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Kendiliğinden Yerleşen Hafif Betonda Mermer Tozu Kullanımının Araştırılması

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ÖZ

Bu çalışmada, doğal kaynaklarımızdan biri olan Nevşehir bölgesine ait asidik pomza agregası ile Kırşehir bölgesinden elde edilen endüstriyel atık olan mermer tozunun kullanılması sonucu kendiliğinden yerleşen hafif beton üretilmesi amaçlanmaktadır. Çimento ikame malzemesi olarak farklı oranlarda (%0, %5, %10 ve %15) mermer tozu kullanılmıştır. Çalışma sonucunda fiziksel ve mekanik olarak kendiliğinden yerleşen hafif betondan üstün bir yapı malzemesi elde edilmesi hedeflenmiştir. Bu kapsamda, kendiliğinden yerleşen hafif betonların taze ve sertleşmiş özellikleri araştırılmıştır. Taze beton özelliklerini belirlemek için; taze beton birim ağırlık, çökme-yayılma, V hunisi, L kutu ve U kutu testi ve taze beton birim hacim ağırlık testi yapılmıştır. Sertleşmiş beton özelliklerini belirlemek için su emme, kuru birim ağırlık testi, basınç dayanımı testi, yarmada çekme dayanımı testleri uygulanmıştır. Çalışma sonucunda; %15 mermer tozu kullanımının uygun olacağı kendiliğinden yerleşen hafif beton üretiminde kullanılmasında bir sakınca olmadığı belirlenmiştir. Mermer tozu gibi endüstriyel atıkların beton üretiminde kullanılması hem çevre kirliliği hem de sürdürülebilirlik açısından önemlidir.

Researching the Use of Marble Powder in Self-Compacting Light Concrete

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ABSTRACT

In this study, it is aimed to produce self-compacting lightweight concrete as a result of using acidic pumice aggregate belonging to Nevşehir region, which is one of our natural resources, and waste marble powder, which is industrial waste and obtained from Kırşehir region, at different rates (0%, 5%, 10% and 15%) as cement substitute material. As a result of the study, it is aimed to obtain a building material that is superior to the self-compacting lightweight concrete in physical and mechanical terms. In this context, the fresh and hardened properties of self-compacting lightweight concretes were investigated. To determine the fresh concrete properties; fresh concrete unit weight, slump-sprawl, V funnel, L box and U box test and fresh concrete unit volume weight test were carried out. In order to determine the hardened concrete properties, water absorption, dry unit weight test, compressive strength test, splitting tensile strength tests were applied. As a result of the study; it has been determined that there is no harm in using it in the production of self-compacting lightweight concrete, where the use of 15% marble powder will be appropriate. The use of industrial wastes such as marble powder in concrete production is important in terms of both environmental pollution and sustainability.

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1. Introduction

Today, the use of concrete in the field of construction is gaining popularity day by day. Concrete produced by using certain proportions of cement, aggregate, water and additives when necessary, is by far the most frequently used, multi-phase, extremely complex, heterogeneous structure of self-forming materials found all over the world, and is the most consumed after water and it is a man-made material (Erdogan, 2003; Hasar et al., 2010; Khodabakhshian et al., 2018; Choudhary et al., 2020). Due to its durability, functionality, sustainability and economy, it is actively used in many different areas such as dams, infrastructure facilities, bridges, concrete roads, buildings, commercial structures (Çelik, 2021).

Various studies and experiments are carried out to improve the different properties of concrete, which is an important part of the construction industry (Aslan, 2020). As a result of studies and experiments, it has been determined that normal concrete cannot fully meet the needs such as strength and durability (Topçuoğlu, 2021). In order to meet these needs, studies have been started to produce special concretes (Ağsu, 2019).

As a result of researches and developments related to concrete, self-compacting concrete (KYB-SCC), high-performance concrete, lightweight concrete, self-compacting lightweight concrete, ultra-high strength concrete, architectural concrete, etc. concrete types have emerged (Zarrog, 2020).

Self-compacting concrete (SCC), developed by Japanese scientists in 1990, is generally used in the construction industry because it can flow freely without the need for any external vibration due to its own weight (Danish and Ganesh, 2021).

Another special concrete is lightweight concrete (Aruntaş et al., 2007). Lightweight concrete is a non-combustible material with high insulation properties, low weight, and sufficient strength. In addition, it is a material that makes architecture look from a new window in terms of the architecture of the future and has a great impact with this aspect. The fact that it is lightweight and has a porous structure that provides sound and heat insulation distinguishes lightweight concrete from other types of concrete.

In recent years, studies have been carried out to develop a new type of concrete as a construction material. This concrete, called self-compacting lightweight concrete (KYHB-SCLWC), consists of the combination of easy flow and stability of SCC with the advantage of lightweight concrete (Lo et al., 2007). Many developments have been made in the field of concrete technology and self-compacting lightweight concrete has been widely used due to its superior properties such as durability, less mold pressure, reduced dead load and chemical attack, high resistance to fire. SCLWC is a more durable and low unit weight material compared to conventional concrete (Altalabani, 2020).

Pumice, which is frequently used in self-compacting concrete, has a pH value of 7-7.3 under normal conditions. Acidic pumice is widely available on earth. It is preferred because it contains high silica (DPT, 2001). Basic pumice is harder and heavier than other types of pumice (Gönen and Yazıcıoğlu, 2018). The properties of pumice are effective in the production of the material.

While concretes were developed to meet the needs, industrial wastes started to be included in this development. The use of waste materials in SCLWC production is important in terms of sustainability. In addition, using industrial waste will be the key to reducing natural resource consumption and achieving cleaner production (Abdul Awal and Mohammadhosseini, 2016; Ashish, 2019; Benjeddou et al., 2020; Mohammadhosseini et al., 2020).

Marble industries generate large amounts of waste and this is harmful to the environment. Accordingly, these waste materials require appropriate management to ensure a cleaner environment. Given this, the use of recycled materials in construction is desirable because of the space saved in landfills and the reduction of carbon dioxide (CO_2), as well as the lower cost associated with waste materials (Benjeddou et al., 2020).

Although waste materials are an important problem today, it is important to make them reusable. For self-compacting concrete technology, such materials will be beneficial in terms of sustainability.

In this study, it is aimed to produce self-compacting lightweight concrete as a result of using acidic pumice aggregate belonging to Nevşehir region, which is one of our natural resources, and waste marble powder, which is industrial waste and obtained from Kırşehir region, at different rates (0%, 5%, 10% and 15%) as cement substitute material. The samples produced as a result of the experimental study were aimed to obtain a building material with superior physical and mechanical properties compared to the self-compacting lightweight concrete.

2. Material and Method

2.1. Material

2.1.1. Marble Powder (MT)

The waste used in the SCLWC produced within the scope of the study was obtained from the ARP granite and marble enterprise located in the Kaman district of MT Kırşehir. The material was taken in the form of precipitate slime in the enterprise. The sludge taken was dried in an oven at 100+5ºC and separated from its water. The grain density of the waste marble powder is 2.73 g/cm^3. Finally, waste marble powder material passing through a 0.125 mm sieve, whose chemical properties are given in Table 1, was used in sample production. The marble powder used in the experiment is given in Figure 1.

Table 1. Chemical properties of MT

Oxide	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO
MT (%)	39.40	15.20	7.65	34.20	0.65

Figure 1. Marble powder used in the production of SCLWC samples

2.1.2. Cement

CEM I 42.5 R class portland cement was used in the experiments (Figure 2). Cement whose physical, chemical and mechanical properties are given in Table 2 is produced by Baştaş Çimento San. A.Ş. Cement production. This cement is produced based on the TS EN 197-1 (2012) "Cement, Composition Properties and Compliance Criteria" Standard.

Figure 2. Cement used in experiments

2.1.3. Aggregate

The pumice used as aggregate in the produced material has grain sizes of 0-2, 2-4, 4-8 mm. In the mixture, 30% of 0-2 mm fine light aggregate, 40% of 0-4 mm fine light aggregate and 30% of 4-16 mm coarse light aggregate were used (Table 3).

Table 2. CEM I 42.5 R chemical, physical and mechanical properties

Analysis	Oxide	Value	Analysis	Experiments	Value
Chemical (%)	CaO	63.5	Physical	Specific Surface (cm^2/g)	3320
	Al_2O_3	5.35		Volume Expansion (mm)	1.2
	Fe_2O_3	3.30		Water requirement (g)	28.5
	SiO_2	20.41		Density (g/cm^3)	3.12
	SO_3	2.93		Setting start time (min.)	163
	MgO	1.65		Setting finishing time (min.)	240
	Na_2O	015	Mechanical	Day	MPa
	Cl	0.011		2 days	28.2
	K_2	0.71		7 days	42.7
	HCl	0.28		28 days	51.4

Table 3. Chemical analysis of pumice aggregates

Components %	Rate %
SiO_2	74.10
Al_2O_3	13.45
Fe_2O_3	1.40
CaO	1.17
MgO	0.35
K_2O	4.10
Na_2O	3.70
SO_3	-

2.1.4. Chemical Additive

The additive used in the experimental studies in the study was supplied from BASF company. Polycarboxylic ether based super-plasticizer Master Glenium SKY608 additive is recommended to be used between 0.8 – 1.5 kg for 100 kg binder by mass in self-compacting lightweight concrete mixes.

2.1.5. Mixing Water

In the production of SCLWC samples, Kastamonu city tap water, which does not contain organic matter and mineral salt, was used as mixing water.

2.2. Method

2.2.1. Production of Self-Compacting Lightweight Concrete Samples

The recipe showing the mixing ratios of SCLWC samples produced within the scope of the thesis study is given in Table 4. In the study, 5%, 10% and 15% marble powder was used as a cement replacement material.

Table 4. SCLWC mixture recipe

Recipe	Marble Powder (MT) (%)	Pumice (%)	Water/Cement	Super plasticizer (SA) (%)
REF	0	100	0.35	0.8-1.5
5% MT	5	100	0.35	0.8-1.5
10% MT	10	100	0.35	0.8-1.5
15% MT	15	100	0.35	0.8-1.5

A concrete mixer with a capacity of 40 dm^3 was used to prepare concrete mixtures in the production of SCLWC samples. First, before the materials are taken into the mixer, the mixer is moistened. Then, all aggregates were taken to the mixer and mixed in dry form for 2 minutes. Then, 2/3 of the mixing water specified in the recipe was added and mixed again for 2 minutes. Finally, the remainder of the water and plasticizer and air entraining additive were added and mixed for another 2 minutes. After the mixing process, some concrete mixture was taken from the mixer and fresh concrete tests were applied to the mixture. SCLWC mortar prepared after the fresh concrete experiments gave the desired results was poured into cube molds of 15x15x15 cm and 10x10x10 cm (Figure 3). The contribution rate was determined as a result of the evaluation of the studies in the literature.

Figure 3. Pouring the mixture into molds

The concrete sample was poured into the mold in two stages in order to minimize the compressed air gap formed in the concrete during the filling process. After the first stage was done, it was waited for a while, then the second stage was done. Surface leveling was applied to obtain a smooth surface on all samples. After leveling, the samples were kept in the mold for 24 hours. After 24 hours, the samples were taken out of the mold and placed in the curing pool at 23±2ºC (Figure 4).

Figure 4. Curing of samples in curing pool

Finally, the samples were removed from the curing pool and subjected to physical and mechanical tests. In all mixtures, the total amount of binder (cement+mineral additive) and water/cement ratio were kept constant.

3. Results and Discussion

3.1. Fresh Concrete Test Results

Whether self-compacting concretes have the ability to self-compact was determined by comparing the report published by EFNARC (The European Federation for Specialist Construction Chemicals and Concrete Systems) (EFNARC, 2002). According to this report, it is said that the concrete between the limit values has the ability to compact on its own. In order for a concrete to be understood to have self-compacting ability, its ability to pass, its filling ability and segregation resistance must be at the desired level.

3.1.1. Slump-Dispersion test results

In order to understand whether the SCLWC samples have the ability to fill or not, a precipitation-dispersion test was performed. The result of the slump-dispersion test is given in Figure 5.

According to the report published by EFNARC in 2005 for self-compacting concretes, self-compacting concretes are divided into three groups. These are; SF1, SF2, and SF3. SF1; those with a spreading diameter of 550-650 mm, SF2; those with a spreading diameter between 660-750 mm and SF3; those with a spreading diameter between 760-850 mm.

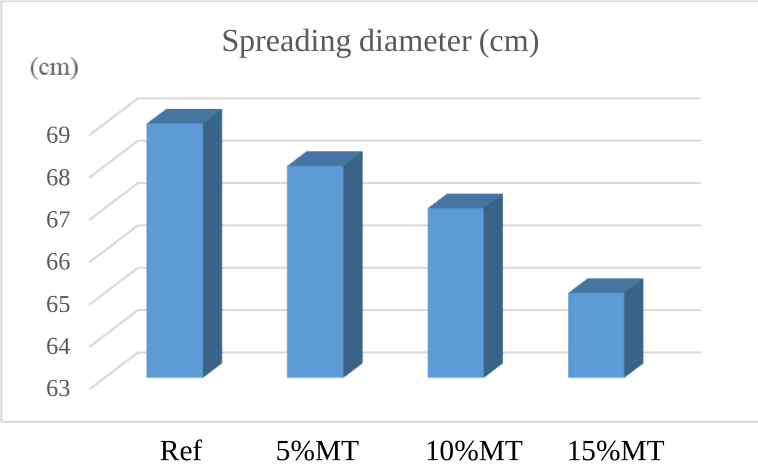

Figure 5. Slump-dispersion test results of SCLWC samples

When Figure 5 is examined; it was observed that the spreading diameter values of SCLWC mixtures varied between 650 and 690 mm. While the reference (REF) sample had the highest spreading diameter with 690 mm, the sample with 15% MT added had the lowest spreading diameter with 650 mm. In addition, it was concluded that the additive of marble powder reduces the workability of fresh concrete. When the literature is examined, there are different opinions on the machinability of marble powder from SCC. While some scientists argue that marble powder increases machinability (Şahmaran et al., 2006; Hallal et al., 2010; Uysal and Sümer, 2011), others reported that it decreases (Gesoğlu et al., 2012; Türkmenoğlu, 2015).

To determine the viscosity of SCC mixtures, the T_{500} time was measured. The values found are given in Figure 6.

According to the report published by EFNARC (2002), the spreading times of SCC mixtures (T_{500} time) are divided into two as VS1 and VS2. Those with T_{500} times ≤ 2 seconds are expressed as VS1, and those with >2 seconds are expressed as VS2.

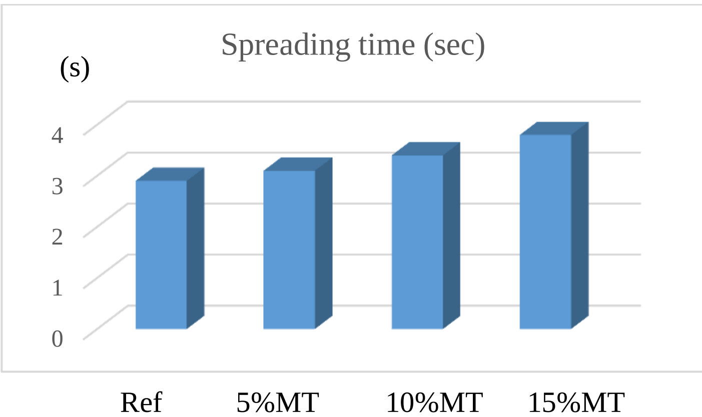

Figure 6. Spread time (T500 time) test results of SCLWC samples

When the figure is examined; it is seen that the spreading times of SCLWC samples vary between 2.9 seconds and 3.8 seconds. The dispersion (spreading) time of the reference sample mixture was measured as 2.9 s.

In SCLWC mixtures with waste marble powder, it was observed that 5% MT mixture had the lowest spreading time with 3.1 s, while the highest spreading time was 3.8 seconds with 15% MT mixture. In addition, it was determined that the spreading time of SCLWC mixtures increased with the increase of marble powder substitution. When the literature is examined, it has been reported that the spreading time is prolonged in some studies (Aruntaş et al., 2007; Uysal, 2010; Gesoğlu et al. 2012), while in some studies it is shortened (Türkmenoğlu, 2015).

3.1.2. V-Funnel test results

In order to determine the viscosity of the SCLWC mixtures produced within the scope of the study, the V-Funnel test was performed. The values found are presented in Figure 7.

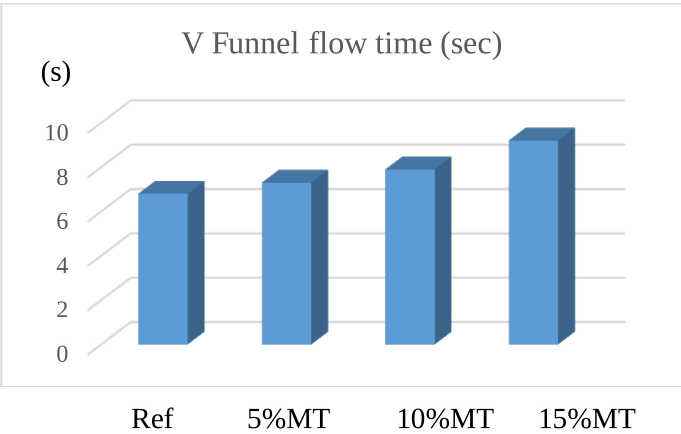

Figure 7. V-Funnel test results of SCLWC samples

According to the report published by EFNARC in 2005; SCCs are divided into two groups, VF1 and VF2, according to their viscosity capabilities. According to this grouping, VF1; V-Funnel means SCC mixtures with a flow time of ≤ 8 sec, and VF2 with a V-Funnel flow time between 9-25 sec.

When the figure is examined, it is seen that the V-funnel flow times of SCLWC mixtures vary between 6.8 and 9.2 seconds. While the shortest flow time was measured from the reference sample, the longest flow time was obtained from the mixtures with 15% MT. In the study, REF is in the 5% MT and 10% MTVF1 class, while 15% MT is in the VF2 class with 9.2 seconds. In addition, it was determined that the flow times increased with the increase in the amount of marble powder additive. There are different studies in the literature that marble powder prolongs the flow time (Gesoğlu et al., 2012; Türkmenoğlu et al., 2015).

3.1.3. U-Box test results

U-Box test was carried out to determine the filling and permeability of SCLWC mixtures. According to the report prepared on the basis of SCC criteria EFNARC; the distance between the arms of the U box should be at most 3 cm. If the value found is below 3 cm, it means that the ability of the concrete material to pass between the reinforcements is high, and if it is above 3 cm, the ability to pass between the reinforcements is low. In the U box test results of the SCLWC mixtures produced within the scope of the study, it was determined that the reference sample was 1 cm and the marble powder added samples were 2 cm.

3.1.4. L-Box test results

L-Box test was carried out to determine the filling and permeability of self-compacting lightweight concrete mixes. L Box test results of SCLWC samples are presented in Figure 8. According to EFNARC (2005), the crossing ability of SCUs is divided into two groups as PA1 and PA2. When the CIB's ability to pass through the two-bar L box is ≥0.80, it is in the PA1 group, and when the SCC's ability to pass through the three-bar L box is <0.80, it is in the PA2 group.

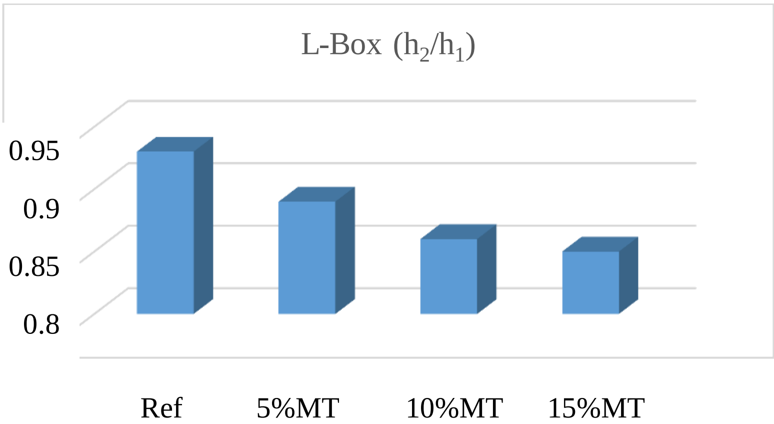

Figure 8. L-Box test results of SCLWC samples

When the figure is examined; h_2/h_1 values ranged from 0.85 to 0.93. Since the three-bar L box was used in the study, it was determined that all samples were in the PA2 group. While the highest value was obtained from the reference sample with 0.93, the lowest value was obtained from 0.85 and 15% MT samples. When the literature is examined, it has been observed that the ability of marble powder to pass through SCC has increased in some studies (Hallal et al., 2010) and decreased in some studies (Gesoğlu et al., 2012).

3.1.5. Fresh concrete unit volume weight test results

Fresh concrete unit volume weight (UVW) values of SCLWC mixtures were determined based on the TS EN 12530-6 standard. The results of the experiments carried out within the scope of the study are given in Figure 9. When the figure is examined; it was observed that the fresh concrete UVW values of the SCLWC samples varied between 1288 kg/cm^3 and 1375 kg/cm^3. While the highest UVW was obtained from the reference sample with 1375 kg/cm^3, the lowest UVW was obtained from 1288 kg/cm^3 with 15% MT added samples. In addition, it was concluded that the UVW value of fresh concrete decreased as the amount of marble powder additive increased.

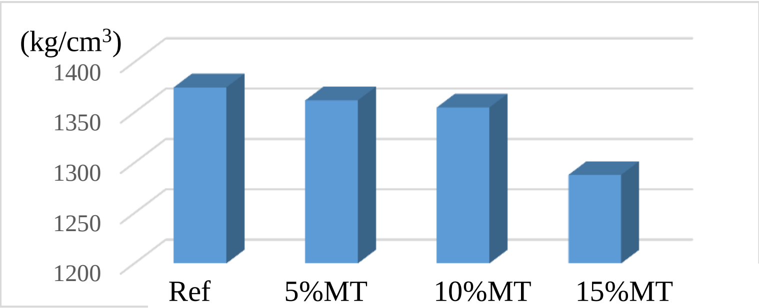

Figure 9. Fresh concrete UVW test results of SCLWC samples

Türkmenoğlu (2015) determined in their study that the addition of marble powder reduces the UVW of fresh concrete. This situation supports the thesis study.

3.2. Hardened Concrete Test Results

3.2.1. Physical Experiment Results

Water Absorption Test Results

The values of the water absorption rates of the SCLWC samples are given in Figure 10. When the figure is examined; it is seen that the water absorption rates of SCLWC samples vary between 14.5% and 18.7%. While the reference sample had the lowest water absorption value with 14.5%, it was determined that 15% MT had the highest water absorption rate with 18.7%. In addition, with the increase in the amount of marble powder in SCLWC production, the water absorption rate decreased. It is thought that this decrease is due to the porous structure of the aggregate used in concrete. In the literature, there are studies showing that marble powder increases the amount of water absorption (Chindaprasirt and Rattanasak, 2011; Jitchaiyaphum et al., 2013; Türkmenoğlu et al., 2015).

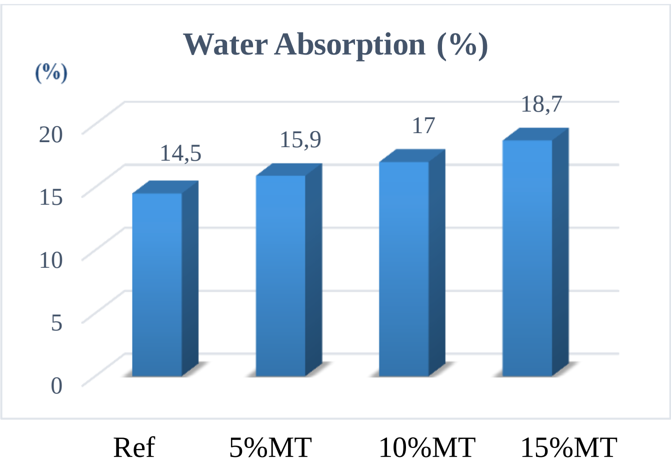

Figure 10. Water absorption test results of SCLWC samples

Dry Unit Volume Weight Test Results

Dry unit volume weight values of SCLWC samples are given in Figure 11. When the figure is examined; it was determined that the dry unit volume weight values of SCLWC samples varied between 1210 kg/m^3 and 1037 kg/m^3 . While the reference sample had the highest dry unit volume weight with 1207 kg/m^3 , it was seen that 15% MT samples had the lowest dry unit volume weight with 1037 kg/m^3 .

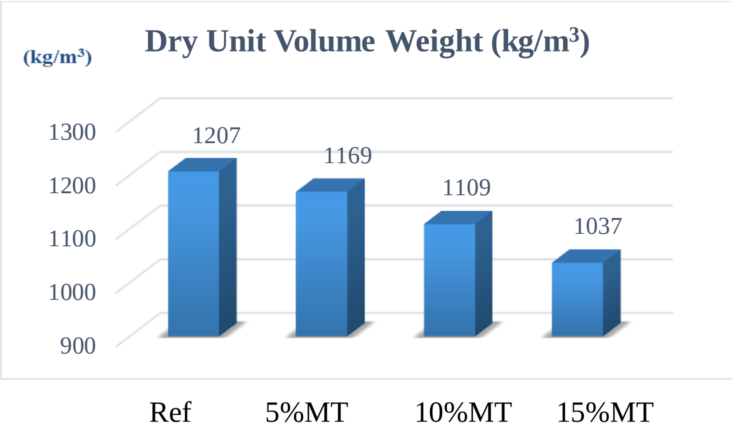

Figure 11. Dry unit volume weight test results of SCLWC samples

When the values found are analyzed based on the TS EN 206-1 (2010) standard; it is seen that all of the SCLWC samples are in the class of medium strength lightweight concrete.

3.2.2. Mechanical Test Results

Compressive Strength Test Results

Compressive strength test of 7 and 28 days old SCLWC samples was made based on TS EN 12390-3 (2019). The compressive strength values of the samples are given in Figure 12.

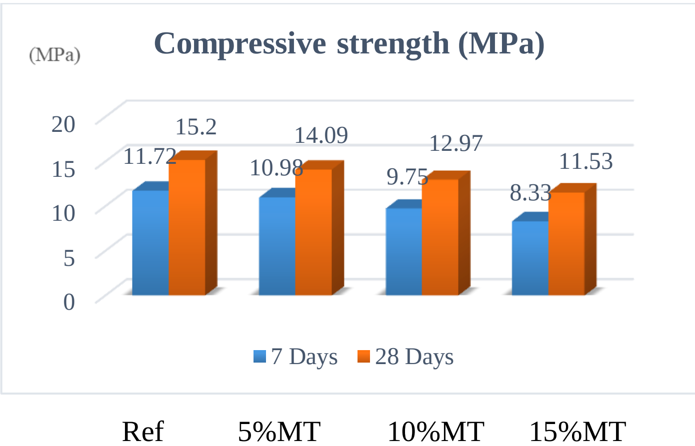

Figure 12. Compressive strength test results of SCLWC samples

When the graph of the 7-day samples is examined; while the reference sample had the highest compressive strength with 11.72 MPa, the samples with 15% MT additive had the lowest compressive strength with 8.33 MPa. In addition, with the increase in the amount of marble powder, the 7-day compressive strength decreases.

When the graph of the 28-day samples is examined; compressive strengths are 15.2 MPa, 14.09 MPa, 12.97 MPa and 11.53 MPa, respectively. The highest value was obtained from the reference samples with 15.2 MPa, while the lowest value was obtained from the 15% MT samples with 11.53 MPa.

When the literature is examined; it has been observed that the compressive strength decreases with the increase in the amount of marble powder (Gesoğlu et al., 2012; Vijayalakshmi et al., 2013; Arshad et al., 2014). Rai et al. (2011) reported in their study that the reason for this decrease was due to the low adherence of cement and marble powder surfaces. In addition, there are studies in the literature reporting that the compressive strength increases with the increase in the amount of marble powder (Aruntaş et al., 2010; Shirule et al., 2012). It is thought that the reason for the increase in the pressure value in the studies is that the active silica in the marble powder reacts with the calcium hydroxide to form secondary CSH (Omar et al., 2012).

Splitting Tensile Strength Test Results

The splitting tensile strength test applied to self compacting lightweight concrete samples was based on the TS EN 12390-6 standard (2010). 7 and 28 days split tensile strength test results of samples are given in Figure 13.

When the splitting tensile strength values of the 7-day samples are examined; it was observed that the reference sample had the highest value with 2.73 MP, while the samples with 1.76 and 15% MT had the lowest value with 1.76 MPa. The splitting tensile strength values of the samples were seen 2.82 MPa, 2.56 MPa, 2.13 MPa, 1.76 MPa respectively. In addition, it was determined that the tensile strength of splitting decreased with the increase in the amount of marble powder.

When the literature is examined; in some studies, the compressive strength decreased with the increase in the amount of marble powder, while in some studies it increased (Uysal and Yılmaz, 2011).

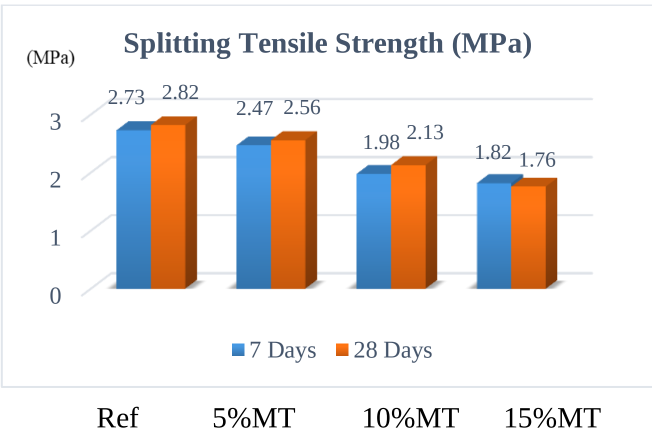

Figure 13. Splitting tensile strength test results of SCLWC samples

4. Conclusion and Recommendations

In this study, it is aimed to produce self-compacting lightweight concrete as a result of using acidic pumice aggregate belonging to Nevşehir region, which is one of our natural resources, and waste marble powder, which is industrial waste and obtained from Kırşehir region, at different rates (0%, 5%, 10% and 15%) as cement substitute material. For this purpose, SCLWC samples were produced and physical and mechanical tests were performed on the samples. In conclusion; it has been determined that the reference and marble powder added samples produced in the study comply with the SCC criteria specified in the EFNARC report.

When the fresh concrete properties of SCLWC are examined; it was determined that the spreading diameter of the fresh concrete decreased and the spreading time extended with the increase of the marble powder additive ratio. The workability of concrete has decreased due to the angular structure of the marble powder used in the production of SCLWC. When the V-funnel test to determine the viscosity of the SCLWC samples is examined; it was determined that the flow time increased with the increase in the amount of marble powder. According to the U-box test result; it has been observed that the addition of marble powder increases the ability of fresh concrete to pass between reinforcements. According to the results of the L-box experiment; all samples were found to be in the PA2 class. In SCLWC production, with the increase in the amount of marble powder, the unit volume weight values of fresh concrete decreased.

When the experiments to determine the physical properties of SCLWC samples are examined; in the water absorption experiment, it was determined that the water absorption rate increased with the increase in the amount of marble powder. In the dry unit volume weight test, it was observed that the dry unit volume weight value decreased as the amount of marble powder increased.

When the tests performed to determine the mechanical properties of SCLWC samples are examined; according to the compressive strength test results; the compressive strength decreased with the increase in the amount of marble powder. In the split tensile strength test, it was observed that the split tensile strength values decreased with the increase in the amount of marble powder.

In addition, it is considered that there is no harm in using it in the production of self-compacting lightweight concrete, where the use of 15% marble powder will be appropriate. The use of industrial wastes such as marble powder in concrete production is important in terms of both environmental pollution and sustainability. With the use of tons of marble powder released every year in the concrete industry, the waste storage costs will decrease and this situation will contribute to the country's economy. In our country, where there are significant pumice deposits around the world, studies should be carried out on the use of pumice as lightweight concrete aggregate. Scientific studies on industrial wastes such as marble powder or local raw materials such as pumice should not remain only in the literature, but should be developed in cooperation with the industry.

Statement of Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal.

References

Ağsu AS. Resistance of self-setting concrete and investigation of fast chlorine ion permeability. Atatürk University Institute of Science and Technology Master Thesis, 141 p, Erzurum, Turkey, 2019.

Altalabani D., Bzeni DKH., Linsel S. Mechanical properties and load deflection relationship of polypropylene fiber reinforced self-compacting lightweight concrete. Construction and Building Materials 2020; 252: 119084.

Arshad A., Shahid I., Anwar UHC., Baig MN., Khan S., Shakir K. The wastes utility in concrete. International Journal of Environment Research 2014; 8(4): 1323-1328.

Aruntaş YH., Dayı M., Tekin İ., Birgül R., Şimşek O. Effect of waste marble dust on self-compacting concrete properties. 2. Chemical Additives in Structures Symposium, April 2007, İzmir.

Aruntaş HY., Gürü M., Dayı M., Tekin İ. Utilization of waste marble dust as an additive in cement production. Materials and Design 2010; 31(8): 4039-4042.

Aslan S. Examining the effects of glass fibre additive on concrete. Avrasya University Institute of Science Master Thesis, 56 p, İstanbul, Turkey, 2020.

Ashish DK. Concrete made with waste marble powder and supplementary cementitious material for sustainable development. Journal of Cleaner Production 2019; 211: 716–729.

Abdul Awal ASM., Mohammadhosseini H. Green concrete production incorporating waste carpet fiber and palm oil fuel ash. Journal of Cleaner Production 2016; 137: 157-166.

Benjeddou O., Alyousef R., Mohammadhosseini H., Soussi C., Khadimallah MA., Alabduljabbar H., Tahir MM. Utilisation of waste marble powder as low-cost cementing materials in the production of mortar. Journal of Building Engineering 2020; 32: 101642.

Chindaprasirt P., Rattanasak U. Shrinkage behavior of structural foam lightweight concrete containing glycol compounds and fly ash. Materials & Design 2011; 32(2): 723-727.

Choudhary R., Gupta R., Nagar R., Jain A. Sorptivity characteristics of high strength self-consolidating concrete produced by marble waste powder, fly ash, and micro silica. Materials Today: Proceedings 2020; 32: 531-535.

Çelik Y. Early age performance and mechanical characteristics of concrete which is used in service buildings. Gaziantep University Graduate School of Natural & Applied Sciences Master Thesis, 56 p, Gaziantep, Turkey, 2021.

Danish P., Ganesh GM. Study on influence of metakaolin and waste marble powder on self-compacting concrete – A state of the art review. Materials Today: Proceedings 2021; 44(1): 1428-1436.

DPT Eighth Five-Year Development Plan, "Mining ÖİK Report Industrial Raw Materials Sub-Commission Building Materials III (PumicePerlite-Vermiculite Phlogopite Expanding Clays) Working Group Report". Turkey, Report. DPT: 2617 2001 (Date of access: 25.07.2021).

EFNARC Specifications and guidelines for self-compacting concrete. European federation of specialist construction chemicals and concrete system February 2002 (Date of access: 25.07.2021).

Erdogan T. Concrete. Ankara: METU Publishing; 2003.

Gesoğlu M., Güneyisi E., Kocabağ ME., Bayram V., Mermerdaş K. Fresh and hardened characteristics of self compacting concretes made with combined use of marble powder. limestone filler and fly ash. Construction and Building Materials 2012; 37: 160-170.

Gönen T., Yazıcıoğlu S. The effect of curing conditions on permeation of self-compacting lightweight concrete with basaltic pumice aggregate. Arabian Journal for Science and Engineering 2018; 43(10): 5157-5164.

Hasar UC., Şimsek O., Aydın AC. Application of varying-frequency amplitude only technique for electrical characterization of hardened cement-based materials. Microwave and Optical Technology Letters 2010; 52(4): 801-805.

Hallal A., Kadri EH., Ezziane K., Kadri A., Khelafi H. Combined effect of mineral admixtures with superplasticizers on the fluidity of the blended cement paste. Construction and Building Materials 2010; 24(8): 1418-1423.

Jitchaiyaphum K., Sinsiri T., Jaturapitakkul C., Chindaprasirt P. Cellular lightweight concrete containing high-calcium fly ash and natural zeolite. International Journal of Minerals, Metallurgy and Materials 2013; 20(5): 462-471.

Khodabakhshian A., Ghalehnovi M., de Brito J., Shamsabadi EA. Durability performance of structural concrete containing silica fume and marble industry waste powder. Journal of Cleaner Production 2018; 170: 42-60.

Lo TY., Tang PWC., Cui HZ., Nadeem A. Comparison of workability and mechanical properties of self-compacting lightweight concrete and normal self-compacting concrete. Materials Research Innovations 2007; 11(1): 45-50.

Mohammadhosseini H., Lim NHAS., Tahir MM., Alyousef R., Samadi M., Alabduljabbar H., Mohamed AM. Effects of waste ceramic as cement and fine aggregate on durability performance of sustainable mortar. Arabian Journal for Science and Engineering 2020; 45(5): 3623–3634.

Omar OM., Abd Elhameed GD., Sherif MA., Mohamadien HA. Influence of limestone waste as partial material for sand and marble powder in concrete properties. HBRC Journal 2012; 8(3): 193-203.

Rai B., Naushad KH., Abhishek K., Rushad TS., Duggal SK. Influence of Marble powder/granules in Concrete mix. International Journal of Civil and Structural Engineering 2011; 1(4): 827.

Shirule PA., Rahman A., Gupta RD. Partial replacement of cement with marble dust powder. International Journal of Advanced Engineering Research and Studies 2012; 1(3): 175-177.

Şahmaran M., Christiano HA., Yaman İÖ. The effect of chemical admixtures and mineral additives on the properties of self-compacting mortars. Cement and Concrete Composites 2006; 28(5): 432-440.

Topçuoğlu Z. Investigation of the manufacturability of self located heavy concrete using barite aggregate. Fırat University Graduate School of Natural and Applied Sciences Master Thesis, 78 p, Elazığ, Turkey, 2021.

TS EN 12390-6 Concrete-hardened concrete tests, Chapter 6: Determination of splitting tensile strength of test samples. Turkish Standards Institute Ankara, 2010.

TS EN 206-1 Concrete - Part 1: Feature, performance, manufacturing and conformity. Turkish Standards Institute Ankara, 2010.

TS EN 12390-3 Concrete-Hardened concrete tests-Part 3: Determination of compressive strength in test samples. Turkish Standards Institute Ankara, 2019.

TS EN 197-1 Cement- Part 1: General cements - Composition, properties and conformity criteria. Turkish Standards Institute Ankara, 2012.

Türkmenoğlu ZF., Kılıç AM., Depci T. Investigation of mechanical properties of self-compacting lightweight concrete produced with Van pumice and marble dust wastes. Journal of Çukurova University Faculty of Engineering and Architecture 2015; 30(1): 105-116.

Uysal M. The effect of mineral additives on the mechanical and durability properties of self compacting concrete. Sakarya University Institute of Science and Technology Doctoral Thesis, 268 p, Sakarya, Turkey, 2010.

Uysal M., Sumer, M. Performance of self-compacting concrete containing different mineral admixtures. Construction and Building Materials 2011; 25(11): 4112-4120.

Uysal M., Yilmaz K. Effect of mineral admixtures on properties of self-compacting concrete. Cement and Concrete Composites 2011; 33(7): 771-776.

Vijayalakshmi M., Sekar ASS., Prabhu GG. Strength and durability properties of concrete made with granite industry waste. Construction and Building Materials 2013; 46: 1-7.

Zarrog MHT. Investigation of the use of fly ash and marble powder in self-compacting concrete production. Kastamonu University Institute of Science and Technology Master Thesis, 94p, Kastamonu, Turkey, 2020.