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Effect of H_2SO_4 on Mixes of Different Grades of Manufactured Sand Concrete

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***Abstract*—Concrete is most important material and plays an important role in every construction work. River sand is the most commonly used fine aggregate in concrete but nowadays the limitations such as its shortage of availability, cost, and its impact on the surrounding or environment are a cause of concern. To avoid these problems, the partial or full replacement of sand with quarry sand, and cement by rice husk ash, fly ash has been done in this experimental investigation. In this article, investigation is done indicating effects of H_2SO_4 on the four different mixes of different grades viz. M25, M30, and M40. The difference in weight of cubes before and after immersion in acid which indicates weight loss, and compression test which gives strength of cubes were done after 28, 56, and 90 days respectively. The composition of 70% cement, 30% fly ash, 55% natural sand, 45% quarry sand, 50-50% of 10 and 20mm coarse aggregate gives maximum strength results and is more workable mix. 70% cement, 22.5% fly ash, 7.5% rice husk ash, 70% natural sand, 30% quarry sand, 50-50% of 10 and 20mm coarse aggregate shows minimal weight loss.**

***Keywords*— Admixture, Concrete, Fly Ash, Quarry Sand, Rice Husk Ash, H_2SO_4.**

I. INTRODUCTION

The widely used construction material in civil engineering is the concrete, which is a site-made material consisting of fine aggregate, coarse aggregate, water and cement used as a binding material for both sorts of aggregates. Mineral admixtures can be used to improve mechanical properties and durability [1-4]. Concrete finds large application for its use in buildings, bridges, dams, roads [4] and varies in its quality and performance based on natural materials used except cement [5].The demand for concrete has been increasing at a rapid rate over the past few decades in order to meet the needs of over-growing population. To meet these excessive needs, binding material and fine aggregate is also required in surplus amount leading to inflation of concrete.

Properties of aggregate affect durability and performance of concrete. The large scale depletion of river sand is also a major threat to environment [5, 6] promoting a need of an alternative for natural sand. For 60% replacement of natural sand, properties of concrete like workability, strength increases but on further increasing proportion causes reduction in compressive strength of concrete mixes. Replacement of natural sand with manufactured sand maintains ecological balance of nature [7]. The first mix, 100% Natural Sand (NS), 100% Cement (C), 50-50% 20 & 10mm Coarse Aggregate (CA), second mix, 100% Quarry Sand (QS), 100% C, 50-50% 20 & 10mm CA, third mix, 55% NS, 45% QS, 70% C, 30% Fly Ash (FA), 50-50% 20 & 10mm CA, and fourth mix, 70% NS, 30% QS, 70% C, 22.5% FA, 7.5% Rice Husk Ash (RHA), 50-50% 20 & 10mm CA of each grade of M25, M30, and M40 grades have been selected on which evaluation of durability of concrete is carried out.

RHA, FA and QS are some of the solid wastes resulting from industry. Effective use of these solid wastes for preparing manufactured sand concrete leads in reduction of cost as well as contributes in sustainable development. Admixture was added which imparts superior workability to the mix and provides more economical solution. FA, a residue generated in combustion of coal is captured from chimneys of power generation facilities which consists of harmful particles causing health hazards and has environmental impact [8]. RHA obtained by burning rice husk serves to be a better alternative as it solves the risks of carbon dioxide emission, depletion of resources and is useful for agricultural waste management [9].Quarry dust is the waste from the rocks formed after the extraction and processing of rocks.

The article focuses effect of acid attack on concrete of different mixes. The durable concrete resists chemical and physical attacks which lead to deterioration of concrete. Leaching, sulphate attack, acid attacks are few of the attacks to enlist. Also, water which is an important ingredient of water may consist of many chemical impurities like chlorides, sulphates, various salts. This leads to deterioration of concrete which depends on concentration of chemicals in water [1-10]. The rate of deterioration depends mainly on concentration of the chemicals in water, the time of exposure and the chemical resistance of concrete [11]. Liquids with pH value less than 6.5 affect concrete but if pH value is below 4.5 the attack is very severe [12]. Sulphuric acid is prone to more danger since it involves acid and sulphate attacks both. The investigation focuses on finding the detrimental effects of sulphate attack on cubes by evaluating weight loss and strength loss in cubes when they are subjected to a mixture of sulphuric acid-water solution for a period of 28, 56, and 90 days respectively.

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II. EXPERIMENTS

The four mixes of different grades namely M25, M30, and M40 have been selected for investigation of durability test like acid attack. Mix proportions of these mixes in percentage are shown in Table I. Various workability tests like Slump, Compaction, and Flow tests were carried out on these mixes.

TABLE I. MIXED PROPORTIONS FOR M25, M30, M40 GRADES

Mixes	Composition
First	100% NS, 100% C, 50-50% 20 & 10mm CA
Second	100% QS, 100% C, 50-50% 20 & 10mm CA
Third	55% NS, 45% QS, 70% C, 30% FA, 50-50% 20 & 10mm CA
Fourth	70% NS, 30% QS, 70% C, 22.5% FA, 7.5% RHA, 50-50% 20 & 10mm CA

The cubes of 4 different mixes of M25, M30, and M40 grades were casted which were dried for one day after remolding. Then the cubes were inserted in curing tank for a period of 28 days after which cubes were taken out and dried for 24 hours. Cubes of each mix and of each grade were then weighed and were also compressed in compression test machine (CTM) for evaluating their strength. The remaining cubes were weighed according to 28, 56, and 90 days and then cubes of each mix and grades were immersed in 1% H_2SO_4 solution mixed with water as shown in Fig. 1. Cubes were then periodically taken out after 28, 56, and 90 days and then washed, dried for 24 hours and then weighed, evaluated compressive strength for each mix of each grade.

Fig. 1. Cubes immersed in H_2SO_4 - Water solution

The difference in the weights of cubes before and after indicates percentage weight loss. The strengths were also evaluated by compressing the cubes in CTM.

III. RESULTS AND DISCUSSIONS

A. *Slump Test*

The effect of different mixes of different grades evaluated by Slump test is shown in Fig. 2. Third mix of M25 shows high slump loss while fourth mix of M40 has low slump loss. Third mix of M25, M30, and M40 shows maximum slump loss which means more workable concrete. Third mix of all grades of concrete is more workable. Fourth mix of all grades is least workable. First mix is more workable than second mix for all grades of concrete. Second and fourth mix both show relatively less workable concrete as compared to two mixes for all grades of concrete.

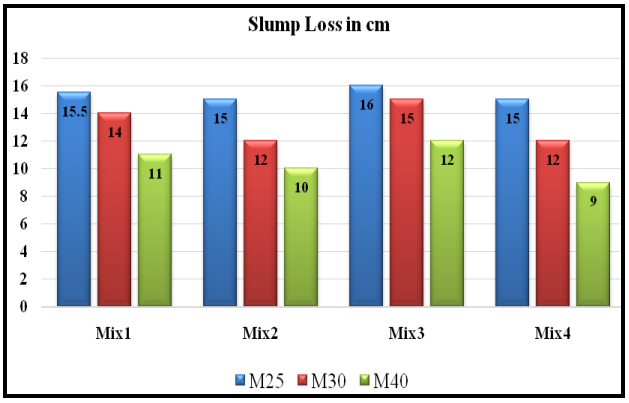

Fig. 2 Slump Loss

B. *Compaction Test*

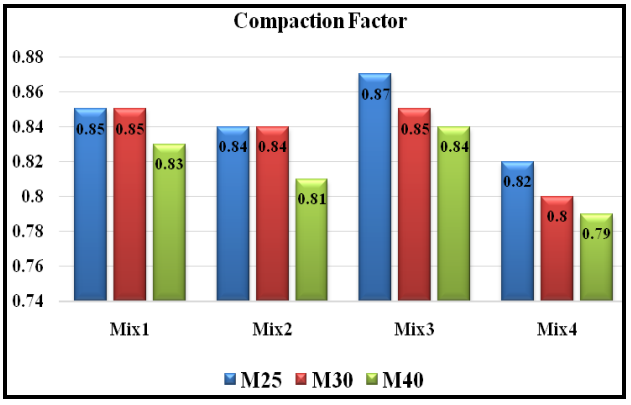

Fig. 3 Compaction Factor

Third mix of M25 grade shows high compaction factor while fourth mix of M40 has highest compaction factor as compared to other mixes. Third mix of all grades show maximum compaction factor, hence they are more workable. Fourth mix of all grades of concrete is least workable. First mix is more workable than second mix for all grades of concrete. High compaction factor value shows more workable concrete.

C. *Flow Test*

Fig. 4 shows the results for Flow test for all four mixes of M25, M30, and M40 grades of concrete. For M25 grade, third mix show high percentage flow loss while fourth mix of M40 grade has low percentage flow loss. M25 grade of all mixes has highest percentage flow los as compared to others. Third mix of all three grades of concrete shows maximum percentage flow loss. Third mix of all grades of concrete is more workable. Fourth mix of all grades of concrete is least workable. First mix is more workable than second mix for all grades of concrete.

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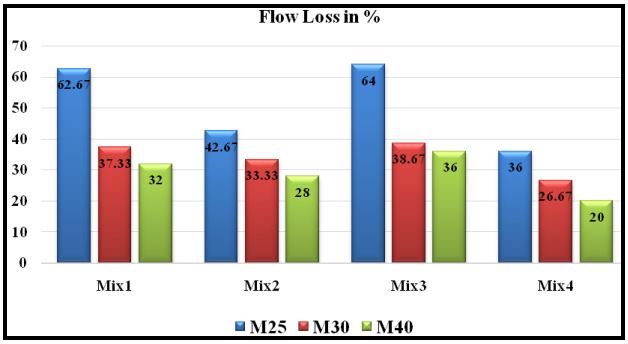

Fig. 4 Flow Loss

D. *Acid Attack Tests*

1) *Weight Loss*

Table II shows weight losses in percentage for each of the four mixes of M25, M30, and M40 grades of concrete. Cubes of first and second mix of M25 and M30 grades of concrete shows maximum weight loss in percentage when they were immersed in H_2SO_4 for a period of 28, 56, and 90 days respectively. Whereas in case of M40 grades, weight loss is approximately same for first and second mix of all three grades under consideration but losses increase in second mix after 56 days and is maximum after 90 days. Fourth mix of M30 grade of concrete showed less weight loss as compared to third mix after 28, and 56 days respectively but sharply undergoes weight loss after 56 days and is maximum at 90 days. Fourth mix of all three grades shows least weight loss which indicates that the concrete of fourth mix is more durable and is least affected by H_2SO_4 acid.

TABLE II. WEIGHT LOSS IN % FOR DIFFERENT GRADES

Grades	No. of days	First Mix	Second Mix	Third Mix	Fourth Mix
M25	28	1.03	1.55	0.59	0.82
	56	2.06	2.17	2.07	1.80
	90	2.94	2.82	2.65	2.69
M30	28	1.77	1.25	0.00	0.23
	56	1.81	1.42	0.23	0.23
	90	2.03	2.30	0.33	0.23
M40	28	0.22	0.23	0.12	0.12
	56	0.33	0.33	0.23	0.23
	90	0.46	0.45	0.34	0.34

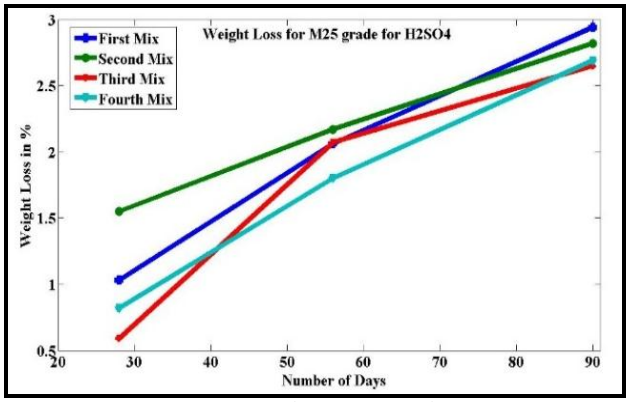

Fig. 2 Weight Loss for M25 grade of concrete

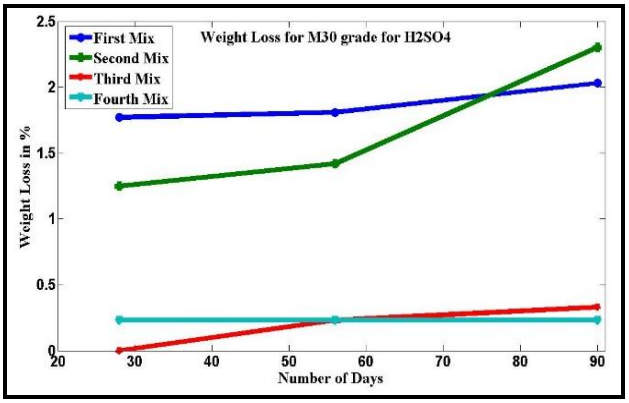

Fig. 3 Weight Loss for M30 grade of concrete in

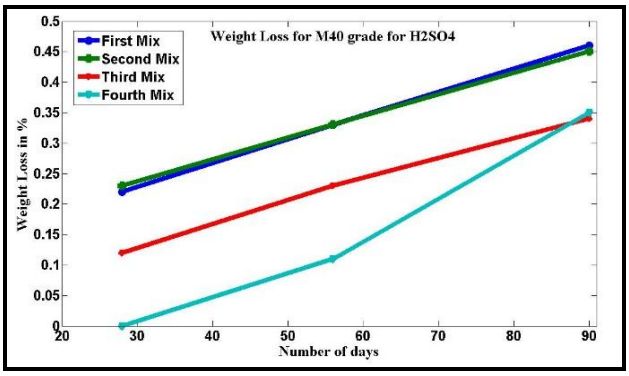

Fig. 4 Weight Loss for M40 grade of concrete in

2) *Strength Loss*

Table III shows strength loss in percentage of each mix of every grade of concrete considered for investigation of acid attack on cubes. Both first and second mix of M25 grade show approximately same strength loss after 28, 56, and 90 days respectively while fourth mix has least strength loss which indicates that it is less affected by acid and has good strength. For M30 grade of concrete, first mix is largely affected by acid undergoing maximum strength loss whereas fourth mix undergoes less strength loss. In M30 grades of concrete, cubes show approximately same strength loss after 56 days. Cubes of second mix of M40 grade show maximum strength loss after 28, 56, and 90 days respectively while third mix is least affected by acid for M40 grades of concrete as compared to other mixes of M40 grades.

TABLE III. STRENGTH LOSS IN % FOR DIFFERENT GRADES

Grades	No. of days	First Mix	Second Mix	Third Mix	Fourth Mix
M25	28	15.17	15.97	12.93	10.90
	56	28.75	29.10	25.23	20.23
	90	48.22	55.81	40.52	30.95
M30	28	15.82	21.80	17.31	11.71
	56	24.32	26.71	23.89	17.17
	90	33.45	38.21	31.97	20.42
M40	28	11.90	23.29	7.36	6.69
	56	23.02	32.65	13.50	17.80
	90	34.27	41.60	17.56	22.36

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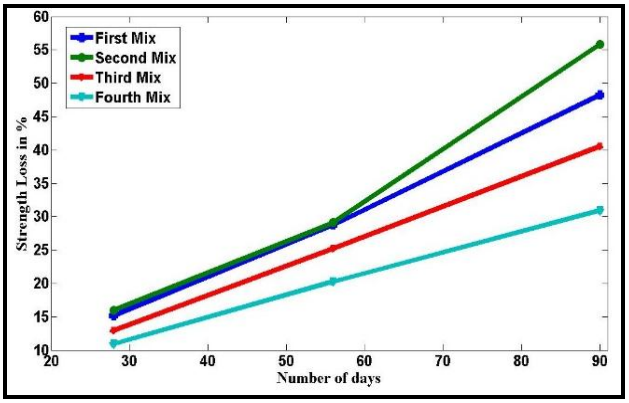

Fig. 5 Strength Loss for M25 grade of concrete in

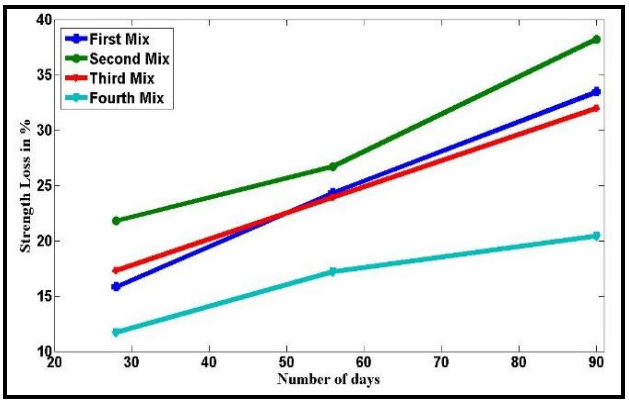

Fig. 6 Strength Loss for M30 grade of concrete

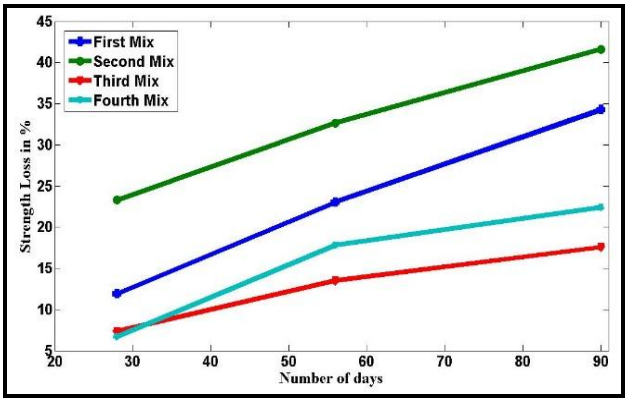

Fig. 7 Strength Loss for M40 grade of concrete

IV. CONCLUSION

For cubes of M25 grade immersed in H_2SO_4, second mix showed maximum weight loss after 28, and 56 days while first mix showing maximum weight loss after 90 days. Third mix of M25 undergone minimal weight loss after 28 days. The weight loss increased after 56 days and further again decreasing after 90 days.

The weight loss for 100% QS, 100 %C, 50-50% 20 & 10mm CA (second mix) maximum weight loss after 28, and 56 days later decreasing after 90 days for M30 grade. Fourth mix almost indicates constant weight loss in % after 28, 56 and 90 days respectively. The weight loss in % for cubes of M40 grade of first and second mix was almost same and was maximum as compared to other two mixes. Fourth mix showing minimal weight loss in % after 28, 56, and 90 days.

It is observed that cubes of M25 and M30 grades of fourth mix showed least weight loss after 28, 56, and 90 days whereas second mix showing maximum strength loss for M25, M30 and also for M40 grades. The results obtained for M40 grade for strength loss in cubes indicate the minimal weight loss for third mix. When 100% natural sand is partially replaced by 50% quarry sand, shows minimal weight and strength loss for each of M25, M30, and M40 grades of concrete.

Concrete prepared by partially replacing cement by 30% fly ash yields more workable concrete mix and gives less strength loss and weight loss.

If cement is replaced by 22.5% fly ash and 7.5% rice husk ash, concrete obtained is not workable comparatively because rice husk ash absorbs more amount of water. But, rice husk ash is more suitable for acid attack. Quarry sand also absorbs more water which affecting workability of concrete.

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