FIG. 12

Separation of an adobe wall, from the adjoining perpendicular wall. Looking from inside. The timber stud, in the corner, supporting the main beam (that in turn supports the ceiling beams), worked well for the wall facing the reader. However, the connection to the other wall was poor. The ceiling beams too, didn't help the adjoining wall.

The rectangular light spot on the left is a window opening.

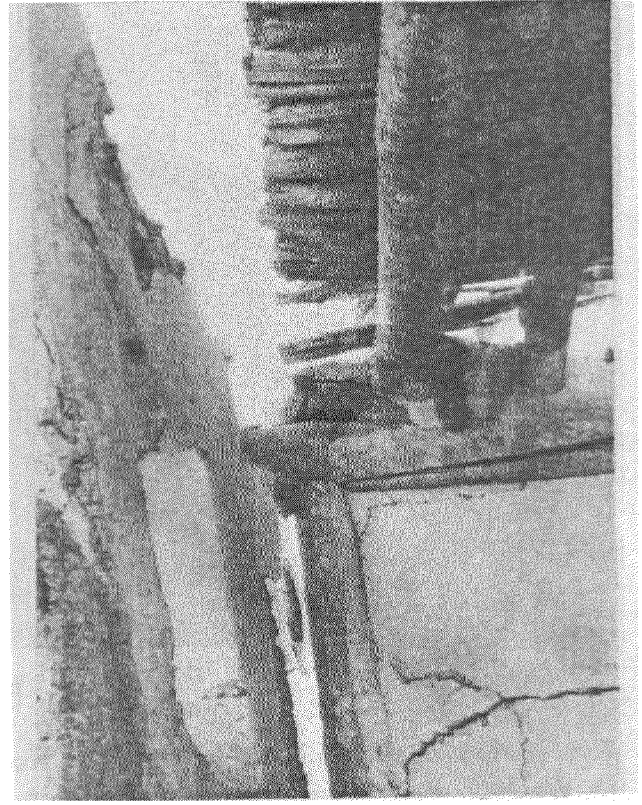
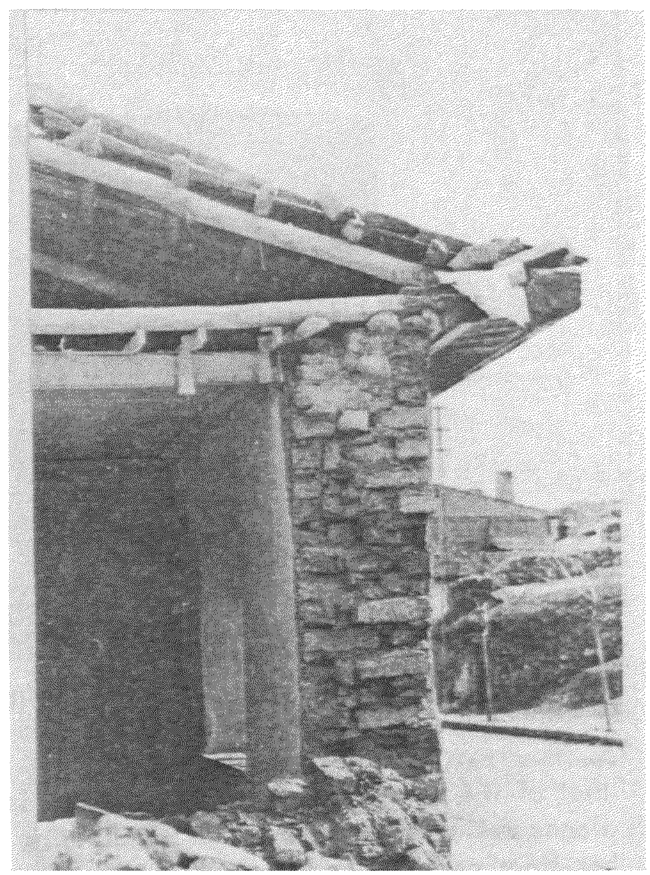


FIG. 13

The section of an adobe building, as revealed by Alaşehir (Western Turkey, 1969) earthquake. The thickness of the wall is of 1 1/2 adobe length. Adequate diaphragm action is provided by the ceiling, where rectangular timber beams are employed. However, insufficient connection at corner and ceiling caused the partial collapse of the front wall.

Note the lack of proper bond beams in the wall. Although the roof did not cause any damage in this case, the irregularity of the sections and the axes are noted.



3.6. The Roof

Heavy, flat earth roofs have caused most of the loss of life in adobe buildings, as they can easily weaken and destroy the load bearing walls, and fall down, (FIG. 16). It consists of logs, placed on top of walls with a certain spacing -typi - cally 0.35 m from center to center - (FIG. 14). The spaces in between, are spanned with branches, then with shrub and foliage, in order to form a base to hold the thick earth layer. In regions where cane grows, dried and flattened canes are used to make a basket-like fabric or mat, to substitute the foliage. The observed thickness of the earth layer varies between 0.15 m and 0.50 m . This provides sufficient thermal insulation.

The roof also functions as a platform for such family activities as drying fruits or vegetables, for certain housework, for preparing food for the winter, even for sleeping at night during the hot season. A slope of 2.5 % is sufficient for draining the rain water in most cases, still not adversly affecting the above functions.

Addition of straw -as in adobe block making- to the thick earth layer, supp- resses shrinkage cracks, improves the water and thermal insulation properties. Lime al - so improves waterproofing. The houseowner generally keeps a roller stone in order to to compress the new material, after the repairs of the top plaster. Such a repair is normally required every year.

In I st and 2 nd earthquake danger zones, the flat earth roof is prohibited. The thickness of the earth layer is limited to 0.15 m in the remaining zones (APPEN- DIX I, Paragraph II.6-). In FIG. 14 various ways of constructing an earth roof are shown. The building in FIG. 3 has the roof type shown in FIG. 14 (a), and the building in FIG. 5 corresponds to FIG. 14 (b) .

(a) In the type shown in FIG. 14 (a) the roof beams directly rest on top of a- dobe wall. The supporting length is approximately half the thickness of the wall. There are no eaves. As the rain washes the wall plasters, frequent repairs are needed.

In case of an earthquake, the ends of the roof beams may undergo large re- lative displacements with the supporting wall. As the earthquake force is of reversing nature and the bearing length is small, this may result in either pulling off the beams or local compression failures in the bearing portion of the adobe wall. In both cases, the heavy roof constitutes a great danger for the inhabitants (FIG. 16).

(b) In the type in FIG. 14 (b), the longer roof beams allow the formation of the eaves, and reduce the probability of pulling off. However the danger of wall failure, as initiated by the local compression failures under the beams, still remain.

(c) In FIG. 14 (c) collar beams are seen, along the wall top, functioning as a load distributor. The heavy load of the roof beams are no more concentrated on the adobe blocks, but is now distributed more evenly. Moreover the collar beam possesses all the merits of the bond beams, as mentioned in 3.5. above.

Most of the earthquake force comes from the roof, due to its large area and huge mass. The load should bear this lateral force, in addition to the previously exis- ting vertical forces. As mentioned before (3.3. above) the wall resists the in-plane lateral forces in shear mode. For materials of high compressive strength,compression

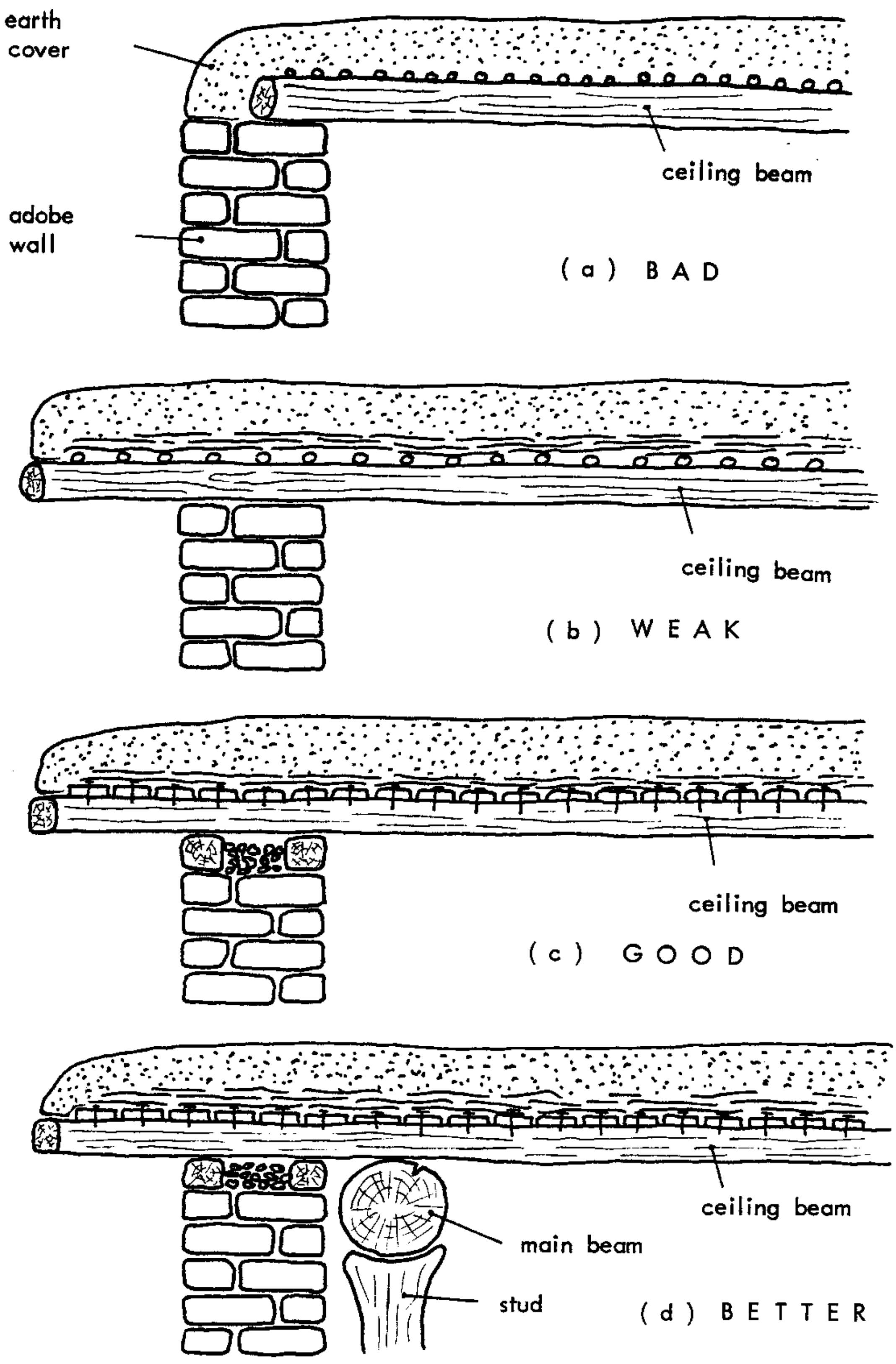


FIG. 14

Various ways of constructing an earth roof. The above four pictures represent gradually better solutions, from the top to the bottom.

has an improving effect on the shear resistance capacity. But the majority of the a - dobes used in Turkey, are of low compressive strength. Consequently, the combining of compression and shear could cause local failures, especially between wall openings. So, FIG. 14 (c) is not the best solution.

(d) In FIG. 14 (d) a larger main beam supports the roof beams, the latter still rest on the collar beams of the wall. The main beam, in turn, is supported by vertical studs. The heavy load of the roof is now relieved from the walls, and also a second line of defense is obtained.

The cases (a), (b), (c) and (d) in FIG. 14, represent gradually better solutions, respectively. Another improvement in (c) and (d) is the employment of flat timber boards, nailed on each roof beam. These connections provide the integrity of the roof, thus improving the earthquake resistance of the whole building, as it functions as a rigid diaphragm. Otherwise, the diaphragm effect is only partly obtained through the transversal slender branches and the earth layer. This effect works only in case of low intensity earthquakes. The employment of nailed timber strips, considerably raises the extent of intensity of the earthquake, under which the building can still hold itself. The same material as mat and/or foliage should be used between the timber strips and the earth layer, both for thermal insulation and preservation purposes.

In FIG. 15 a roof is seen from inside, in the type shown in FIG. 14 (d). The stud is built in the wall. As its lateral rigidity is provided by the wall, cracks and a permanent lateral deformation are seen due to earthquake excitation. However, the limitation of the openings, sufficient solid wall portions, and the bond beams, in addition to the stud and the main beam system, described above, all contributed to the survival of the building.

3.7. Floors, Ceilings

In case of double-slope light roofs (FIGS. 10 and 13), and in case of two storied buildings (FIGS. 10 and 11), a ceiling capable of resisting in-plane forces and deformations is essential. They should be securely connected to the walls, on which they rest. FIGS. 11 and 13 show the lack of these connections, although such ceiling diaphragms exist.

3.8. Chimneys and Appendages

Chimneys and appendages are generally the most sensitive portions of adobe buildings. Even in earthquakes of low intensity, they break off easily. Appendages are not common in adobe buildings in Turkey. The Turkish Code has provisions on chimneys (APPENDIX I, Paragraphs 4.1.2- and 4.1.3-).

Wherever possible, the chimney must be an independent structure, resting on its own foundation (FIG. 11), instead of transmitting its weight to the roof. Pipes of sufficient diameter should be preferred, because of their strength and lightness.