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An investigation on usage of marble dust as an additive in concrete surrounding Sivas

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ABSTRACT

Turkey has an important position in the world in terms of marble reserves. Marble has a wide range of uses due to the calcite mineral in its chemical structure. During the extraction and processing stages of marble, 50%-70% waste is generated. In this case, waste management and recycling become very important in reducing marble waste. The aim of this study is to investigate the possibilities of using travertine waste, a type of marble, as a building material. The final paper is based on a literature review and field study. The study consists of three parts. In the first part, a general information about the marble is given, the sections of the study, the purpose and the limits of the study are mentioned. In the second part, information about the material and method of the study is given. The material of the study was obtained from the BETA marble factory located in Sivas Organized Industrial Zone and producing Sivas travertine. In the last part of the study, the data obtained from the study were interpreted and recommendations were made. The study was concluded with suggestions about the utilization of marble wastes, such as checking these values with concrete samples to be produced by substituting the dried and ground travertine sludge into cement as a powder in the next stage, especially field concretes, sub-base plain concrete (in works where strength is not important).

Keywords: Composite Materials, Compression strength, Marble wastes, Travertine Powder.

Sivas çevresinde mermer tozunun betonda katkı maddesi olarak kullanımı üzerine bir araştırma

ÖZ

Türkiye mermer rezervleri açısından dünyada önemli bir konuma sahiptir. Mermer, kimyasal yapısında bulunan kalsit minerali nedeniyle geniş bir kullanım alanına sahiptir. Mermerin çıkarılması ve işlenmesi aşamalarında %50-%70 oranında atık ortaya çıkmaktadır. Bu durumda mermer atıklarının azaltılmasında atık yönetimi ve geri dönüşüm çok önemli hale gelmektedir. Bu çalışmanın amacı, bir mermer türü olan traverten atıklarının yapı malzemesi olarak kullanılma olanaklarını araştırmaktır. Nihai çalışma, literatür taraması ve saha çalışmasına dayanmaktadır. Çalışma üç bölümden oluşmaktadır. Birinci bölümde mermer hakkında genel bir bilgi verilmiş, çalışmanın bölümleri, amacı ve sınırlarından bahsedilmiştir. İkinci bölümde ise çalışmanın materyali ve yöntemi hakkında bilgi verilmiştir. Çalışmanın materyali Sivas Organize Sanayi Bölgesi'nde bulunan ve Sivas travertenini üreten BETA mermer fabrikasından temin edilmiştir. Çalışmanın son bölümünde ise çalışmadan elde edilen veriler yorumlanmış ve önerilerde bulunulmuştur. Özellikle saha betonları, alt temel grobetonları (dayanımın önemli olmadığı işlerde) olmak üzere, kurutulmuş ve öğütülmüş traverten çamurunun bir sonraki aşamada toz olarak çimentoya ikame edilerek üretilecek beton numuneleri ile bu değerlerin kontrol edilmesi gibi mermer atıklarının değerlendirilmesine yönelik öneriler ile çalışma sonlandırılmıştır.

Anahtar Kelimeler: Kompozit Malzemeler, Mermer atıkları, Sıkıştırma dayanımı, Traverten Tozu.

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Introduction

Turkey has 40% of the world's marble reserves. Turkey is also very rich in terms of marble diversity due to its geography. Turkey has an important position in the world in terms of natural stone exports and imports. According to 2017 data from IMIB and MTA. Turkey competes with the lunar giants in terms of marble trade. Turkey, which is the world's leader in marble reserves, is unable to utilize this reserve effectively. In Turkey, where only 2% of the world's marble reserves are utilized, 50-70% of the extracted marble ends up as waste [1]. According to this waste percentage, more than half of the marble extracted from actively operated marble quarries is wasted. In this context, the recycling of marble waste is very important for the country's economy and to prevent the unconscious consumption of natural resources [2-3].

Marble is a compound formed as a result of the metamorphosis of limestone and dolomitic limestone under a certain temperature and pressure. Marble contains high levels of calcium carbonate and low levels of magnesium carbonate [4].

Waste occurs due to some properties of marble arising from its natural structure. These features are fractures and cracks, veins, voids, crystal texture, foliation and fossils. In addition to these features, the structure of the bedrock in which the marble is found is also one of the reasons that cause marble waste. The resulting wastes can be analyzed under two main headings as lump and powder marble waste according to their particle size. The area of use of these wastes varies according to the particle size of the waste. Marble piece wastes are mostly used in the construction sector, while marble powder wastes are used in the production of industrial raw materials [5-8]. The Marmara, Western Anatolia, Southern Anatolia, and Central and Northern Anatolia regions are areas with significant potential in our country. Among these regions, the Sivas area in the Central Anatolia region holds an important place in terms of travertine and onyx type marble reserves due to its unique structure and characteristics [9].

Marble powder is produced during the cutting of marble stones and blocks. Although it lacks pozzolanic properties, it enhances concrete mixtures by filling voids, resulting in denser concrete [10]. This, in turn, positively influences the compressive strength of the concrete. However, because marble powder has a relatively small specific surface area, it increases the water demand in the concrete. Consequently, using more than the ideal amount in concrete mixtures can lead to a decrease in compressive strength [11].

The accumulation of large volumes of waste leads to significant harm to the environment and the organisms in those regions [12]. Consequently, the safe management of these wastes is crucial for promoting sustainability [13]. Failure to recycle wastes causes environmental pollution, excessive consumption of natural resources, decreased productivity during production and the problem of waste storage. In this direction, recycling of wastes reduces the problems that may arise due to environmental pollution and contributes to the national economy. In this regard, in this study; it is aimed to minimize the damages caused by the waste of travertine, which is one of the most important mines of Sivas.

Materials and Methods

Preparation of test samples

In this study, which is important for the utilization of wastes, experimental study method was used. Travertine mud samples were substituted into cement at certain ratios and new samples were formed. Compressive strength tests of the samples were carried out and compared with the samples without additives. To minimize the damage caused by the waste of travertine. To reduce the waste stack in addition to waste costs of travertine factories and to improve the mechanical properties of concrete while doing these. For a 1 cubic meter mix, the contribution of travertine mud to the strength of the concrete was investigated by performing uniaxial compression tests on samples obtained by substituting 20 kg, 40 kg, 60 kg and 80 kg of travertine mud into cement. The samples produced with pure cement were considered without additives and the results were compared. Sand, cement (CEM1 42,5R Votarantim Sivas), water and travertine mud were used as consumables in pure cement tests. The travertine sludge was obtained from the waste products of an industrial facility situated within the boundaries of the city of Sivas. Samples were produced by substituting travertine mud into cement in certain proportions. Molds with dimensions of 150x150x150 mm were used to produce the samples. In order to distribute the travertine mud homogeneously in the specimen, the mud was added to the specimen by mixing with water. The samples were kept in the mold for a period of 24 hours to allow for the setting process to occur. Then the samples were placed in the curing pool and kept there for 28 days to reach their strength. At the end of the 28th day, the samples were subjected to compression tests and the results were compared with the samples produced with pure cement.

(a)

(b)

(c)

Resim 1. Resim 1. Atık mermer geri dönüşümlü beton numunelerinin üretimi. (a) Traverten çamuru, (b) Beton ile traventen karışımı, (c) Kalıp ile traventen karışımı

Figure 1. Figure 1. Manufacturing of waste marble recycled concrete samples. (a) Traverten mud, (b) Traventen mixture with concrete, (c) Traventen mixture with mold

Çizelge 1. 1 m² karışım için malzeme oranları

Table 1. Material ratios for 1 m² mixture

Sample	Cement (kg)	Water	Sand (kg)	Filler (Waste of travertine)
1	420	0.55	1200	0
2	400	0.55	1200	20
3	380	0.55	1200	40
4	360	0.55	1200	60

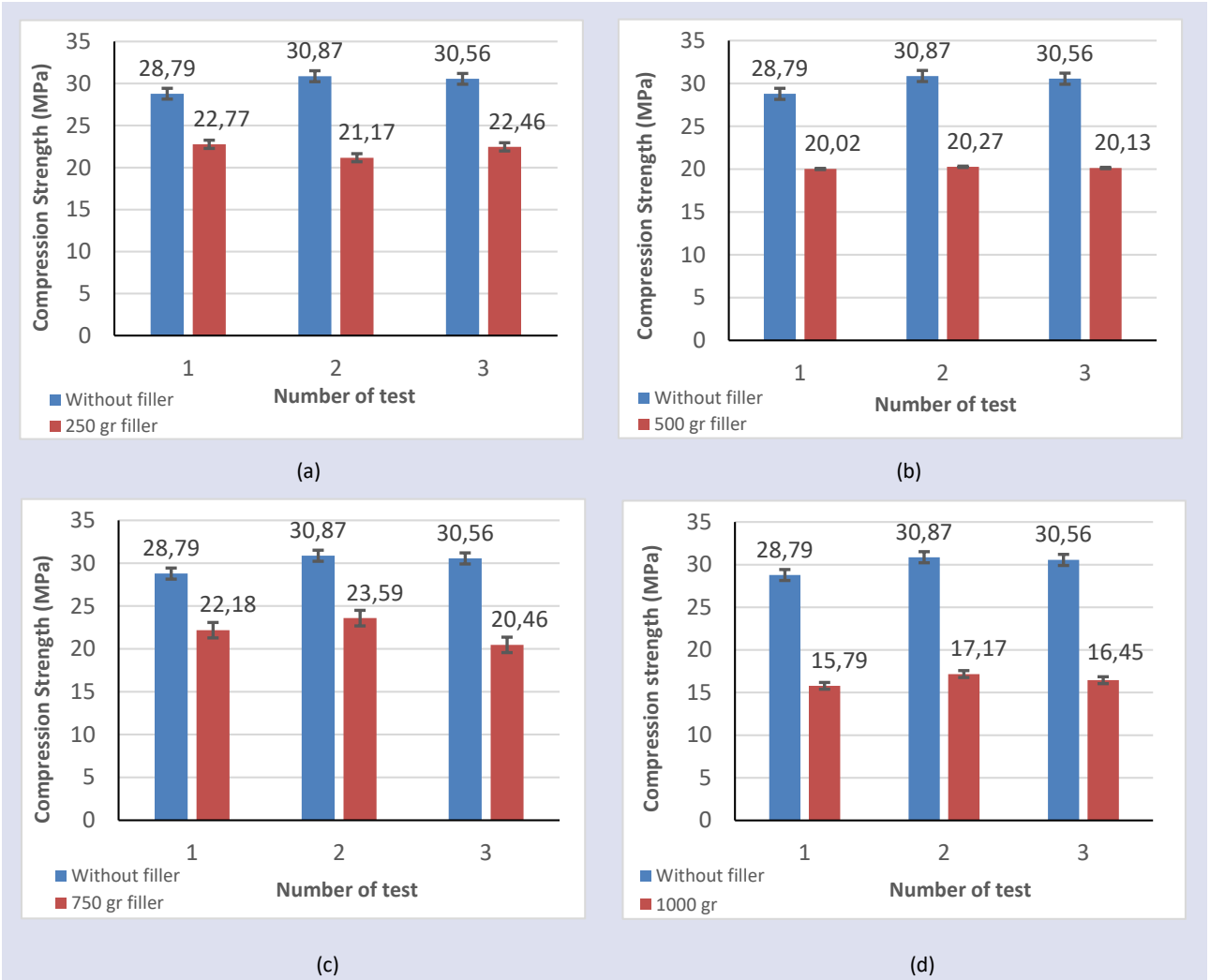
In this study, sand used as aggregate has 0-4 mm diameter with density of 1750 kg/ m^3 and cement has a density of 3000 kg/ m^3.

Evaluation of concrete compression strength

The compressive strength of concrete is defined as "the ability of concrete to resist breaking under the effect of axial compressive load, the maximum stress that occurs in concrete under the effect of axial compressive load. Among the different types of strength investigated in concrete, compressive strength is the most widely used in engineering applications. After the preparing concrete mix with the filler, it was sent to the laboratory for compressive strength values according to the ASTM C39/C39M standards.

Results and Discussions

Figure 2 illustrates the results of compressive strength values experimentally. In the first results of the pure cement tests, the samples produced by substituting 20 kg of travertine mud for cement in cubic meter mix showed a 26% decrease in compressive strength. 40 kg travertine mud substituted samples showed a 33% decrease in compressive strength compared to witness samples. 60 kg travertine mud substituted samples showed 24% less compressive strength compared to witness samples. 80 kg travertine mud substituted samples showed 45% lower compressive strength values compared to witness samples. The substitution of waste travertine mud into cement showed that it can also be used as a binder, at least partially. Experiments that are more detailed can be carried out and the additive ratios can be determined by obtaining the results. In this study, although positive results were not obtained with additives up to 80 kg for 1 cubic meter, it was seen that it can be used according to the condition of the work to be done by conducting new studies. Similarly, Safiuddin et al. [14] indicated that partial replacement of cement with mud, fly ash, and lime, highlighting that the 60% cement replacement variation achieved optimal strength compared to M20 grade concrete.



Resim 1. Mermer dolgulu beton numuneler için basınç testlerinin sonuçları. (a) 250 gr mermer parçacıkları ile doldurulmuş numuneler, (b) 500 gr mermer parçacıkları ile doldurulmuş numuneler, (c) 750 gr mermer parçacıkları ile doldurulmuş numuneler, (d) 1000 gr mermer parçacıkları ile doldurulmuş numuneler

Figure 1. The results of compression tests for marble filled concrete samples. (a) Samples filled with 250 gr marble particles, (b) Samples filled with 500 gr marble particles, (c) Samples filled with 750 gr marble particles, (d) Samples filled with 1000 gr marble particles

Conclusion

This study was conducted to investigate the possibilities of using travertine wastes in the production of building materials in the marble sector. Within the scope of this study, samples were formed by substituting travertine mud for cement and uniaxial compression tests were performed and the effect of the related material on concrete strength was discussed. Results from this study showed that travertine sludge, which is produced during the cutting and processing of travertine blocks and precipitated in sedimentation ponds with the help of a chemical called flocculants, especially narrows agricultural areas. It is important to reduce the environmental damage of this material, it has been demonstrated that travertine mud, which can be obtained free of charge from marble quarries in Sivas, can be used in concrete production, albeit to a limited extent.

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