RECYCLING OF BRICK DUST/GROUND MORTAR MIXTURES AS PARTIAL REPLACEMENT OF PORTLAND CEMENT

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ABSTRACT

This study investigates the effect of brick dust and ground mortar mixtures as partial replacement of Portland cement in mortar production. Masonry is one of the most important and most widespread building methods in our country. Different advantages such as: low cost, versatility and resistance to atmospheric conditions has made masonry so widespread and a technique of choice. Despite the resistance to different atmospheric conditions and other physical and chemical factors, there comes a time that masonry is amortized or loses the state of its initial stability. For that reason, the reuse of these deteriorated materials has increased the interest for further research studies. Therefore, the aim of this research is to recycle masonry materials and evaluate the possibility of reusing them as components in composite cement in mortar production. For that reason, seven series of mortars with different replacement levels of brick dust and ground mortar were produced. The water to cement ration was kept constant at 0.5 w/c for all the mixtures and limestone sand was used as aggregate. The samples were tested for water absorption, flexural and compressive strength. The test results showed that ground masonry can be effectively used as cement substitute in the production of mortar mixtures. The brick dust has a greater impact than mortar dust in increasing the compressive strength values. But when combined in controlled replacement levels higher strength result compared with the case when these ingredients are used separately can be achieved.

KEYWORDS: Recycle, cement, mortar, brick dust

INTRODUCTION

Masonry has been one of the most widely used construction technique in Albania for the construction of low rise and midrise buildings. During the Communist period up to 1990, masonry structures were built using typical blueprints. Masonry was used both for residential and public buildings as a low-cost construction method. Today these buildings are still in use and mainly serve for residential purposes (Guri, 2016).

Albania is one of countries most prone to seismic action in the Balkans. The recent destructive earthquakes in neighbouring countries (Italy, 2009, Greece and Turkey-2008-1999) have shown that masonry buildings have suffered the maximum damage and are responsible for maximum losses of life. Due to reasons such as seniority, human-made interventions, and improper design code of that time, these types of buildings are endangered by earthquakes.

On the other hand, the construction sector is one of the greatest generators of inert wastes in Europe, approximately 900 million tons per year (Torres-Gómez, 2016). An important part of these wastes is masonry which in some countries is still underutilized. Every year 3000 Mt (metric ton) of waste are produced in the European Union, of which 90 million are considered hazardous. The construction industry generates in the EU around 900 million tons per year of wastes. Therefore, this waste flow represents around 25% - 30% of all wastes produced. CDW (construction and demolition waste) have a very heterogeneous composition. The most important fraction corresponds to inert material, i.e. between 40% and 85% of the overall waste volume discounting excavation soils. The main sources of inert material are concrete and ceramic materials. Researchers reports that the amount of “concrete, masonry and mortar” in inert material, accounts for 58% and 67% in Portugal and Norway, 85% in Italy and Spain, respectively (Torres-Gómez, 2016). The amount of waste from the construction industry used as filling material or illegally dumped in vacant lots has been increasing over time. This has led to an increasing lack of landfill areas, useful lands becoming dumping yards and highly increased dumping costs at landfill sites. So, handling wastes has become one of the most important environmental issues in developed countries. In 2010, around 75% of all CDW (construction and demolition waste) produced in the EU were dumped. However, reuse ratios over 80% have already been reached by countries such as the Netherlands, Denmark and Germany. The Community Directive 2008/98/EC establishes that the EU state members must take the necessary measures to reach until 2020 a minimum of reuse ratio 70% (in weight) of the CDW produced (Bravo, 2015). Currently, in Spain, the fine fraction obtained from the recycling process of masonry waste is underutilized, and in most cases, it is deposited in landfill or stored in recycling plants (Torres-Gómez, 2016).

On the other hand, in Mediterranean countries, the main components of masonry waste are ceramic bricks and mortar, and roughly estimating the ratio of brick to mortar for a portion of masonry is 1.5/1 by weight.

For that reason, research on development of different methodologies to recycle these types of wastes has become a necessity.

MATERIALS AND METHODS

Preparation of the Specimen Mixtures

Seven mortar mixtures of different combinations of (PC Portland Cement/BD Brick Dust/MD Mortar Dust), 1350 sand and 0.5 water to binder ratio were produced. The materials used for the preparation of the specimens were weighed separately on an accuracy scale. The ingredients used for the mixture are shown in table 1.

Table 1: Preparation of specimens

	(MD/BD/PC)	sand (g)	PC (g)	water (g)	BD (g)	MD (g)
1	450/0/0	1350	400	225	0	0
2	400/25/25	1350	400	225	25	25
3	375/75/0	1350	375	225	75	0
4	375/0/75	1350	375	225	0	75
5	350/50/50	1350	350	225	50	50
6	325/25/100	1350	325	225	25	100
7	325/100/25	1350	325	225	100	25

Casting of the Specimens

Every mortar mixture is mixed in the Hobart mixer according to EN 196-1. The specimens were cast into prismatic moulds of 40 x 40x 160 mm dimensions. 24 hours after casting, the specimens are removed from their moulds and cured for a period of 3, 7 and 28 days in water at 21±1 ºC.

Determination of the Water Absorption

The sample were weighted in saturated surface dry conditions (SSD) and completely dry (CD) in the oven at 105°C for the next 24 hours. After that, the specimens were taken out of the oven. They stayed in the room temperature until they cooled up. The water absorption followed the equation, where:

$$WA\ (\%) = ((SSD-CD)/\ (CD)) * 100 \quad (1)$$

WA: Water absorption (%)
CD: Mass of the completely dried specimen (g)
SSD: Mass of the saturated surface dried specimen (g)

Determination of the Flexural and Compressive Strength

The flexural test of the specimens requires a performance according to the (EN 1015–11) Standard. The specimens were strength tested for 3, 7 and 28 days under three-point loading and the span used among in order to support is 100 mm. These tests are developed in two fineness levels of the brick dust and mortar dust such as 0.250mm and 0.125mm. Whereas the compressive strength test was performed based on (EN 196-1). The loading area is 40 x 40 mm.

RESULTS AND DISCUSSION

Water absorption results

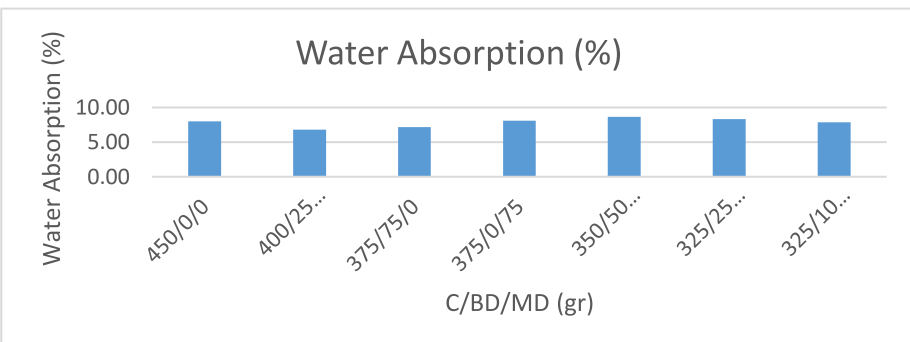

Figure 1: Water Absorption

Figure 1 shows the Water absorption values of the mortar series. It can be noticed notice that the highest percentage of water absorption is found in No. 5 (350/50/50). The water absorption values vary between 6.8% and 8.6%. this graph it can be concluded that the ground mortar absorbs more water than brick dust. While the lowest percentage is found in No. 2 (400/25/25) where the amount of additional materials is at the lowest rate.

Flexural Strength Results

The Flexural Strength test was performed on 3,7 and 28-day with two different Brick Dust and Mortar Dust fractions. The values were compared with the control mixture. Two different fractions were used to study the change of results and to reduce the processing cost of Brick Dust and Mortar Dust. In the graph we have seen both types of materials to conclude and compare the change of the values achieved.

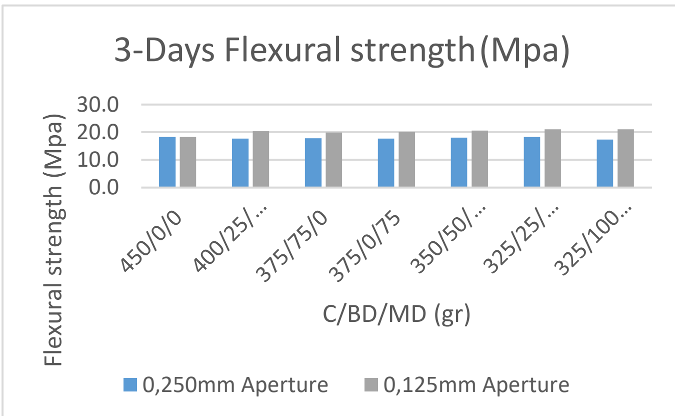

Figure 2: 3-Days Flexural Strength

Noticed that the examples used with the 0.125mm sieve opening have a Flexural Strength increase compared to the examples used with the 0.250mm opening. Concerning cement mortar, there is an increase in Flexural Strength of other compounds when we used the 0.125 mm aperture fraction while the maximum value in relation to cement mortar is 3.3 MPa larger. The highest maximum values achieved in the 3-day tests are examples 5 (350/50/50) and 6 (325/25/100).

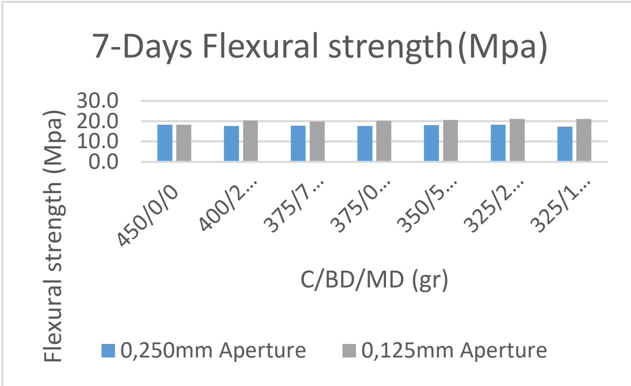

Figure 3: 7- Days Flexural Strength

Even for the 7-day tests, the same difference is observed from the fraction of the material used. The increase of Flexural Strength appears even in the 7 days- tests, where the finest material makes the difference. The highest values are reached in series 7 (325/100/25) and 6 (325/25/100) where there is a difference of 2.8 MPa compared to cement mortar.

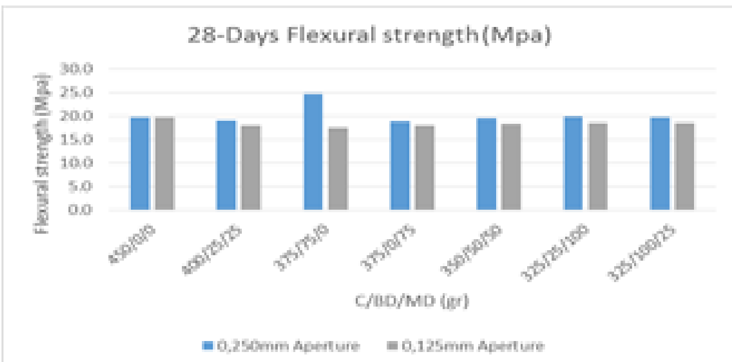

Figure 4: 28- Days Flexural Strength

Unlike the 3- and 7-day results, the material fraction does not show an increase in the Flexural Strength, meanwhile there is a decrease also of Flexural Strength compared to the control specimen.

Compressive Strength Results

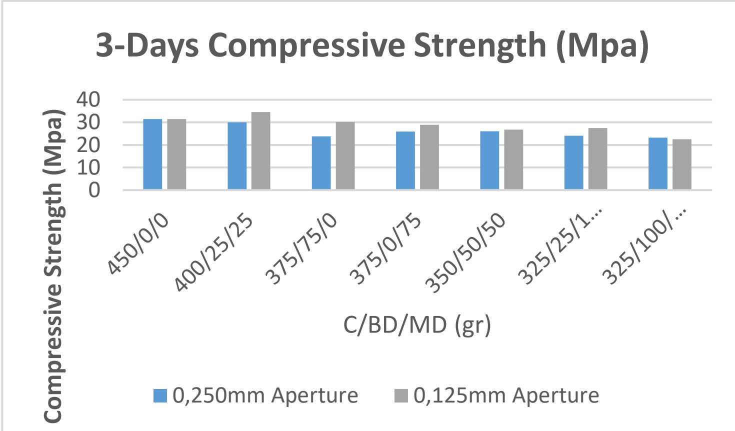

Figure 5: Results of 3-day Compressive Strength

The 3-day test shows that the Compression Strength values of the composite mixes, are lower than the value of cement mortar itself. Only series 2 (400/25/25) with a 0.125 mm fraction shows an increase of 3.2 MPa. While the lowest value in relation to the cement mortar is that of the series 7 (325/100/25) with a difference of 8.87 MPa.

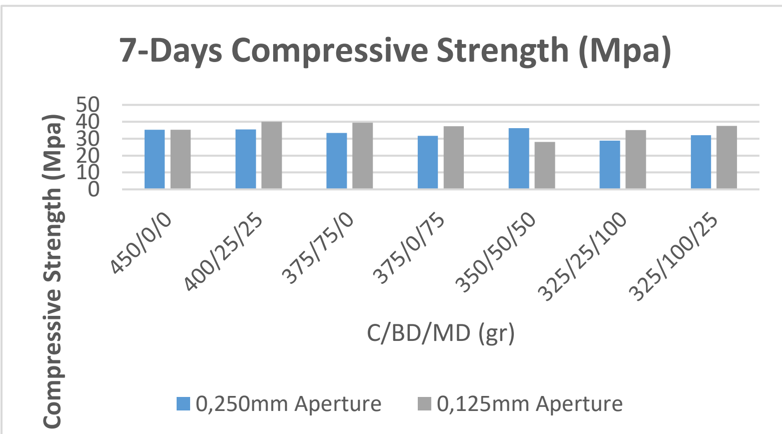

Figure 6: Results of 7-day Compressive Strength

The 7-day test values have a significant increase. Some of them show higher values than the ones of cement mortar. But this increase occurred in the 0.125 mm fraction and is noticed in all the samples except for series 5 (350/50/50) where there is a 7.2 MPa decrease. The highest value is again series 2 (400/25/25) where this time, it reaches 4.8 MPa higher than cement mortar.

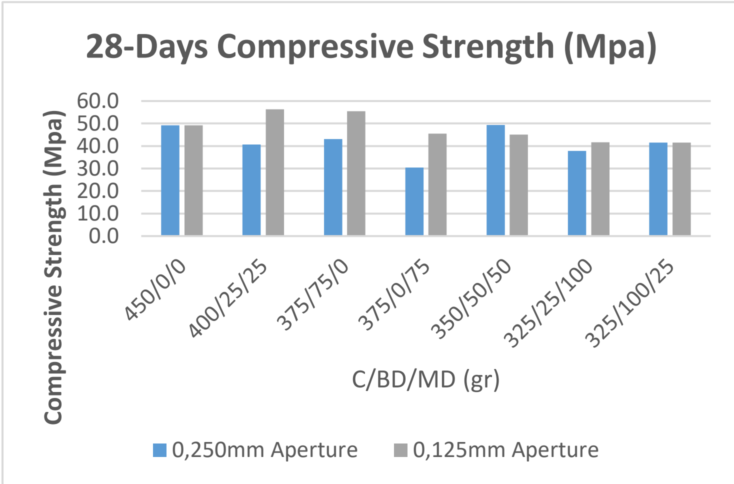

Figure 7: Results of 28-day Compressive Strength

On 28-day compressive test results there is an increase of series 2 (400/25/25) and series 3 (375/75/0) of 0.125 mm fraction. Series 2 and series 2 values are 7.1 MPa and 6.3 MPa respectively higher than the values of cement mortar. While another series, that is similar to cement mortar is series 5 (350/50/50). These results show that Brick Dust increases the value of Compression Strength. While in cases where the amount of Mortar Dust is greater in relation to Brick Dust, we do not have any increase in value compared to cement mortar.

CONCLUSION

In this experimental study the partial replacement of brick and mortar dust in cement mortar has been analysed.

From the conducted test of the water absorption, it is observed that if used in controlled amounts the use of these waste materials can improve the water absorption values of the mortars.

The particle size of the supplementary material has an important effect on the increase of the flexural strength result during the 3- and 7-days period, but in the 28 days test there is a decrease in these values.

The results show that Brick Dust increases the value of Compression Strength. While in cases where the amount of Mortar Dust is greater in relation to Brick Dust, we do not have any increase in value compared to cement mortar.

Based on these results, it is concluded that masonry can be used as cement substitute in mortar and also give high and acceptable results. In these mixtures the brick dust has a greater impact than mortar dust in increasing the compressive strength values. But when combined in controlled quantities higher result can be achieved.

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