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Research paper

Strength properties of high volumes of slag concrete for rigid pavements

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Abstract

Concrete is one of the most versatile materials used in the construction industry in which cement is used as main ingredient playing a dominant role in gaining of strength. Despite of it, the production of cement leads to depreciation of natural materials. Regarding this aspect, in this study an attempt has been made to use GGBS (Ground Granulated Blast Furnace Slag) as a substitute material to cement with a percentage replacement of 50% .Specimens with various geometric shapes like cubes, cylinders and prisms were casted and tested with(High Volume Slag Concrete) and without replacements of GGBS, varying water-cement ratios of 0.55, 0.45, 0.36 & 0.27 for mechanical properties, Young's Modulus of elasticity, impact strength with and without the addition of steel fibers and also abrasion resistance after 28 days and 90 days of curing.

Keywords: *GGBS; Mechanical Properties; Young's Modulus; Affect Strength; Abrasion Resistance*

1. Introduction

Cement has been extensively used as binding material in concrete since golden era. Despite of major drawbacks of cement like extensive consumption of natural resources, emission of greenhouse gases and causing leaching of concrete mainly found in the case of rigid pavements when they are exposed to soils containing sulphates. Due to the pozzolanic property of the substituting materials to cement like Ground Granulated Blast Furnace Slag (GGBS), Silica Fume, Fly Ash, Metakaoline etc., the strength as well as durability can be improved.

Ground Granulated Blast Furnace Slag is a residual waste material obtained in the production of iron ore. Besides, being a waste material, GGBS is rich silicates, alumina-silicates and calcium – alumina silicates. Rapid utilization of GGBS in concrete results in attaining durability, strength and sustainability of raw materials and also eco-friendly by reducing the usage of cement which further reduces greenhouse effects.

1.1. Literature survey

GGBFS can be replaced with cement for the purpose of grouting and attainment of optimum Compressive Strength of concrete for 50% slag replacement under water curing condition. Drying shrinkage test result proved that the above grouting material with proper mix proportion which is appropriate to be used in normal grade concrete repairs under hot climate (Hussin, 2007). Some numerical methods are proposed to find the binder reaction for gaining of strength, the capillary cavities at different periods of curing and chloride diffusion coefficient (Ki-Bong & Xiao-Yong, 2017). Concrete mixes with PFA and GGBS exhibit significant increase in resistance to chloride ingress than PC mixes (Bamforth, 1999). The partial substitution of natural aggregates with slag aggregates improves the strength in later ages (Zeghichi, 2006). The adhesion between the aggregate of crystallized slag and hydrated paste is good and it improves the strength Alkali Aggregate reaction can be controlled by using Steel Slag powder as partial substituting material to Portland cement in concrete by its the synergistic effect and mutual activation (LI Yun-feng, 2009). Artificial Neural networks (ANN) is a more appropriate method than regression analysis (Yeh, 1998). The progressive release of alkalis by the GGBS, together the formation of calcium hydroxide by Portland cement, resulting in continuing reaction of GGBS over a long period. Thus, there is a long term gain in strength. However, the later rate of hydration of blended cement containing GGBS is accelerated. Thus heat of hydration is reduced by inclusion of GGBS mix (Neville, 2011). There is a simple linear relationship between static and dynamic elastic moduli which tend to predict static modulus of elasticity using dynamic elastic modulus which may avoid the problems in determining static elastic modulus of concrete (Salman, 2006). A slight retarding effect appeared in the gaining of early strengths of concrete due to the presence of GGBS. Consequence of low curing temperature would be low early strength of GGBS concrete. The 28-day strengths are reduced than their design strength for high temperature curing at 75o C and it may be necessary to limit the peak temperature of concrete in pours of mass in practice (Leung Peter, 2010).Two empirical equations were proposed by the authors to calculate its static Young's modulus and dynamic Young's modulus for dynamic Poisson ratio which varies with nearly 0.20. P-wave velocity and elastic modulus varies with equal tendency as letter N. When the rate of loading increases, μ, μd will decrease and μd greatly affects the parameters Ed and average value of two Ed values (Shi-you, 2000).

2. Properties of ingredients

Table 1: Properties of Ingredients

S. No.	Material	Specific Gravity
1	Cement (Ultratech)	3.1
2	Ground Granulated Blast Furnace Slag (from Visakhapatnam)	2.2
3	Super Plasticizer (Endure flowcon04)	1.2
4	Fine Aggregate (River Sand)	2.55
5	Coarse Aggregate (Crushed Granite Material)	2.60

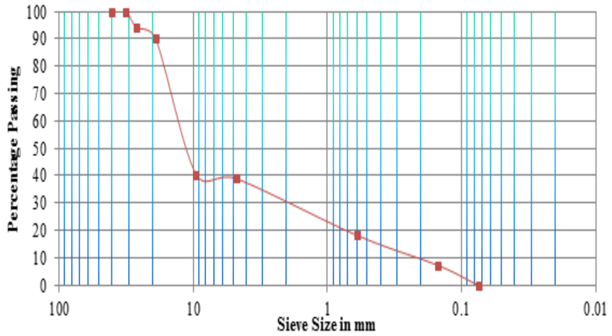


Fig. 1: Particle Size Distribution Curve of Combined Aggregate.

3. Mix proportioning

Mix Proportioning has been prepared as per IS 456-2000 and IS 10262(2009). The properties of ingredients are shown in Table 1and particle distribution of combined aggregate shown in Fig.1. mixes were prepared for various water- binder ratios ranging from 0.55 to 0.27 with 0% and 50% GGBS as replacement material for cement respectively are shown in Table 2.

3.1. Preparation, casting and testing of specimen

The specimens of OC and HVSC were cast, cured and tested for Compressive Strength and Flexural Strength as per IS: 516-1959.

Table 2: Mix Proportions of Ordinary Concrete and High Volumes of Slag Concrete

Series	OC				HS			
w/c or w/b	0.55	0.45	0.36	0.27	0.55	0.45	0.36	0.27
Mix	OC 1	OC 2	OC 3	OC 4	HVS C1	HVS C2	HVS C3	HVS C4
Cement (Kg)	320	392	488	640	160	196	244	326
GGBS(Kg)					160	196	244	326
FA(Kg)	786	743	659	518	763	715	625	477
CA(Kg)	1020	1004	1009	1025	990	996	961	945
Superplasticizer (ml)	---	1185	2470	3295	--	---	2122	4698
Slump(mm)	80	70	85	120	75	65	100	140

4. Experimental investigations

4.1. Compressive strength test

Concrete cube specimens of size 150 mm and 100 mm are used to determine the Compressive Strength of Ordinary and High Volumes of Slag Concrete as per IS 516-1959for 28 days.

4.2. Flexural strength test

Beam specimens of Ordinary and High Volumes of Slag Concrete of size 100 x 100 x 500 mm, cast for various w/b are tested by applying third-point loading as per IS 516 for 28 Days. Casting and testing of HVSC specimens are shown in Fig.2.

A) Casting of Specimens

B) Testing of Specimen

Fig. 2: Flexural Strength of HVSC.

4.3. Modulus of elasticity

4.3.1. Static modulus of elasticity

Cylinders of 150 mm X 300 mm of OC and HVSC are cast and tested in Universal testing machine for maximum load and axial strain as per IS 9221-1979 (Reaffirmed-1996). The deflections are being taken by using dial gauge. The testing of specimen is shown in Figure 3. From the observations, stress, strain and Young's modulus have been calculated.

4.3.2. Poisson's ratio

Specimens are cast and tested in Universal testing machine for maximum load and axial strain as per IS 9221-1979 (Reaffirmed-1996). From the observations, stress, axial strain (Ea) and diametric strain (Ed) are calculated. Then, Young's modulus and Poisson's ratio have been calculated using above findings.

4.3.3. Dynamic modulus of elasticity

Dynamic modulus is the modulus found out by using non-destructive testing method. This test is conducted as per IS 13311 (Part-1):1992. In the present investigation, Ultrasonic Pulse velocity tester is used for determining the pulse velocity of Cylinders of 150mm X 300mm of OC and HVSC are that are cast and tested are shown in Figure 3.

The Dynamic Young's modulus of elasticity (E) of the concrete may be determined from the pulse velocity and Dynamic Poisson's ratio (μ).Test results are shown in Table 5 & Table 6.

Fig. 3: Test Setup for Finding Young's Modulus Velocity.

Fig. 4: Test Setup for Ultrasonic Pulse.

4.4. Impact strength test

To study the impact strength, test specimens of size 100 x 100 x 500 mm are cast with OC and HVSC with various w/c and w/b with and without crimped steel fibres of aspect ratio 47.5 (length is 38 mm and diameter is 0.8 mm). After completion of curing period of 28 and 90 days, the specimens are tested for impact resistance. The Photographs of the apparatus and Test set up for impact specimens are shown in Figure 5 to Figure 6.

Fig. 5: Specimens of HVSC with and without Fibres.

Fig. 6: Impact Strength Test on HVSFSC.

4.5. Abrasion resistance

The Cantabro test has been successfully used to characterize the abrasion resistance off or open-graded friction course (OGFC) mixtures of Hot-Mix Asphalt (HMA) in the world for many years (Dong, 2013). The specimens of size 150 mm dia. X 100 mm height are cast and tested at 28 and 90 Days for abrasion resistance of OC and HVSC. The results of abrasion test on Ordinary Concrete and High Volumes of Slag Concrete are tabulated in Table 10 to Table 11. The specimens of OC and HVSC before testing and after testing are shown in Figure 7, Figure 8, Figure 9 and Figure 10.

5. Results and discussions

In these investigations, OC & HVSC for different w/c ratios or w/b are cast and tested for Compressive Strength, Flexural Strength, Young's modulus, Impact Strength and Abrasion resistance for 28 days and 90 days. Sample sizes of 3 are considered in the present study.

Fig. 7: Specimens of OC before.

Fig. 8: Specimen of OC after Cantabro Cantabro Test Test.

Fig. 9: Specimens of HVSC before Cantabro test.

Fig. 10: Specimens Of HVSC after Cantabro Test.

5.1. Variation of compressive strength and flexural strength of OC & HVSC for 28 days and 90 days

The Compressive Strengths of OC and HVSC for various w/b ratios are determined for 28 days as shown in Table 3.

Table 3: Variation of Compressive Strength and Flexural Strength of OC & HVSC for 28 Days

Mix	w/c or w/b	Compressive Strength (MPa) 28 days	Compressive Strength (MPa) 90 days	Variation (%)	Flexural Strength (MPa) 28 days	Flexural Strength (MPa) 90 days	Variation (%)
OC							
OC1	0.55	38.94	39.36	1	3.76	4.08	9
OC2	0.45	53.24	61.76	16	5.20	5.28	2
OC3	0.36	64.22	76.80	19	5.52	5.64	2
OC4	0.27	72.61	85.78	18	6.52	6.80	4
HVSC							
HVSC1	0.55	29.09	35.70	23	3.80	4.12	8
HVSC2	0.45	33.90	40.31	19	4.10	4.34	6
HVSC3	0.36	42.00	51.30	22	4.28	4.60	7
HVSC4	0.27	54.00	62.00	15	4.76	5.25	10

It is observed that there is an increase in Compressive Strength varies from 1% to 20% and an increase in Flexural Strengths 2% to 9% for 90 days for OC with respect to 28 days strength as shown in Table 3. It is observed that an increase in Compressive Strength varies from 15% to 25% an increase in Flexural Strengths 6% to 10% for 90 days for HVSC for 90 days, with respect to 28 days strengths whose values are given in Table 4. Higher strengths are observed for lower w/c or w/b ratios for both cases of OC and HVSC for all periods. The flexural strengths of OC and HVSC for 28 and 90 days for various mixes are shown in Table 3.

It is observed that the flexural Strength of OC mixes have higher flexural strength than HVSC at all w/c ratio except for w/c ratio 0.55. However, HVSC shows good flexural strength for low w/b ratios and this property is important for rigid pavements. From the observations, it is revealed that the rate of strength gain for HVSC is controlled by slag with respect to time by its fineness and chemistry of OPC.

5.1.1. Empirical equations

Empirical equations for Compressive Strength in terms of w/b and Flexural Strength in terms of Compressive Strength for OC mixes, HVSC mixes and Duff Abram's equation are shown in Table 4.

Table 4: Empirical Equations

Series	Period	Relation between	Equation	R^2
General	28 Days	Compressive Strength & w/c (Abram's)	$f_c = A/(B)^{w/b}$	-
OC	28 Days	Compressive Strength &w/c	$f_c = 137.9/(9.22)^{w/b}$	0.97
	90 Days		$f_c = 195.32/(15.91)^{w/b}$	0.93
HVSC	28 Days	Compressive Strength & w/b	$f_c = 95.5/(9.18)^{w/b}$	0.98
	90 Days		$f_c = 105.89/(7.64)^{w/b}$	0.98
OC	For all days	Flexural Strength & Compressive Strength	$f_t = 0.34(f_c)^{0.67}$	0.92
HVSC	For all days		$f_t = 1.04(f_c)^{0.38}$	0.96

5.2. Variation of static and dynamic modulus of elasticity of OC & HVSC for all days

In this investigation, the cylindrical specimens cast for various w/c or w/b ratios of OC and HVSC 0.55, 0.45, 0.36 and 0.27 are tested in the laboratory for Static Modulus of elasticity and Dynamic Modulus of elasticity for 28 and 90 days. Sample sizes of 3 are considered in the present study.

Table 5: Static Modulus of Elasticity and Dynamic Modulus of Elasticity of OC for 28 Days& 90 Days

Series	w/c ratio	Time (Micro Sec)	Pulse Velocity (Km/sec)	Density (Kg/m^3)	Static Modulus, E_c (MPa)	Poisson's ratio (μ)	Dynamic Modulus, E_d (MPa)	E_c/E_d
28 days								
OC1	0.55	69.6	4.261	2451	29091	0.32	31100	0.94
OC2	0.45	66.6	4.510	2464	37720	0.29	38251	0.99
OC3	0.36	66.5	4.522	2469	44678	0.24	42835	1.04
OC4	0.27	66.3	4.530	2474	49995	0.18	46753	1.07
90 Days								
OC1	0.55	74.0	4.31	2515	30117	0.29	35651	0.84
OC2	0.45	66.4	4.532	2635	44576	0.19	49296	0.90
OC3	0.36	66.2	4.591	2643	48921	0.18	51305	0.95
OC4	0.27	65.0	4.678	2649	51515	0.15	54901	0.94

Static Modulus of Elasticity of Ordinary Concrete exhibits an increasing tendency in its value i.e from 29091 MPa to 49995 MPa and 30117 MPa to 51515 MPa as w/c ratio varies from 0.55 to 0.27 for 28 and 90 days and the results are shown in Table 5.Similarly, the behavior of Dynamic Modulus of Elasticity also show an increasing tendency in its value whereas Poisson's ratio is decreasing, for w/c ratios varying from 0.55 to 0.27 for 28 and 90 days respectively. The ratio of Static Modulus of Elasticity (Ec) to Dynamic Modulus of Elasticity (Ed) of OC varies from 0.94 to 1.07 and 0.84 to 0.95 for 28 and 90 days. From the results, an increase is observed in Static and Dynamic Modulus of Elasticity and decrease in Poisson's ratio of OC for 90 days which is found comparing with 28 Days result.

It is observed that Static Modulus of Elasticity possesses an increasing tendency in its value whereas Poisson's ratio of HVSC is decreasing for 28 and 90 days respectively. The results are shown in Table 6. Dynamic Modulus of Elasticity of HVSC shows an increasing tendency in its value and the results are shown in Table 6. The ratio of Static Modulus of Elasticity (Ec) to Dynamic Modulus of Elasticity (Ed) of HVSC varies from 0.67 to 1.0 and 0.51 to 0.81 for 28 and 90 days respectively.

Table 6: Static Modulus of Elasticity and Dynamic Modulus of Elasticity of High Volumes of Slag Concrete for 28 Days & 90 Days

S. No.	w/b ratio	Time (Micro Sec)	Pulse Velocity (Km/sec)	Density (Kg/m^3)	Static Modulus, E_c (MPa)	Poisson's ratio (μ)	Dynamic Modulus, E_d (MPa)	E_c/E_d
28 Days								
HVSC1	0.55	61.5	4.39	2502	16970	0.43	16936	1.0
HVSC2	0.45	61.0	4.405	2508	22174	0.33	32842	0.67
HVSC3	0.36	60.7	4.41	2509	25991	0.33	32933	0.78
HVSC4	0.27	59.0	4.51	2523	33239	0.26	41939	0.79
90 Days								
HVSC1	0.55	68.2	4.88	2568	22596	0.31	44121	0.51
HVSC2	0.45	68.1	4.94	2572	24226	0.29	47897	0.51
HVSC3	0.36	68.0	4.96	2585	35144	0.25	52996	0.66
HVSC4	0.27	67.8	5.01	2598	45653	0.23	56250	0.81

5.2.1. Empirical relations

In this investigation, empirical relation (Power Equation) between Compressive Strength (f_{ck}) and Static Modulus of Elasticity (E_c) of HVSC for All Days is shown in Fig. 11. The equation obtained is

$E_c = 303.38 * (f_{ck})^{1.199}$ with 'R^2' equal to 0.91.

Empirical relation (Power equation) between Static Modulus of Elasticity and Dynamic Modulus of Elasticity of HVSC for all days is shown in Fig. 12. The equation obtained is $E_d = 1.8*E_c^{0.98}$.

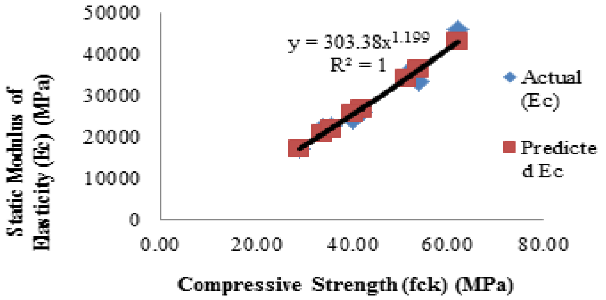


Fig. 11: Relation between FCK and EC of HVSC for All Days.

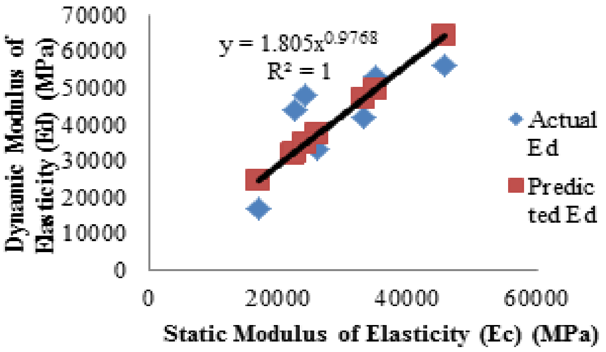


Fig. 12: Relation between EC & Actual ED and Predicted Ed of HVSC for All Days.

High Volumes of Slag concrete exhibits ‘Good and Excellent Quality Grading’ when comparing to the standard Table 3.4.1 (as per IS 13311 (Part-1):1992) for 28 and 90 days respectively.
Modulus of Elasticity is linearly and proportionally related with the Compressive Strength of OC and HVSC. An appreciable amount of Compressive Strength of HVSC is observed in later ages.For w/b ratio 0.36; E value fulfills the above requirement for later ages (55 days onwards) days.
The Variation in Impact Strength HVSC for all days
Impact Strength at First crack and at Ultimate Crack of HVSC at 28 and 90 days for 20 degree angle of swing respectively is found and the values are given in Figure 13, Figure 14, Figure 15 and Figure 16.

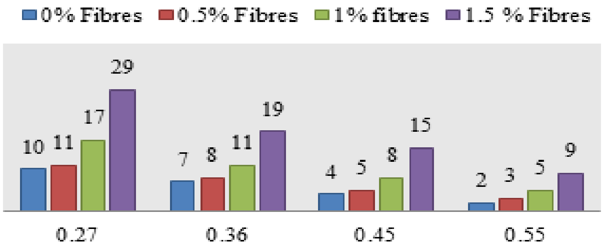


Fig. 13: No. of Blows required for First Crack HVSFSC for 28 Days.

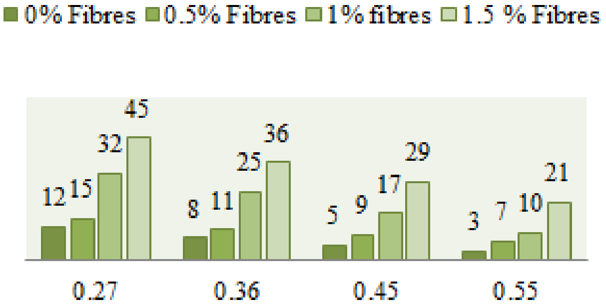


Fig. 14: No. of Blows Required for of Ultimate Crack of HVSFRC for various W/B s for 28 Days.

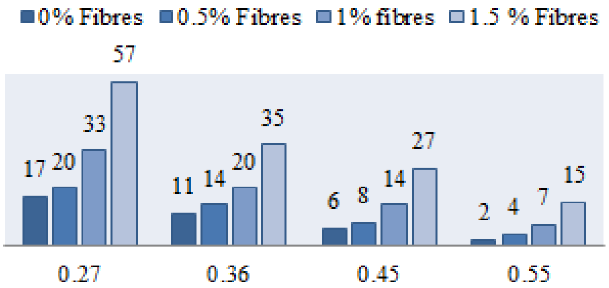


Fig. 15: No. Of Blows Required for First Crack of HVSFRC for Various W/B S for 90 Days.

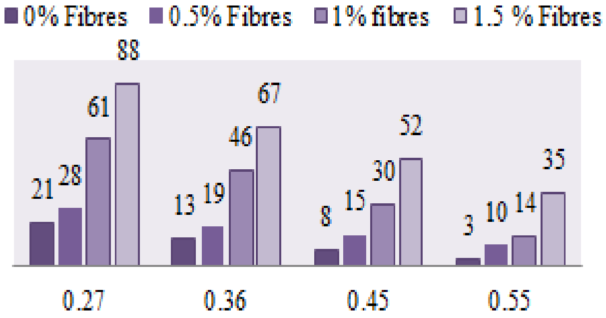


Fig. 16: No. of Blows Required for Ultimate Crack of HVSFSC for 90 Days.

From the results, it is observed that the number of blows required for first crack and ultimate crack of HVSFSC increase with decrease in w/b ratio and increase with percentage of fibres. HVSC with 1.5% fibres shows higher impact resistance.

5.3.1. Percentage improvement in first crack strength of HVSC with & without fibers over 28 day’s strength

The percentage improvements in first crack strength and Ultimate Crack Strength of HVSC with 0%, 0.5%, 1% and 1.5% fibres for 90 and 180 days strength over 28 days strength are shown in Table 7. Similar Percentage improvement in strength is observed at First Crack and at Ultimate Crack also.

Table 7: Percentage Improvement in First Crack Strength and Ultimate Crack Strength of HVSC with & without Fibers over 28 Days Impact Strength

w/b	Percentage of fibre	Percentage Improvement for 90 Days First Crack Strength	 Ultimate Crack Strength
0.55	0	0	0
	0.5	33	43
	1	40	40
	1.5	67	67
0.45	0	50	60
	0.5	60	67
	1	75	76
	1.5	80	79
0.36	0	57	63
	0.5	75	73
	1	82	84
	1.5	84	86
0.27	0	70	75
	0.5	82	87
	1	94	91
	1.5	97	96

It is observed that the percentage improvement for First Crack is 0% to 70%, 33% to 82%, 40% to 94% and 67% to 97% for HVSC with 0%, 0.5%, 1% and 1.5% steel fibres for 90 Days with respect to 28 Days for w/b from 0.55 to 0.27 respectively. The Ultimate Crack is 0% to 75%, 43% to 87%, 40% to 71% and 67% to 96% for HVSC with 0%, 0.5%, 1% and 1.5% steel fibres for 90 Days with respect to 28 Days for w/b from 0.55 to 0.27 respectively. From the results, it can be concluded that HVSC with 1.5% fibre exhibits more Impact strength and more percentage improvement for 90 days with respect to 28 Days than HVSC with 0.5%, 1.0% and 1.5% fibres.

5.3.2. Percentage improvement in first crack strength and ultimate crack strength of HVSC with fibers over HVSC without 28 and 90 days strength

Percentage improvement in First Crack Strength and Ultimate Crack strength of HVSC with fibres over HVSC without 28 and 90 Days strength of various w/b ratios are given in Table 8.

Table 8: Percentage Improvement in First Crack Strength and Ultimate Crack Strength of HVFC with fiber over HVSC without fiber

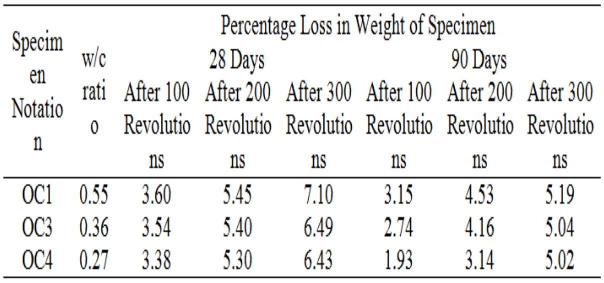
Percentage Improvement					
w/b	Percentage of fibre	First Crack Strength		Ultimate Crack Strength	
		28 Days	90 Days	28 Days	90 Days
0.55	0.5	50	100	133	233
	1.0	150	233	250	367
	1.5	350	600	650	1067
0.45	0.5	25	33	33	88
	1.0	100	240	133	275
	1.5	275	480	350	550
0.36	0.5	14	27	38	46
	1.0	57	82	213	254
	1.5	171	171	350	415
0.27	0.5	10	18	25	33
	1.0	70	94	167	190
	1.5	190	235	275	319

The percentage improvement variations for HVSC with 0.5% Fibres, in First Crack were 50% to 100% and 10% to 18%and in Ultimate Crack are 133% to 233% and25% to 33% for w/b 0.55 to 0.27for 28 days to 90 days. The percentage improvement variations for HVSC with 1.5% Fibres in First Crack were350% to 600% and 190% to 235% and in Ultimate Crack were 650% to 1067% and 275% to 319% for w/b 0.55 to 0.27for 28 days to 90 days.

5.4. Variations in abrasion resistance of ordinary concrete and high volumes of slag concrete

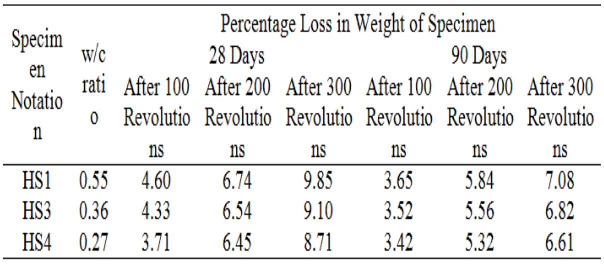
In the present investigations, abrasion of OC and HVSC is evaluated according to Cantabro test and results are tabulated in Table 9.

Table 9: Percentage Loss in Weight of Specimen after Exposed to Abrasion of OC for 28 Days and 90 Days



Specimen Notation	w/c ratio	Percentage Loss in Weight of Specimen					
		28 Days			90 Days		
		After 100 Revolutions	After 200 Revolutions	After 300 Revolutions	After 100 Revolutions	After 200 Revolutions	After 300 Revolutions
OC1	0.55	3.60	5.45	7.10	3.15	4.53	5.19
OC3	0.36	3.54	5.40	6.49	2.74	4.16	5.04
OC4	0.27	3.38	5.30	6.43	1.93	3.14	5.02

Table 10: Percentage Loss in Weight of Specimen after Exposed to Abrasion of HVSC for 28 Days and 90 Days



Specimen Notation	w/c ratio	Percentage Loss in Weight of Specimen					
		28 Days			90 Days		
		After 100 Revolutions	After 200 Revolutions	After 300 Revolutions	After 100 Revolutions	After 200 Revolutions	After 300 Revolutions
HS1	0.55	4.60	6.74	9.85	3.65	5.84	7.08
HS3	0.36	4.33	6.54	9.10	3.52	5.56	6.82
HS4	0.27	3.71	6.45	8.71	3.42	5.32	6.61

Specimen Notation w/c ratio Percentage Loss in Weight of Specimen
28 Days 90 Days
After 100 Revolutions after 200 Revolutions after 300 Revolutions after 100 Revolutions after 200 Revolutions after 300 Revolutions
HS1 0.55 4.60 6.74 9.85 3.65 5.84 7.08
HS3 0.36 4.33 6.54 9.10 3.52 5.56 6.82
HS4 0.27 3.71 6.45 8.71 3.42 5.32 6.61
From the results, it is observed that the percentage weight loss is less in both lower w/c ratio and w/b ratios of OC and HVSC. OC shows good abrasive resistance than HVSC for 28 days. However, HVSC exhibits good resistance at 90 days i.e. the percentage losses of HVSC for 90 days are similar to that of OC for 28 Days. This indicates that HVSC shows good abrasion resistance for later ages due to higher hydration which makes the concrete a more densified structure.

6. Conclusions

- High Volumes of GGBS (50%) can be used as a substituting material with good strengths (Compressive, Split Tensile and Flexural) at low water binder ratios for all ages.
- The flexural strength of High Volumes of Slag Concrete with w/b ratio 0.27 for 28 days is more than 4.5 MPa. Hence it fulfils PQC requirement.
- The relation between Compressive Strength and Static Modulus of elasticity of HVSC is non-linear for all days. Similar pattern is observed in the relation between Static Modulus of Elasticity and Dynamic Modulus of Elasticity of HVSC for all days.
- The percentage weight loss is less when it is subjected to abrasion in both lower w/c and w/b ratios of OC and HVSC.
- The percentage loss of HVSC due to abrasion is less than 20%. Henceforth, they are proven to be durable.
- An increase in impact strength of HVSC with and without steel fibres is observed at later ages and this phenomenon is more visible in the case of HVSC with 1.5% fibres.
- HVSC with 1.5% steel fibre exhibits more impact strength and percentage improvement for 90 with respect to 28 days than HVSC with 0%, 0.5% and 1.0% steel fibres.
- HVSC for w/b ratio 0.27 is recommended for rigid pavements. HVSC for lower w/b ratios exhibited good strength for later ages
- Pavements for local streets and collector streets can be laid with HVSC with higher w/b ratios (0.55 to 0.45)where heavy wheel loads are less. These mixes can also be used as base course (DLC Layer).
- A relation is obtained between Compressive Strength of HVSC and the ingredients of mix and age of curing from the regression analysis. This can be used to know the Compressive Strength for given quantities of ingredients and curing period.

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