

# 7

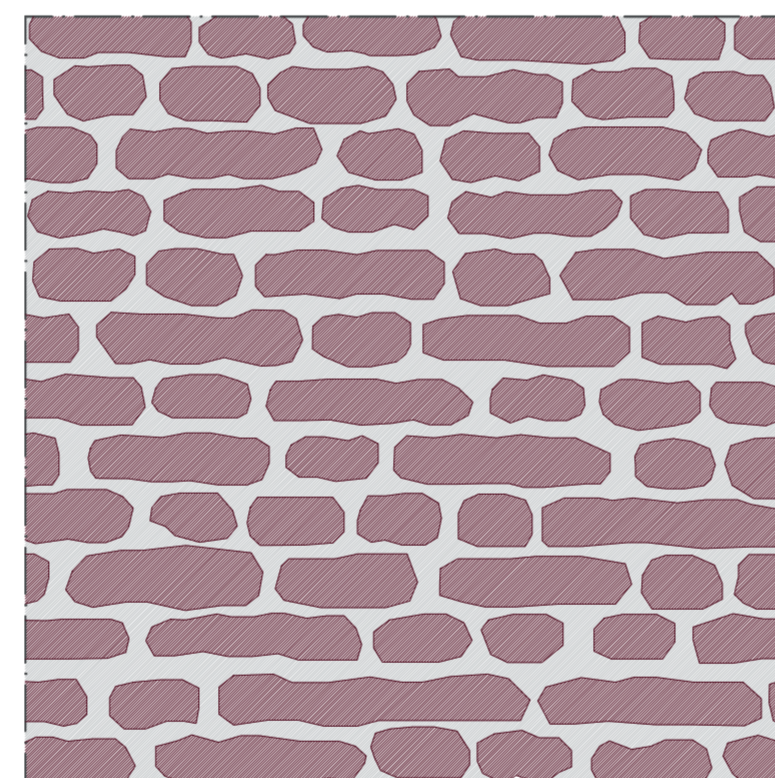
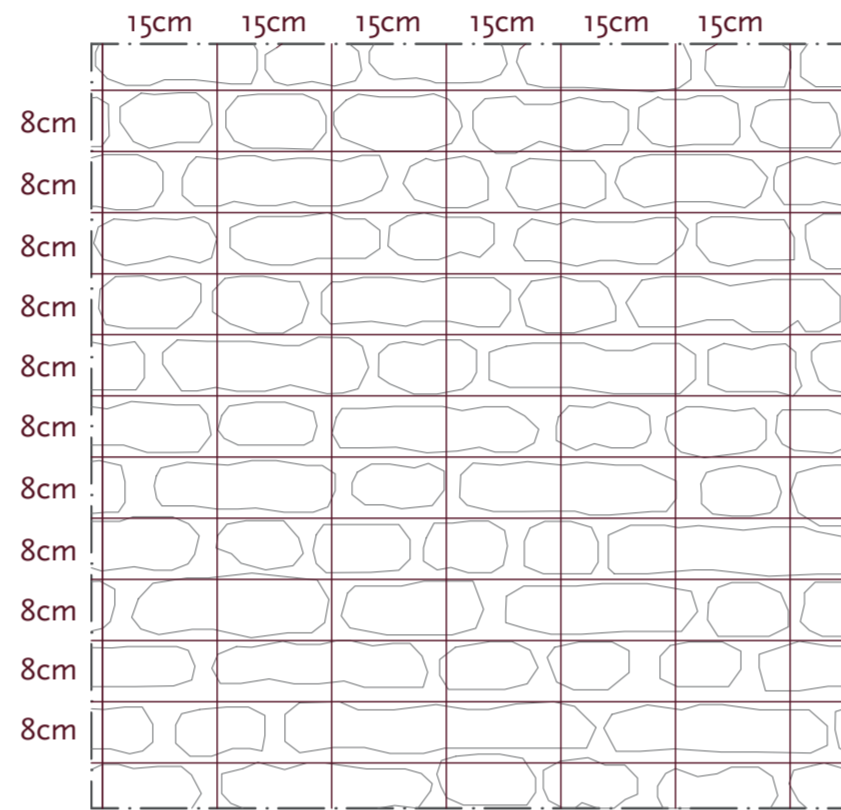
## THE MASONRY INVESTIGATION



### material survey



### masonry analysis



#### BRICKS

**MATRIX:** Uneven, characterized by a strong heterogeneity and widespread macro and micro porosity.

**COLOUR:** Varied, due to the inhomogeneity of dough and cooking. Tendentially reddish and blackish.

**DIMENSION:** Various, mainly about 5,5x12 x24 cm. Some bricks have a longer length, reaching 27/28 cm

**TEXTURE:** Arrangement to regular and staggered horizontal courses of bricks predominantly of band, alternating with header ones.

#### LIME MORTAR

**MATRIX:** Homogeneous, consisting of lime and aggregate of various grain sizes and colors typical of the sands coming from the lake. The mixtures used have a high inert binding ratio and in some places there are traces of cocciopesto.

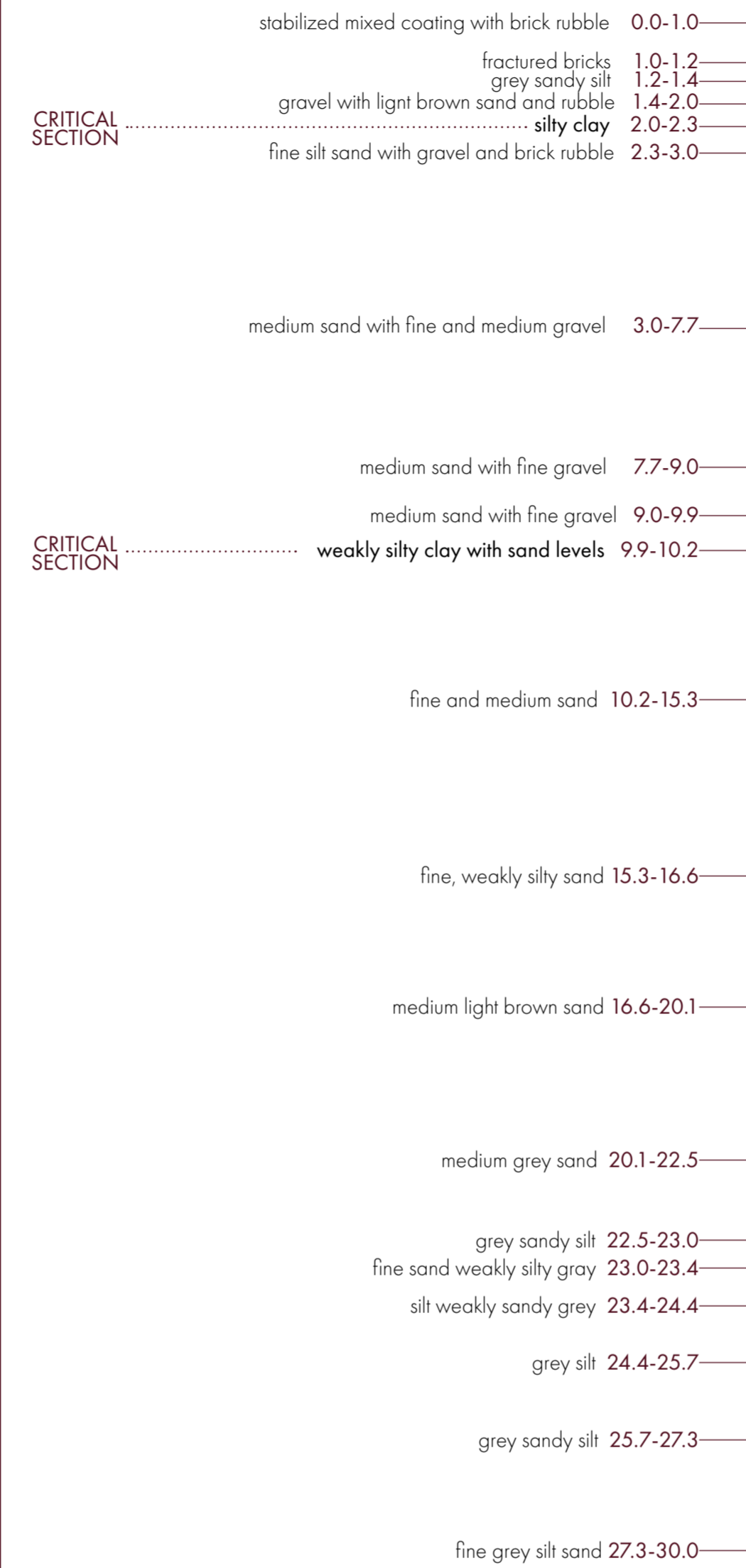
**COLOUR:** Generally light gray

**DIMENSION:** Height horizontal joints 2.5cm, width vertical joints

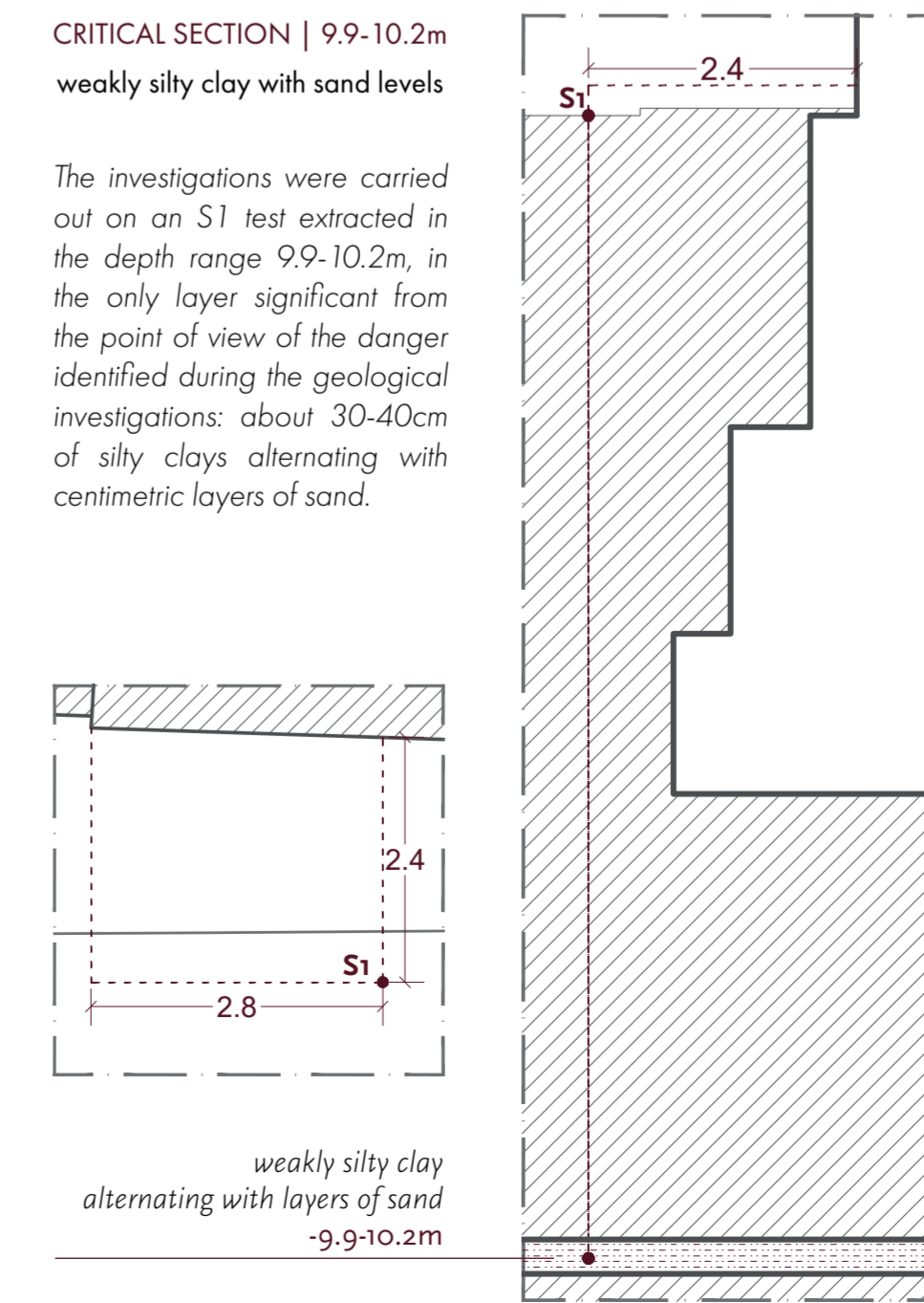
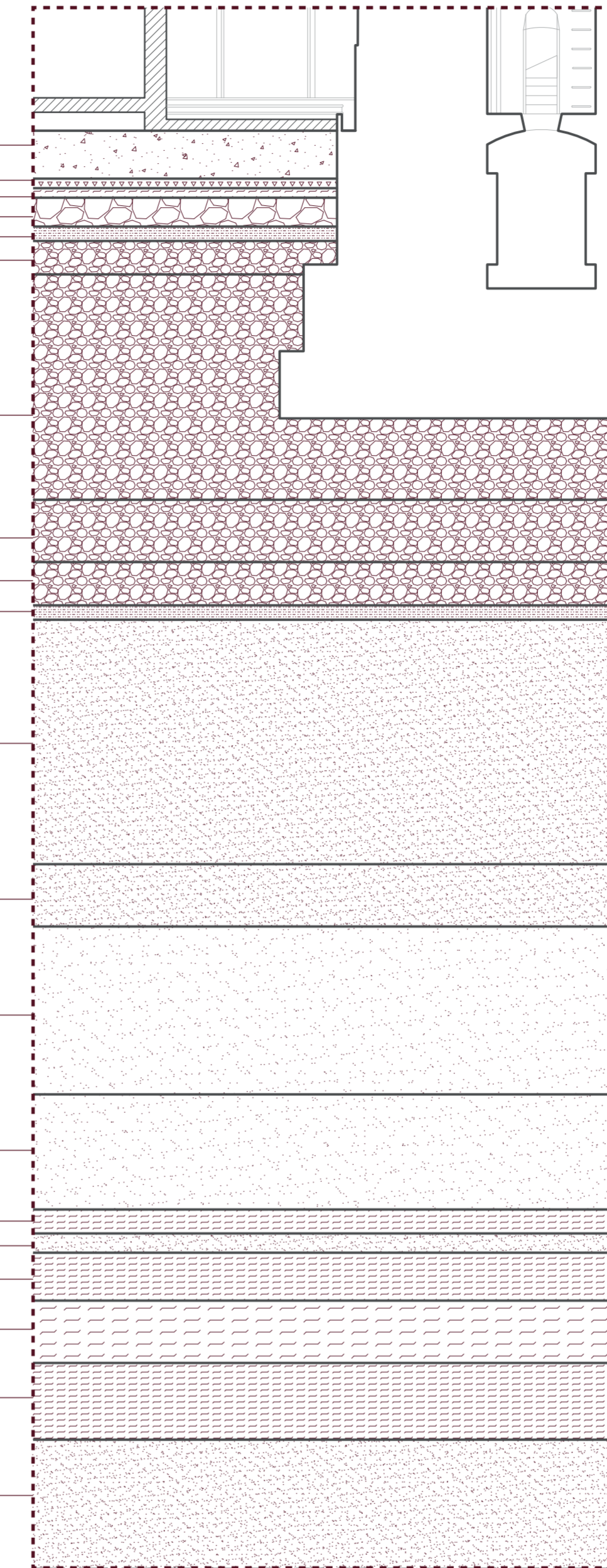
**TEXTURE:** Distance vertical joints 8cm, distance horizontal joints uneven

**NB:** The types of stilatura realized originally and during the preservation interventions over the years don't give the possibility to clearly define the profile of the bricks inside the masonry, that have been retraced in this analysis following the drawing of the mortar.

### 90's investigations



### geological investigations



### laboratory analysis on the critical section

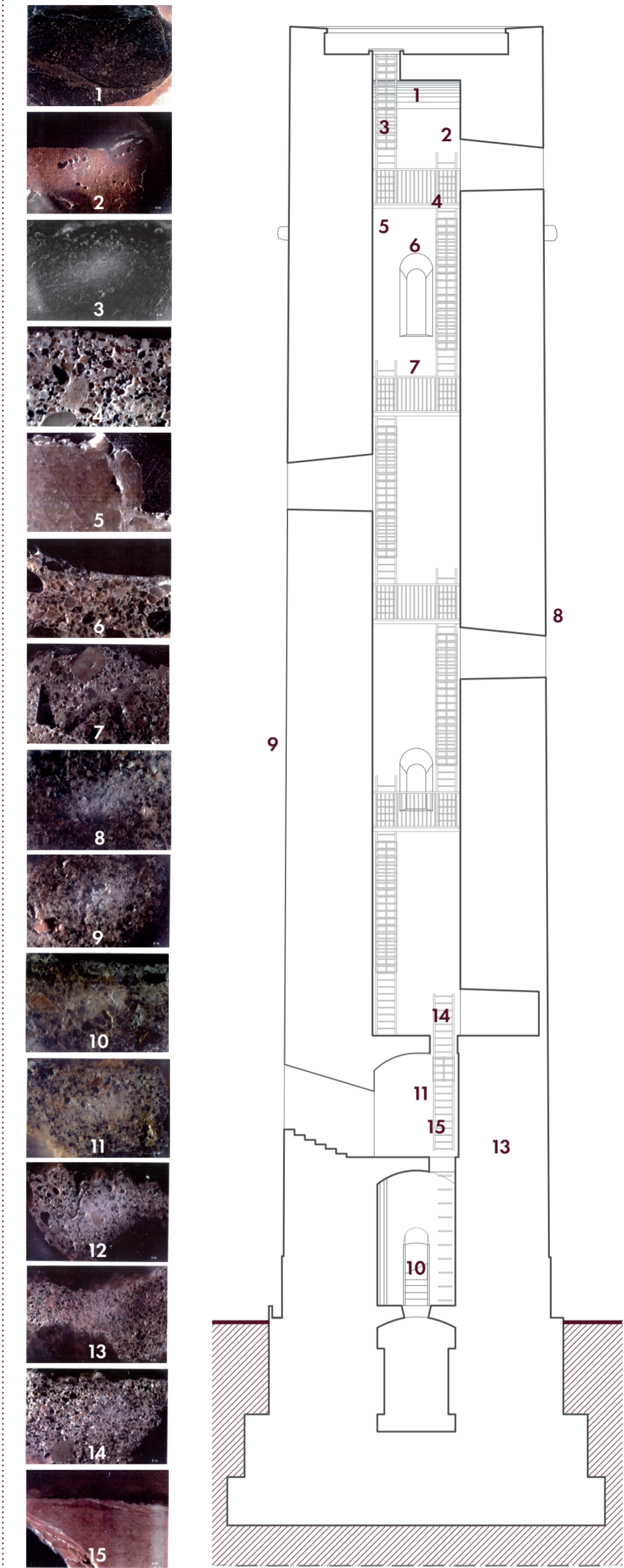
direct shear test  
Atterberg limits  
consolidation coefficient  
hedometric consolidation test

A series of laboratory analysis has been developed on the test taken from the critical section found during the geognostic verifications. Considering the absence of evident out of plumb and an apparent homogeneous distribution of the loads, it can be assumed that this level has a uniform development. Considering the small dimension of the test withdrawn and its dishomogeneity it has been developed ad unconsolidated, undrained shear test instead of a triaxial test. The others tests have been developed regularly.

The results of the tests, analyzed together, show a good degree of over-consolidation and a permeability typical for this type of soil. In general, the results of the edometric tests have shown a fair degree of over-consolidation due to the load imparted by the structure and fair characteristics of bearing capacity, compatible with the loads to which the soil is subjected.

### laboratory analysis on bricks

bricks microscope inspection



#### porosity measurements

5 samples were taken from as many points in the tower. The specimens were dried at 105 ° and weighed, before being subjected to immersion, boiling and reweighing.

The microscope inspection of the bricks tests collected all around the masonry and the porosity measurements have showed how effective porosity of each is likely different on the basis of different compositions, which resulted in a diversified response to atmospheric agents. In general, the values relating to the surface portions, most exposed to degradation sources, showed greater porosity and lower density.

#### load tests with flat jacks

12 tests were performed with the aim to identify the maximum pressure beyond which lesions form in the portions of masonry adjacent to the shear. The data obtained have allowed to reach informations about the load-bearing capacity of the masonry and on its effective originality.

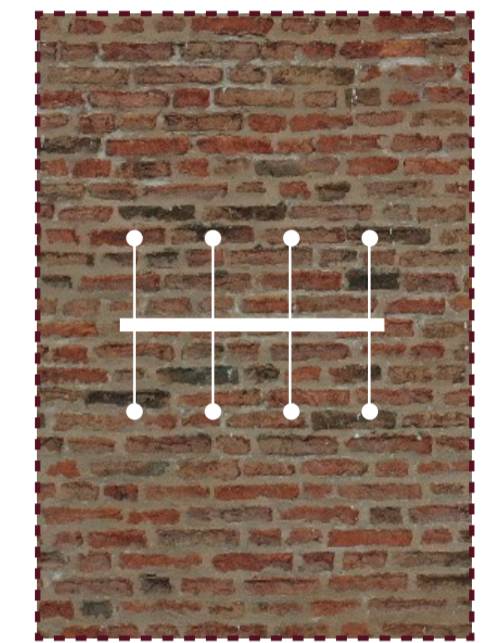
NB: The values shown are the result of tests carried out in the 1990s, with techniques that are now unusual compared to current potential. For this reason they must be considered the basis for further investigations necessary to obtain a more realistic point of view of the state of the masonry.

### deepening hypotesis

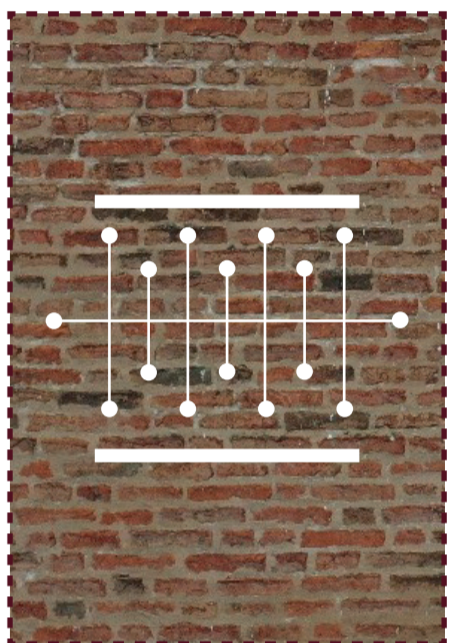
On the basis of the data collected during the surveys carried out in the '90s and during the personal direct survey of the Tower, it is possible to hypothesize a new survey project that will allow to analyze exhaustively all the questions that have remained unresolved as a result of the investigations already carried out and the problems that have emerged in recent years.

The following is therefore a hypothesis of deepening with respect to what, over the years, by different people and with different techniques, can be considered as already evaluated and still valid, although in some cases, as has been better explained, the data collected should be used critically as the techniques used to obtain them are now obsolete and sometimes even questionable.

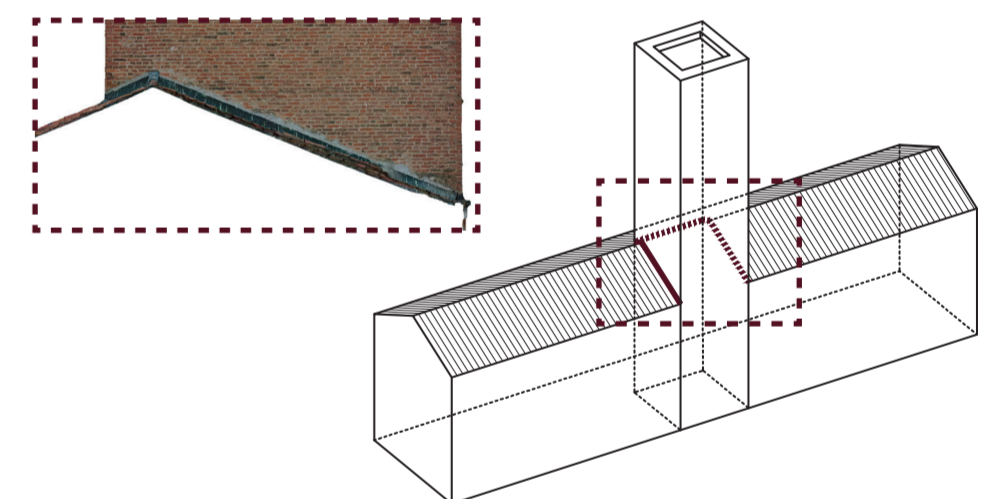
#### single flat jack tests



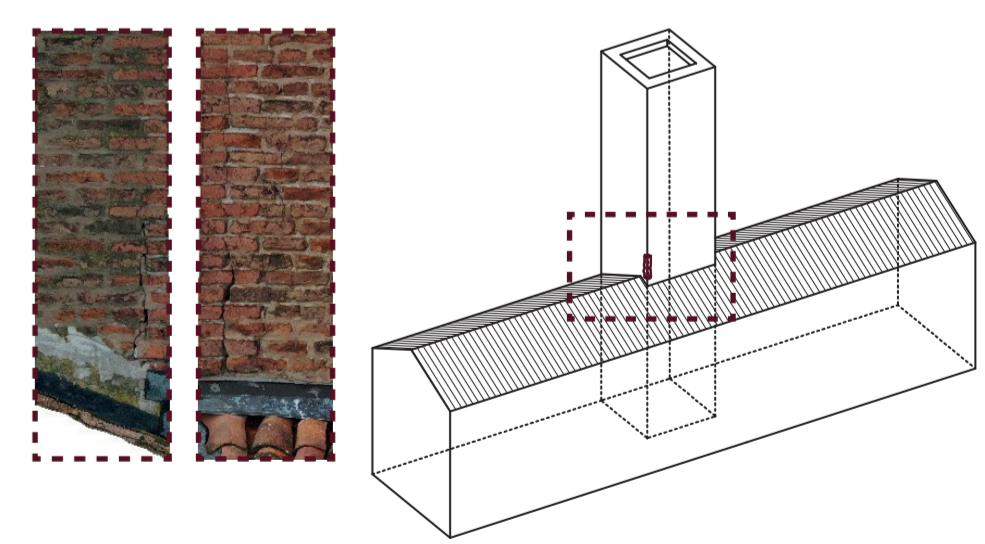
#### double flat jack tests



#### discontinuities and modified areas inspection



#### cracking static and dynamic monitoring



#### top area inspection

