

Investigation of Properties of Foam Concretes Produced Using Pumice at Different Ratios

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Foam concrete is a type of light weight concrete having self-compacting properties. It can be obtained by mixing the foam, formed by the foaming agent, with a mixture consisting of cement, water and aggregate. It contains independent closed pores with a volume of 75–80% within its body. In this study, three series of foam concrete were produced using different ratio of pumice. Compressive strength, splitting tensile strength and thermal conductivity of foam concrete samples were determined for each density set. It is found that, pumice ratio has a linear relationships with dry bulk density, compressive strength, tensile strength and thermal conductivity. It can also be concluded that strong relationship exist between higher correlation coefficients and pumice ratio.

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1. Introduction

Properties of materials used in construction of buildings are important for both the durability and to carry architectural culture to next generation [1, 2]. The pumice, formed after volcanic event, has a lot of cavities. It is a spongy, porous and light building material [3, 4]. As the estimated reserve of pumice in Turkey is very high, it becomes an important material in engineering sectors [5].

Instead of using a single type of building material, using a mixture of them is more useful. Thus a number of problems with mechanical deformation, thermal and voice conductivity can be solved [6]. The foam concrete has an excellent resistance to water and frost [7]. Foam concrete is an environmentally friendly building and insulation material that provides heat and impact sound insulation. It is lightweight and non-harmful to human health [8, 9]. When foam concrete is in fresh state, it has a high flow capability. After hardening, it has low density, function-dependent strength and low thermal conductivity properties. Generally, its dry density is around 400–1600 kg/m³, while its compressive strength is in the range of 1–15 MPa. In recent years it has become widespread in the semi structural or non-structural construction applications [10].

2. Materials and methods

2.1. Materials

The aim of this work is to study foam concrete, prepared by mixing cement, pumice powder, super plasticizer and protein-based foaming agent, with the dry density in the range of 400–500 kg/m³. Three different series of

foam concrete design mixes were prepared with (i) 100% limestone aggregate, (ii) 50% to 50% pumice-limestone aggregate, and (iii) 100% pumice aggregate.

According to the targeted theoretical density for each mix design, mixture components were calculated based on the amount of volume. In all mixtures, cement dosage was kept at 300 kg/m³ and water/solid (w/s) ratio was held constant at 0.30. The dry density and component amounts for 1 m³ of mixture are given in Table I. The mixtures were prepared by mixing cement, limestone powder, water and plasticizer. Foam with a density of 80 g/l, in average, was added to the mixtures until theoretical fresh density value was reached according to the mix designs.

TABLE I

The mix designs of foam concretes.

Series	D_{dry} [kg/m ³]	Cement [g]	Limestone [g]	Pumice [g]	Water [g]	Plasticizer [g]	Foam [g]
PKB	400	4200	0	2100	2280	2.48	250
KKB	450	4200	1050	1050	2280	1.98	350
NKB	500	4200	2100	0	2280	1.48	600

2.2. Methods

The compressive strength and splitting tensile strength of specimens were tested under dried air conditions. The production and experiments with all specimens were conducted in Natural and Industrial Building Materials Research Centre of Suleyman Demirel University. The standards used in the experiments are given in Table II.

3. Results and discussion

The results of compressive strength, splitting tensile strength tests and ultrasonic pulse velocity tests were conducted with foam concrete specimens after the 28-day

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TABLE II

The standards used in the experiments.

Experimental	Standards	Sample shape
Dry densities	TS EN 678	Unit volume
Compressive strength	TS EN 1354	15 cm ³
Splitting tensile stren.	TS EN 12390-6	15 cm ³
Thermal conductivity	TS EN 12667	30 × 30 × 5 cm ³

curing period. Compressive strength f_c , splitting tensile strength f_{ct} , ultrasonic pulse velocities V_p of foam concrete samples were determined according to arithmetic mean of results of three measurements for each density set. The results as functions of density ρ_{gk} of specimens are given in Table III.

TABLE III

Average results of compressive strength, splitting tensile strength and thermal conductivity of foam concrete specimens after 28 days of curing.

Series	ρ_{gk} [kg/m ³]	f_{c-28} [MPa]	f_{ct-28} [MPa]	Thermal conductivity [W/mK]
PKB	0.402	0.374	0.071	0.0882
KKB	0.480	0.756	0.113	0.1058
NKB	0.504	0.938	0.136	0.1103

The variations of compressive strength, splitting tensile strength and thermal conductivity versus dry density have been plotted in Fig. 1. It is seen that there is a strong relationship between dry density, compressive strength, splitting tensile strength and thermal conductivity coefficient in the foam concrete.

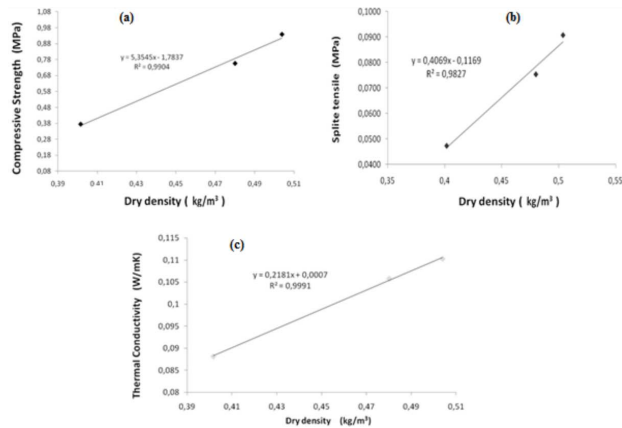


Fig. 1. The variation of (a) compressive strength, (b) splitting tensile strength and (c) thermal conductivity with dry density.

4. Conclusions

As a result of the study, the relationships of values of compressive strength and thermal conductivity coefficient with dry density were proposed for foam concretes. It is seen that there is a strong relationship between dry density – compressive strength and dry density – thermal conductivity coefficient in the foam concrete. It is found that pumice ratio has a linear relationships with dry bulk density, compressive strength, tensile strength and thermal conductivity. It can also be concluded that strong relationships exist between higher correlation coefficients and pumice ratio.

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