MECHANICAL BEHAVIOUR OF MORTAR USING POZZOLANA AS PARTIAL REPLACEMENT OF CEMENT

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Abstract- Lightweight concrete structures are being built by human beings since ancient time for shelter and other purposes. These structures are composed of different materials like concrete, wood, glass, steel, stones and mud. But in the modern world, the use of lightweight concrete is increasing. After water, concrete is the most widely used material on our planet. Due to its relatively low cost, it is commonly used building material. The major binding material of concrete is cement. This leads to the production of cement in very large amount. The excess use and production of cement leads to environmental problems and concrete structure disintegration. We can reduce the production of cement by adding different types of pozzolanic materials as partial replacement of cement which will also decrease the dead load of the building. In this study we will evaluate the results of adding different proportions of Pozzolana as partial replacement of cement. The type of pozzolanic material used in this study is pumice. Pumice is available naturally in the form of stones. The pumice stone is always easily available everywhere and having low density then all the other aggregates used in the concrete mortar. The light weight mortar cubes are prepared by partially replacing the cement with powdered pumice aggregate by 12, 24, and 36%. The mix design and all the respective percentages are prepared by mixing it with water. After proper curing the mechanical and the durability properties of conventional control mix and the partially replaced mortar cubes are compared by conducting compressive strength and porosity tests for specific replacement of the

Keywords- Lightweight concrete, Admixtures, Durability, control mix.

1 Introduction

Construction is a very old human practice. Human beings are involved in construction since ancient times. With time the structures become more durable and stronger. For more than 2000 years LWC has been used as a building material [1]. In this study, the main focus is on concrete. As cement is the major constituent of concrete, there are many side effects of excess cement production such as environmental degradation [2]. Chromium in it that can cause allergy. Crystalline silica is not good for lungs and skin, lime and other alkaline compounds are highly corrosive to human tissues [3]. The solution is to use as minimum cement as possible. One of the ways is to replace this with another material that needs to have the same properties or even better properties than cement. We have to reduce the use of cement in concrete by replacing it with another material that is pozzolanic or simply known as pozzolan [4]. Pumice stone being embossed volcanic rock, comes into form when lava with a very high content of gases and water is squeezed out of volcanic action. Pumice is a lightweight stone that floats on the surface of the water [5]. The main objective of this study is to find a combination of cement and pumice that should not affect the properties of concrete.

Nowadays we need a type of concrete that will be LWC to decrease the weight of the building, which leads to economical and safe building construction. The novelty of this research is that pumice stone being lightweight when used as a partial replacement for cement will decrease the weight of the concrete, which decreases the weight of the structure and hence will lead to less cement production and economical building construction. In this study, different percentages of pumice were used to obtain such a percentage of pumice as a replacement for cement to improve its properties.

2 Research Methodology

2.1 Material Collection

The following is the material collected for the research as shown in Table 1.

Table 1: Material collection

S. NO	Material	Description	Image
1	Pumice Stone	In this study, the pumice stone was collected from Lahore and then brought to Peshawar. Pumice stones were then ground at 100 ˚C and 700 ˚C temperatures in PCSIR Laboratory located on Nasir Bagh Road, Peshawar. Then it was passed through sieve no 200, in this way the desired fine form of pumice stone was obtained.	
2	Sand	In this study, different samples of sand were collected from different locations, in search of sand having a modulus of about 2.5. The fineness modulus of all the collected samples was evaluated and the sand with a fineness modulus of 2.5 was selected for the study. The selected sample was obtained from Uzair Material Stock Forest Bazar Peshawar.	
3	Cement	The type of cement used in this study was ordinary Portland cement conforming to ASTM C204-18e1., from a company called Kohat Cement. An admixture of Sika-viscocrete was also added to reduce shrinkage and creep in the concrete.	
4	Water	Looking into different parameters such as alkalinity, turbidity, oxygen saturation, temperature, conductivity, and freshwater conforms IS 456-2000 were used for the preparation of concrete.	

2.2 Percentage of Pumice Stone as Partial Cement Replacement

Different percentages of pumice stone were used as a replacement for cement to find out the required percentage of a pumice stone to achieve high-performance quality. In this study 12, 24, 36% of pumice stone was used as a partial replacement for cement, and properties were evaluated.

2.3 Quantity of Specimens

The number of specimens prepared and tested in this study is given in Table 2.

Table 2: Calculation for Number of Samples

Percentages	Ages	No. of cubes for Compression test	No. of cubes for Porosity test	Sum
P-12	7	9	6	15
	28	9	6	15
P-24	7	9	6	15
	28	9	6	15
P-36	7	9	6	15
	28	9	6	15

2.4 Mixing Procedure

The mixing procedure of cement mortar was followed by ASTM C-305 to get a uniform mix, having plastic consistency and adequate workability to be placed easily in the mould.

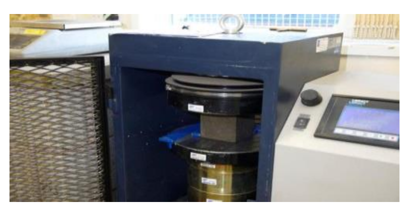
2.4 Specimen Preparation

In this study, the standard cubes of size (25.4 x 25.4 x 25.4) mm were prepared in the cube moulds. For compression, the 9 specimens will be cast for each age and each percentage. The casting of partially replace pumice mortar is similar to that of conventional control mix design, before grinding the pumice it should be uniformly pre-wet to get its total saturation, then allow to sit until the whole of the water drains out from it [8]. After the casting of concrete, the specimens were kept for 24 hours and then de-mould. After the demolding, all these will have immersed in the curing tank for curing, and then they should be extracted at their specific testing time.

2.5 Laboratory Tests

The following are the tests performed in this research as shown in Table 3.

Table 3: Laboratory Tests

S. No	Test	Standard	Description	Image of Assembly
1	Compressive strength	ASTM C109	It gives the determination behavior of the material under a load and the maximum stress that a material can sustain over a period under applied load.	
2	Porosity	ASTM C1754	Porosity is the percentage of void spaces in mortar or concrete. It is the measure of the volume of voids in concrete.	

3 Results and Discussion

3.1 Compressive Strength

The following are the results of compressive strength as shown in Table 4.

Table 5: Compressive strength

S. No	Compositions	Compressive strength (Ksi)			
		P-700		P-100	
		7-days	28-days	7-days	28-days
1	Control	2.342	3.290	2.342	3.290
2	P-12	2.623	3.417	2.299	3.053
3	P-24	2.105	3.797	2.502	3.373
4	P-36	2.194	4.321	2.001	3.549

3.1.1 Compressive Strength Comparison

It is clearly shown in Figure 1 below that P-36-700 at 28 days curing gives us maximum strength i.e 4.321 ksi. And P-36-100 at 7 days curing gives us minimum strength i.e 2.105 ksi.

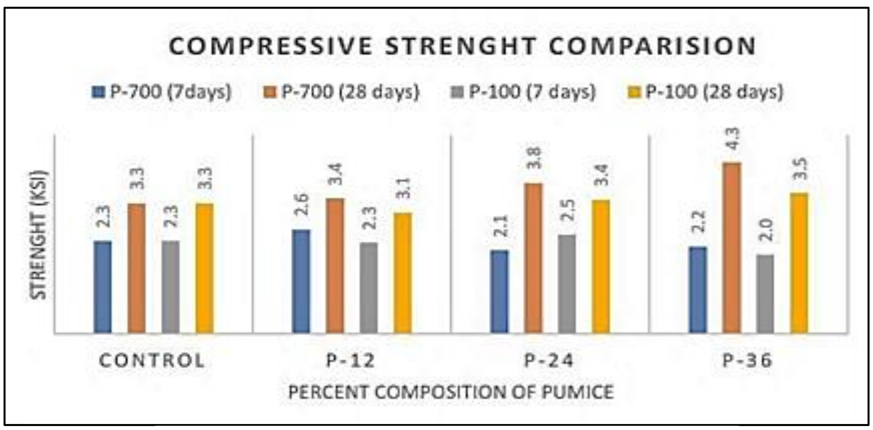


Figure 1: Compressive strength comparison chart

3.2 Porosity

To find porosity, we need the oven-dried weight (Wd), surface saturated weight (WssD), and submerge in water weight (Ww). The soaked and dry weights were founded for all the specimens of all ages and the average was taken for each set. Table 5 below shows the porosity of samples.

Table 5: Porosity of samples

S. N.	Compositions	P-700						P-100					
		7 days			28 days			7 days			28 days		
		Ww	WssD	Wd	Ww	WssD	Wd	Ww	WssD	Wd	Ww	WssD	Wd
1	Control	167	294.2	277	164	292	274	167	294.2	277	164	292	274
2	P-12	162	293.3	267	160	290	263	161	296.3	276	159	289.5	268
3	P-24	163	297.5	270	162	294	268	159	296.7	275	162	300	282
4	P-36	164	299.7	289	165	296.7	280	160	292.5	270	162	300	282

3.2.1 Porosity Comparison

The following column chart as shown in Figure 2 below is showing the comparison of porosity for different pumice compositions for 7- and 28-days curing. It is clear from the chart that P-24-700 7 days curing has maximum porosity of 20.497% while P-36-700 7 days have a minimum porosity of 7.721%.

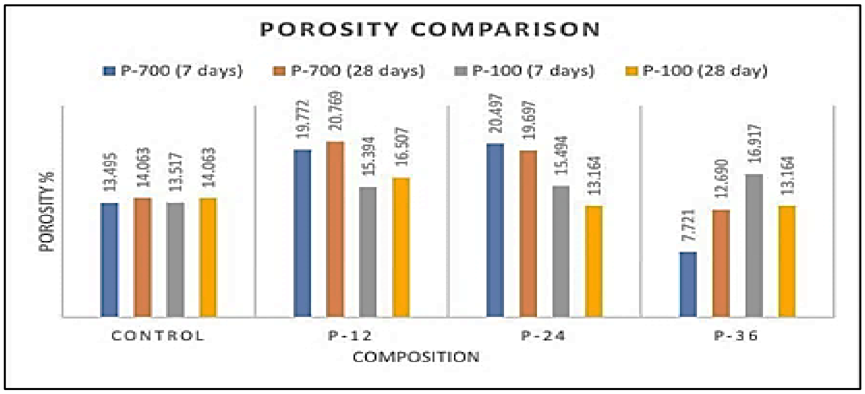


Figure 2: Porosity comparison chart

From the results, it is clear that compressive strength increases with the increasing percent of pumice and curing period as shown in Figure 3. Generally, porosity is going to decrease when pumice stone percentage is going to increases as shown in Figure 3.

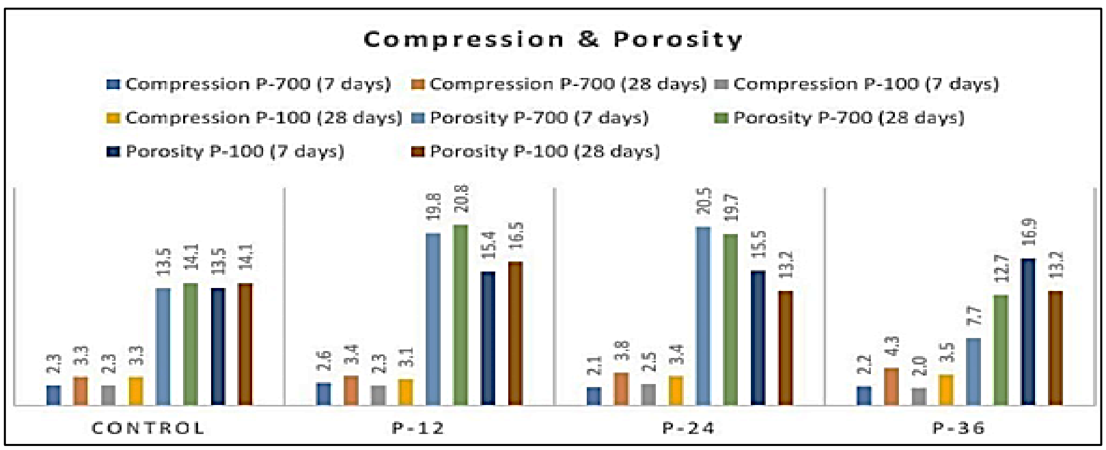


Figure 3: Compression & Porosity

3.3 Discussion

From our research being lightweight, when pumice is used as a partial replacement for cement it will form LWC having the following benefits:

1. It will decrease the production of cement and hence environmental degradation will decrease.
2. It will decrease the health risks associated with cement.
3. It will decrease the dead load of the building.
4. It will reduce transportation costs.

Conclusion

From the conducted study the following conclusions can be drawn:

1. P-36-700 at 28 days curing give us maximum strength i.e 4.321 ksi. And 36-100 at 7 days curing gives us minimum strength i.e 2.105 ksi.
2. P-24-700 7 days curing has maximum porosity of 20.497% while P-36-700 7 days have a minimum porosity of 7.721%.
3. The best combination is P-36-700 (28 days) which gives compressive strength of 4.3 ksi and 12.7% porosity.

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