High-Temperature Fire Resistance For Concrete Using Sustainable Building

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Abstract
The purpose of this research;production olivine doped concrete is subjected to various experiments by designing and applying to provide to increase the fire resistance. The olivine doped concrete samples were obtained by using TS 802,which provide from olivine mining facilities located in Isparta-Sütçüler-Ayvalıpınar. Aggregate was provide from aggregate mine in Isparta-Atabey. Ordinary concrete samples were obtained by using same mixing rate on the olivine doped concrete . Olivine doped and ordinary concrete samples were heated at 300^0 C,600^0C and 900 ^{0}C during 2 hours in the spring laboratory of Dokuz Eylul University in İzmir, which have been taken their cure of 28 day. Later the ultrasound pulse velocity (UV) and compressive strength of samples have been determined at construction laboratory of Suleyman Demirel Universty in Isparta.It has been found that normal aggregate descreased compressive strength by heat increasing, whereas using olivine instead of normal aggregate increased compressive strength until 600^0C,but decreased at 900^0C.

Keywords: Olivine, aggregate, compressive strength, ultrasound pulse velocity

1.Introduction

Compared to other construction materials; it's the most used construction material with its easy shaped condition, being economical, durability, less energy usage in its production, being producible and its aesthetic quality. Durability is a quality of a building's long lasting and other functions through its service-life and under the environmental effects in which a building is found and will be found. An artificial material, reinforced concrete's continuing of its positive qualities is related to its lasting. As a result of fire which is one of the dangers that can be seen in buildings, construction components are exposed to high temperature. The fires on the buildings, temperature of 1200^0 C resulting has been calculated. When construction materials are heated till 1200^0 C it has been observed that the wood burnt up, steel softened and lost its resistance, concrete or stones pulled into pieces. In that case, none of the construction materials can

resist such high temperatures. However, among these concrete is more durable and pulled into pieces in a longer period compared to others. [1]
With the effects of high temperature, concrete loses its beginning pressure resistance. Decrease quantity on the pressure resistance shows difference as the qualities of the materials and the most high temperature, heating speed and cooling types of some variables. However, on temperatures above 300^0 C, clear losses of the concrete's pressure resistance is an emphasized opinion in technical literature. [2]
In a fire withdrawal of water as drying in a concrete leads to shrinkages on concrete, changes of crystal structure and elasticity, resistance drop and changes on colour and chemical structure. [3]
Resistance losses also can be explained by different reasons such as micro and macro-level cracks, expansion of aggregate volume, the degradation of hydrated calcium silicate (C-S-H) ties in cement paste. [2]
On previous studies effects of the high temperatures of up to 900^0 C on concrete's pore structure has been investigated by the method of mercury porosimeter and it has been determined high temperatures cause a rise on total pore volume. [4]
The fire has many effects on concrete resistance. When concrete beams has been exposed to heat, it leads free moisture to evaporate. Upon continuing of fire, on the beam surface, exposed to fire, heat rises and concrete resistance falls. In some cases, pressure of moisture on beams is higher than the resistance of concrete cover and the cover is broken up leading concrete resistance to decline.
Building in case of fire should perform at least to the extent required by legislation. In addition stability of building is required to live, escape and to extinguish fire. It has especially so much importance for bigger and multi level buildings. [5]
Olivine because of having high melting temperature, quickly cools the steel inside of it. For this reason it is used in iron and steel industry. With refractory, significant amount of olivine is used on the production of forstrikt brick, fire brick, chemical tied bricks, various refractory construction and materials. [6]. Rocks of which chemical composition is $(Mg,Fe)_2SiO_4$, crystal system being ortorombic and crystal shape magmatic, are isolated granular aggregates. Their crystals consist of three different prism's combination. Twinning can be observed. Its hardness is 6,5-7 according to Mohs's criteria. The density changes between 3,22 and 4,40 gr/cm3 according to its Fe amount. [7]
The aim of this research is designing production of olivine blended concrete and subject it to various experiments, to increase the fire resistance of concrete, to prevent collapse of the structure than what is designed before, to prevent the spread of fire around.

2.Material And Method

2.1Material

In this research, two types of materials are used as aggregate of limestone origin obtained from sand-gravel quarry of Isparta-Atabey that meet the significant agregate need of Isparta Zone and olivine obtained from Isparta- Sütçüler Ayvalıpınar olivine mining facilities. Aggregate granulometric curve is given in the following Fig 1.
As additives Sikament NP from Sika and air entraining AER additive are obtained. Cement is obtained as Isparta-Göltaş origin type CEM I 42,5 R.

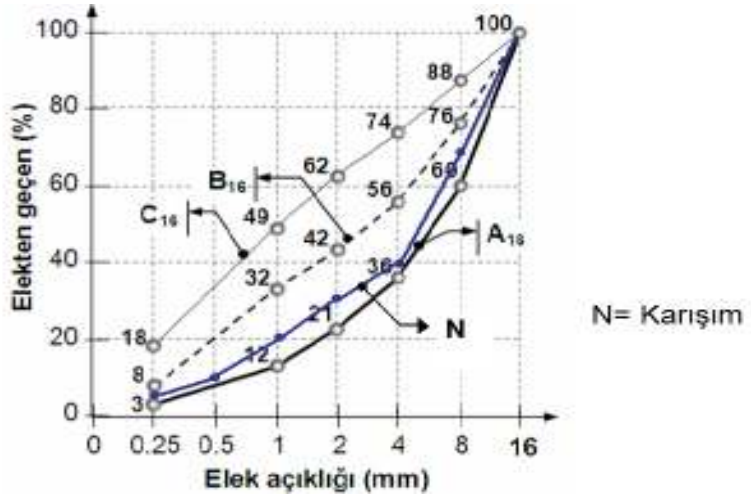

Fig 1.Material passing through sieve % and sieve openness(mm)

2.2 Method

In the study, concrete mix calculations have been made using TS802 and concrete class has been determined using TS500. Obtained samples were exposed to 300^0 C, 600^0 C, 900^0 C temperatures, weight differences were found, compressive strength and ultra-sound experiments were conducted.

2.3 Preparation of experiment samples

Mixture calculations were prepared for the first preliminary experiments targeting concrete class of BS30 and suitable for TS 802. For homogeneous concrete mixture, Sikament NP super plasticisers contribution up to 2% of cement was added to mixture water. The concrete obtained with olivine aggregate was named as OB, first two preliminary experiments' amount of concrete components were calculated and concrete samples were poured. For the first preliminary experiment concrete was poured into 20 cube samples with the size of to 10x10x10cm and 1 cube sample with the size of 15x15x15cm.
According to first preliminary experiment samples' pressure resistance conclusions with an improvement in the mix, second experiment samples were prepared. Accordingly, for the second experiments concrete was prepared targeting concrete class of BS30 and suitable for TS 802; to obtain a flat surface and to prevent water absorption of concrete olivine was holded in water for one day and left to drying until it became surface dried and while pouring concrete air entraining additive Sika AER was used. Concrete was poured into 20 cube samples with the size of to 10x10x10cm. Second experiment with olivine and normal concrete mixture rates were given in table 1.

Table 1. Normal and olivine concrete components added to mixture

Concrete	Water (lt)	Cement (kg)	Additive (ml)	Fine sand (kg)	Fine olivine /aggregate (kg)	Thick olivine / aggregate (kg)
Olivine	2,4	8,69	0,17	2,22	11,20	24,81
Normal	4,93	8,82	0,17	2,5	11	22,50

Second experiment after completing their 28-day cures, normal and olivine concrete samples were exposed to different temperatures 2 hours to remain constant on 300^0 C, 600^0 C, 900^0 C temperatures in the heat treatment furnace at the source laboratory of Izmir Dokuz Eylül University, mechanical engineering department and the samples were cooled in the furnace till room temperature. The samples removed from the furnace at first were weighed and weight difference at the end of heat treatment was determined, then to avoid getting their lost moisture back they were wrapped with aluminum foil and were stored in secure bags. Olivine concrete and

normal concrete samples, the ones exposed thermal processing and normal room temperature samples pressure resistance and ultra sound experiments were carried on in Süleyman Demirel University, Technical Training School Structure education department laboratories.

3.Test Results And Suggestions

As a result of preliminary test results, concrete samples were in a space structure and compressive strength values were obtained lower. The reason for this was thought as the high water absorption olivine aggregate and in second experiments olivine was used as concrete aggregate material after dry surface became water-saturated. In the second preliminary experiment, w/c rate was reduced and more flat surface was obtained using olivine as dry surface and adding air entraining Sika AER additive.
28-day pressure resistance of second samples completing their cures were determined approximately 25 N/mm2 on the 10x10x10cm cube samples. In chart 3, olivine concrete's28-day pressure resistance conclusions were given. 28-day pressure resistance conclusions of concrete samples produced according to olivine concrete experiment conclusions were obtained as 52,7 N/mm2 on average and were shown in table 2.

Samples	Weight (kg)	Pressure resistance (N/mm2)
N14	2,38	53,2
N5	2,35	52,3
OB19	2,45	27,8
OB11	2,35	22

Table 2. Olivine and normal concrete's 28- day pressure resistances

Normal and olivine concrete samples were exposed to different temperatures 2 hours to remain constant on, 300^0 C, 600^0 C, 900^0 C temperatures in the heat treatment furnace at the source laboratory of Izmir Dokuz Eylül University, mechanical engineering department and the samples were cooled in the furnace till room temperature. When these samples were weighed, normal concrete samples' weight 2,325 kg at 300^0 C fell down 2,2 kg; 2,41 kg at 600^0C fell down 2,25 kg; 2,35 kg at 900^0 C fell down 1,76 kg. Olivine concrete samples' weight before and after heating: 2,4 kg at 300^0 C fell 2,3 kg; 2,41 kg at 600^0 C fell down 2,16 kg; 2,39 kg at 900^0 C fell down 2,18 kg. Olivine and normal concrete samples' weight changing rate according to temperature were given in fig 2.

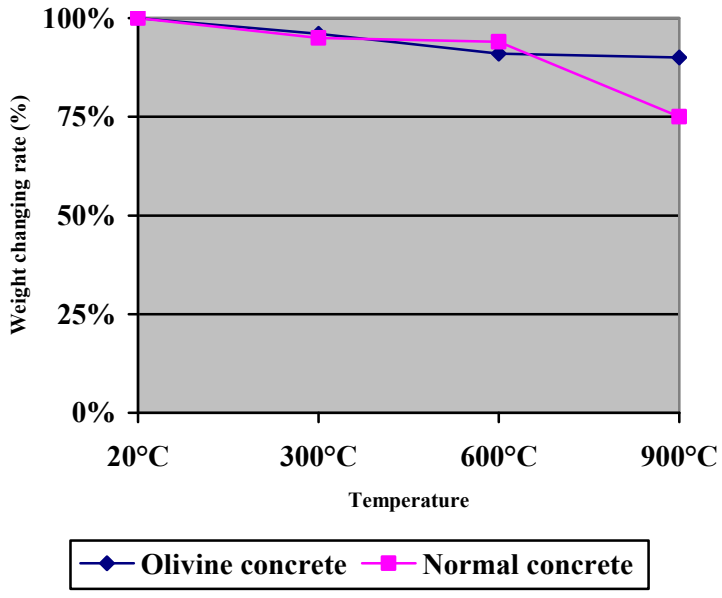

Fig 2. Olivine and normal concrete samples' weight changing rate according to temperature

Ultra sound and pressure resistance experiments were carried on with heated samples and samples holded in normal room temperature in Süleyman Demirel University, Technical Training School Structure education department laboratories. Ultrasound tests were found to result in normal concrete samples at 20^0C temperature 22,5 µs, 300 ^{0}C temperature 25,95 µs, 600 ^{0}C temperature 41,6 µs, and at 900 ^{0}C temperature 57,1 µs. Olivine concrete samples resulted in 20^0C temperature 22,05 µs, 300 ^{0}C temperature 27,85 µs, 600 ^{0}C temperature 39,25 µs, and at 900 ^{0}C temperature 84,9 µs. Olivine and normal concrete samples' ultrasound pulse velocity-temperature relation were given in fig 3.

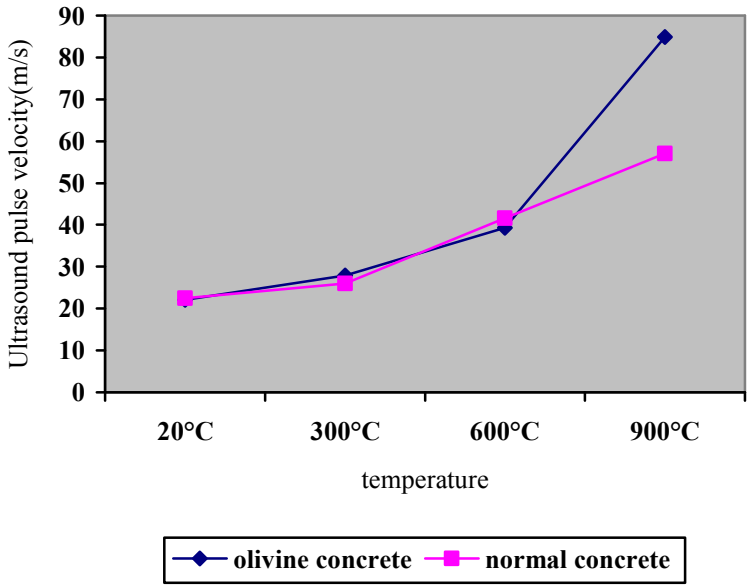

Fig 3. Olivine and normal concrete samples' ultrasound pulse velocity-temperature relation

On pressure resistance experiment normal concrete samples resulted in 20^0C temperature 52,5 N/mm2, 300 ^{0}C temperature 40 N/mm2, 600 ^{0}C temperature 16,21 N/mm2,and at 900 ^{0}C de 7 N/mm2. Olivine concrete samples resulted in; 20^0C temperature 23 N/mm2, 300 ^{0}C temperature 23,9 N/mm2, 600 ^{0}C temperature 30,23 N/mm2, 900 ^{0}C temperature 3,8 N/mm2. Olivine and normal concrete samples' pressure resistance -temperature relation were given in Fig 4.

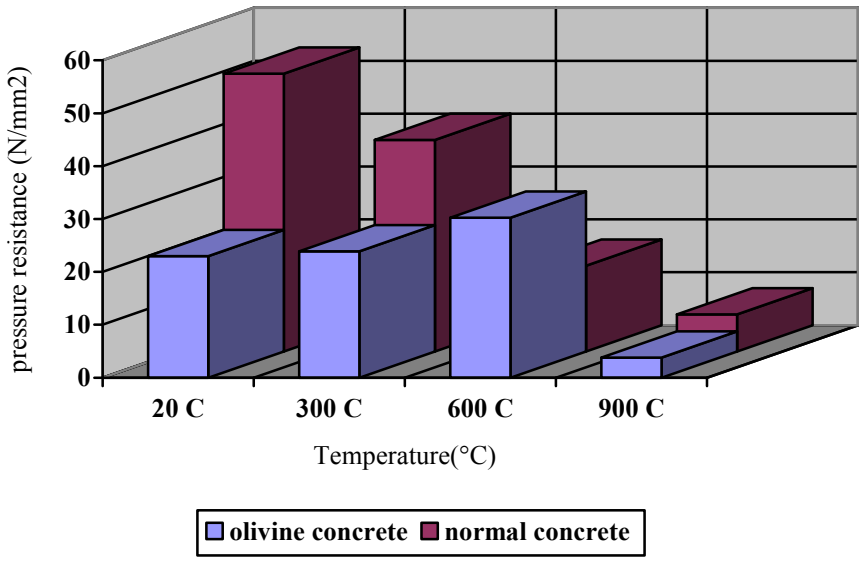

Fig 4. Olivine and normal concrete samples' pressure resistance -temperature relation

4.Results

Olivine and normal concrete samples carried out in studies, at first were exposed to different temperatures 2 hours to remain constant on, 300^0 C, 600^0 C, 900^0 C temperatures in the heat treatment furnace. When the samples removed from the furnace were weighed, it's found that while temperature increased and within the water evaporated their weight decreased.

Accordingly, the first weight of samples and weight after their exposure to temperature were given in table 3. Heated samples and normal samples holded in normal temperaturewere applied ultra

sound and pressure resistance experiments in Süleyman Demirel University, Technical Training School Structure education department laboratories. In ultra sound experiment as the heat rose, conclusions rose, up to 900^0 C olivine and normal concrete samples showed values close to each other. Conclusions of ultra sound experiments were given in table 3.

In pressure resistance experiment, in normal concrete samples as the heat rose pressure resistance decreased and up to 600^0 C it was determined that it lost approximately 70% of resistance. In olivine concretes in contrast to normal concrete samples, with the heat rise pressure resistance also increased and at 600^0 C it was determined that it rose approximately 30% of its resistance. At 900^0 C both different samples were determined huge loss of strength. Pressure resistance experiment conclusions were given in table 3.

	20°C		300°C		600°C		900°C	
	Normal concrete	Olivine concrete	Normal concrete	Olivine concrete	Normal concrete	Olivine concrete	Normal concrete	Olivine concrete
Ultra sound µs	22,5	22,05	25,95	27,85	41,6	39,25	57,1	84,9
Pressure resistance (N/mm2)	52,5	23	40	23,9	16,21	30,23	7	3,8
Weight (kg)	2,35	2,39	2,2	2,295	2,25	2,16	1,76	2,18

Table 3.Olivine and normal concrete samples' weight, ultrasound and pressure resistances according to temperature

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