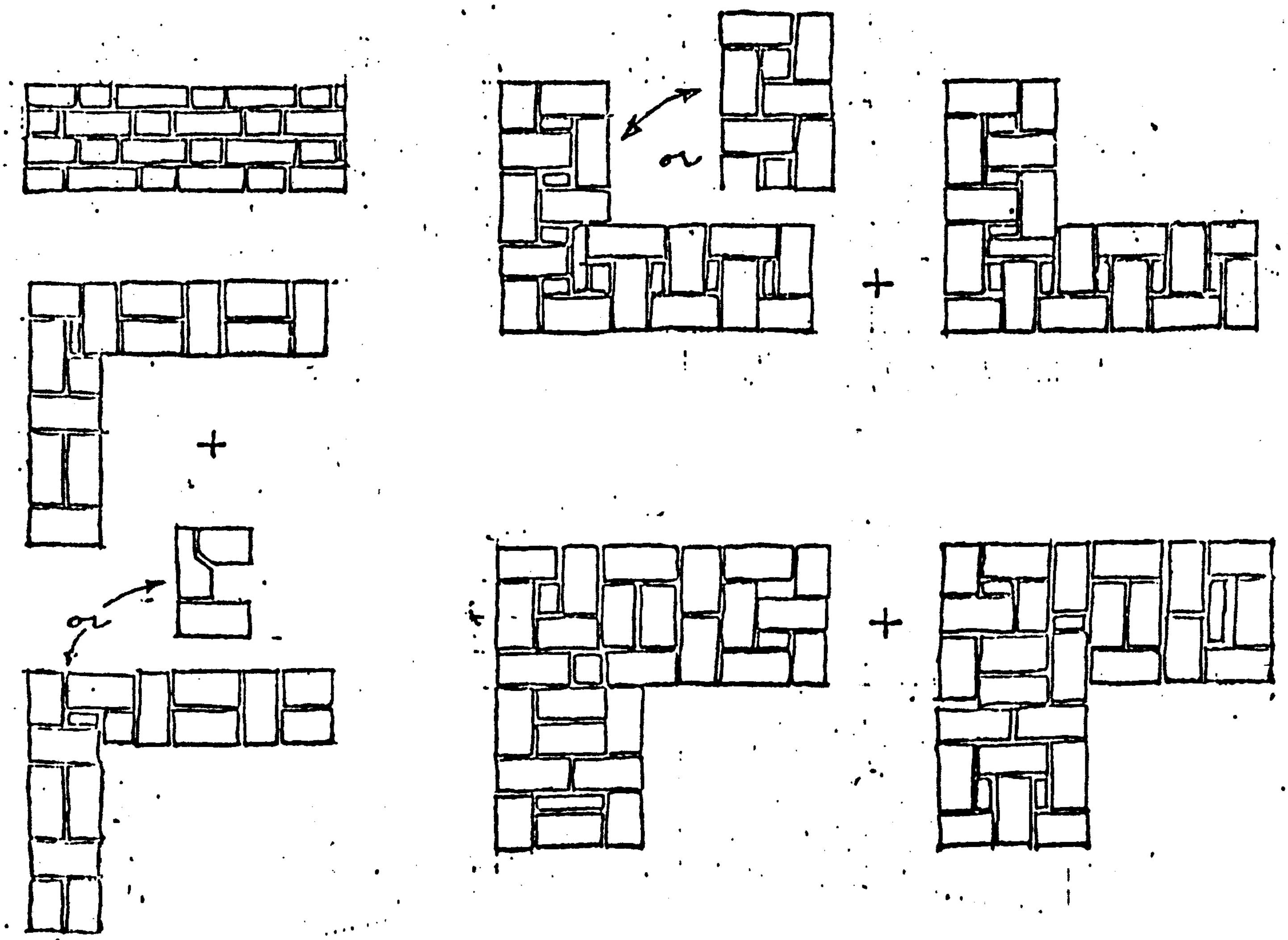
Mortar Joints: it is a common habit to save on mortar by applying mortar only to horizontal joints. By properly filling vertical joints the strength of a wall can be increased by 20% to 25%.

Bonding Corners: it is common practice in Iran to build up corners before infilling the wall. This is done to simplify the problems of lining up and levelling. This practice produces badly bonded and weak corners.



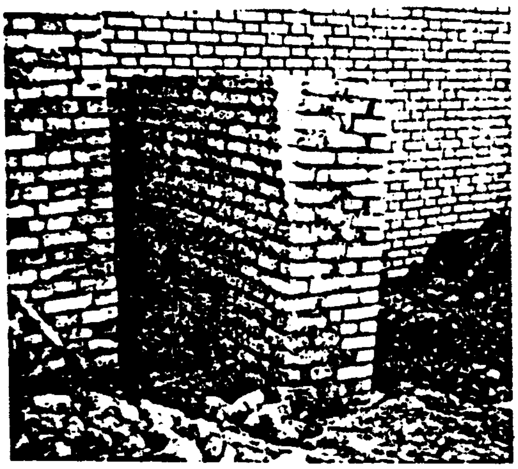
Since corners are critical stress areas, this practice should be discontinued. Brick courses should be laid continuously and wall building should progress evenly.

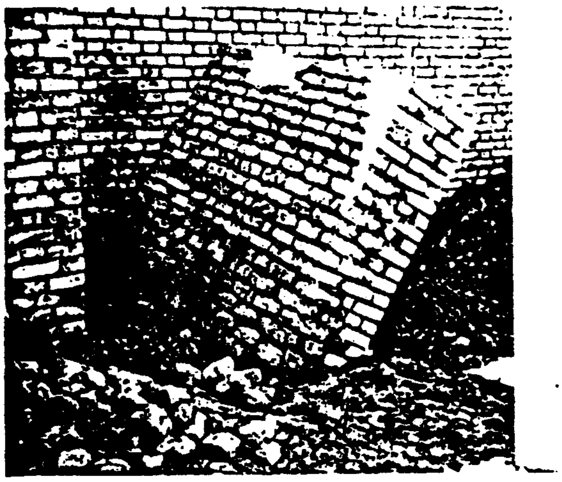
Proper Bonding: suggested bonding for brick walls of various dimensions.

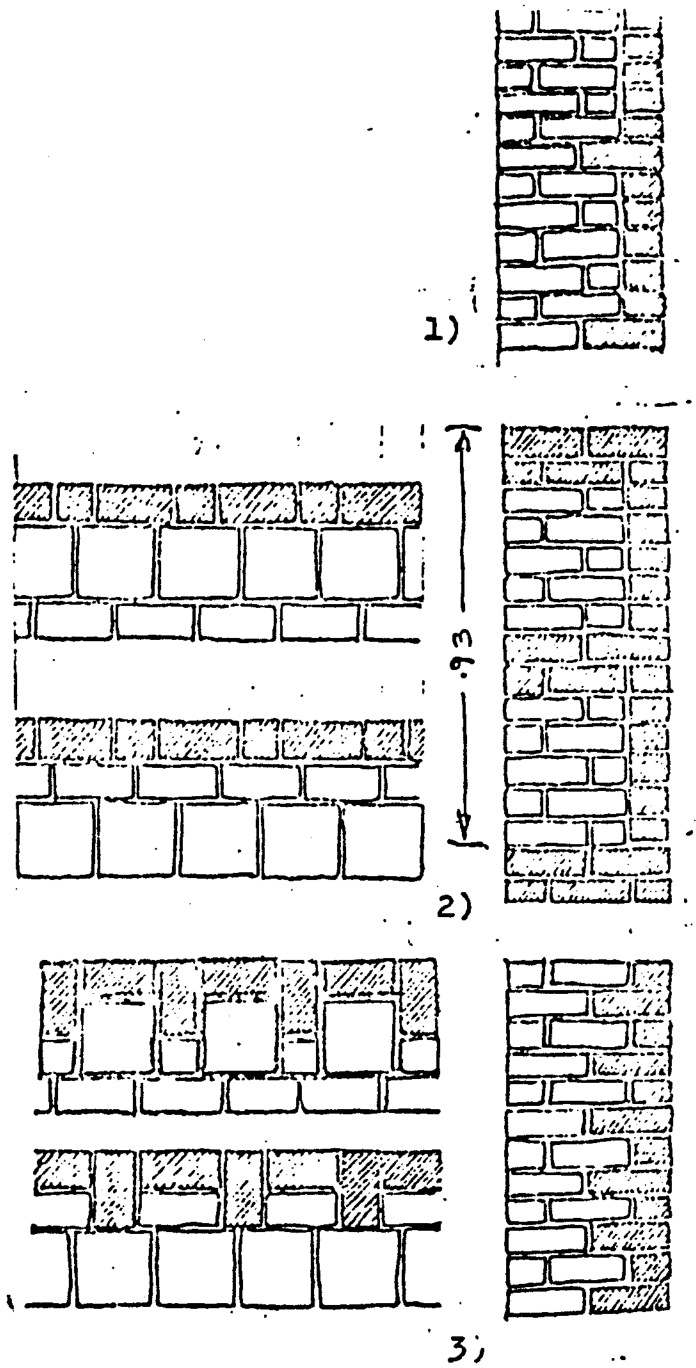


From Bonding Experiments

1) poor bonding
2) good bonding
3) good bonding







Bonding Unlike Materials

In many areas of Iran it is a common practice to use kiln fired bricks as an external skin to protect mud-brick walls against weathering and water damage.

Mud-brick walls with fired-brick facing usually are unsuited to earthquake areas because the fired-brick tends to peel off and falls outward, threatening people in the street. Since this practice is widespread and an efficient and economical system for protecting mud-brick walls, experiments were carried out in the workshop to develop a better bonding system.

Walls were built using different systems of fired and mud-brick bonding. Each wall was undermined and destabilised, and its collapse was studied for indications of bonding failure.

The second and third types (Figs. 2 and 3) collapsed as a unit without the brick separating from the mud-brick and were thus the more successful types.

4.0 CONCLUSION

In summary, the following main weaknesses in construction techniques were noted, most of which could be easily avoided, thus improving the buildings' resistance to earthquakes:

1. Weak or non-existent foundations.
2. Weak bonding at corners and in the width and depth of the walls.
3. Poor maintenance of mud-brick walls.
4. Filling in openings at a later stage without bonding them into the existing walls.
5. Using mud-mortar in stone wall construction.
6. Damp rot or termite borings weakening timber beams.
7. Timber lintels and roof beams not projecting sufficiently into walls.
8. Door and window openings near corners.

This list and the suggestions for improvement in the last section of the paper are by no means exhaustive. It is, however, sufficient to indicate that in most cases it is not necessary to jump to too complicated and expensive building techniques. A thorough study and development of the indigenous methods would result in earthquake resistant solutions that are both socially and economically acceptable to the people. Local building workshops would act as the vehicles to both develop these solutions and introduce them into the affected community.

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