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Evaluation of acid resistance in concrete Admixed with silica fume and M-sand

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ABSTRACT

The M40 grade conventional concrete is made and its response towards acid resistance is compared with concrete partially modified with mineral admixtures and manufactured sand. 5% by weight of binder is replaced with silica fume. Fine aggregate is replaced partially with range of 0%, 15%, 25%, 35% and 45% by manufactured sand. All the mixes are cured under water for 28 days and also cured in two acidic mediums. Acid attack on concrete is studied for HCl and H_2SO_4 solution with concentration of 1%. All the mixes are observed for its loss in weight and compressive strength after acid attack. The mix with 45% manufactured sand and 5% silica fume showed better performance. There was reduction in loss of weight when manufactured sand is replaced for 45%. Addition of silica fume enhances pozzolanic action at early age and hence early strength of concrete. Modified Concrete resists HCl than H_2SO_4 solution.

Keywords

Silica fume, manufactured sand, Hydrochloric, Sulphuric acid, loss in weight, compressive strength

1. INTRODUCTION

Imparting mineral admixtures in concrete, that too as wastes and industrial by-products are the present solution to reduce the cost of high performance concrete. These admixtures can be used as part of binder, resources conservation and improved properties. Of many recyclable products, silica fume provides high level cementitious medium while producing high performance concrete. Silica fume increases compressive strength of concrete. Silica fume significantly offers high durability properties [1]. Silica fume when incorporated in concrete imparts resistance to sulfate and improved engineering properties. This resistance is offered by its particle size and effective pozzolanic action during the hydration of cement in concrete [2]. The production of cement emits high level of CO_2 which leads to global warming. This can be reduced by reusing the industrial by-products. Increased amount of silica fume have greater fineness and surface area that increases consistency of cement. The range of 10-15% by weight of binder replaced with silica fume offered increased compressive and flexural strength. The weight loss due resisted by acid is found to be significant in 10% cement replaced with silica fume [3]. Silica fume is a by-product of smelting process in silicon and ferrosilicon industries. Addition of silica fume in concrete shows decreased transition zone thickness and orientation of CH crystals which is significant for microstructure properties. Silica fume increases compressive strength, flexural strength and reduces strain due to creep when compared with conventional concrete [4]. The constituents together to make homogenous concrete will have alkaline property and it has poor sensitivity towards acid attack. Acidic environment considerably impacts on the hydroxides in the concrete that degrades the strength parameters of concrete. Reduction in weight loss under HCl acidic medium is observed to be good when concrete is modified with silica fume [5, 8]. Concrete with silica fume insignificantly prevent deterioration due to sulphuric acid rather resists expansion of matrix under sulphate medium [6]. When concrete modified with silica fume, it is observed that it showed compressive strength 100MPa greater than that of same mix design of conventional concrete. Silica fume provide the required amount of C-S-H gel at an early age leading to early age strength [7]. On the other hand, fine aggregate in the concrete matrix is also under lack of resources. River sand is replaced with manufactured sand for producing economical high strength, high performance concrete. The concrete with manufactured sand showed increase in durability and mechanical properties [9]. Optimum of manufactured sand that can be used in high performance concrete is 50% and however beyond shows reduction in strength parameters [10].

Concrete modified with 15% of binder with micro silica and 50% M-sand showed greater mechanical properties [11]. Incorporation of M-sand for replacing fine aggregates increases compressive strength by nearly 20% [12]. Manufactured sand with 0.5% and 1% by weight of binder of chemical admixtures proved to be better under mechanical properties [14]. Different levels of fine aggregate replacement is done with M-sand and found effective upto 50% replacement [15-18].

In this study, the concrete was modified for its partial amount of fine aggregate by manufactured sand against acid attack and 5% by weight of binder is replaced by silica fume to enhance the pozzolanic activity.

2. MATERIALS AND MIX DESIGN

The Ordianry Portland cement (OPC 43 grade) conforming to IS8112 – 2013 is used throughout this study. The mix design for M40 grade is done according to IS 10262 – 2009. Water to binder ratio is 0.4 and the mix ratio and mix quantity is given in **Table 1.**The proportions of various percentage replacement of fine aggregate is shown in **Table 2.**

Table 1. Mix Design and Proportion

Design Mix	Water	Cement	Fine Aggregate	Coarse Aggregate
By Volume (kg/m^3)	164	350	729	1250
By ratio	0.4	1	2.08	3.57

Table 2. Mix Proportions with percentage replacement for cement and sand

Mix ID	Binder		Fine Aggregate	
	Cement	Silica Fume	River Sand	Manufactured Sand
	%	%	%	%
SF0MS0	100	0	100	0
SF5MS15	95	5	85	15
SF5MS25	95	5	75	25
SF5MS35	95	5	65	35
SF5MS45	95	5	55	45

3. TESTING PROCEDURE

Acid attack Test

Concrete cubes of 100mm are casted. The specimens are demoulded after 24hrs and cured in fresh water for 28days. After 28 days, each specimen is weighed. The weighed specimens are then placed in plastic tubs. Then the specimens are immersed in 1% concentrated solutions of hydrochloric / sulphuric acid. The specimens should be arranged such that the clearway above the specimens should not be less than 30mm. Every day the solution was checked for the clearance. After 28 days, the specimens are taken out, brushed with soft nylon brushes and washed with tap water ensuring that the loose particles on the surface of the specimens are removed. The specimens were weighed and observed for the average percentage of loss of weight and compressive strengths were calculated by,

$$\% \text{ loss of weight} = \frac{W1-W2}{W1} \text{ X } 100$$

Where,

W1 - Weight of specimen after 28 days of water curing.

W2 - Weight of specimen after 28 days of hydrochloric / sulphuric acid curing.

4. RESULTS AND DISCUSSIONS

The experimental results are observed as shown in **Table 3.** It is observed that silica fume enhances transition zone thickness with its fine nature and pozzolanic action. Loss in weight is reduced with increase in percentage of manufactured sand. Compressive strength of water cured concrete is of significant margins whereas compressive strength of acid cured concrete showed lesser. The loss in weight and compressive strength is less for specimens cured under HCl than that of H_2SO_4 solution. Control specimens showed greater loss in weight as well as compressive strength. The modified concrete showed improved impermeabilty with increase in amount replaced for river sand. The concrete modified with 45% M-sand for fines and 5% silica fume for binder proves to be better reduction in loss in weight and compressive strength. It is inferred that M-sand can be replaced for fines upto 50% by its weight beyond which increases loss on weight and compressive strength of concrete.

Table 3. Loss in weight and compressive strength after acid curing,

MIX ID	Hydrochloric acid		Sulphuric acid	
	Loss in weight (%)	Loss in Compressive Strength (%)	Loss in weight (%)	Loss in Compressive Strength (%)
SF0MS0	2.31	10.21	2.93	18.951
SF10MS15	2.18	8.92	2.78	14.792
SF10MS25	1.77	6.350	2.45	13.061
SF10MS35	1.54	4.538	2.32	11.028
SF10MS45	0.96	3.848	1.41	6.670

5. CONCLUSION

This investigation on acid resistance of concrete containing industrial by-products and crushed dust as manufactured sand concludes that the loss in weight and compressive strength is reduced with increase in M-sand. Thus it is observed

to be effective response for replacement of M-sand for 50% by weight of fine aggregates. 5% by weight of binder replaced with silica fumes enhanced the early strength and accounted to be producing good quality concrete.

6. REFERENCES

1. Fereshteh Alsadat Sabet, Nicolas Ali Libre, Mohammad Shekarchi. 2013. Mechanical and durability properties of self consolidating high performance concrete incorporating natural Zeolite, silica fume and fly ash. Construction and Building Materials. 44, 175-184.
2. Lee, S.T., Moon, H.Y., Swamy, R.N. 2005. Sulfate attack and role of silica fume in resisting strength loss. Cement and Concrete Composites. 27, 65-76.
3. Amudhavalli, N.K., Jeena Mathew. 2012. Effect of silica fume on strength and durability parameters of concrete. International Journal of Engineering Sciences and Emerging Technologies. 3, 28-35.
4. Rafat Siddique. 2011. Utilization of silica fume in concrete: Review of Hardened Properties. Resources, Conservation and Recycling. 55, 923-932.
5. Vladimir Zivica. 1999. Acidic resistance of materials based on the novel use of silica fume in concrete. Construction and Building Materials. 13, 263-269.
6. kazuyuki Torii, Mitsunori Kawamura. 1994. Effects of fly ash and silica fume on the resistance of mortar to sulfuric acid and sulphate attack. Cement and Concrete Research. 24, 361-370.
7. langan, B.W., Weng, Ward, M.A. 2002. Effect of silica fume and fly ash on heat of hydration of portland cement. Cement and Concrete Research. 32, 1045-1051.
8. Vladimir Zivica. 2000. Sulfate resistance of the cement materials based on the modified silica fume. Construction and Building Materials. 14, 17-23.
9. Umamaheswaran, V., Sudha, C., Ravichandran, P.T., Kannan Rajkumar, P.R. 2015. Use of M sand in high strength and high performance concrete. Indian Journal of Science and Technology. 8(28).
10. Shanmugapriya, T., Uma, R.N. 2012. Optimization of partial replacement of M-sand by natural sand in high performance of concrete with silica fume. International Journal of Engineering Sciences and Emerging Technologies. 2, 73-80.
11. Puneeth, G.T., mamatha, A. 2016. An experimental investigation on the strength of concrete by partial replacement of cement with micro silica and natural sand with manufactured sand. International Journal of Civil and Structural Engineering Research. 3, 52-57.
12. Dona Maria Joseph, Manjula Devi, Senthil Kumar, S. 2013. Experimental Investigation of concrete with combined high alumina cement, silica fume and M-sand. International Journal of Engineering Research and Applications. 3, 425-428.
13. Satish Chandra, Leif Berntsson. 1996. Use of silica fume in concrete. Waste Materials Used in Concrete Manufacturing. 554-623.
14. Lokesh Gowda, Ramesh, V., Srinivas Raju. 2015. Experimental Investigation on strengths and Durable properties of concrete on Manufactured sand and GGBS with chemical admixtures. International Journal of Civil and Structural Engineering Research. 3, 128-133.
15. Daisy Angelin, P., Rabi Kishore, P. 2015. Durability Studies on concrete with manufacturing sand as a partial replacement of fine aggregate in HCl solution. International Journal of Engineering Research and Development. 11, 44-50.
16. Manjunatha, M., Akshay, N.K., Jeevan, H. 2016. Durability Studies on concrete by replacing natural sand with M-sand – A Review. International Journal of Engineering Technology and Advanced Engineering. 6, 293-296.
17. Thandavamoorthy, T.S. 2015. Durability of concrete in which fine aggregate is soil. International Research Journal of Engineering and Technology. 2, 18-29.
18. Senhadji, Y., Escadeillas, G., Mouli, M., Khelafi, H., Benosman. 2014. Influence of natural pozzolan, silica fume and lime stone fine on strength, acid resistance and microstructure of mortar.
19. IS: 10262: 2009.Concrete Mix Proportioning – Guidelines. Bureau of Indian Standards. New Delhi. India.
20. IS: 12269: 1987. Ordinary Portland Cement, 53 Grade — Specification.Bureau of Indian Standards. New Delhi. India.
21. IS 383:1978. Specification for Coarse and Fine Aggregates from Natural Sources for Concrete. BIS. New Delhi. India.
22. IS516:2004. Methods of Tests on Strength of Concrete. Bureau of Indian Standards. New Delhi. India.