



ALBUM OF TECHNICAL DECISIONS FOR REINFORCEMENT OF
SELF-CONSTRUCTED RESIDENTIAL BUILDINGS (EXISTING AND
NEW) FROM LOCAL MATERIALS IN EARTHQUAKE-PRONE AREAS

**DEVELOPMENT OF ALBUM OF
TECHNICAL DECISIONS FOR
REINFORCEMENT OF SELF CONSTRUCTED
RESIDENTIAL BUILDINGS (EXISTING AND
NEW) FROM LOCAL MATERIALS IN
EARTHQUAKE PRONE AREAS OF CENTRAL
ASIA**

TEAM LEADER: Timur Abduvakhidov

TEAM MEMBER: Alina Abduvakhidova

ADVISOR : DR. SHAMIL KHAKIMOV

CONSULTANT: DR. BAKHTIAR NURTAEV

TASHKENT 2003

Content

1. Introduction
2. Urgency and practical value of the guidelines
3. Purpose of development of album with the guidelines
4. Materials and strength properties
5. Design system with a wood frame and infill from adobe brick (synch)
6. Design system from rammed earth (pahsa), adobe bricks, saman bricks or blocks
7. Design system with use of natural rock
8. Antiseismic strengthening of existing buildings
9. Examples of implementation of antiseismic strengthening and construction of seismic resistant buildings from local materials
10. Conclusion

1. Introduction

Since ancient and up to present time in cities and settlements of Uzbekistan and all Central Asia construction of the houses from local materials was carried out.

As a load-bearing wall material were used:

- rammed earth - pressed clay called "pahsa",
- "gualyak" - prepared beforehand and air dried clay blocks of the spherical shape with diameter from 10 up to 20 cm,
- adobe bricks,
- saman bricks or units (clay with parts of straw (2-5cm)),
- natural sledged rock, limestone.

As the mortar, mostly, was used clay, less often clay with lime. For the foundations construction the sledged stones or boulder was used. Sometimes buildings were erected without the foundations. The buildings were constructed one-storey without special design.

For construction the population was guided mainly by services of the national masters, using their expertise and traditions. Lifetime of such houses was nearly –10-15 years. At earthquake impact with intensity 7 and more units (MSK-scale) majority of houses of local materials have gained severe damages, up to total collapse. The facilities constructed using of indicated materials are dangerous for dwelling in conditions of strong earthquakes.

In the given album the attempt is made to present the ways of antiseismic strengthening of houses from local materials which are popular in republics of Central Asia.

These ways of strengthening are based on engineering analysis of consequences of earthquakes in Central Asia, expertise of the engineers, which dealt with problems of seismic resistant construction.

The majority of given engineering solutions were realized in practice, and some of them have passed test by earthquakes. Alongside with engineering decisions the examples of conventional national methods of strengthening of buildings are presented. As an example the design system with a wood frame with infill from adobe bricks is presented.

The album of engineering solutions may be useful for individual builders, and professionals at construction of new and strengthening of existing buildings from local materials.

2. Urgency and practical value of the guidelines

The earthquakes, occurred in Kashkadarya region (Uzbekistan) and Lugovaya station (Kazakhstan) evidently showed that adobe buildings constructed from local materials without special measures have obtained heavy damage, some houses were completely collapsed.

Situation may be explained by several reasons:

- houses were constructed without antiseismic measures;
- non awareness of population about antiseismic measures for construction from local adobe and stone materials;
- the absence of standard design for construction from adobe materials and antiseismic reinforcement.

In this regard we proposed to develop simple methods of reinforcement of houses and school buildings from adobe materials as the most cheap and ecological clean type of construction. All available experience of reconstruction of old buildings and new construction in process of liquidation of consequences of Kamashi and Lugovaya earthquakes in 2000-2003 were used.

The album of engineering solutions may be useful not only for individual builders, but also for professionals at construction of new and strengthening of existing buildings of school and hospitals from local materials in rural earthquake prone areas.

Development and implementation of simple methods of reinforcement of existing buildings and new construction oriented to risk mitigation in earthquake prone areas.

3. Purpose of development of album with the guidelines

In rural areas of Uzbekistan and Central Asia as a whole, the most typical type of residential buildings, constructed using traditional adobe and stone materials. Absence of knowledge among

population about methods of earthquake resistant construction and of standard design for safe construction from adobe materials will increase amount of vulnerable buildings in earthquake prone regions. The same time in the world and national literature is available experience in seismic resistant construction from adobe materials

The main purpose of the given album is provision of measures of seismic risk mitigation of constructions from local weak materials.

This purpose may be reached by following steps:

- Compilation of available expertise in seismic resistant construction of buildings from local materials
- Development of engineering solutions with the guidelines on seismic reinforcement of buildings from adobe materials and natural stones.

In process of album development were utilized results of engineering analysis of consequences of earthquakes in Central Asia, and also calculation and design solutions.

Implementation in practice of construction of seismic resistant houses will allow to mitigate risk of facilities from local materials at earthquakes and to save life of peoples in earthquake prone regions.

4. Materials and strength properties

As materials for construction of buildings from local materials were used:

- adobe bricks,
- rammed earth called "pahsa",
- air dried clay rolled out of spherical shape "gualyak",
- clay blocks, reinforced by saman (parts of gramineous plants),
- natural sledged stones, limestone.
- silicate bricks etc.

The properties of materials are presented in table 1.

Type of material	compressional strength kgs/cm ²
1. rammed earth "pahsa",	5-25
2. adobe bricks	10-25
3. air dried clay rolled out of spherical shape "gualyak"	5-15
4. clay blocks, reinforced by saman	5-20
5. natural sledged stones, limestone	50-200
6. silicate bricks	50-100

As a mortar was used cement-sand mortar with compression strength 25-100 kgs/cm².
For foundation was used concrete or rubble concrete with compression strength 100 kgs/cm².

5. Design system with wood frame, filled by adobe brick (synch)

The settled population of many regions of Central Asia traditionally used reliable enough type of construction applying wood frame with infill by rammed earth, called "synch". The design system synch is capable to resist 7-8 intensity units earthquakes in case of proper construction without danger for life of the people. To withstand 9-ball earthquake the supplementary measures on their strengthening are required.

In fig. 5.1 the building of school from synch frame in city Shahrizabz, Kashkadarya region after earthquake with intensity 7 ball is presented. And in fig. 5. 2 is shown part of wall from frame synch in Bukhara after Gazli earthquake of 1984. At site of location of house the intensity of earthquake was equal to 7 ball by MSK scale.





Fig. 5.2 Fragment of damaged synch wall in Bukhara after earthquake impact with intensity 7.

The main types of damage of buildings from synch frame are: fractures in walls, deposition of filler from frame.

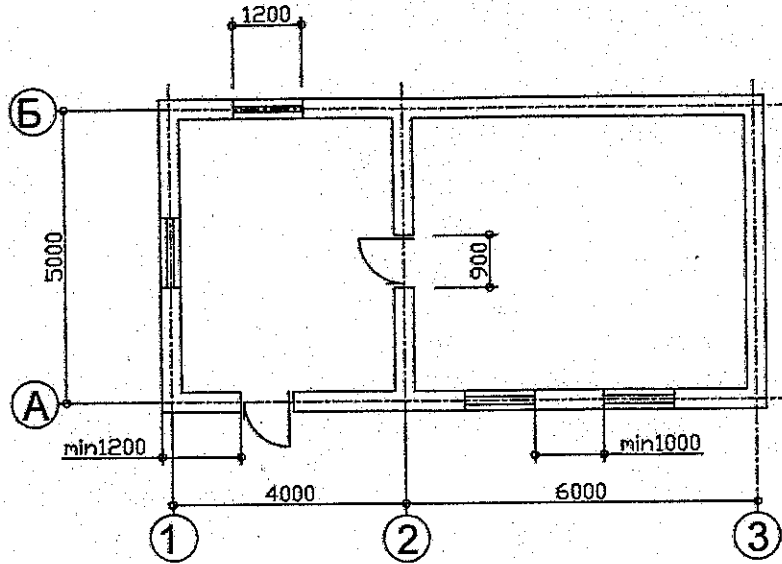
For construction of house from a wood frame synch it is required: the wood bolsters with cross-section not less 15x15 cm, wood pole with cross-section not less 8x8 cm, brick - adobe or gualyak. For the foundation construction - concrete M100 or rubble concrete, metal bars with diameter not less 10mm for reinforcement of the foundation, creation of discharges for fixing frame to the foundation, small amount of metallic cramps with diameter 16mm sharpened at ends.

Besides it is required clay saman mortar, elements of window, doors, floors, plaster, roof. List of these materials may be miscellaneous.

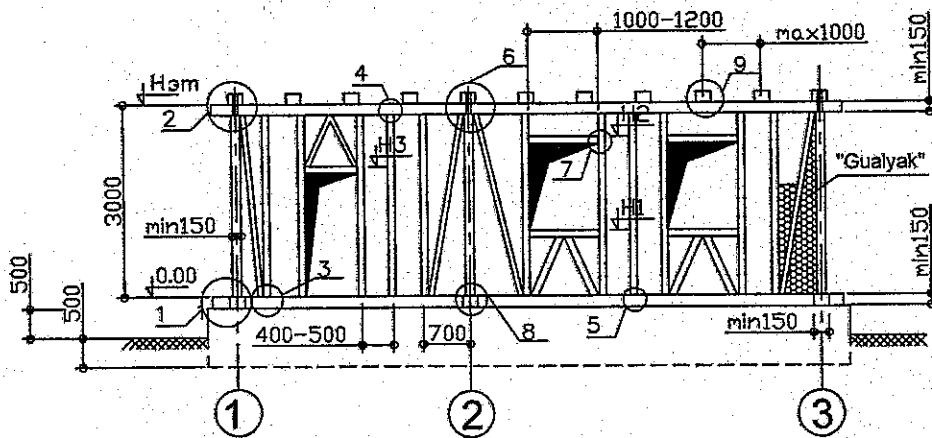
The seismic loads were accepted by all frame at the expense of its dimensional operation. The stability and geometrical invariance is provided with acclinal braces or braces, included in each edge of wall, and also fixing of parts among themselves in "thorn" and with metal cramps. The pieces of frame, fragment of joint are presented in fig. 5.3-5.6. Schematic presentation of construction process from frame "synch" is presented in fig. 5.7. In fig. 5.8 and 5.9 the view of wood frame is presented during construction. Filled by adobe brick the frame is plastered from both sides by saman mortar with thickness from 30 up to 50 cm.

Shown frame is ordinary, but may be double by thickness. To withstand the earthquake with intensity 9 the walls in corners should be reinforced along 120cm from corner by cement-sand plastering by steel wire mesh with diameter 5mm and size of cells 15x15cm.

Plan of the building



View of frame along axe "A"



View of frame along digital axe "3"

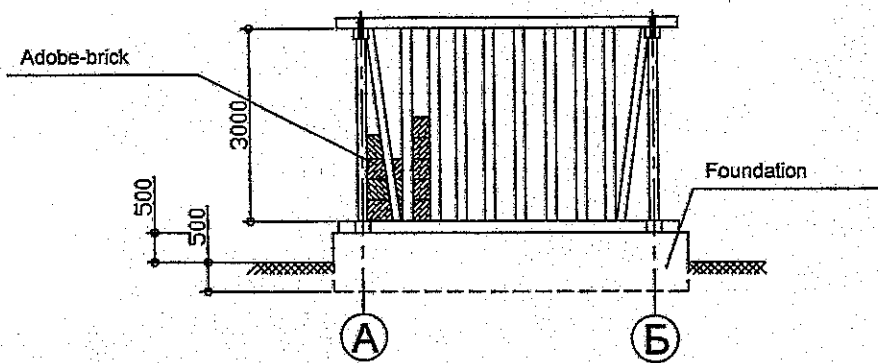


Fig. 5.3 House with wooden frame "synch". Part of walls.

Typical joints of elements of traditional frame
"Synch" for adobe construction

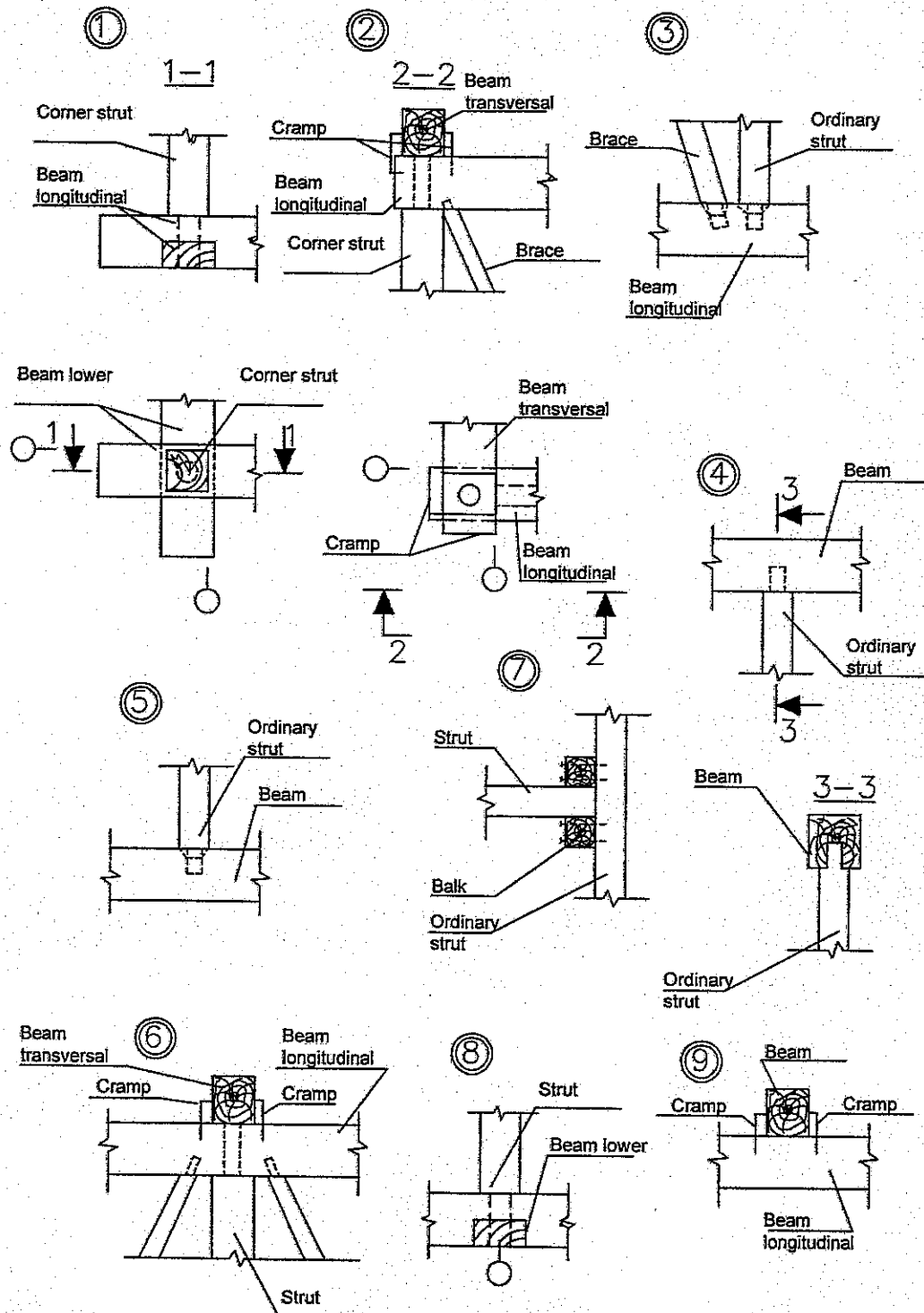


Fig.5.4 Typical joints of wooden frame "synch" of one storey buildings from adobe materials

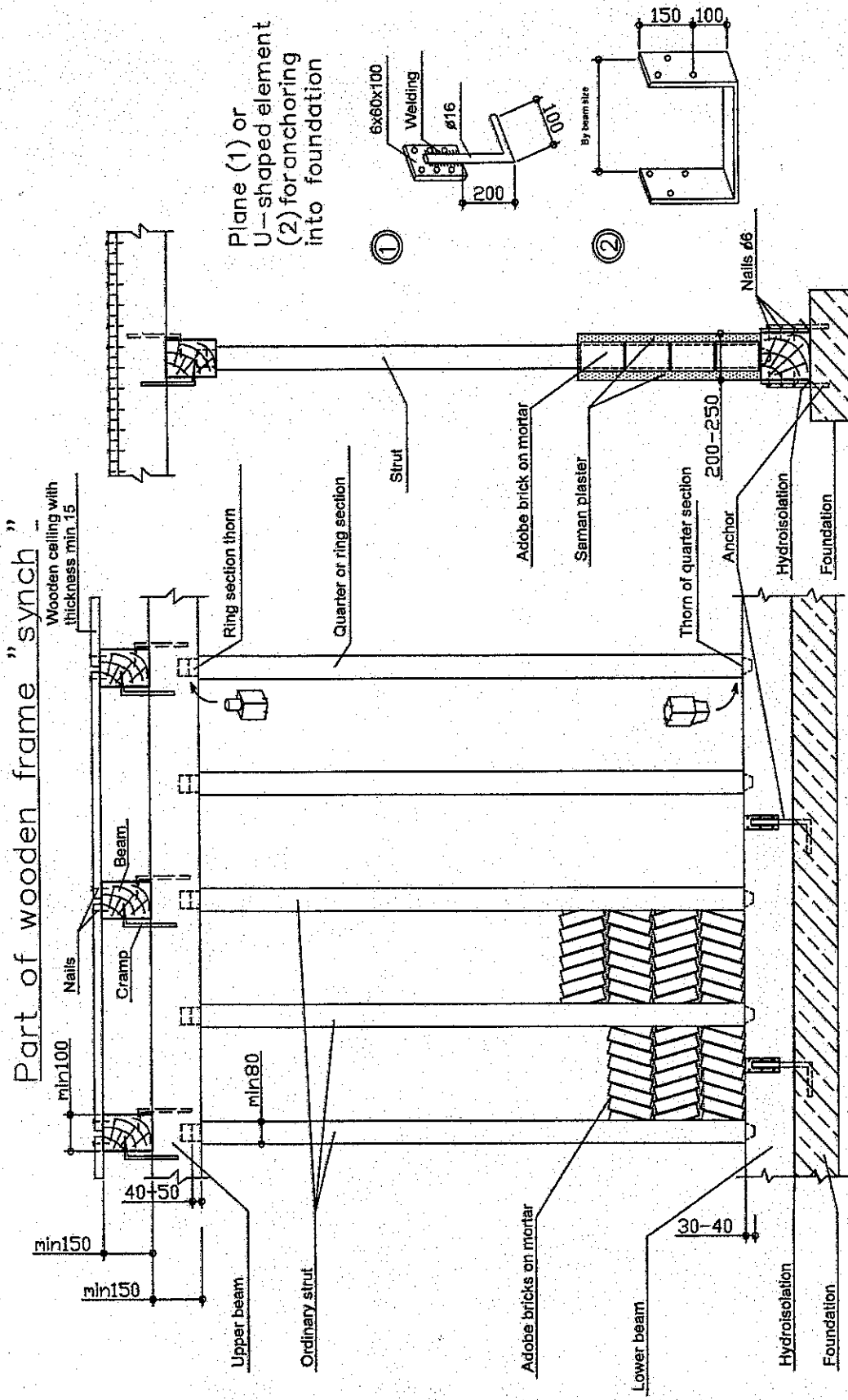


Fig.5.5 Fragment of wooden frame synch wall

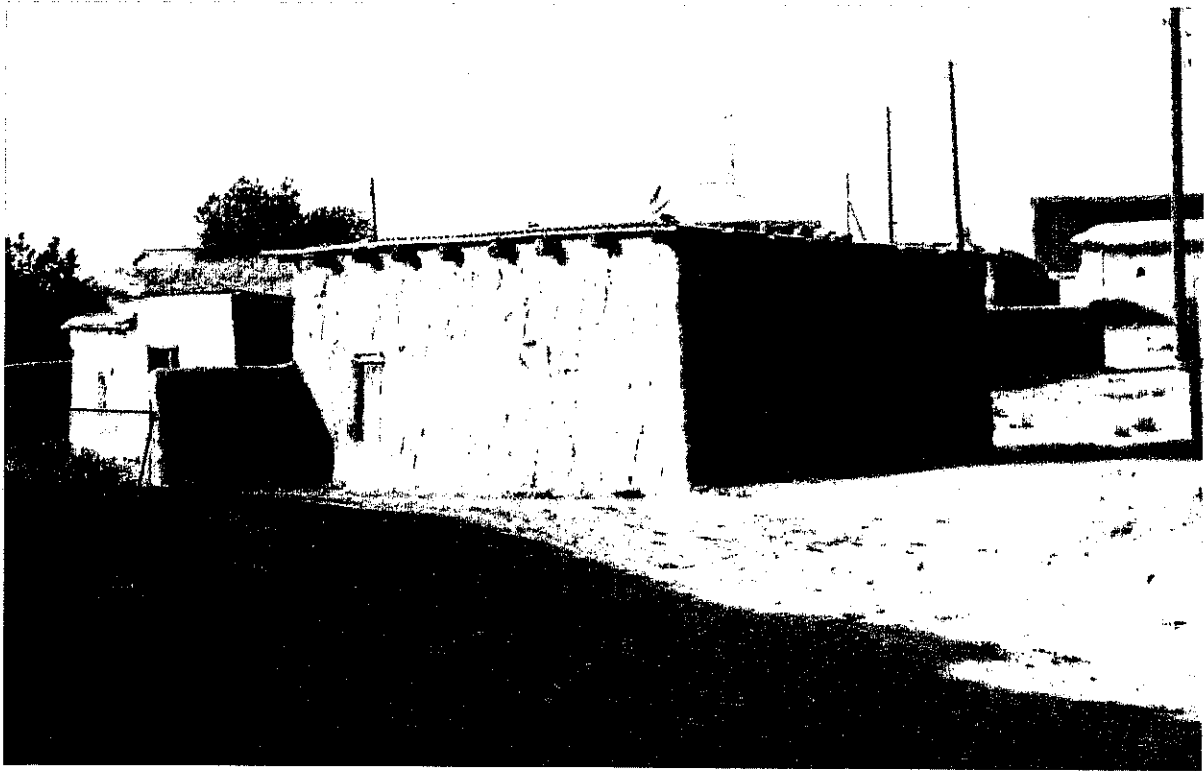


Fig.6.2 View of house, constructed from adobe blocks without antiseismic measures

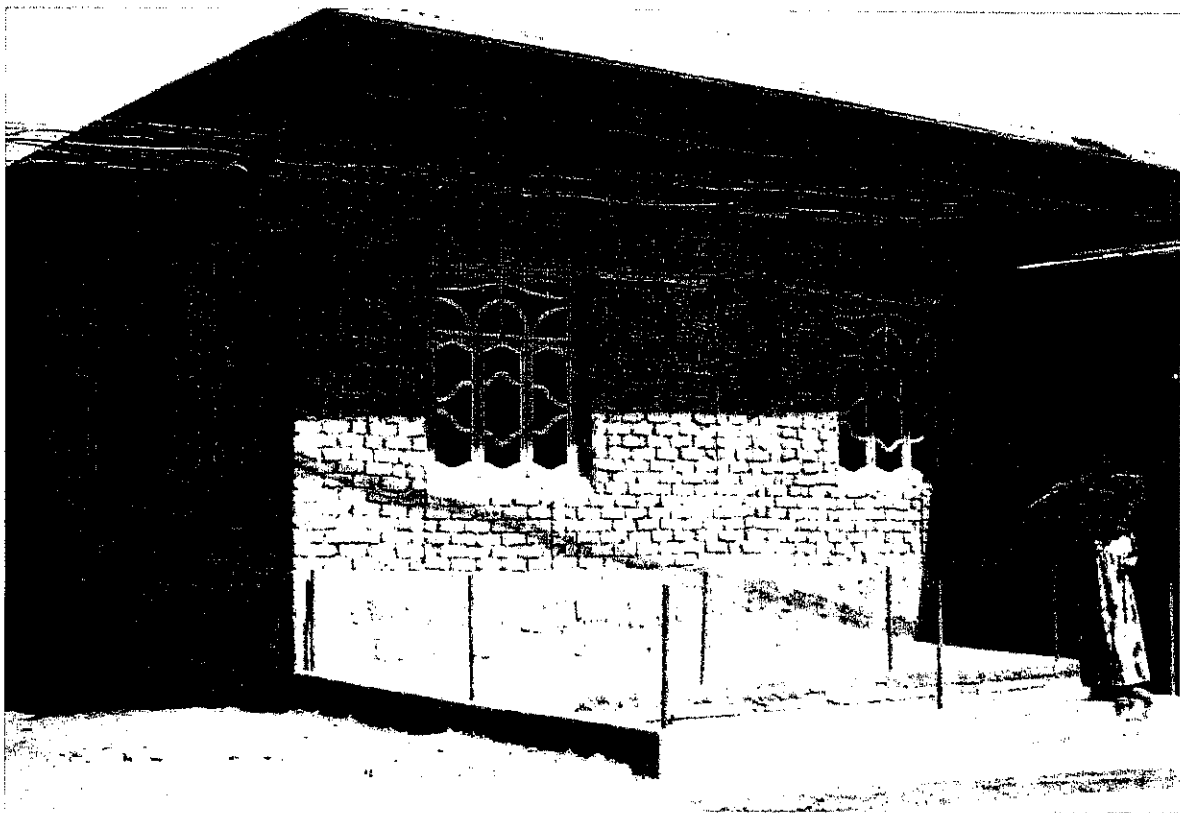


Fig. 6.3 General view of house from adobe bricks without any antiseismic measures.