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DURABILITY ASPECTS OF BINARY CONCRETE

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***Abstract*: The study was conducted by Muneeb and Dixit to analyze the durability aspects of Binary Concrete. In our study we used 'Perlite' as a Supplementary Cementing Material to make the concrete and caste them into cubes after which the tests on water durability was conducted and the water absorption in concrete cubes was monitored along with the porosity. Concrete moulds of (100*100*100) mm were taken for casting.**

***Keywords*: PERLITE, BINARY CONCRETE, CONPLAST SP-430, CONCRETE**

INTRODUCTION

Binary concrete is a concrete in which cement is replaced by pozzolanic materials like fly ash, perlite etc. These additions are called Supplementary Cementing Materials (SCMs). SCMs do not have binding property naturally but when water is added to cement, due to hydration, Ca(OH)2 is formed which when comes in contact with the pozzolans, give them the binding ability like cement. In our study, we used perlite as the SCM which has the following properties:

- Perlite powder has moderately high-water substance and comprises of the property of expanding exceptionally when subjected to high temperature.
- Perlite is a mineral aggregate having glass structure (crystalline) which is developed from the process of rapid cooling of lava.
- Perlite has low thermal conductivity which reduces the effect of high temperature.
- When PP is mixed in concrete as partial replacement of cement, it will not only show good fire resisting capacity but also give considerable strength and durability.

PERLITE POWDER USED FOR PRESENT STUDY

FORMS OF PERLITE

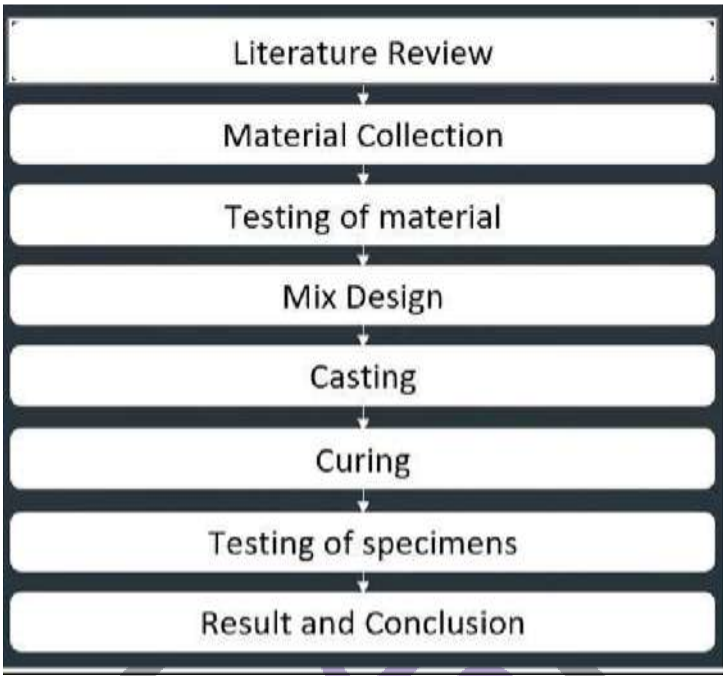
LITERATURE REVIEW

- Assessment of Sorptivity and Water Absorption of Concrete with Partial Replacement of Cement by Sugarcane Bagasse Ash (SCBA) and Silica Fume
  T.Santhosh Kumar Department of Civil Engineering, GITAM University, Visakhaptnam-530045, India
  K.V.G.D Balaji Department of Civil Engineering, GITAM University, Visakhaptnam-530045, India
  K.Rajasekhar Department of Civil Engineering, Andhra University, Visakhaptnam-530003, India

- Water sorptivity and chloride diffusivity of oil shale ash concrete Sammy Yin Nin ChanU, Xihuang Ji
  Department of Ci¨il and Structural Engineering, The Hong Kong ¨Polytechnic UniversityHung Hom, Kowloon, Hong Kong

- Drying shrinkage in concrete assessed by nonlinear ultrasound Gun Kim, Jin-Yeon Kim, Kimberly E. Kurtis, Laurence J. Jacobs
  School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta 30332-0355, Georgia
  G. W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta 30332-0405, Georgia

METHODOLOGY



FLOW CHART OF THE METHOD IN WHICH THE WORK WAS CARRIED OUT

COLLECTION AND TESTING OF MATERIALS

Cement:

- 53-Grade Ordinary Portland Cement (OPC) was used
- Care was taken to preserve it by fixing the sacks air-tight
- This prevents it from getting influenced by mugginess and environmental dampness
- The physical properties of cement were tested as per IS12269-2013.

S. No	TESTS CONDUCTED		VALUE
1	Fineness of cement		7.63%
2	Specific Gravity		3.09
3	Setting Time	Initial	36 min
		Final	396 min

Coarse Aggregate:

- Locally available pulverized rock, sieved through a 20 mm sieve, was utilized.
- It was then washed to expel dirt, dust and dried under dry shell conditions.
- The aggregates were tested according to Indian Standards specifications IS 383-2016. Table 2 portrays the properties of the coarse aggregate total utilized for this study.

S. No	TESTS CONDUCTED	VALUE
1	Specific gravity	3.06
2	Water absorption	0.201%
3	Fineness modulus	7.3%

Fine Aggregate:

- The closest open waterway sand agreeable to zone-II of IS 383- 2016 was utilized
- It was ensured that the fine aggregate was:
- dirt-free
- inactive and
- free from natural issue, clay and silt.

S.NO	PROPERTY	VALUE
1	Specific gravity	2.436
2	Fineness modulus	2.69
3	Water absorption	4.16

Water and Super Plasticizer:

- Tap water available in our lab is used for the entire research
- CONPLAST SP-430 was used as super plasticizer to achieve better workability of the mix
- Water-cement (w/c) proportion was maintained at 0.43
- The specific gravity was changing from 1.220 to 1.225 at 3000 C
- Air entrained in the mix is roughly taken as 1%
- The different physical properties of CONPLAST SP-430 are as recorded in the table given below.

S. NO	DESCRIPTION	PROPERTY
1	Appearance	Brown liquid
2	Specific Gravity [BSEN 934-2]	1.22 @ 22° C + 2° C
3	Alkali Content [BSEN 934-2]	Typically lesser than 55 g. Na_2O equivalent/ litre of admixture

Sieve analysis of Course Aggregate – Results

Sieve size	Weight retained(gm.)	Cumulative weight retained (gm.)	Cumulative % retained (gm.)
80mm	0	0	0
40mm	0	0	0
25mm	354	354	7.08
20mm	2000	2354	47.08
16mm	1419	3773	75.46
10mm	900	4673	93.46
4.75mm	327	5000	100
2.36mm	0	5000	100
1.18mm	0	5000	100
600micron	0	5000	100
300micron	0	5000	100
150micron	0	5000	100

Sieve analysis of Fine Aggregate – Results

Sieve size	wt. retained (g)	% Retained	Cumulative % retained	% Finer
4.75mm	41	4.1	4.1	95.9
2.36mm	82	8.2	12.3	87.7
1.18mm	134	13.4	25.7	74.3
600micron	170	17	42.7	57.3
300micron	416	41.6	84.3	15.7
150 micron	157	15.7	100	0

MIX DESIGN DETAILS

Grade of concrete= 35
Characteristic compressive strength required in field at 28 days= 38.25 N/mm2 Field at 28 days= 3

- Type of Exposure = Moderate Design mix target slump = 75 mm

Maximum size of coarse aggregate = 20mm Specific gravity of cement = 3.09
Specific gravity of water = 1
Specific gravity of coarse aggregate = 3.06 Specific gravity of fine aggregate = 2.936
Water absorption of coarse aggregate = 0.201% Water absorption of fine aggregate = 4.61% Zone 3

1. Target strength of concrete : f'ck= fck+1.65s.

Where, f'ck= Target mean compressive strength at 28 days fck= Characteristic compressive strength at 28 days N/mm2= 30N/mm2
S= Standard deviation= 5 N/mm2 (For IS 456:2000 Table:8 (pg 23))
1.65= Tolerance factor
=30+1.65*S
=38.25 N/mm2

2. Determination of W/C ratio: Taken as 0.43(opted)
3. Max. water content for 20 mm aggregate is 186 L.
   [This value is for 25-50 mm slump(Ref: IS: 10262-2009 clause 4.2(Pg-2))] Our target slump is75 mm.
   Estimated water content for 75 mm slump = 186 + ((3/100)* 186) = 191.58 L

4. Calculation of cement content
   As per table 5 of IS: 456: 200(Pg 20), for moderate expose, Min. cement = 300 Kg/m3
   Water Cement ratio = 0.45 Water used = 191.58 L
   Cement content = (Water content/ W.C. ratio)
   = 191.58/0.43
   = 445.5 Kg
   which is less > 300, hence OK.

Calculation of vol. of coarse and fine aggregate

From table 3 of IS: 10262-2009, vol. of coarse aggregate corresponding to 20mm size aggregate
Corrected proportion vol.for coarse aggregate = 0.6% Vol of f.A=1-0.6=0.39
Design Mix. Calculations:
Vol of concrete = mass of cement/sp.gravity*1000=0.144 m^3 Vol of water = mass of water/sp.gravity*1000
=191.58/1*1000=0.19158
Vol of all aggregate (C+F) = vol of concrete - (vol of cement+vol of water)
= 1-(0.144+0.19158)
= 0.667
Mass of course aggregate
= Vol of all aggregates X Vol. of course X specific gravity X 1000
= 0.667X0.39X2.436X1000=712.74
Mass of fine aggregate:
= Vol. of all aggregate* Vol. of Fine agg.* spec. grav.* 1000
= 712.74
Proportion:
Cube size(0.1*0.1*0.1)=0.001 Cement=0.45
Wastage (20%)= 0.08910
Cement Required= 0.53
Quantity of material required for 1 cube= Proportion X Cement required (0.53)

Cement	FA	CA	Water
445.53	712.735	1114.8	191.58
1	1.599	2.502	0.42.5023

For control of Perlite percentage:

Name	1 cube	9 cubes
Cement	0.53	4.73
F.A.	0.847	7.759
C.A.	1.325	12.136
Water	0.227	2.035

Hence the final results for 9 cubes of M 35 grade Perlite mixed concrete is:

S. No.	Replacement	Cement (Kg)	F.A. (Kg)	C.A. (KG)	% Perlite	Water (Litres)
1	0 %	4.73	7.75	12.136	0	2.035
2	1 %	4.68	7.75	12.136	0.0473	2.035
3	3 %	4.59	7.75	12.136	0.1420	2.035
4	5 %	4.49	7.75	12.136	0.236	2.035
5	7 %	4.40	7.75	12.136	0.331	2.035

MOULDING FOR 1% PERLITE CUBES

MOULDING FOR 3% PERLITE CUBES

CURING OF CUBES IN TANK

AFTER CURING (DRYING)

TESTING OF SPECIMENS AND RESULTS

Standard Test Method for
Density, Absorption, and Voids in Hardened Concrete

PROCEDURE

1. Oven-Dry Mass—Determine the mass of the portions, and dry in an oven at a temperature of 100 to 110°C for not less than 24 h. After removing each specimen from the oven, allow it to cool in dry air (preferably in a desiccator) to a temperature of 20 to 25°C and determine the mass. If the specimen was comparatively dry when its mass was first determined, and the second mass closely agrees with the first, consider it dry. If the specimen was wet when its mass was first determined, place it in the oven for a second drying treatment of 24 h and again determine the mass. If the third value checks the second, consider the specimen dry. In case of any doubt, redry the specimen for 24-h periods until check values of mass are obtained. If the difference between values obtained from two successive values of mass exceeds 0.5 % of the lesser value, return the specimens to the oven for an additional 24-h drying period, and repeat the procedure until the difference between any two successive values is less than 0.5 % of the lowest value obtained. Designate this last value A.

2. Saturated Mass After Immersion—Immerse the speci- men, after final drying, cooling, and determination of mass, in water at approximately 21°C for not less than 48 h and until two successive values of mass of the surface-dried sample at intervals of 24 h show an increase in mass of less than 0.5

% of the larger value. Surface-dry the specimen by removing surface moisture with a towel, and determine the mass. Designate the final surface
- dry mass after immersion B.

3. Saturated Mass After Boiling—Place the specimen, processed as described in 5.2, in a suitable receptacle, covered with tap water, and boil for 5 h. Allow it to cool by natural loss of heat for not less than 14 h to a final temperature of 20 to 25°C. Remove the surface moisture with a towel and determine the mass of the specimen. Designate the soaked, boiled, surface- dried mass C.

4. Immersed Apparent Mass—Suspend the specimen, after immersion and boiling, by a wire and determine the apparent mass in water. Designate this apparent mass D.

CALCULATIONS

Absorption after immersion, %=[(B-A)/A] *100 Absorption after immersion and boiling, %=[(C-A)/A] *100 Bulk density, dry= [A/(C-D)] *ϱ = g1
Bulk density after immersion= [B/(C-D] *ϱ
Bulk density after immersion and boiling=[C/(C-D)] *ϱ Apparent Density = [A/(A-D)] *ϱ = g2
Volume of permeable pore space (voids), = (g2-g1)/ g2*100 Where,
A = mass of oven-dried sample in air, g
B = mass of surface-dry sample in air after immersion, g
C = mass of surface-dry sample in air after immersion and boiling, g
D = apparent mass of sample in water after immersion and boiling, g
g1 = bulk density, dry, Mg/m and
g2 = apparent density, Mg/m

RESULTS

- For 7 day cured concrete specimens

1. For 0% perlite:

0%				
% Replacement	Oven Dry(A)	After immersion(B)	Immersion & Boiling (C)	Apparent mass (D)
0%	2.199	2.314	2.404	1.4
	2.074	2.232	2.318	1.34
	2.167	2.262	2.362	1.4
Avg	**2.147**	**2.269**	**2.361**	**1.380**
Absorption after immersion %				5.714
Absorption after immersion and boiling %				10.000
Bulk Density (g1)				2.188
Bulk density after immersion				2.313
Bulk density after immersion and boiling				2.406
Apparent density (g2)				2.800
Volume of permeable pore space				21.875

2. For 1 % perlite

1%				
% Replacement	Oven Dry(A)	After immersion(B)	Immersion & Boiling (C)	Apparent mass (D)
0%	2.317	2.474	2.479	1.43
	2.41	2.532	2.552	1.43
Avg	**2.3635**	**2.503**	**2.5155**	**1.43**

Absorption after immersion %	5.902
Absorption after immersion and boiling %	6.431
Bulk Density (g1)	2.177
Bulk density after immersion	2.306
Bulk density after immersion and boiling	2.317
Apparent density (g2)	2.532
Volume of permeable pore space	14.003

3. For 3 % perlite:

3%				
% Replacement	Oven Dry(A)	After immersion(B)	Immersion & Boiling (C)	Apparent mass (D)
0%	2.411	2.623	2.542	1.44
	2.373	2.575	2.508	1.4
Avg	**2.392**	**2.599**	**2.525**	**1.42**

Absorption after immersion %	8.654
Absorption after immersion and boiling %	5.560
Bulk Density (g1)	2.165
Bulk density after immersion	2.352
Bulk density after immersion and boiling	2.285
Apparent density (g2)	2.461
Volume of permeable pore space	12.036

4. For 5 % perlite:

5%				
% Replacement	Oven Dry(A)	After immersion(B)	Immersion & Boiling (C)	Apparent mass (D)
0%	2.46	2.699	2.542	1.44
	2.402	2.678	2.508	1.4
Avg	**2.431**	**2.6885**	**2.525**	**1.42**

Absorption after immersion %	10.592
Absorption after immersion and boiling %	3.867
Bulk Density (g1)	2.200
Bulk density after immersion	2.433
Bulk density after immersion and boiling	2.285
Apparent density (g2)	2.405
Volume of permeable pore space	8.507

7 days		
% replacement	water absorption values	Permeable voids
0%	5.714	21.875
1%	5.902	14.003
3%	8.654	12.036
5%	10.592	8.507

- For 28 day cured concrete specimens

1. For 0 % of perlite:

0%				
% Replacement	Oven Dry(A)	After immersion(B)	Immersion & Boiling (C)	Apparent mass (D)
0%	2.374	2.441	2.471	1.41
	2.156	2.201	2.254	1.42
	2.118	2.214	2.219	1.42
Avg	**2.216**	**2.285333**	**2.31466667**	**1.416667**
Absorption after immersion %				3.129
Absorption after immersion and boiling %				4.452
Bulk Density (g1)				2.468
Bulk density after immersion				2.545
Bulk density after immersion and boiling				2.578
Apparent density (g2)				2.772
Volume of permeable pore space				10.987

For 1 % of perlite:

1%				
% Replacement	Oven Dry(A)	After immersion(B)	Immersion & Boiling (C)	Apparent mass (D)
0%				
	2.45	2.522	2.528	1.43
	2.38	2.464	2.468	1.41
Avg	**2.415**	**2.493**	**2.498**	**1.42**
Absorption after immersion %				3.230
Absorption after immersion and boiling %				3.437
Bulk Density (g1)				2.240
Bulk density after immersion				2.313
Bulk density after immersion and boiling				2.317
Apparent density (g2)				2.427
Volume of permeable pore space				7.699

2. For 3 % perlite:

3%				
% Replacement	Oven Dry(A)	After immersion(B)	Immersion & Boiling (C)	Apparent mass (D)
0%	2.178	2.259	2.238	1.4
	2.232	2.312	2.299	1.39
Avg	**2.205**	**2.2855**	**2.2685**	**1.395**
Absorption after immersion %				3.651
Absorption after immersion and boiling %				2.880
Bulk Density (g1)				2.524
Bulk density after immersion				2.616
Bulk density after immersion and boiling				2.597
Apparent density (g2)				2.722
Volume of permeable pore space				7.270

3. For 5% perlite:

5%				
% Replacement	Oven Dry(A)	After immersion(B)	Immersion & Boiling (C)	Apparent mass (D)
0%	2.563	2.668	2.642	1.41
	2.419	2.509	2.486	1.41
Avg	**2.491**	**2.589**	**2.564**	**1.410**
Absorption after immersion %				3.914
Absorption after immersion and boiling %				2.931
Bulk Density (g1)				2.159
Bulk density after immersion				2.243
Bulk density after immersion and boiling				2.222
Apparent density (g2)				2.304
Volume of permeable pore space				6.326

Water absorption and void results for 28 days cured concrete

28 days		
% replacement	water absorption values	Permeable voids
0%	3.129	10.987
1%	3.23	7.699
3%	3.651	7.27
5%	3.914	6.326

CONCLUSION

From the above project, after conducting the tests on the caste specimens, it is very clear that perlite can act as a very good supplementary cementing material. As more and more perlite is added in concrete, its water durability increases because all the water is absorbed by the perlite present inside the concrete and the porosity of perlite decreases. This is because perlite occupies space and when it absorbs the water, its volume increases, its porosity decreases. From all the experiments conducted the best results were obtained at 5%. So, after considering all the situations, it is recommended to replace 5% cement with perlite for good water durability of concrete. Also, during the experiment, it was seen that as the percentage of perlite increased, the concrete became more and more light weight. Hence, perlite can also be used to make light weight concrete.