Study on Compressive Strength of on Concrete Incorporating Quartzite as Coarse Aggregate Replacement under Different Exposure Conditions

S. Satya Narayana Raju[1] B. Ramya Maduri[2]
[1]P.G. Student [2]Assistant Professor
[1,2]Department of Civil Engineering
[1,2]Srinivasa Institute of Engg. & Technology, Andhra Pradesh, India

Abstract— In the present study, the compressive strength of the concrete incorporating quartzite as a replacement material for coarse aggregate was investigated under tap water, acidic and sulfate exposure conditions. The concrete mix of grade M25 was designed in accordance with Indian standard code IS 10292-2009. The compressive strengths of the cubes were determined for curing period of 28, 60, 90 days. The experiment was done on triplicates. The percentage increase in compressive strength from 28 days to 60 days is constant in all the three exposure conditions. Performance of quartzite was good under different exposure conditions.

Key words: Quartzite; Compressive Strength; Coarse Aggregate; Concrete; Curing

I. INTRODUCTION

Increase in population, rapid urbanization, demographic transfers, and industrial developments are major factors contributing to the development of housing schemes. The Ministry of Housing and Urban Affairs, Government of India is coordinating and monitoring the issues of housing affairs in the country. Housing schemes like Pradhan Mantri Awas Yojana (housing for all) were launched in 2015, and Pradhan Mantri Gramin Awaas Yojana (previously Indira Awas Yojana) is aimed to provide shelters to the homeless by 2022. Rajiv Awas Yojna is a scheme launched in 2009 with an aim to develop a slum-free India [1]. Smart cities, Swacch Bharat Mission, and Make in India programs are providing a huge scope for infrastructure and construction sector.

In the construction and infrastructure using concrete is being used for development of pavements and building structures. The preparation of concrete requires enormous quantities of sand (fine aggregate), stone (coarse aggregate) and cement (binder) and water [2]. Alternative materials are being used as replacement materials in place of traditional ingredients for the preparation of concrete. Steel slag, blast furnace slag, quartzite, coconut shells, recycled aggregate, ceramic have been utilized by the researchers as an alternative material for coarse aggregate The structural and durability properties play a pivotal role in increasing the lifespan of the structure. These properties depend upon different factors such as water to cement ratio, aggregate to cement ration, curing and exposure conditions [3-10].

Curing of concrete is a process performed to achieve the intended strength by controlling the fast hydration process, and early volume changes. This is achieved by maintaining the favorable moist conditions under suitable temperature conditions. Proper curing of the concrete will enhance the microstructure development and maintain the dimensional stability. In case of improper curing during the early stage results in an irreparable loss as the desirable properties are not achieved because of a low degree of hydration, resulting in an early-age crack. For concrete mixes with lower water/cement (w/c) ratios, inappropriate curing leads to autogenous shrinkage and drying leading to cracks in concrete [11-15].

The present study is aimed to investigate the compressive strength of the concrete incorporating quartzite as a replacement material for coarse aggregate under normal, acidic and sulfate exposure conditions.

II. MATERIAL AND METHODS

In the present study, Ordinary Portland cement (OPC) 53 grade conforming to IS 12269: 1987 was used as a binder material. Locally available river sand conforming to Zone II of IS 383: 2000 was used as fine aggregate. Crushed granite rock and quartzite of maximum size 20mm confirming to IS 383:2000 were used as coarse aggregate. The concrete mix design was performed in accordance with IS 10262:2009 standard volumetric mixture proportioning method. The chemicals (Hydrochloric acid, magnesium sulfate, and sodium sulfate) used for the preparation of the curing water are of reagent grade. The mixing water meeting the specifications as prescribed in ASTM 1602M-06 was used in this study.

III. RESULTS AND DISCUSSIONS

A. Mix Design

The mix design was performed for M30 grade concrete as per IS 10262:2009. Mixing of various ingredients of concrete was performed in a vertical rotating mixer. Accurate weighed raw materials were mixed in dry condition to get a homogeneous mixture. 75 % of the water was added and the mixer was rotated in both directions for proper mixing. The complete mixing of the concrete was done by adding remaining water and it is observed that no dry patches are formed. After each run, workability parameters were calculated to determine the consistency of the fresh concrete. The fresh concrete was filled in steel mold of size 150 x 150 X 150 mm cube molds in three layers with each layer being compacted using a tamping rod. Further vibrators were used to compact the concrete and remove the air voids and excess water. The test specimens were immersed in water after 24hrs of cube casting. The water used for curing was maintained at near neutral pH and chlorides in the range 50-70 mg/l. Table 1 presents the mix used for M30 grade concrete

Grade of concrete	M30
Slump(mm)	25 to 50
Water (liters)	197
Cement (kg)	435
Fine Aggregate (kg)	670
Coarse Aggregate (kg)	990
Quartzite (kg)	250
Quantities per m³ of Concrete (Kg)	

Table 1: Mix Used for M30 Grade Concrete

B. Determination of Compressive Strength under Different Exposure Conditions

Compressive tests were conducted on concrete cube (150× 150× 150 mm) samples. The samples were placed for curing under tap water, acidic and sulfate exposure conditions. The curing was done for a period of 28, 60, and 90 days and the samples were regularly investigated by visual inspection. Three cube specimens each were cast for each exposure to determine the compressive strength. The cubes were air dried before specified testing date. The dimensions of the cubes were measure after air drying. The samples were tested in a compressive testing machine at the loading rate of 5.3 kN/sec.

To achieve the acidic exposure condition, hydrochloric acid (HCL) of 1% concentration was mixed with tap water. HCL was considered to be representative of aggressive sewer environments. Sulfate exposure condition was achieved by mixing magnesium sulfate ($MgSO_4$) and sodium sulfate, Na_2SO_4.

The percentage increase in compressive strength from 28 days to 60 days in tap water curing was 6.87%, acidic exposure condition was 6.02% and sulfate exposure condition was 6.31%. The percentage increase in compressive strength from 60 days to 90 days in tap water curing was 2.91%, acidic exposure condition was 0.72% and sulfate exposure condition was 0.91%. Figure 1 represents the compressive strengths under different exposure conditions.

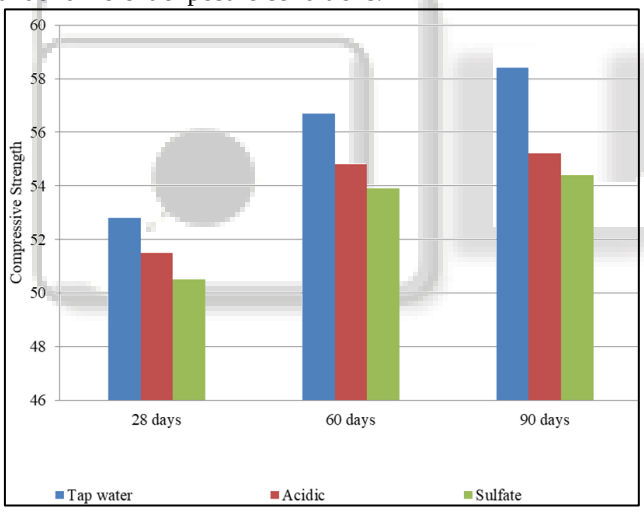

Fig. 1: Compressive Strengths under Different Exposure Conditions

IV. CONCLUSIONS

a) The concrete performed well under acidic exposure condition in terms of compressive strength when compared sulfate exposure.
b) The percentage increase in compressive strength from 28 days to 60 days is constant in all the three exposure conditions, while form 60 days to 90 days the percentage increase was observed to be least in acidic exposure condition (0.72%) and maximum in tap water curing condition (2.91%).
c) Overall, the performance of quartzite was found to be good under exposure conditions; hence it can be recommended as a replacement material for coarse aggregate in concrete.

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