A Study of Mechanical Properties on Concrete with Rice Husk Ash
Lavanya Velpula; Dr. S. Vijay Bhaskar Reddy, M.Tech., Ph.D.
1M.Tech. (Engineering Structures) CMR Engineering College, Telangana, India
2Professor, Department of Civil EngineeringmCMR Engineering College, Telangana, India

Abstract
Concrete has become basic material in day to day life of humans. In recent years lot of research is going on the development of high strength concrete by using supplementary materials for cement and aggregates. The present investigation is mainly focused on the effect of mechanical properties and durability of high strength concrete with supplementary materials. In this investigation concrete having compressive strength 50 and 70MPa and rice husk ash (RHA) as supplementary material. Sulphuric Acid (H_{2}SO_{4}) and Hydrochloric acid (HCl) has been used as curing media in this investigation apart from the water. Rice husk added to the concrete with 0 to 20 % by weight of cement. Fresh properties of concrete like slump and hardened properties like compressive strength, split tensile strength after 28 days of curing are conducted along with durability. The results are quite impressive by using rice husk in the concrete strength point of view and acid resistance.

Key words: Rice Husk ash, durability, supplementary materials, high strength concrete.

1.0 INTRODUCTION
Concrete is the basic engineering material used in most of the civil engineering structures. Its popularity as basic building material in construction is because of, its economy of use, good durability and ease with which it can be manufactured at site. The ability to mould it into any shape and size, because of its plasticity in green stage and its subsequent hardening to achieve strength is particularly useful. Concrete like other engineering materials needs to be designed for properties like strength, durability, workability and cohesion. Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way. With advent of high-rise buildings and pre-stressed concrete, use of higher grades of concrete is becoming more common. Even the revised IS 456–2000 advocates use of higher grade of concrete.
for more severe conditions of exposure, for durability considerations. Rice husk is a potential material, which is amenable for value addition. The usage of rice husk either in its raw form or in ash form. Most of the husk from the milling is either burnt or dumped as waste in open fields and a small amount is used as fuel for boilers, electricity generation, bulking agents for composting of animal manure, etc. The exterior of rice husk are composed of dentate rectangular elements, which themselves are composed mostly of silica coated with a thick cuticle and surface hairs. The mid region and inner epidermis contain little silica confirmed that the presence of amorphous silica is concentrated at the surfaces of the rice husk and not within the husk itself.

2.0 LITERATURE REVIEW

Marble and limestone specimens were exposed for one year by Youngdall and Doe [1] to ambient atmospheric conditions in four cities of Eastern USA. The results show that the specimens were damaged by calcium loss due to acid deposition. Neal et al. [2] conducted the experiments on marble were exposed to simulated acid rain of different pH values by to corrosion levels equivalent to exposure to ambient atmosphere for a 10 – year period. Results shows the dissolution rate decreased logarithmically with time and was determined by the transport rate of dissolved ions. Rands et al. [3] found that both the acidity and ionic strength in rainwater played an important role in limestone deterioration. Shadong et al [4] conducted the laboratory experiments on the acid rain effect on cement concrete. They have concluded that the deterioration of acid rain on the concrete specimen is caused by both H+ dissolution and SO$_4^{2-}$ expansion. Rostami and Brendley [5] tested the acid resistance of alkali fly ash concrete (cured at 40–90˚C) in terms of mass loss. Torii and Kawamura [6] investigated the effect of using silica fume and fly ash as partial replacement for cement on the resistance of concrete to a 2% solution of sulphuric acid. They concluded that such a partial replacement for cement could not effectively prevent the acid-type deterioration involving surface scaling and softening of mortar.

Ali Reza [7] investigated mechanical and durability properties of ternary concrete by combining silica fume and low blast furnace reactive slag with different mix proportions. By the use of ternary mixes,
28 day durability properties of slag based blended concrete was increased compare to the conventional concrete with addition of silica fume. The present investigation mainly focused on the curing of concrete in acid environment. In this investigation two types of acids i.e., HCl and H2SO4 are used and concrete having compressive strength 50MPa has been used.

3. MATERIALS USED

3.1 Cement
Ordinary Portland cement of 53 grades available in local market is used in the investigation. The cement used has been tested for various proportions as per IS: 4031-1988 and found to be conforming to various specifications of IS: 12269-1987. The specific gravity was 3.16

3.2 Fine aggregate
River sand procured from Karimnagar has been used. The fine aggregate having specific gravity 2.62. The sample is confirming to zone II and fineness modulus is 3.16.

3.3 Coarse aggregate
10 mm and 20 mm crushed gravel of 2.69 specific gravity was used. The coarse aggregate was air-dried in the laboratory and sieve analysis was carried out.

3.4 Rice husk
The chemical composition of rice husk is similar to that of many common organic fibres and it contains of cellulose 40–50%, lignin 25–30%, ash 15–20% and moisture 8–15%. Rice husk ash contains 87–97% of silica with small amount of alkalis and other trace elements.

3.5 Superplasticizer
High Range Water Reducing Admixture (HRWRA) confirming to ASTM C 494 [19] commonly called as super plasticizers, are used for improving the flow or workability for decreased water-cement (w/c) ratio without sacrifice in the compressive strength. These admixtures when they disperse in cement agglomerates significantly decrease a viscosity of the paste by forming a thin film around the cement particles. In the present investigation water-reducing admixture CONPLAST SP430 obtained from FOSROC Chemicals, Bangalore was used.

3.6 Sulphuric acid
Historical name of this acid is oil of vitriol. Sulphuric acid is a highly eroding, tough mineral acid with the molecular formula H2SO4. It is a pungent-ethereal, colorless to slightly yellow viscous liquid which is soluble in water at all concentrations. Sometimes, it is dyed dark
brown during production to alert people to its hazards. Sulphuric acid at a high concentration can cause very serious damage upon contact, as it not only causes chemical burns via hydrolysis, but also secondary thermal burns via dehydration. It burns the cornea and can lead to permanent blindness if splashed onto eyes.

3.7 Hydrochloric Acid

Hydrochloric acid is a clear, colorless, highly pungent solution of hydrogen chloride (HCl) in water. It is a highly corrosive, strong acid with many industrial uses. Hydrochloric acid is found naturally in gastric acid. Historically called spirits of salt, hydrochloric acid was produced from vitriol (sulphuric acid) and common salt. We poured 1ml acid for 1 litre of water to dilute the both acids. So that it could not harmful for the skin while putting and taking of specimens.

3.8 Water

Potable water was used in the experimental work for both mixing and curing.

4. EXPERIMENTAL PROCEDURE

The investigation was aimed at studying the acid resistance of ternary blended concrete on compressive strength, split tensile strength of M50 and M70 grade of concrete. The mix proportions are calculated based on the IS 10262–2009 [10] and SP 23 [11]. The mix proportions for M50 and M70 concrete are shown in table 1. Rice husk was used in the above mix proportion by replacing cement by weight in the volume fractions of 0%, 5%, 10%, 150% & 20%. A total of 12 cubes and 3 cylinders were cast for mix of concrete. Cubes of 150 × 150 × 150 mm and cylinder specimen of 150 mm diameter & 300 mm length were casted to know the mechanical properties of concrete.

5. RESULTS AND DISCUSSION

5.1 Compressive Strength and Split Tensile Strength:

Fresh properties of concrete like workability has performed using slump test. Slump is decreasing as the percentage of rice husk increases. Compression testing machine of 2000 kN used for the compression test and 600 kN UTM has been used for the split tensile test. The results of compressive strength and split tensile strength are given in the Table 2 and 3 respectively.
Table – 1: Mix Proportions of mixes M50 and M70 grades in kg/m³

<table>
<thead>
<tr>
<th>Mix</th>
<th>Cement</th>
<th>FA</th>
<th>CA</th>
<th>Fly ash</th>
<th>Silica Fume</th>
<th>W/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>M50</td>
<td>387.6</td>
<td>549.1</td>
<td>1145.5</td>
<td>102</td>
<td>20.4</td>
<td>0.35</td>
</tr>
<tr>
<td>M70</td>
<td>435.1</td>
<td>518.8</td>
<td>1130.25</td>
<td>100.5</td>
<td>22.32</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Table – 2: Compressive strength (MPa)

<table>
<thead>
<tr>
<th>Compressive strength</th>
<th>Replacement of fine aggregate with RHA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
</tr>
<tr>
<td>M50-7 Days</td>
<td>37.4</td>
</tr>
<tr>
<td>M50-28 Days</td>
<td>56.5</td>
</tr>
<tr>
<td>M70-7 Days</td>
<td>50.5</td>
</tr>
<tr>
<td>M70-28 Days</td>
<td>76.2</td>
</tr>
</tbody>
</table>

Table – 3: Split Tensile Strength (MPa)

5.2 Durability

The specimens are weighed before drying. The drying was carried out in a hot air oven at a temperature of 105°C. The drying process was continued until the difference in mass between two successive measurements at 24 hours intervals agreed closely. The dried specimens were cooled at room temperature and then immersed in acid. The specimens were taken out at regular intervals of time, surface dried using a clean cloth and weighed. This process was continued till the weights became constant (fully saturated). The difference between the measured acid saturated mass and oven dried mass expressed as a percentage of oven dried mass gives the absorption of acid. The acid solution becomes less acidic after a concrete specimen has been submerged in it for a period of time. The reason for decrease in acidity is that concrete is an alkaline material.

When the concrete is exposed to sulphuric acid solution, hydrogen ions and sulphate ions deteriorate the concrete properties by reacting with hydration products to make cement matrix more porous and/or expansive (Joong-KyuJeon 2006 [13]).
Concrete is chemically stable in an alkaline environment, but unstable in neutral or acidic environment. Hydrogen ions in sulphuric acid usually react with calcium ions in cement matrix then to decompose the hydration products as seen in the following chemical equations.

\[ \text{Ca (OH)}_2 + 2\text{H}^+ \rightarrow \text{Ca}^{2+} + 2\text{H}_2\text{O} \]

CSH gel: \[ 3\text{CaO} \cdot 3\text{H}_2\text{O} + 6\text{H}^+ \rightarrow 3\text{Ca}^{2+} + 2\text{SiO}_2 + 6\text{H}_2\text{O} \]

Ettringite: \[ 3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 3\text{CaSO}_4 \cdot 32\text{H}_2\text{O} + 6\text{H}^+ \rightarrow 3\text{Ca}^{2+} + \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O} + 3\text{CaSO}_4 + 32\text{H}_2\text{O} \]

Sulphate ions penetrated into concrete in general react with calcium hydroxide of cement matrix to form gypsum, which softens the inner concrete structure and decreases the concrete properties. The gypsum in cement softens concrete and decomposes hydration products and thus the weight and strength of the concrete specimens are reduced. It is observed that, the degree of deterioration is dependent on binder and it is attributed to different hydration products and the rate of hydration. The higher calcium hydroxide implies that higher probability of formation of gypsum in the cement matrix. In this investigation rice husk is acts like a fibre in the concrete matrix. Mechanical properties like compressive strength and split tensile strength of concrete is more in concrete cured HCl solution compared to concrete cured in sulphuric acid.

6.0 CONCLUSIONS

The workability of concrete is marginally effected with the addition of RHA. Rice Husk Ash replacement to cement has increased the compressive and split tensile strength of both grades of concrete. Upto 10% replacement of RHA the strength properties have increased but later with the increase in replacement decrement is observed. Thus, 10% replacement of RHA is observed to be the optimum replacement in strength characteristic point of view. The percentage loss of weight due to acid and alkaline attack has decreased with the increase in replacement upto 20% RHA. Certainly, considering workability, mechanical properties and durability 10% RHA replacement to cement will be optimum usage.

7.0 REFERENCES


[9] IS 2386 – 1963: Methods of Test for Aggregates for Concrete

[10] IS 10262–2009: Recommended Guidelines for Concrete Mix design

