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Experimental Analysis on Behavior of Concrete Under High Temperature Pressurized Steam

KEYWORDS: Dying Mills, degradation, pozzolanic materials, resistivity meter, compressive strength, flexural strength.

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ABSTRACT *The major problem faced by a Dying Mills industries structure is of degradation of concrete at a pretty early age. Average life expectancy of structure in dying mills where the outlet to washing drums are provided is only around 15-20 years which is very less compared to other structures and amount of money involved in building process of the industries. To reduce or control this penetration, M30 concrete grade was designed as per IS 10262-2009 and pozzolanic materials like metakaolin and silica fume is substituted in place of cement with different proportions to control the permeability and porosity of concrete. Before and after exposure, resistivity meter test and compression and flexural strength test was done. Results of exposed specimens and unexposed specimens are compared and most optimum blend was found out.*

Introduction

This project is especially carried out for "Dying Mills". Dying mills are important part of Gujarat's textile industry. Textile industries are one of the booming industries at present scenario.The major problem faced is the degradation of concrete due to high temperature pressurized steam the temperature of steam released ranges from 120-160 degree Celsius. Steam is released in the industry during various processes such as washing of raw clothes into washing drums, from the outlet of washing jets and during the process of treating the raw material with dyes allowing the cloth to pass from tanks of hot and cold water alternatively. Temperature of hot water is around 100 degree Celsius and that of cold water is 5 degree Celsius. Water released from the washing drums contains chemicals along with it, while water released during dying process contains of dying of pigments of colors.

Steam is not released constantly throughout the day but only at a specific period of time. For washing jets and washing drums steam is released for 4 times in 24 hrs. Steam is released approximately for half an hour every time. This process is called batches. During the time of release of steam a layer of steam of about 2-3 feet is form near the ceiling of a factory in the whole industry. Atmosphere there becomes hazy , due to this it has adverse effects on concrete being porous material steam enters the concrete as a result it comes in contact with steel bars inside it , steam having high amount of moisture content and in presence of oxygen reacts with it to corrode steel, which results in expansion of steel and it puts pressure on concrete and as a result concrete expands and cracks are formed which with passage of time gets more widened and results in degradation of concrete and lumps of concrete gets detached and bond between concrete and steel gets weakened which may result in collapse of some part of structure.

Present Scenario: -At present concrete of M20 grade is used with reinforcement of steel bars of 12 mm diameter with c/c spacing of 6 inches. This type of concreting is done for slabs and floorings. The area in which washing jets and washing drums are kept is kept open to sky up to 3 storey's. For ventilation purpose pressure difference ventilators are kept at top roof. Roof is built of steel supporting on steel truss. Steel truss is used as they are cheap compare to RCC work and they can be easily replaced.

Exposure Conditions: -

Degradation of concrete due to high temperature pressurized steam, temperature of steam released ranges from 120-160 degree Celsius. Steam is released in the industry during various processes such as washing of raw clothes into washing drums, from the outlet of washing jets and during the process of treating the raw material with dyes allowing the cloth to pass from tanks of hot and cold water alternatively. Temperature of hot water is around 100 degree Celsius and that of cold water is 5 degree Celsius. Water released from the washing drums contains chemicals along with it, while water released during dying process contains of dying of pigments of colors. Steam is not released constantly throughout the day but only at a specific period of time. For washing jets and washing drums steam is released for 4 times in 24 hrs. Steam is released approximately for half an hour in each batch.

Major Effects on Concrete: -

Degradation of concrete, Wide cracks being developed, Rusting of steel reinforcement, Corrosion of steel bars,Concrete is eroded, and Collapse of ceiling.

Objective: -

M30 concrete grade as per IS 10262-2009 is design and cement is replaced by different pozzolonic material likes Fly ash(2), Metakaolin(1,4) and Silica fume(3) making it binary, ternary(2) and tertiary blended to reduce and control the permeability and porosity of concrete(5) The main objective is to prepare different blends of concrete and to compare the results and find the optimum blend to solve the problem. Different blends of concrete are as shown below proportions of different materials.

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Table no: - 4 Different blends of concrete with proportion of different materials

Sr No	Blend	Cement %	Fly Ash %	Metakaolin %	Silica Fume %
1	Primary	100	-	-	-
2	Binary	65	35	-	-
3	Ternary	65	20	15	-
4	Ternary	65	22.5	12.5	-
5	Ternary	65	20	-	15
6	Ternary	65	22.5	-	12.5
7	Tertiary	65	20	7.5	7.5
8	Tertiary	65	22.5	6.25	6.25

12 (6 beams and 6 cubes) specimens of each blend (as shown in above table) of concrete is prepared. Out of 12, 6 specimens for each blend will be exposed at the J.R Dying Mill, Surat. Before and after exposure, resistivity meter test to see its resistance against corrosion and compression for cube and flexural strength test for beams will be carried out. Results of exposed specimens and unexposed specimens is be compared and most optimum blend is found out.

Experimental Result
Resistivity Meter, Compression and Flexural Strength Test: -

Resistivity meter and compression tests will be carried out on exposed and un-exposed specimens.Resistivity meter measures the amount of current flowing through the specimen.(6)

Following table shows the results of resistivity meter for exposed and unexposed specimens.

RESULTS OF RESISTIVITY METER FOR CUBES: -
Table no: - 5 Resistivity Meter Test for Cube

% Replacement of cement	Specimen Identification	Resistance Unexposed Specimen (ohm)	Resistance Exposed Specimen (ohm)	Average Unexposed (ohm)	Average Exposed (ohm)
Reference Mix Cement- 100	P1	43	37	42.667	35.667
	P2	42	35		
	P3	43	35		
Binary Blend C + FA- 65+35	PA1	45	37	45.33	37.667
	PA2	45	38		
	PA3	46	38		
Ternary Blend C+FA+M - 65+22.5+12.5	M12.5-1	48	39	48.33	39.667
	M12.5-2	48	40		
	M12.5-3	49	40		
Ternary Blend C + FA + M – 65+20+15	M15-1	50	42	51	43
	M15-2	52	44		
	M15-3	51	43		
Ternary Blend C+FA+S – 65+22.5+12.5	S12.5-1	51	44	52.33	46
	S12.5-2	52	46		
	S12.5-3	54	48		
Ternary Blend C+FA+S – 65+20+15	S15-1	53	47	54	48
	S15-2	55	47		
	S15-3	54	50		
Tertiary Blend C+FA+M+S – 65+22.5+6.25+6.25	T6.25-1	59	50	58.33	50.667
	T6.25-2	58	51		
	T6.25-3	58	51		
Tertiary Blend C+FA+M+S 65+20+7.5+7.5	T7.5-1	63	57	61.667	55.667
	T7.5-2	62	56		
	T7.5-3	60	54		

C- Cement, FA- Fly Ash, M – Metakaolin, S – Silica Fume

RESULTS OF RESISTIVITY METER FOR BEAMS: -
Table no: - 6 Resistivity Meter Test for Beams

% Replacement of cement	Specimen Identification	Resistance Unexposed Specimen(ohm)	Resistance Exposed Specimen(ohm)	Average Unexposed (ohm)	Average Exposed (ohm)
Reference Mix Cement- 100	P1	25	20	26	18.667
	P2	26	19		
	P3	27	17		

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% Replacement of cement	Specimen Identification	Resistance Unexposed Specimen(ohm)	Resistance Exposed Specimen(ohm)	Average Unexposed (ohm)	Average Exposed (ohm)
Binary Blend C + FA- 65+35	PA1	29	21	28.667	20.33
	PA2	28	20		
	PA3	29	20		
Ternary Blend C+FA+M - 65+22.5+12.5	M12.5-1	32	23	32.33	24.33
	M12.5-2	32	25		
	M12.5-3	33	25		
Ternary Blend C + FA + M – 65+20+15	M15-1	35	27	36	28.667
	M15-2	35	29		
	M15-3	38	30		
Ternary Blend C+FA+S – 65+22.5+12.5	S12.5-1	40	32	41.33	33.33
	S12.5-2	43	33		
	S12.5-3	41	35		
Ternary Blend C+FA+S – 65+20+15	S15-1	47	36	48.33	37
	S15-2	48	39		
	S15-3	50	39		
Tertiary Blend C+FA+M+S – 65+22.5+6.25+6.25	T6.25-1	52	43	52.667	42.33
	T6.25-2	52	43		
	T6.25-3	54	41		
Tertiary Blend C+FA+M+S 65+20+7.5+7.5	T7.5-1	57	47	58	46.33
	T7.5-2	57	47		
	T7.5-3	60	46		

C- Cement, FA- Fly Ash, M – Metakaolin, S – Silica Fume

COMPARISON OF RESULTS AND DISCUSSION

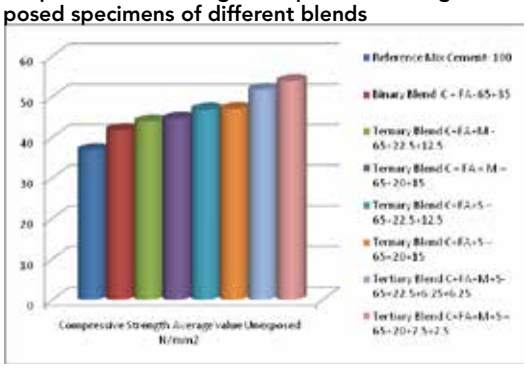
Following table shows the comparison of results of compressive strength.

Table no: - 11 Comparison of results of compressive strength

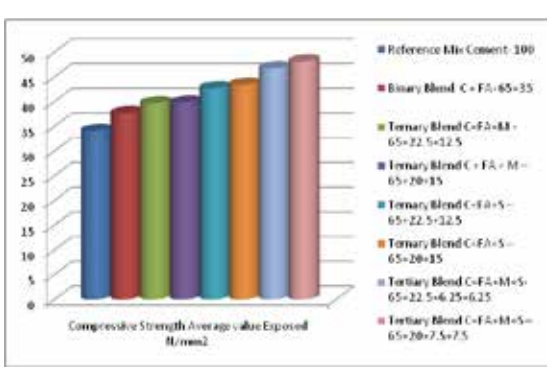
% Replacement of cement	Average value Unexposed N/mm^2	%Increase compared to reference mix	Average value Exposed N/mm^2	%Increase compared to reference mix
Reference Mix Cement- 100	36.81	-	34	-
Binary Blend C + FA- 65+35	41.8	13.56	37.6	10.59
Ternary Blend C+FA+M - 65+22.5+12.5	43.85	19.12	39.61	16.5
Ternary Blend C + FA + M – 65+20+15	44.586	21.12	39.746	16.9
Ternary Blend C+FA+S – 65+22.5+12.5	46.83	27.22	42.68	25.53
Ternary Blend C+FA+S – 65+20+15	46.94	27.52	43.4	27.65
Tertiary Blend C+FA+M+S-65+22.5+6.25+6.25	51.77	40.64	46.71	37.38
Tertiary Blend C+FA+M+S –65+20+7.5+7.5	53.826	46.23	48.106	41.49

C- Cement, FA- Fly Ash, M – Metakaolin, S – Silica Fume

Graph no: - 1 Average compressive strength for unexposed specimens of different blends



Graph no: - 2 Average compressive strength for exposed specimens of different blends



Following table shows the comparison of results of flexural strength

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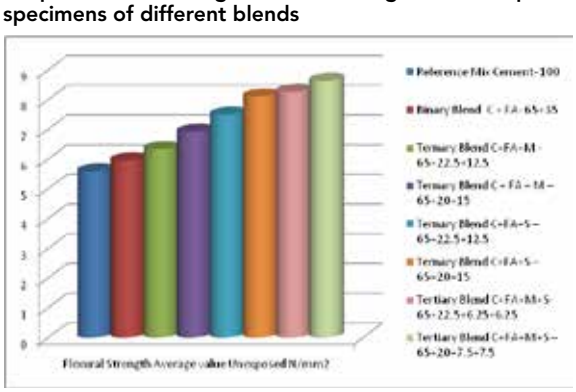
Table no: - 12 Comparison of results of flexural strength

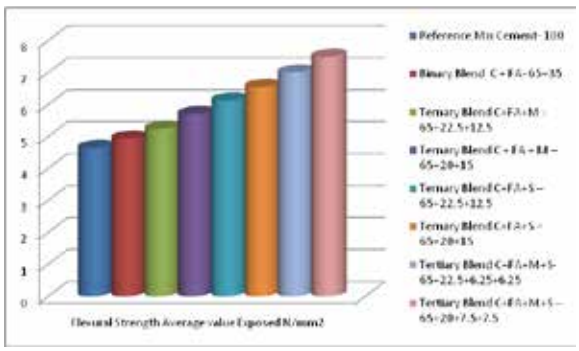
% Replacement of cement	Average value Unexposed N/mm²	%Increase compared to reference mix	Average value Exposed N/mm²	%Increase compared to reference mix
Reference Mix Cement- 100	5.59	-	4.636	-
Binary Blend C + FA- 65+35	5.96	6.62	4.93	6.34
Ternary Blend C+FA+M - 65+22.5+12.5	6.34	13.42	5.23	12.81
Ternary Blend C + FA + M – 65+20+15	6.92	23.80	5.7	22.95
Ternary Blend C+FA+S – 65+22.5+12.5	7.5	34.17	6.12	32.01
Ternary Blend C+FA+S – 65+20+15	8.113	45.13	6.55	41.13
Tertiary Blend C+FA+M+S-65+22.5+6.25+6.25	8.27	47.94	7	50.99
Tertiary Blend C+FA+M+S –65+20+7.5+7.5	8.64	54.56	7.49	61.56

C- Cement, FA- Fly Ash, M – Metakaolin, S – Silica Fume

Graph no: - 3 Average flexural strength for unexposed specimens of different blends



Graph no: - 4 Average flexural strength for exposed specimens of different blends



Discussion: -

It is observed that the corrosion resistance, compressive strength and flexural strength of binary, ternary and tertiary blended concrete shows higher strength as compared to primary blended concrete. This may be attributed to the fact that due to the blended concrete most of the pores in the concrete matrix gets filled up there by rendering a dense microstructure. Also it may be due to the fact that the higher pozzolanic reaction takes place which can induce the later age strength. The pozzolanic reaction forms secondary hydrated products or C-S-H gel which is responsible for the additional flexural strength. Thus the synergistic effect of metakaolin, silica fume and fly ash plays an important role.

CONCLUSION

1. Results have shown that the compressive strength, corrosion resistance and flexural strength of binary, ternary and tertiary blended concrete is more as compared to primary blended concrete
2. Results shows that between metakaolin and silica fume, ternary blends with silica fume shows more compressive strength, corrosion resistance and flexural strength
3. Moreover results for binary, ternary and tertiary blended concrete shows an increasing trend
4. Results indicate that the tertiary blended concrete with proportion C+FA+M+S = 65+20+7.5+7.5 is the most optimum blended concrete.

REFERENCE

1. ACI material journal's technical paper - Strength and Durability Properties of High Performance Concrete incorporating High Reactivity Metakaolin by B.B.Patil and | | 2. Indian Concrete Journal – Strength-Porosity relationship for ternary blended concrete by P.Murthi and V.Sivakumar (July, 2008) | 3. Silica Fume Association ,April 2005 | 4. Technical paper - Effects of Metakaolin and Silica Fume on Properties of concrete by Jian-Tong Ding and Zongjin Li | 5. Third international conference on sustainable construction materials and technologies (www.claisse.info/Proceedings.htm) | 6. Resistivity Meter hand book | 7. IS code 10262:2007 |