3.3. Foundation aspects
3.3.1. Health center in Huaytara
Huaytara is located some 130 km away from the epicenter, high up in the mountains. Here the ground shaking was not so severe and mainly vertical cracks in adobe walls were observed. One of the church towers suffered damage as well. A damaged school building is described in Chapter 4.

The health center in Huaytara suffered cracking of walls due to a foundation problem. At the construction there was a sewage canal, which is not in use any more, and on top of which an unreinforced foundation slab was placed. Due to the earthquake there was some soil movement around the canal and there was uneven settlement of the slab, causing it to crack as seen in Fig. 3.14.

Fig. 3.12. Damage house located at point 79 in Fig. 3.6.

Fig. 3.13. Health center in Huaytara with cracks in walls due to foundation differential settlement.
The health center was built on a slope, which likely exaggerated the soil movements and their effects on the slab foundation.

Fig. 3.14. Huaytara health center foundation slab with 1cm wide crack due to differential settlement.

### 3.3.2. Adobe foundations and ground humidity an example from Guadalupe

Guadalupe is located on kilometer 290 of the Pan-American Highway. There was a lot of damage to adobe house in this area ranging from completely collapsed house to houses with cracked walls. There was greater amount of damaged houses on the east side of the Pan-American Highway, possibly related to higher moisture content of the soils weakening the adobe walls. The adobe walls absorb the moisture from the surrounding ground, which thereby softens the mud bricks. This problem is wide spread in many locations in Peru and likely in other countries as well. The moisture absorption was evident inside one house as shown in Fig. 3.15.
A typical foundation method for the adobe houses consists excavating a narrow trench and putting the adobe blocks inside trench, right on top of the soil. With time the buried part of the adobe wall absorbs moisture becomes soil again, i.e. the wall is virtually placed on the ground. It is questionable if it is of any help to excavate the trench in the first place. An example of such a wall is shown in Fig. 3.16. The moisture also accelerates decomposition of organic materials within the adobe blocks, further reducing the strength of the blocks, since the organic materials function as sort of “fiber reinforcement”. In addition to reducing the earthquake resistance of an already earthquake vulnerable building type, the moisture also constitute a general health problem. With the above in mind it is necessary to convey the message of proper foundations preventing moisture to be absorbed in the walls. The adobe moisture absorption is a big problem in the “Barrios Altos” area in Lima and the vulnerability of these houses will show itself in the next big earthquake in Lima.

In the northern part of Ica a drainage dike was constructed to drain the soil in the area (according to local engineer), but due to the suspended material entering, the dike clogged up and the drainage capacity was reduced drastically. Proper maintenance of these civil infrastructure is thus important.
Fig. 3.16. Temporary self-built house. The original house collapsed in the earthquake. The dashed box shows how the lower part of the wall is darker due to moisture absorption.
3.3.3. **Good performance by two liquefaction resistant buildings in Pisco**

We found two buildings with good performance even though damage to buildings around them was severe. The location is indicated in Fig. 3.17. This area was severely damaged by liquefaction as seen in the ground cracks in Fig. 3.18. Lateral spreading caused the soil to displace towards the ocean and the creating some 10-15 cm wide cracks in the soil. The crack probably continues in front of and/or beneath the blue building and then up through the confined masonry wall as marked by the black arrow in Fig. 3.18. The soil settled some 10-15 cm next to the blue house as shown in Fig. 3.19.

Settlements and cracks like these caused by the liquefaction damage in many houses in this and other areas of Pisco.

![Google earth satellite view of location of buildings with pile foundation (blue mark) and strong foundations slab (green mark).](image_url)