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COMPLEXITY OF STONE WALLING TECHNOLOGY

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Abstract: The present work is the result of a study, of the restoration of medieval churches. In the Middle Ages the walls were built either from carved or uncarved stones. The major buildings – for example cathedrals – were built with carved stones, while the simpler buildings – for example the village parish churches – with uncarved stones. In the present paper a complex problem related to limestone walling is investigated. The related walling was built from uncarved stones. Both smaller and larger stones need to be used to obtain thixotropic walling from uncarved stones. To build walling like this demands considerable expertise, so this is a complex task. From the number and the distribution of the differently sized stones we can draw a conclusion about the complexity of the technology used.
Keywords: restoration, medieval churches, buildings, limestone walling, uncarved stones

1. INTRODUCTION AND EXPERIMENTAL PRELIMINARIES

The present work is the result of a study, of the restoration of medieval churches. In the Middle Ages the walls were built either from carved or uncarved stones. The major buildings – for example cathedrals – were built with carved stones, while the simpler buildings – for example the village parish churches – with uncarved stones [1-8]. In Figure 1 some types of wall are shown [4, 8]. Mantle wall technology was employed with the thicker walls, but not with the thinner walls.

Typically, mantle wall technology was used for walls built from uncarved stones, but some mantle walls do feature carved stones. When uncarved stones were used, the outer wall was constructed with bigger stones and was filled and supported with smaller stones. While mortar was not necessary to hold the wall together, it contributed to the stability of the structure. From previous study, in case of the wall, built from uncarved stones a stratification is observed, which are followed by each other in equidistant way [3, 8].

The series of measured data is derived from an authentic wall construction technology. The wall in question, built from limestone was produced during the reconstruction of a Middle Ages rotunda [4, 5, 7]. A part of the walling is illustrated in Figure 2.

The used stones were measured in size and the occurrence of the different sizes in the distribution was established.

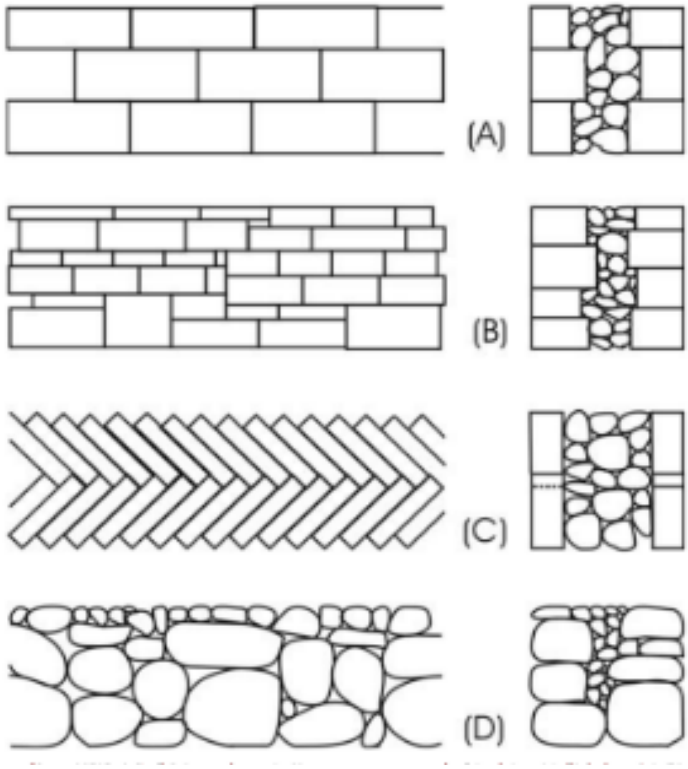

Figure 1. Different walling types A) wall, built from carved stones with same heights, B) wall, built from carved stones with different heights, C) opus picatum type wall D) wall, built from uncarved stones

An average diameter for the stones concerned was established, and their weight was measured. The bigger stones, which were few in number, were weighed on bathroom scales. The very large number of smaller stones were weighed on kitchen scales (Figure 3). The data of several hundred stones were tabulated onto a spreadsheet and presented as a log-log diagram.

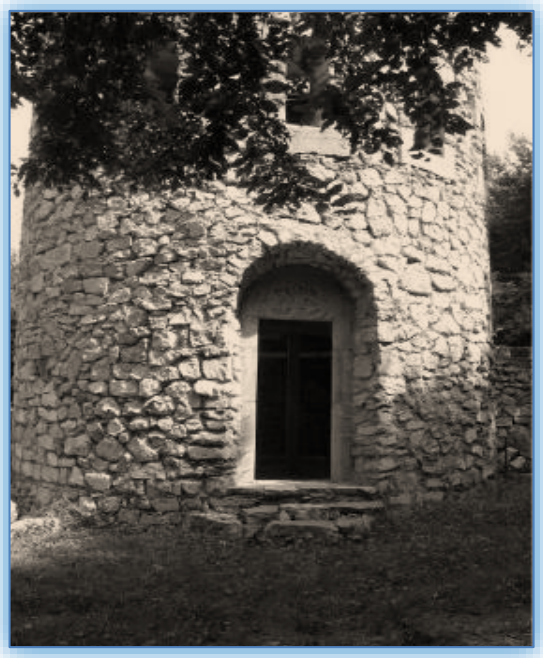

Figure 2. A section of walling from uncarved tones. (View of the rotunda from the entrance.)

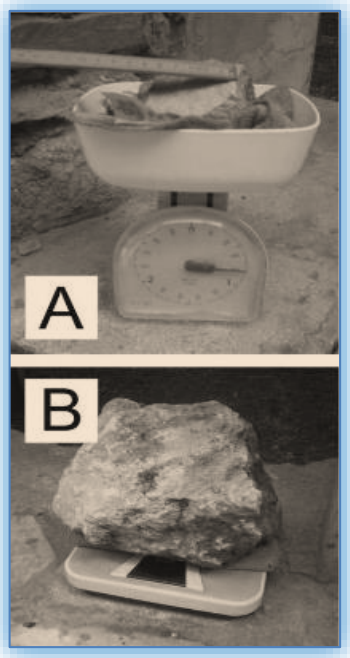

Figure 3. The weighing of the stones used. The smaller stones on kitchen scales (A), the largerr stones on bathroom scales (B).

2. DISCUSSION AND RESULTS

The above mentioned diagram is shown in Figure 4. This figure shows a relatively smooth statistical distribution. The initial part of the distribution displays a straight line, with few variations.

The method of construction depends on many factors. One criterion is how the component parts fit together. In this study, the size and number of the stones display a pattern. The distribution in Figure 4, can be expressed as a power law, a mathematical equation. In similar cases a correlated result can be observed [9]. In practice this means that the quantities of large and small stones are interrelated. When large stones are used, small stones are needed to support the walling. Smaller stones are also needed to fill the gaps between the large stones, and their size and quantity depends on those of the large stones.

This complex pattern is supported by the earlier observation, that with walls constructed from uncarved stones a regular stratification is observed. From our observation this stratification is characteristic of the walling stones, i.e. the distance between the strata depends on the kind of stones used. The walling in this research serves as an illustration, as does the walling, originating from the 4th century in Cella Septichora in Pécs (Figure 5.) [8]. The type of the stones is determined by the need to create a stable structure, and by their provenance.

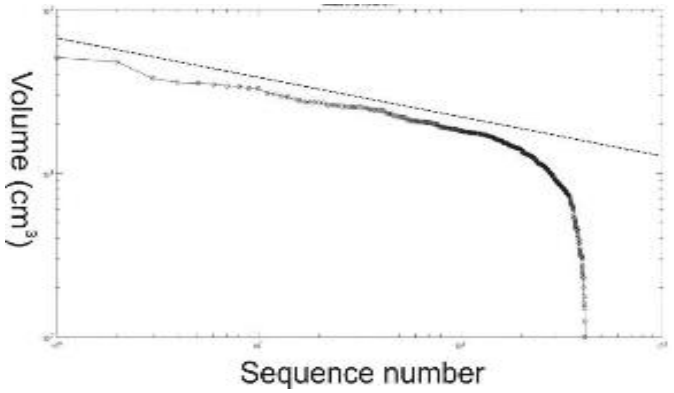

Figure 4. The sequence of the different sized of pieces of limestone arranged in the wall corresponds to a pattern of power law

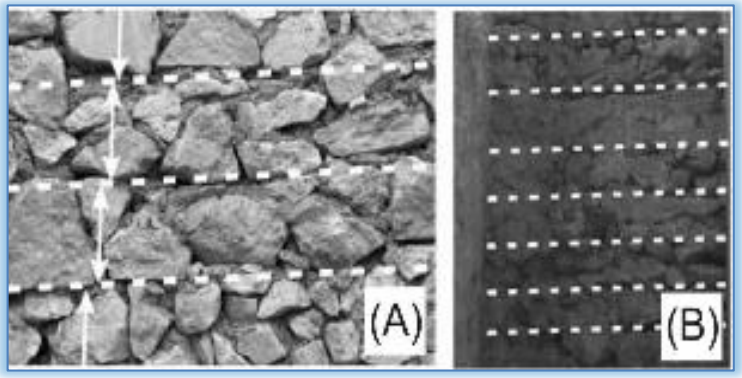

Figure 5. The walling, constructed with: uncarved stones: symmetrical equidistant stratification is observable. (A) The statification of the rotunda walling. (This walling features in the building is shown in Figure 2) (B) The stratification of the walling of the Cella Septichora from the 4th century [8].

The research also considered other salient patterns [11]. The present work is a summary of initial research, which will continue along these lines.

The above mentioned stratification came to notice after construction, and was not intentional. The spacing of nearly horizontal virtual dividing lines occurred spontaneously. We conclude that the spaces between the strata could depend on the kind of stones used. It is not probable, that in the walling mentioned as an example from the 4th Century the stratification would have been made consciously. This was certainly not the case with the wall which we constructed.

The logarithmic function of the distribution of the stones illustrated in Figure 4, originates from an authentic walling technology. Figure 6 shows a cross section of such a wall, which can be of differing thicknesses. It is generally the case that the smaller irregular stones are placed between the larger bordering stones. The stones, excavated from mines by demolition or explosion, are incorporated into the construction with the minimum possible carving. Therefore some very large stones could form part of a thick wall. If the wall is thinner, then the stone needs to be cut to the necessary size. Not only can the exterior stones be large ones. With a thicker wall, larger stones could appear among the bordering stones as well.

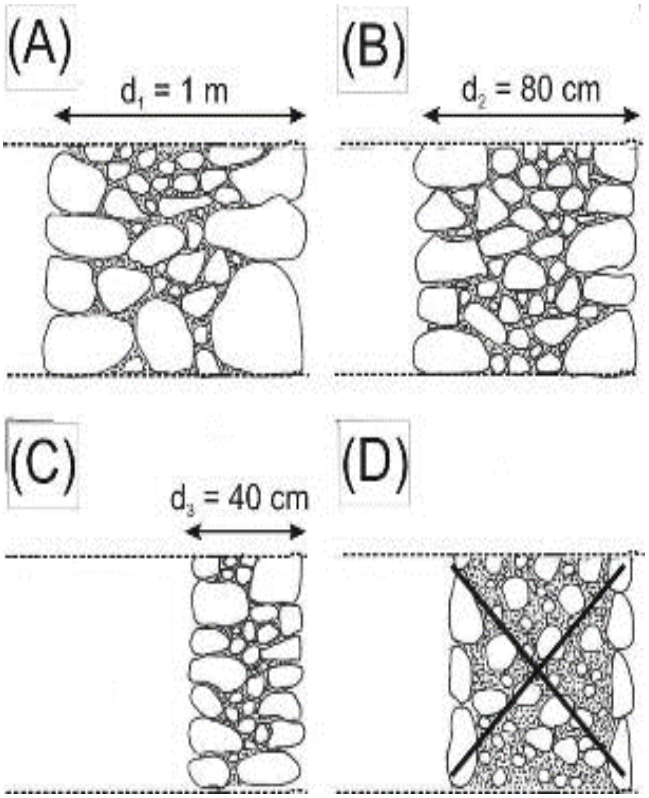

Figure 6. Cross sections of authentic mantle walling, showing different wall widths (A,B, and C), and the non-authentic walling technology (D).

With authentic walling technology, mortar is used to fill spaces. This type of wall building technology has been used over centuries. The stones are put in place with unset mortar, so that the wall is thixotropic in each stage of its construction. The area between the bordering stones is built together with the outer stones. (The skills of authentic wall construction, originate from a well skilled local craftsman [1].)

A method distinct from authentic walling is shown in the last quarter of Fig. 6. Here, cement or concrete acts as a bonding agent. The walling technology consists of two stages. Firstly, the outer border walls are built from flat stones using cement mortar. When the cement has set, the hollow space is filled with a mixture of thin concrete and small stones. (In this kind of walling, stratification is not observable.). Nowadays fence pillar walling is built in this way. Walling technology in Middle Ages was quite distinct from this.

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