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HIGH PERFORMANCE CONCRETE HAVING SILICA FUME AND METAKAOLIN AS A LIMITED REPLACEMENT OF CEMENT

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Abstract

The reason for this investigation is to create HPC using locally accessible ingredients in Pakistan. The trial study incorporates the utilization of silica fume and Metakaolin mostly. The mixture of preliminaries is made utilizing various volumes of the local supplementary cementitious materials SCM and aggregates to deliver HPC. Different tests are carried out, for example, compressive strength, Rapid chloride Penetration test and Concrete cured in dilute sulphuric acid solution are assessed. The water to cement proportion was kept at .5. Every concrete samples have 0, 5, 10, 15 and 20 percent cement replacing with metakaolin and silica fume halfway. The compression strength tests are done on 28 and 90 days of cured specimens. The rapid chloride permeability test and compressive strength on the concrete cylinder when place in dilute sulphuric acid solution is done after 28 days.

The outcomes appeared by utilizing MK and SF in concrete improves the mechanical properties of the concrete with different degrees up to some level. The compressive quality of the concrete cylinder is maxed on 15%

cement replacing with SCM. At 5% MK and SF cement replacement the strength of the concrete samples cured in dilute H_2SO_4 after 28 days shows rising in the result and its strength decreases at 10% cement replacement with SCMs than its strength increased again and gives max compressive strength with 15% replacement then strength reduces again at 20% cement additional with MK and SF moderately. The charge passing rate is maxed for normal concrete samples of RCPT. There is an inverse relationship between the charge passage and cement replacement. The Charge passage is decreased by increasing the quantity of cement additional with SCMs. 20% cement additional has the least charge level and is the best mix among all.

Keyword: High Performance Concrete, Silica Fume, Metakaolin

I. Introduction

Concrete is broadly utilized substantial since its disclosure. The reason for existing is to utilize concrete in the development industry to oppose compressive force in the compression zone. Concrete have three noteworthy qualities, for example, workability, strength & durability. Workability relies upon water Cement (w/c) proportion. More water cement proportion more will be workable however decrease in strength. The strength of concrete likewise relies upon the size & shape of materials. The durability of concrete means capacity to counterattack chemical attack, abrasion & weathering action. A few reasons that effect the durability of concrete, i-e cement content, compaction, curing, cover & permeability [VII]. In other word we trusted that durability of concrete rely upon solidify concrete & also workability is related to the fresh concrete, anyway hardened properties might be specifically interlinked to the mix & fresh properties. In other words, mix & fresh properties of concrete are the extreme values to control in relation to the mechanical characteristics of hardened concrete. To gauge of harden properties of concrete are generally important. The issue is that mechanical properties & harden process don't make improve. The nature of concrete relies upon mixing properties & material properties of the composite framework & additionally these variables don't change after hardening of concrete [II].

Concrete is a broadly utilized material in each field of civil structures. Its arrangement gives us great structures unwavering quality against different extraneous elements. Solid structures, for example, dams, bridges & power plants, can be presented to extraordinary & concentrated loadings, for example, earthquakes, impacting & blasts. During these variable loading

circumstances, distinctive disappointment are happen, for example, tensile failure, shear damage modes can likewise be seen as catering on the front face & high shear strain close to the hollow[VIII]. In other work bear on UHPC, when contrasted with its compressive & tensile strength, the shear strength of UHPC remains relatively unidentified & the impact of fiber & strain-rate on the shear strength should be tentatively explored in more detail. The Punch through Shear (PTS) trial method was 1st declare by Watkins (Li Qm, Meng H) [I].

II. Literature Review

High performance concrete (HPC) is utilized in the development industry around the world now a day's. Different types of admixtures like silica fume SF, fly ash & metakoline & practical agent's super-plasticizer are also used to produce HPC with normal materials. To rise the durability & strength of concrete some admixture are used. Compressive strength are determining use of mineral admixture like SF of different percentages 0%,5%,10%,15% and 20% at seven days & 28 days of curing. This research aims for creating HPC through mix design by using silica fume.

HPC has converted more common material in latest ages. On the other hand, blend proportioning of HPC is a more complicated process than NSC. Mix design techniques of NSC are not specifically relevant for designing HPC mixes. Tropical nations as a rule demonstrate considerable varieties in temperature and humidity [III].

These varieties have a significant impact on the properties of HPC as mix extents are typically chosen at research center conditions. Subsequently, the mixed design of HPC in a tropical atmosphere requires unique regard for consolidating the variety in its properties. This paper introduces another technique for the constituent contribution of HPC mixes seeing impacts of changing moisture and temperatures by presenting them to various environments. The anticipated strategy is tentatively observed to be legitimate & delivers mix proportions getting wanted workability and strength [V]. By adding of some pozzolanic ingredients, having different properties of concrete, workability, durability, strength, resistance to cracks and permeability can be moved forward. SF is one such pozzolanic material. Utilization of SF as admixture in concrete has opened up one more chapter on the headway in concrete innovation. More sticky mix can be acquired by adding of Silica

fume in concrete. By utilizing it in concrete expands its compressive, tensile, flexural and impact strength and decreases permeability and bleeding [VI].

III. Experimental Work

Preliminary examinations were led for normal combination for various extents of constituents. At long last the predefined strength of around 3500.00 psi was accomplished by mix with 1.0: 1.5: 3.0 extent with water/cement proportion of 0.5. This proportion was utilized to figure cluster amounts for 1.0m^3 of concrete. Mixed blends are gotten from normal concrete by limited supplanting of concrete with MK and SF. The group measures for normal and mixed blends are specified in stand 10. Mix design is shown in table 1.

Table 1: Mix Design.

Cement Additional	Cement In Kilograms	SF In Kilograms	MK In Kilograms	Sand In Kilograms	Crush In Kilograms	Water In Kilograms
0%	395.0	0.0	00.0	672.0	1344.0	197.0
05%	375.250	9.870	9.870	672.0	1344.0	197.0
10%	355.50	19.750	19.750	672.0	1344.0	197.0
15%	335.750	29.620	29.620	672.0	1344.0	197.0
20%	316.0	39.50	39.50	672.0	1344.0	197.0

Compressive Strength Test

The Cement content is particularly replaced to some extent 0%, 5%, 10%, 15% and 20% with equal levels of MK and SA. Compressive quality results in concrete specimens for different additional levels at 28 and 90 days. The test was executed on a 6 inch dia and 12 inch height cylinders.

Compressive strength results are used to guarantee that a strong mix meets the requirements of predetermined axial strength. These test samples are used to determine the quality control, the rigidness, the ability to evaluate the quality of a structure or to calibrate basic concrete. These samples were tested to calculate its compressive strength as shown in fig2.

Figure 1 Concrete cylinders Curing.

Figure 2 compressive strength test.

Strength of concrete cured in dilute Sulphuric Acid

Determined by the resistance for sulphate occurrences on material, concrete can eliminate the amount of sulphate barrier fixed water. The expansion of the test specimens, measuring 6 inches and 12 inches in diameter, was immersed in 3% sulphuric acid and the water was left in normal temperature. These specimens were tested for calculating the compressive strength as shown in fig3.

Figure 3 Compressive strength of cured dilute sulphuric acid concrete.

Rapid Chloride Penetration Test (RCPT)

RCPT is broadly executed to recognize the concrete obstruction for chloride particle infiltration. This test really screens the concrete specimens allowing the ions went in Coulombs. RCPT Concrete specimens are shown in fig4.

Figure 4 RCPT concrete specimens after 28 days.

IV. Result and Discussion

Compressive Test Results

The compressive strengths CS results for different samples having a different percentage of SCM in concrete cylinders were tested after 28 & 90 days as shown in table 2.

Table 2: CS outcomes after 28 days & 90 days.

Cement Additional	C S after 28 days	C S after 90 days
0%	3682 **psi**	4624 **psi**
5 **%** (2.5 SF & 2.5 MK)	3935 **psi**	4908 **psi**
10 **%** (5 SF & 5 MK)	4258 **psi**	5320 **psi**
15 **%** (7.5 SF & 7.5 MK)	4389 **psi**	5426 **psi**
20 **%** (10 SF & 10 MK)	3265 **psi**	4478 **psi**

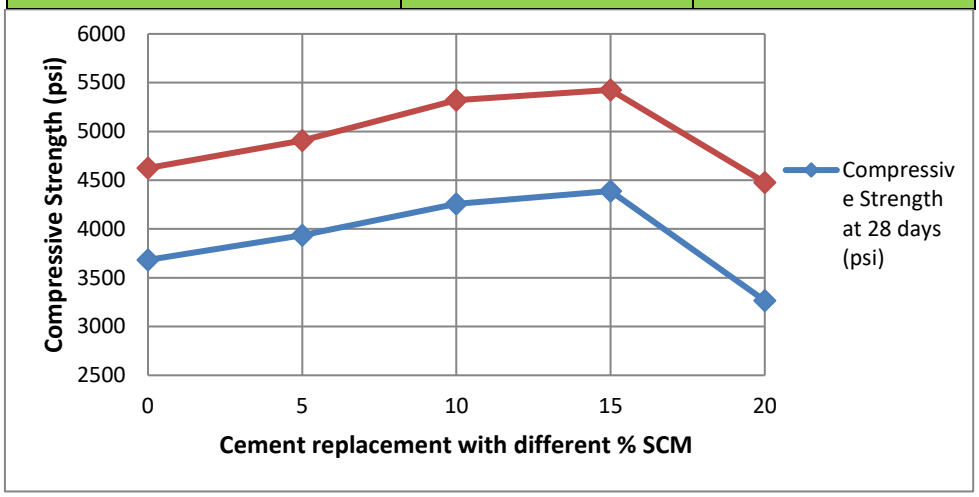

Figure 5 CS results after 28 & 90 days.

In this research the concrete specimens were examined after 28 & 90 days and SF and MK with different percentages replacement in which the compressive strength of the concrete increases slowly and its strength becomes maximum at 15% replacement and then strength decreases by increasing its replacement after 15% as it can be seen in table 2 and fig 5.

Strength of concrete cured in dilute Sulphuric Acid Results

Determined the opposition for sulphate attacks on the concrete, Concrete can decay from sulphate impedance resolved water content. Sulphates are commonly set up in sea-water. Extension of test chambers having measurements of dia 6 inches and height 12 inches was immersed in 3% sulphuric acid and leftover water arrangement at room heat.

Three samples of every % replacing of cement with SCM specimens were prepared, restored in dilute H_2SO_4 arrangement and was dry at room

temperature once curing, following 28 days relieving of test estimations were noted as found in table 3.

Table 3 CS cured in water VS cured in dilute H2SO4.

	Result after 28 days curing in H_2SO_4	Compressive Strength Result after 28 days	Compressive Strength Result drops
0	3118 psi	3681 psi	18.04 psi
5 % (2.5 SF and 2.5 MK)	3577 psi	3934 psi	09.96 psi
10 % (5 SF and 5 MK)	3360 psi	4257 psi	26.67 psi
15% (7.5 SF and 7.5 MK)	3953 psi	4388 psi	11.01 psi
20 % (10 SF and 10 MK)	2636 psi	3264 psi	23.80 psi

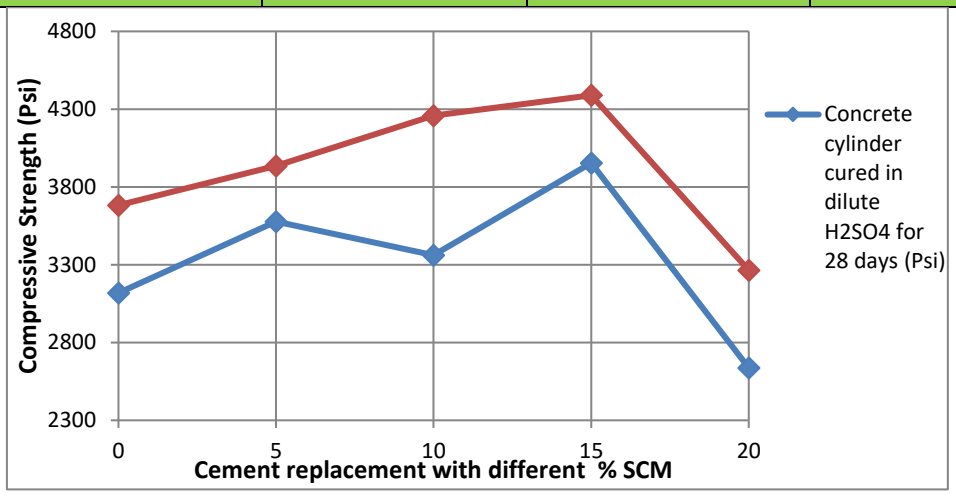

Figure 6 CS of concrete when cured in dilute sulphuric acid after 28 days.

The outcomes of concrete samples were restored in dilute H_2SO_4 for 28 days and were tried by UTM which indicates its CS. As appeared in fig 6 the strength level increases by including MK and SF up to 5 percent and decreases on 10 percent cement replacing with SCMs and increases again and invigorates the most extreme CS at 15 percent. MK and SF mix specimens give great outcomes as far as durability 5, 10 and 15 percent cement replacing of concrete with these 2 SCMs indicates great durability outcomes as a contrast with OPC without utilizing SCMs.

Rapid Chloride Penetration Test (RCPT) Results

RCPT is broadly executed to recognize the concrete obstruction for chloride particle infiltration. This test really screens the concrete specimens permitting

the ions went in Coulombs. RCPT outcomes show concrete expansion with SF and MK replacement show superb evaluations after 28 days' time span. The beneath table 4 give the total aftereffects everything being test. These test outcomes were done with 0, 5, 10, 15 and 20 percent cement supplanting with SCM.

Table 4 RCPT outcomes after 28 days.

Cement replacement	RCP test after 28 days
	Columbus
0%	2824 coulombs
5 % (2.5 SF and 2.5 MK)	2270 coulombs
10 % (5 SF and 5 MK)	1934 coulombs
15 % (7.5 SF and 7.5 MK)	1815 coulombs
20 % (10 SF and 10 MK)	1344 coulombs

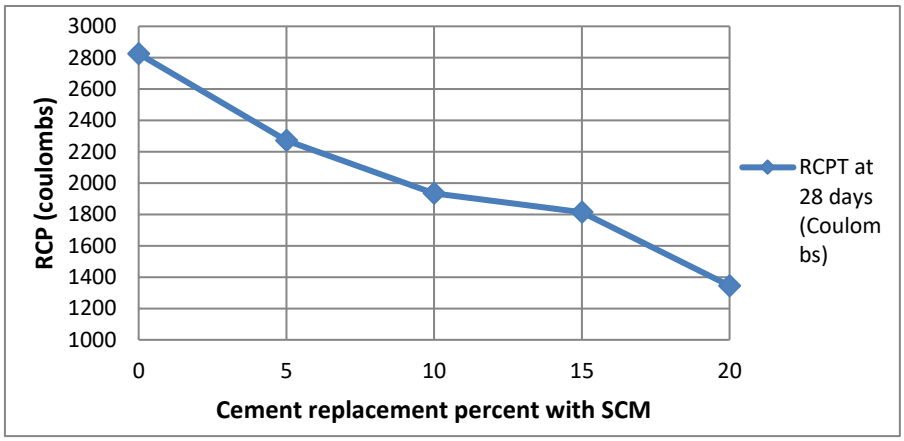

Figure 7 RCPT results after 28 days.

The RCPT outcome indicates the particular decline in ions entry in the combination of SCM. A 20 percent additional of the cement substance is the perfect state for most slight charge section. These charges extended from high coulombs to low as by expanding the SCM with same water cement ratio. These RCPT outcomes propose that mixing with MK and SF extremely concentrations the conditions, which diminishes porousness notwithstanding expanding durability, as examined. By testing the concrete specimen of 0 percent replacement of concrete isn't that acceptable, which comes in medium porousness run implies it has little spaces present there and by utilizing 15

percent gives great outcomes when contrasted with 0 percent cement additional, it approaches in the lowly charge range. The 20 percent additional of cement displays the amazing outcome have charge go close to the poor range, which is viewed as the finest among all the others. The better material was required to show more prominent decreases in penetrability than the thicker because of its bigger surface region, quicker response rate and increasingly expressed quality upgrading impact likewise delivered the best measure of chemical shrinkage, which was unforeseen. This infers inception or increasing speed of a response in the framework that is creating denser response mixes that possess a little volume and accordingly lead to the more noteworthy substance shrinkage. From the RCPT information, gathered at 28 days, it appears to be likely that these denser mixes are well ready to delay entrance and permeation of chloride ions.

V. Conclusion

Below written conclusions are drawn from the experimental examination in this research.

- The concrete specimens were tested after 28 and 90 days to discover its compressive strong point, its strength rises with the adding of MK and SF steadily and then its shows max strength when the additional is 15 percent and the strength reduces by replacing over 15 percent.
- At 5% MK and SF concrete substitution the quality of the solid examples relieved in weakening H2SO4 following 28 days show ascending in the result and its quality declines at 10% concrete supplanting with SCMs than its quality expanded again and invigorates max compressive with 15% substitution then quality lessens again at 20% concrete extra with MK and SF respectably.
- The charge passing rate is maxing for normal concrete samples of RCPT. There is an inverse relationship between the charge passage and cement replacement. The Charge passage is decreased by growing the quantity of paste additional with SCMs. 20% cement additional has the least charge side by side and is the best combination among all.

VI. Recommendation

Further durability assessments should be focused such as freezing and thawing, drawing shrinkage etc.

- Reducing the w/c ratio further should also be observed.
- Different types of ashes with different dosage needs to be studied.
- SF with different content should be examined.

Conflict of Interest :

No conflict of interest regarding this article

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