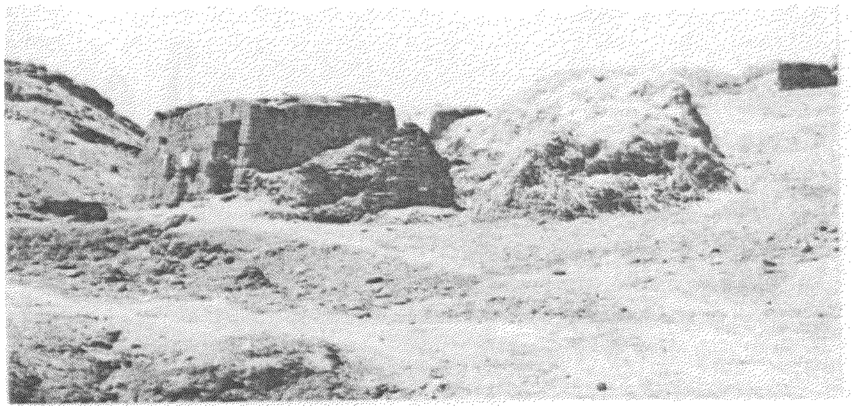

FIG. 3

An individual adobe building. Note the stacks of dung and straw, two essential materials, used for heating and for animal breeding, respectively. The latter is also used in producing adobe blocks, while the former is more desirable as a fertilizer.

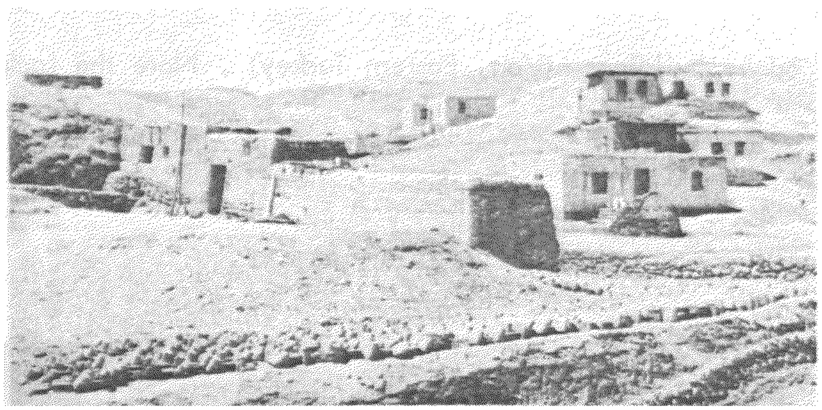

FIG. 4

A view of a village . In the foreground, over the set, a row of fresh adobes are seen, laid for drying under the sun.

FIG. 5

Adobe buildings in a small town. In fact the three photos above represent a transition from rural types to those of urban.

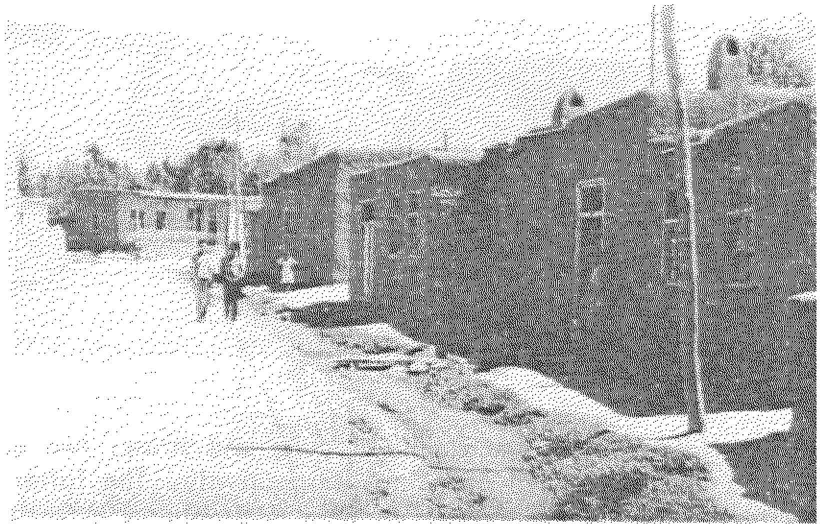

FIG. 6

A row of urban adobe buildings (Van, Eastern Turkey) . Note the lack of eaves.

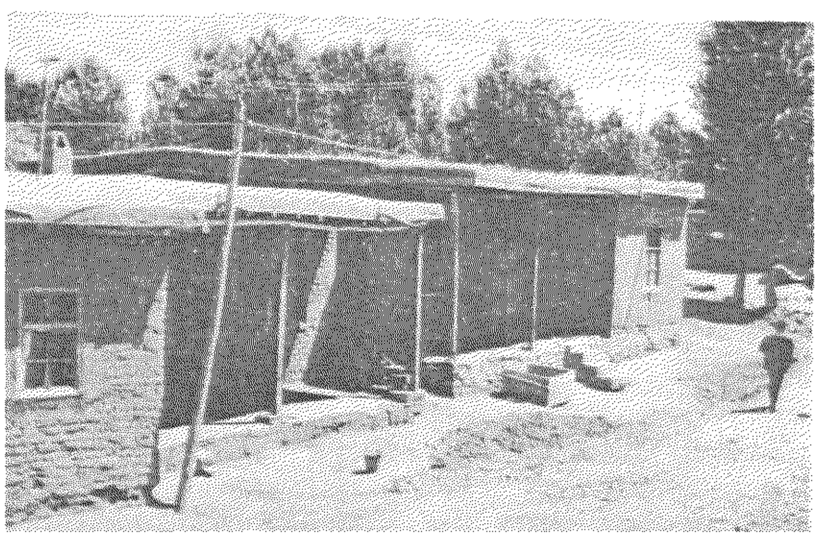

FIG. 7

A row of urban adobe buildings (Van, Eastern Turkey) . Note the eaves.

3.3. Stability of and the Openings in the Walls

The main members to resist vertical and/or lateral loads, in traditional adobe buildings, are the bearing walls. The bearing walls are either solid or contain openings (FIG. 4), as required by architecture. It is obvious, in the latter case the strength of the wall is weakened to some extent. However, if some limitations are imposed, still some resistance is offered by the solid portions - "piers" - between the openings, and it may be sufficient against earthquake effects. The "pier" tops are connected by the wall portions over the openings and also by the bond beams (if any) along the window tops and along the wall top.

The lateral earthquake force is finally transferred to the wall top, either in-plane or perpendicular to the plane. The resistance of the wall to perpendicular lateral forces is very small, since it behaves as a free cantilever. The bending moment and tensile stresses at the bottom, can easily form a horizontal crack on the pushing side, which may further develop into a separation, ending in tilting or overturning of the upper portion. As the earthquake force is of reversing character, the crack may occur on both sides in alternation, with corresponding crumbling on the opposite side under the temporal compression effects. Due to the slenderness or height of the wall, the cracking surface may take place at higher levels. The height of the wall should be limited and it should be intersected by strong perpendicular walls with limited spacing (e.g. 4.50 m), and the wall tops should be securely connected to the ceiling diaphragm, so the forces perpendicular to the wall plane can be transferred without doing much harm. The Code brings provisions about this (see APPENDIX I, Paragraph II.3.3.1-). FIGS. 11 and 12 show that the lack of such connections may lead to the collapse of the wall.

The "piers" may react either in shear or in bending, depending on the height-to-width ratio. If this ratio is higher than 2, bending may dominate, subject to the extent of vertical load. Otherwise shear dominates. The vertical load helps to force the bending conditions toward shear conditions, and if the compressive strength of the blocks is sufficiently high, this is an improvement. However, in most cases the adobes don't possess high compressive strength. Consequently the height-to-width ratio should be kept under 2, and the excessive vertical loads should not be given to the "piers".

A sort of load distribution is provided as a result of common deflection of the "pier" tops, to the extent at which connecting elements fulfill their function. However, the differences should not be too abrupt. The Turkish Code (see APPENDIX I, Paragraph II.3.3.2-) limits the size of window and door openings and specifies minimum lengths of solid wall portions between openings and between an opening and the corner. These provisions aim at assuring shear resistance domination and pooling the strength of elements that are not abruptly different.

3.4. Plan Arrangement

As a general principle for providing earthquake resistance, the plan must be simple (preferably a rectangle) and the bearing walls both in longitudinal and transversal directions must be arranged symmetrically about the two principal axes (APPENDIX I, Paragraph II.1-). The symmetry, mentioned above, should cover also the openings in the walls. Partial basements should be avoided. Otherwise, torsional effects of unpredictable extent may be confronted.

3.5. Bond Beams

Timber beams are employed traditionally. The most popular kind of timber is poplar, as it is easily grown in Anatolia. The Turkish Code allows the employement of either timber or reinforced concrete bond beams on foundation or basement walls, requiring asphalt treatment in the former (APPENDIX I, Paragraph II.5.I-). They should be constructed in the manner shown in FIG. 8 and in Paragraph II.5- of APPENDIX I . The bond beams have a number of functions and if provided sufficiently, increase the earthquake resistance of an adobe building considerably, as follows :

(a) As described in 3.3. , they act as a load distribution means, relieving the stresses from the weaker members, and increasing the share of more rigid (generally stronger) ones.

(b) In general, diagonal cracks are formed in the walls, as a result of high shear stresses, and X-shape is then assumed due to stress reversals. The bond beams prevent the propagation of these cracks to the other portions of the wall. In a way, they act as "suppressors" by limiting the damaged area. This may lead the creation of secondary failure zones at other locations. However, this is usually desirable as a kind of distribution is performed.

(c) The adobe wall is equipped with a tensile strength in the direction of the bond beams, provided that they have enough continuity. The tensile forces are turned into shear forces within the wall. So, occurence of vertical tension cracks are suppressed. This also improves the vertical load bearing capacity, in the same way as stirrups do in reinforced corcrete columns.

(d) The adobe wall is equipped with a shear strength, perpendicular to the direction of bond beams. The wall can, then, tolerate differential settlements or ground ruptures with vertical movement, probable occurences in seismic areas.

The merits of timber bond beams, as mentioned in (c) and (d) above, are seen in FIG. 9 .

(e) The lateral connections between the two members of the bond beams, prevent the adobe wall from splitting into vertical layers (FIG. 8), as observed in some thick walls. The wall thus functions in its full thickness.

(f) The bond beams, with their bending rigidity, perpendicular to the wall plane, increase the bending resistance of the wall, about a vertical axis. This allows the construction of walls with as long a span as 4.50 m, even with openings.

(g) The bond beams, connected together in the corner of two (or three or four) joining walls, provide the monolythicity of the load bearing system (FIG. 8) , preventing separation under seismic actions.

FIGS. II , I2 and I3 show the cases where this function lacks.

Summarizing, the bond beams incorporate ductility to the adobe wall, substantially increasing its earthquake resistant qualities.

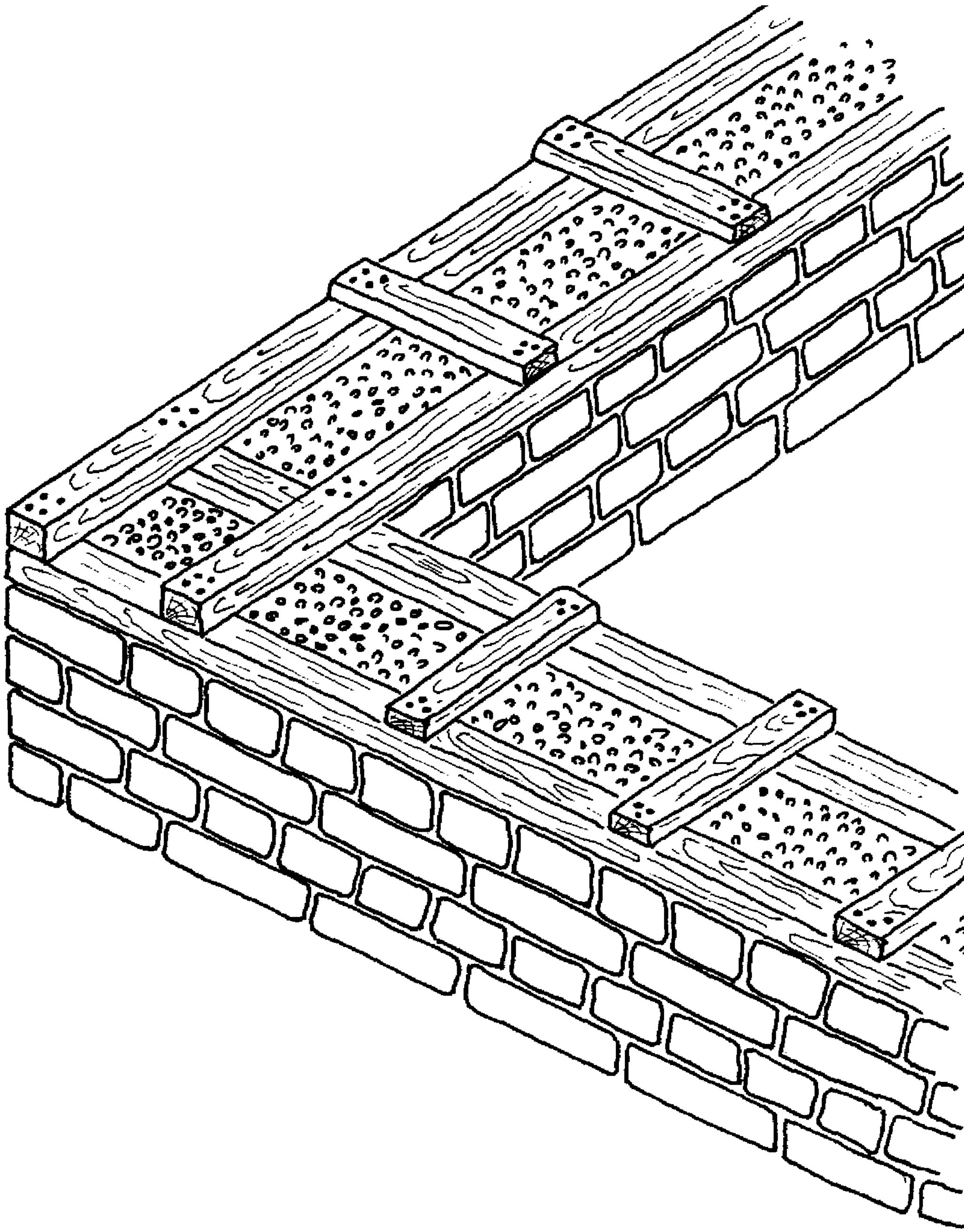

FIG. 8

Timber bond beams, to be provided at certain levels of the adobe wall. The bond beams have numerous functions in increasing the earthquake resistance of adobe buildings.