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Effect of Chloride Ion Penetration on Marble Slurry Powder Contained Concrete

Mahipal Burdak[1], Amita[2], A K Gupta[3]

[1, 2&3] *Department of Structural Engineering, MBM Engineering College, JNV University Jodhpur*

Abstract — *Construction industry boom in late 70's had lesser attention towards codal provisions and with lack of attain results in early serious durability draw backs. The problem of early deterioration of the concrete structures assumed serious proportion all over the world and durability of the concrete structures has remained major issue to engineers. The creation of the durable concrete structures requires adequate quality monitoring by the skilled workers a per codes and updating of codes. It is difficult to ensure uniform material quality and good density in heavily reinforced locations without out proper attention. The present research paper covers the study of effect of marble slurry powder on rheology and improvement in disability properties in terms of air permeability index and resimeter index. It also covers the effect and study of % replacement on compression & flexural strength of concrete.*

Keywords- *Experiment, RCC Structure, Marble Slurry, Resimeter, Auto Clam, % Replacement, Mix Design*

I. INTRODUCTION

Corrosion is one of the main critical issues which ruin the strength of reinforced concrete structures. Carbonation and chloride-induced corrosion equally reign in civil infrastructure all over the world. Extensive products are formed because of continuous deterioration. Currently, the demand to observe and take the deterioration edge off just to keep up and expand the service period of RCC structures is extensively admitted globally. Concrete generally is alkaline with an aperture solution pH of 12–13 which purely passivizes entrenched rebar (Zhou, et al 2015).

Performance dilapidation of RC structures as a result of deterioration set off by chloride attack is an important problem particularly in infrastructure and marine field. The chloride ions go through in the concrete and that causes corrosion. Wardhana and Hadlipriono (2003) described unsuccessfulness of RC structure as "incapability of a constructed provision or its elements to carry out as stated in the plan and necessities of construction." Chloride ion will possibly spoil the defending passive film and result in deterioration instigating deficit of area of steel, diminution in load transport facility of structure and loss of stability Li et al (2011). Stability of concrete structures subjected to chloride atmosphere based largely on the defiance of concrete contrary to chloride ingress (Verma, et al 2013). RC has good stability and remarkable structural performance. However there are conditions of early corrosion as a result of many elements, one important element being deterioration of steel corroboration. The procedure of deterioration rests in as a result of ingress of humidity, oxygen and other components into the group of concrete that is unsafe, permeable and porous. Appropriate addition of mineral admixture similar to silica fume in concrete enhances the potency and stability of concrete as a result of substantial development in the microstructure of concrete compounds, particularly at the conversion zone. Corrosion generates crisis in RC structures due to two different reasons. Initially as steel rusts, there is a related fall in the cross-sectional part. Secondly, the deterioration products engage a higher volume than the earliest steel that uses considerable tensile forces on the close concrete and affects it to crack up and spall off (Shanmugam, et al 2013). Therefore, this study is aimed in the estimation of effects of chloride on RCC having a remarkable replace,ment of better finer filler which gives denser concrete.

Marble Slurry (MS) is a processing and polishing waste industrial sludge. Yearly about 10MT stone used in india as reported (http://www.worldstonefairs.com) and only about 30 % is used as finished stone product. Reaming 50% as mining waste, 15 % processing waste and up to 5% as polishing waste is generated. The present dumping stations all around country spreads environmental hazard and affects human health. MS used as cementious supplementary raw material to reduce their adverse effect on environment and make it eco-friendly. Marble sludge powder can be used as filler and helps to reduce the total voids content in concrete. Concrete prepared by marble dust which helpful to reduce consumption of natural resources and energy and pollution of the environment. The physical and chemical properties of MS Powder are given in the Table.

Table 1 Physical & Chemical Properties of Marble Slurry Powder

S N	Constituents/ Properties	Percent by Weight
1.	Colour	White
2.	Texture	Powder
3.	Particle Size	4.75mm-75micron
4.	Fineness Modulus	1.27
5.	Natural moisture absorptions	<0.4 %
6.	Bulk Density (Kg/m3)	920
7.	Solubility	Insoluble
8.	Densification	Lesser
9.	Specific gravity	**2.56**
10.	SiO_2 + Al2O_3 + Fe_2O_3	60%- 80%
11.	CaO	1-2 %
12.	MgO	0-1%
13.	Loss on Ignition	2-3 %

Table 2 Sieve analysis of Marble Slurry Powder

S. No	IS Sieve Size	Cumulative weight Retained (%)	Cumulative weight Passing (%)	Zone II (IS 383 - 1970)
1.	4.75 mm	0.0	100.0	90-100
2.	2.36 mm	0.0	100.0	75-100
3.	1.18 mm	0.0	100.0	55-90
4.	600 micron	0.0	100.0	35-59
5.	300 micron	0.0	100.0	8-30
6.	150 micron	27.4	72.6	1-10
7.	75 micron	69.8	30.2	
8.	Pan	30.2		

II. RESEARCH METHODOLOGY & EXPERIMENTAL PROGRAM

Here, an experimental study is made to study the characterization of the basic ingredients of different material used in concrete as per the Indian standard specifications. The various tests are performed to characterize the materials to be used for the production of desired grade and type of concrete

III.I Characterization of Material Used

III.I.I Cement- Ordinary Portland cement (OPC 43 grade) Wonder Cement brand conforming to IS 8112: 1989 was used with specific gravity of 3.09, fineness of 2278 cm2/g, Normal consistency of 29 minute, Initial setting time of 80minute and final setting time of 205 minute. Compressive strength 28days (06 cubes Average) found 48.8 N/mm^2.

III.I.II Water- Potable tap water having pH of 7.4 and other tests are performed as per IS 3025: 1964.

III.I.III Aggregates- The natural river bed sand from Binawas, Jodhpur was used as fine aggregate. The coarse aggregate (from Kakani, Jodhpur) of two sizes were used.

Table 3 Properties of fine aggregate

SN	Property	Value obtained
1	Specific Gravity	2.55
2	Bulk Density (Kg/m^3)	1680
3	Fineness modulus	2.65
4	Water Absorption	1.88 %
5	Void Content	26.4 %
6	Gradation	Zone II as per IS: 383-1970

Table 4 Properties of coarse aggregate

SN	Property	for 20 mm size	for 10 mm size
1	Specific Gravity	2.67	2.66
2	Bulk Density (Kg/m3)	1610	1575
3	Fineness modulus	6.96	6.03
4	Water Absorption	1.3%	1.65%
5	Void Content	45.13 %	44.13 %
6	Gradation	20 mm Single Size	10 mm Single Size

III.I.IV Chemical Admixtures- A unique multipurpose modified plycarboxylate based superplasticiser SicaPlast 5202 NS, that is particularly suitable to provide high water reduction and improved fresh concrete characteristics is used.

III.I.V SCMs- Marble Slurry (MS) Powder-Properties are in table-1 & 2 as above.

III.I.VI Autoclam Permeability System

The Autoclam can be used to measure the air and water permeability and the water absorption (sorptivity) of concrete and other porous materials, both in laboratory and on site. Using this equipment, the rate of decay of air pressure is recorded for the air permeability test, whereas the volume of water penetrating into the concrete, at a constant pressure of 0.02 bar and 0.5 bar are recorded for the sorptivity and the water permeability tests respectively. These tests, which can be carried out quickly and effectively on site without prior planning, are essentially non-destructive in nature and a skilled operator is not needed.

III. EXPERIMENTAL RESULTS & DISCUSSION

IV.I Fresh& Harden Concrete Results-

Design Mix of M-25 as per IS 10262 and SP (23)-1982 and IS 456-2000, based on target mean strength of concrete and for a tolerance factor of 1.65 as specified in IS 456-2000 and the standard deviation 5.0 N/mm2 (as given in table 1, IS-10262).

(i) Target mean strength of concrete:

Ftms = 25+5*1.65

Ftms = 33.25 N/mm2

(ii) Selected W/C ratio for the desired target mean strength = 0.45

(iii) Thus the proposed mix for the grade M-25 is by weight

Water		Cement		Fine Aggregate		Coarse Aggregate
0.45	:	1	:	1.58	:	3.22

Marble Slurry Powder Replacement 5%, 7%, 10% of cement.

0.85% Admixture (Plastisizer) by weight of cement

(For coarse aggregate mix proportion as 60% for 20 mm size aggregate and 40% for 10 mm size aggregate)

Table 5 Results of MSP based M-25 Grade Concrete

MIX	Mix Proposed (M-25)	MSP Replacement	Slump	7 Days Comp Strength (N/mm2) (Average of 3 cubes)	Modulus of Elasticity (N/mm2) by IS 456 - 2000
M-25-1	0.45 : 1 : 1.58 : 3.22	0%	70mm	25.59 N/mm^2	29583.23
M-25-2	0.45 : 1 : 1.58 : 3.22	5%	69mm	27.67 N/mm^2	29591.86
M-25-3	0.45 : 1 : 1.58 : 3.22	7%	66mm	28.44 N/mm^2	29581.67
M-25-4	0.45 : 1 : 1.58 : 3.22	10%	66mm	30.54 N/mm^2	29588.34

IV.I Chloride Ion Migration & Permeability & Photographic Analysis of Samples at-

Table 6: Comparison of Concrete with Autoclam testing with salt concentration at 20 days exposure

Parameters	Salt concentration	Type of Concrete		
		NC25	SCC25	FSCC25
Air Permeability Index [Ln(Pressure)/Minute]	0%	0.144(G)	0.078(VG)	0.089(VG)
	10%	0.397(G)	0.151(G)	0.145(G)
	15%	0.737(P)	0.376(G)	0.338(G)
Water Permeability Index (m3/√min) x 10-7	0%	31.33	7.55	7.52
	10%	85.64	39.47	7.63
	15%	155.77	111.22	69.24
Sorptivity Index (m3/√min) x 10-7	0%	0.333(VG)	0.277(VG)	0.212(VG)
	10%	0.254(VG)	0.255(VG)	0.132(VG)
	v	0.456 (VG)	0.164(VG)	0.241(VG)
Note: VG: Very Good, G: Good, P: Poor, VP: Very Poor				

IV. CONCLUSION

The chloride ion penetration study has been carried out with the different chloride concentrations ranging from 0 -15 % and the alternate dry wet cycle with same concentrations with elevated temperature ranging 40-50 0degree. And at higher temperature, the results of destructive and non destructive testing show the better use of marble powder in concrete. Bleaching Powder (Cl- Ion) concentrations – 0%, 5%, 10% and 15% with time variations as 0, 5, 10, 15 days and 27, 50, 100 and 150 degree temperature (after 28 days curing) used for various concentrations of ion penetration.

The durability properties are evaluated in terms of chloride-ion penetrability as measured by autoclam tests. The results indicate that the Marble Slurry mixes would have lesser permeable voids than the normally-vibrated concrete mixes of comparable strengths. The experimental results also show that large improvements against chloride penetration can be realized with 10% replacement of pulverized powder with higher surface area and better chemical composition.

Non destructive testing results of the existing structure:

To establish the equivalent exposure conditions to the casted specimens, the NDT testing has been carried out on the existing old water contacted concrete structures exposed to the high chlorides (ranging 0.1% to 0.4%) concentrations and temperature variations (ranging 17 0C to 41 0C) at various water treatment plants in rajasthan. Where some times due to sudden breakdown in electricity and continuous dose of bleaching the concentration reached up to 15 % in particular sections and on second part the ion migration and contact with rebar started and corrosion mechanism is about to begin. . The rebound hammer and ultra sonic pulse velocity pulse velocity testing was done at the places, where the concrete is in intact position in the extensive manner and the observations were recorded. The observations recorded in the field have been reported below.

Table 4.106: Details of Structures Studied

S. No	Place	Age	Average Chloride Concentrations	Range of Rebound No. readings	Range of UPV readings (m/sec)
1	WTP Gajner Bikaner	About 5 Years	08 mg/L	33to 37	3245 to 3755
2	WTP Phalodi-1	About 2 Years	26 mg/L	39 to 44	3350 to 3670
3	WTP Phalodi-2	About 3 Years	33 mg/L	38 to 44	3365 to 3660
4	WTP Phalodi-3	About 10 Years	28 mg/L	35 to 37	2980 to 3255

Fig-1-6 Autoclam Testing, Samples and Field Visit with Failure pattern

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