PROCEEDINGS

OF THE

NATIONAL CONFERENCE ON
RECENT INNOVATIONS IN CIVIL ENGINEERING MATERIALS

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17th August 2019

Organized by

Department of Civil Engineering

Gokaraju Rangaraju Institute of Engineering & Technology
Nizampet Road, Bachupally, Kukatpally
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Dr. V Srinivasa Reddy

Dr. V Mallikarjuna Reddy

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Late Sri Gokaraju Rangaraju Garu

Great Visionary and our Guiding Spirit

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Dr Jandhyala N Murthy has done his B.Tech. (Mechanical) from IIT Madras (1970-75), MS (Thermal Power)(1982-84) and PhD (Thermal Power)(1985-88) from Cranfield Institute of Technology, UK. He served in the Maintenance Branch of the Indian Air Force as an AE (M) officer for over 25 years since 1975. He assumed the responsibility as the Director of GRIET since 31 January 2018, after a successful tenure as the Principal of GRIET since March 2004.

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About Department of Civil Engineering

The Department of Civil Engineering is established in the year 2008, with an intake of sixty students which is further increased to 120 students from the academic year 2009. It is a fast growing discipline in tune with the infrastructure growth. The department has Master's programme in Structural Engineering, established in the year 2014 with an intake of eighteen students. The department has well equipped laboratories with an emphasis on practical skills and fundamentals. The Department has experienced and well talented faculty which includes nine doctorates from the field of civil engineering.

About RICEM 2019

National Conference on Recent Innovations in Civil Engineering Materials

RICEM 2019 held during August 17, 2019 in Department of Civil Engineering, Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad, Telangana, India, helps to bring together researchers, academicians and Industrial experts in the field of Civil Engineering to a common forum.

The primary goal of the conference is to promote research and development activities in Engineering and Technology. Secondly, it provides a platform to exchange the knowledge and scientific information amongst researchers, academicians, engineers, students and practitioners.

This conference will be held regularly to make it an ideal workstation for researchers, academicians, engineers and students to share views and research and field experiences on recent innovations in relevant areas of Civil Engineering.

I sincerely thank the participants of the conference for contributing their research findings. Department of Civil Engineering is grateful to the Management of GRIET for motivating us to conduct this conference.

- Convenor

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Inaugural Ceremony:

Er. V. V. Krishna Reddy

CEO, Continental Designers, Hyderabad.

Er. K. Krishna Murthy

Engineering Consultants, Hyderabad.

Valedictory Ceremony:

Er. P Srinivasa Reddy

Chairman, Indian Concrete Institute (ICI), Telangana Centre

KEYNOTE LECTURES

1. Er. V. V. Krishna Reddy, CEO, Continental Designers, Hyderabad.
2. Er. K. Krishna Murthy, Engineering Consultants, Hyderabad.
3. Sri V Sambasiva Rao, Materials Testing Expert, National Accreditation Board for Testing and Calibration Laboratories (NABL)

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Chair of Session 1: Dr. N Sanjeev, Professor of Civil Engineering, GRIET

Chair of Session 2: Dr. S Shrihari, Professor of Civil Engineering, VJIT

RICEM -2019

Programme Schedule

(17-08-2019)

9.30 am -10.00 am	Inauguration Ceremony
10.00 am – 11.15 am	Keynote Lecture 1 by **Er. V. V. Krishna Reddy** **CEO, Continental Designers, Hyderabad.**
11.15 am – 11.30 am	Tea Break
11.30 am – 12.45 pm	Keynote Lecture 2 by **Er. K. Krishna Murthy** **Engineering Consultants, Hyderabad.**
12.45 pm – 1.45 pm	Lunch
1.45 pm – 3.15 pm	Keynote Lecture 3 by **Sri V Sambasiva Rao** **Materials Testing Expert** **National Accreditation Board for Testing and Calibration Laboratories (NABL)**
3.15 pm – 3.30 pm	Tea Break
3.30 pm – 4.30 pm	Paper Presentation (Parallel Sessions) **Chair of Session 1: Dr. N Sanjeev, Professor of Civil Engineering, GRIET** **Chair of Session 2: Dr. S Shrihari, Professor of Civil Engineering, VJIT**
4.30 pm – 5.00 pm	Valedictory address by **Er. P Srinivasa Reddy** **Chairman, Indian Concrete Institute (ICI), Telangana Centre**

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CONTENTS

BACTERIA INCORPORATED CONCRETE

Dr. M V Seshagiri Rao[1], Dr. V Srinivasa Reddy[2], K Satya Sai Trimurty Naidu[3]
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[2]Professor of Civil Engineering, GRIET, Hyderabad, Email: vempada@gmail.com
[3] Executive Engineer, Panchayat Raj, Kandukur, Andhra Pradesh.

The idea of self-healing phenomenon, in repairing cementitious materials itself without human interference, has been proposed and been studying for a longtime. Research on bacteria incorporated concrete, conducted at JNTU Hyderabad; realize the prospective of the bio-inspired self-healing phenomenon as innovative method of crack remediation and also in enhancing durability of concrete. In concrete structures, presence of the micro-cracks will affect its visual appearance and also its strength and durability performance. Methods currently used for crack-remediation often use organic synthetic polymers which are expensive, incompatible and aesthetically unpleasant particularly in repairing historic monuments. Because of these disadvantages of chemical surface treatments, attention has been drawn toward bacteria incorporated concrete, an alternative technique for the improvement of the mechanical and durability properties of concrete.

The pioneering research was conducted on self-healing phenomena in bio-concrete by V Ramakrishnan, Sookie S Bang etal.(2001) at South Dakota School of Mines and Technology, USA. Willem De Muynck, Nele De Belie , Willy Verstraete, Kim Van Tittelboom et al. at Ghent University, Belgium and Henk M. Jonkers et al. at Delft University of Technology, Netherlands has studied extensively on the self-healing capability of bacteria induced cementitious materials. In India, P. Ghosh, S. Mandal, B.D. Chattopadhyay et al. of Jadavpur University, Kolkata ; V Achal, Abhijeet Mukerjee, Rafat Siddique et al. of Thapar University, Patiala, and M V Seshagiri Rao , V Srinivasa Reddy et al. of Jawaharlal Nehru Technological University Hyderabad have done extensive research on the development of high performance self-remediating bacterial concrete.

Researchers around the world started working on the use of specific bacteria in cementitious materials to self-heal and seal cracks without human intervention. Though it is reported that the use of specific alkaliphilic mineral forming bacteria enhances the properties of cement mortar but there exists little understanding of the effect of bacteria on the mechanical and durability properties of concrete.

This paper is aimed to presents the findings of investigations on the properties of self-healing concrete based on microbiologically induced calcite precipitation by Bacillus subtilis JC3. Bacteria integrated self-crack-healing concrete is formed by incorporating Bacillus subtilis JC3 spore suspended nutrient-rich water to the concrete environment during the mixing phase of concrete. When cracks occur, water enters the crack and germinates the dormant bacterial spores into metabolically-active and highly alkaline resistant endospores which will precipitate insoluble white crystalline calcium carbonate minerals. Continual precipitation of bacteria produced minerals seal off the cracks and pores thereby restoring the integrity of the damaged concrete structure. Modifying the structure, distribution and connectivity of pores by biologically deposited calcite crystals have a great influence on the concrete strength and durability. This phenomenon of bacteria producing calcite crystals during its multistep microbial chemical reactions is called ‘Microbiologically Induced Calcium Carbonate Precipitation (MICP)’.

Bacillus subtilis through nitrogen cycle metabolically precipitates calcium carbonate crystals by oxidative de-amination of amino acids (ammonification process). The present work reports the investigations on the effect of bacteriogenic calcinosis on the mechanical and durability properties of bacteria incorporated concrete mixes of compressive strength range between 20 and 80 MPa. The optimum cell concentration of 105cells/ml of mixing water is used in the preparation of bacterial concrete. The incorporation of bacteria Bacillus subtilis JC3 (105 cells per ml) found to increase compressive strength, split tensile strength by 16 to 29%, 14 to 23% respectively and the increase of flexural strength is about 19 to 31% for concretes' of strength range between 20 and 80 MPa. This improvement in strengths are due to mineral deposition within the pores of cement–sand matrix, making the concrete dense by modifying the pore structure which is characterized using scanning electron micrograph (SEM) and x-ray diffraction analyses. The stress values are found to be high in bacteria incorporated concrete grades than conventional concrete grades when compared at the identical strain levels.

Durability studies showed that, the percentage of weight loss and the percentage of strength loss in bacteria incorporated concrete are comparatively less than the conventional concrete when subjected to aggressive chemical attack, sulphate attack test and sea water attack substantiating the better durability performance of bacteria incorporated concrete in aggressive environments. Reduction in chloride permeability values during rapid chloride penetration test indicates that bacteria induced concrete has shown higher resistance against the chloride ion penetration than conventional concrete due to minimum interconnecting voids present. It was established through accelerated corrosion test that bacteria incorporated concrete will have the higher resistance to corrosion than conventional concrete. Water permeability test demonstrate that bacterial concrete was less permeable than conventional concrete due to improved pore structure as a result of precipitation of calcite crystals. Reduction in water permeability of specimens treated with bacteria is nearly 88%, 86%, 75% and 66% in concretes' of strength range between 20 and 80 MPa at 28days age of curing. Water absorption capacity (WAC) of bacteria incorporated concrete specimens is reduced by nearly 50 to 75% for low to high strength concretes as compared with WAC of controlled concrete specimens due to pore plugging with bacteria produced calcite minerals thereby modifying the pore structure of the cement –sand matrix. Porosity of concrete specimens is reduced by nearly 34 - 73% with induction of bacteria into concrete for high to low strength concretes. Volume of permeable voids present in bacteria incorporated concrete is less by 50-65 % than in controlled specimens. The reduction in capillary due to induction of bacteria into concrete specimens is between 9 to 27 % for high to low grades. The water absorption, capillary and porosity characteristics indirectly reflect the durability performance of the bacteria incorporated concrete. Pore structure analysis using BET Nitrogen adsorption test designate that there is significant decrease in total pore volume and average pore diameter of bacteria incorporated concrete. Porosity in bacteria incorporated concretes is reduced by 20 to 60% for low to high strength concretes. Total Pore volume in bacteria incorporated concretes is reduced by 20 to 60% for low to high strength concretes. The resistance to freezing/thawing and drying/wetting of bacteria incorporated concrete is found to be considerably superior to conventional concrete when referred to percentage loss of compressive strength and percentage loss of weight after the exposure. After 28 cycles of freeze-thaw, the compressive strength loss in controlled concrete specimens is in between 8.1 to 46.4% and in bacteria incorporated concrete specimens is in between 4.7 to 17.5 % as the strength of concrete increases from 20 to 80 MPa. Temperature studies on bacteria incorporated concrete specimens exhibited much better resistance to elevated temperatures up to 600 ºC. It is observed that bacteria incorporated specimens performed better than controlled concrete specimens up to 400 ºC but at 600 ºC their performance is inferior to controlled concrete specimens due to decomposition of bacteria precipitated calcite crystals.

In summary, bacteriogenic calcite mineral precipitation using Bacillus subtilis JC3 mechanism can be used effectively in improving the properties of concrete. This positive impact on both strength and durability properties can be attributed to the activity of Bacillus subtilis JC3 in development of dense and refined microstructure of bacteria incorporated concrete. This application of bio-mineralization in concrete can be considered as a best environmental friendly bio-based durable self -crack remediation technique for Indian conditions.

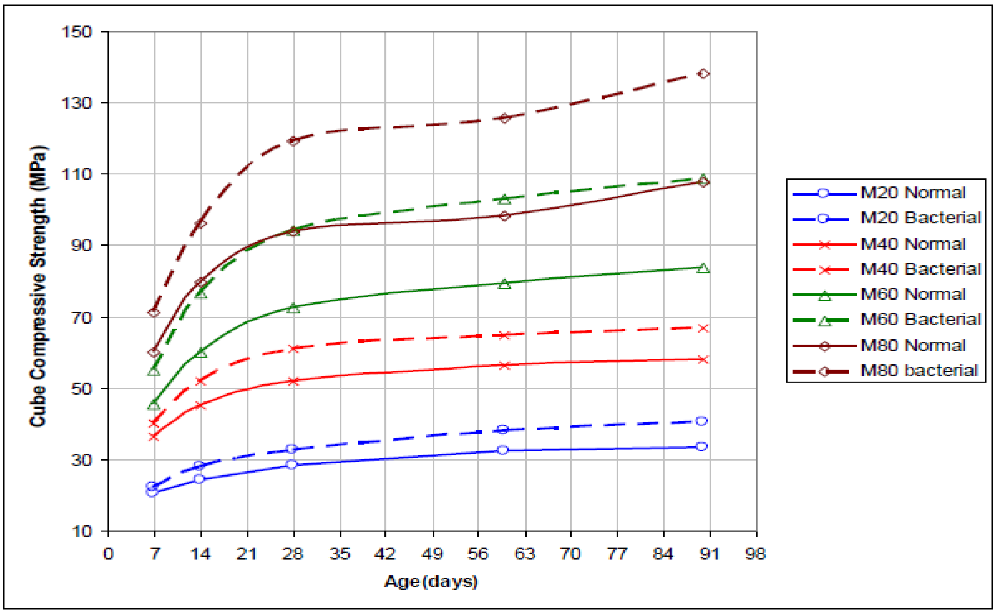

Figure 1: Strength development of a Normal concrete and Bacterial concrete

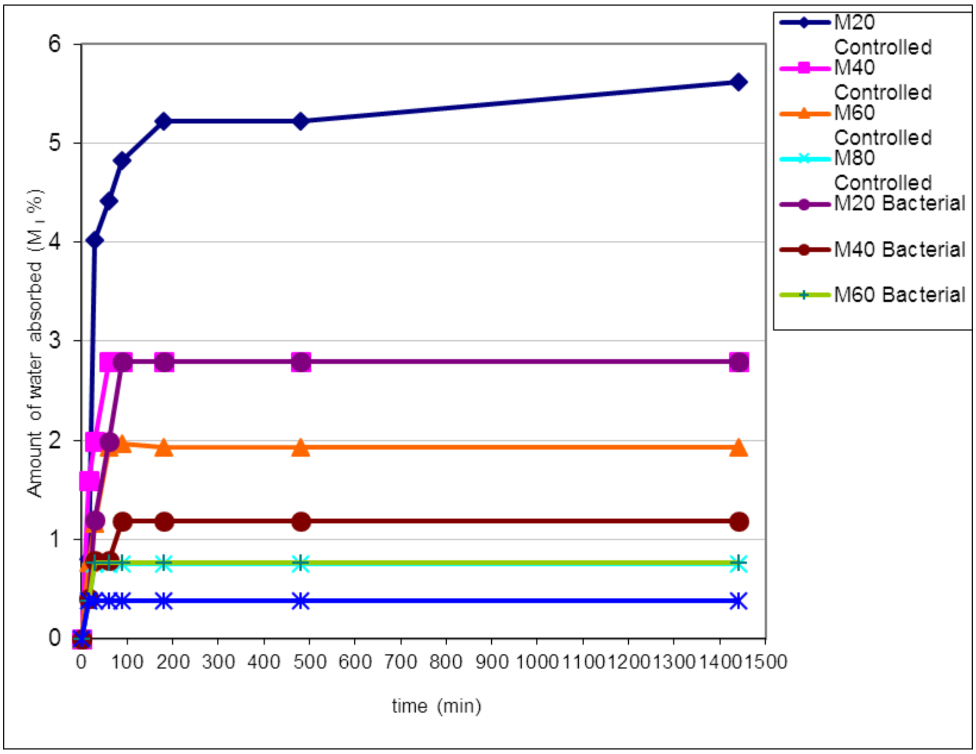

Figure 2: The amount of water absorption with time for different grades of controlled and bacterial specimens

SOIL STRENGTH ENHANCEMENT BY ADDING OF FLY ASH

[1]P.V.V.S.S.R.Krishna, [2]Y. Kamala Raju, [3]Md Gouse Mohiuddin, [4]G Rahul, [5]Ch Usha kiran
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Abstract: Fly ash is an industry development and also freely available so we intend to apply it. This paper deals with the experimental have a look at on development of homes of expansive soil via fly ash replacement. Soil pattern used on this task is an expansive soil that is collected from Bachupally, By engaging in diverse assessments like plastic restriction, liquid limit, free swell index, unconfined compressive test (UCC) and California bearing ratio (CBR) we came to know that the soil sample is weak in shear, bearing and plasticity hence we repeated those experiments by replacing the soil sample with fly ash in various percentages like 10%, 20%, 30% and 40% and came to know that the soil properties are improved at 30% replacement like max dry density increased by 5.5%,plasticity index decreased by 25.4% and CBR value increased by 200%.

***IndexTerms* -** Maximum dry density, Plasticity index, shear, Bearing and Plasticity.

1. INTRODUCTION

Almost 20% of land in India is covered by using expansive soils. With the speedy growth in industrialization and urbanization, land shortage appears to be an imminent hazard. So Construction of civil engineering systems on expansive soils, but, pose a primary danger to the shape in itself, because of the extra diploma of instability in those kinds of soils. Tallied in billions of dollars consistent with yr is the loss in belongings every 12 months globally thanks to the instability inside the expansive soils. On the other hand, disposal of fly ash has turn out to be a developing difficulty. India, as a growing us of a, is exceedingly dependent on coal based thermal power flora for production electricity, and this dependency isn't going to falter every time quickly. Pulverization of coal in these power flowers produces many waste substances, consisting of fly ash. As of 2012, the generation of fly ash rose to one hundred thirty MT/12 months. However, best 56% of this generated fly ash wastes had been simplest applied. The residual fly ash is disposed off in locations, and this poses hazard to health, and also the reduction in land region that can be in any other case applied for functions apart from the disposal of fly ash. The following targets are studied. To determine the Atterberg limits of the clay pattern for exceptional probabilities of fly ash replacements (0%, 10%, 20%, 30%, and forty%), CBR cost of the clay sample for special probabilities of fly ash replacements the use of CBR take a look at, shear power fee of the clay sample through UCC check, swelling of the clay sample by means of free swell index test.

2.LITERATURE REVIEW

Meei-Hoan Ho and Chee-Ming Chan (2010) Soft clays usually show extremely low yield stresses, high compressibility, low power, low permeability and consequently low first-class for construction. Soil stabilization like soil-cement blending may be efficaciously adopted to enhance the electricity and deformation characteristics of the smooth clays. To include a „inexperienced" element within the current stabilization technique, rubber chips derived from waste rubber tyres have been used collectively with cement to stabilized kaolin inside the laboratory, exploring the feasibility of the progressive stabilizer.

Rajesh et al. (2006) talked about experimental investigation of clay beds stabilized with fly ash-lime segments and fly ash segments. An commentary of swelling in clay beds of one hundred mm thickness reinforced with 30 mm diameter fly ash-lime and fly ash segments. There become a full-size decrease in heave in both fly ash-lime and fly ash columns.

Wagh (2006) applied rock flour, lime and fly ash independently, moreover in diverse extent to stabilize the black cotton soil from Nagpur Plateau, India. Rock flour or fly ash, or each together, while delivered to the black cotton soil confirmed an stepped forward value of CBR to a few degree, and there was an growth in attitude of shearing resistance with the reduction in cohesion price.

S.Bhuvaneshwari and S.R. Gandhi (2005) A study changed into finished by means of S.Bhuvaneshwari and S.R. Gandhi at the effect of engineering properties of expansive soil thru an experimental programme. Infrastructure initiatives which includes highways, railways, water reservoirs, reclamation and so on. Requires earth fabric in very big quantity.

Baytar (2005) contemplated the stabilization of expansive soils the usage of desulphogypsum and fly ash obtained from a thermal energy plant by using zero to 30%. A variable percent of lime (zero to 8%) become appended into the expansive soil-desulphogypsum-fly ash mixture. The samples, consequently formed, were treatment for a length of seven days and 28 days. It changed into located that swelling percentage lower, and there was an increase in price of swell with growing percentage of the stabilizer within the combination.

Phanikumar and Sharma (2004): A comparable examine changed into performed with the aid of Phanikumar and Sharma and the impact of Fly Ash on engineering homes of expansive soil through an experimental programme. The effect on parameters like unfastened swell index (FSI), swell potential, swelling pressure, plasticity, compaction, strength and hydraulic conductivity of expansive soil changed into studied.

3.METHODOLOGY

To evaluate the effect of the fly ash as a stabilizing agent in expansive soils a series of tests are conducted, where the content of fly ash in the expansive soil was varied in values of 10% to 40% (multiples of 10) by weight of the total quantity taken. The Indian Standard codes were followed during the conduction of the following experiments:

1. Standard proctor test – IS : 2720 (Part 7) - 1980
2. Unconfined compressive strength (UCS) test – IS : 2720 (Part 10) - 1991
3. California bearing ratio (CBR) test – IS : 2720 (Part 16) - 1987 20
4. Free swell index test – IS 2720 (Part 40) - 1977
5. Liquid & Plastic limit test – IS 2720 (Part 5)

Table 1. Soil properties for various fly ash percentages

PROPERTIES	0% Fly ash	10% Fly ash	20% Fly ash	30% Fly ash	40% Fly ash
Liquid limit (%)	73	69.5	61	59	54
Plastic limit (%)	29	28	26	24.2	17.3
Plasticity index (%)	44	41.5	35	32.8	36.6
Max dry density(g/cc)	1.62	1.662	1.69	1.71	1.675
Optimum moisture content (%)	25.6	22.7	18.4	14.3	12.6
UCC(N/mm^2)	0.197	0.195	0.206	0.176	0.170
CBR (%)	2.53	3.80	5.83	7.61	6.85
Free swell index (%)	100	50	40	20	10

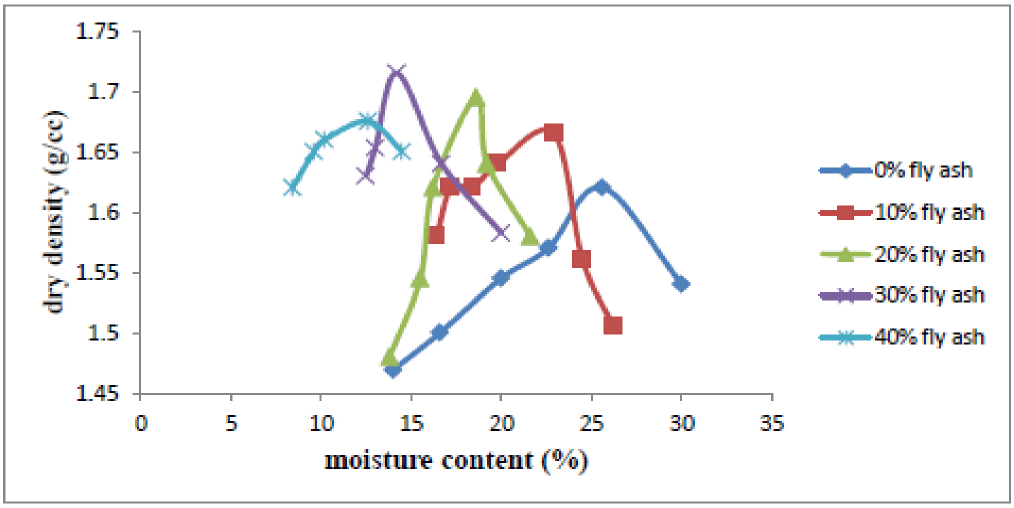

Fig 1 comparison curves of compaction for various fly ash percentages

4. RESULTS AND DISCUSSIONS

From the above graph it is clear that dry density increases up to 30% and then decreases, whereas optimum moisture content goes on decreasing.

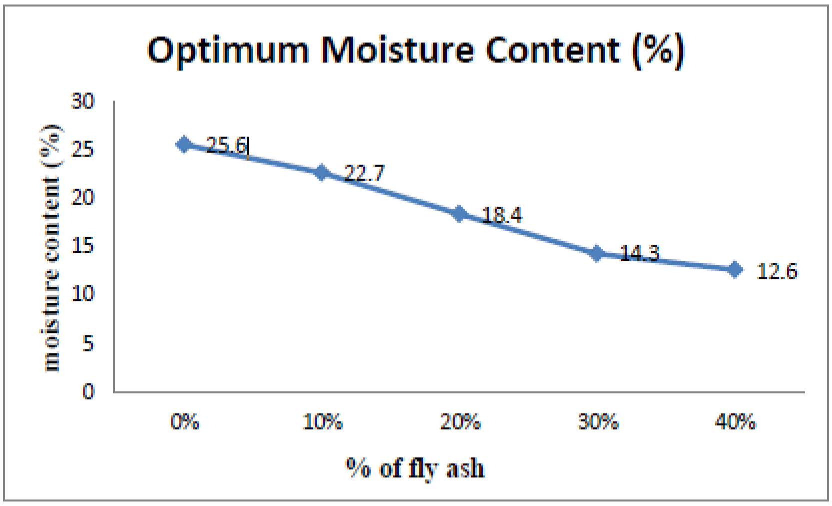

Fig 2 variation of optimum moisture content for increase in fly ash content

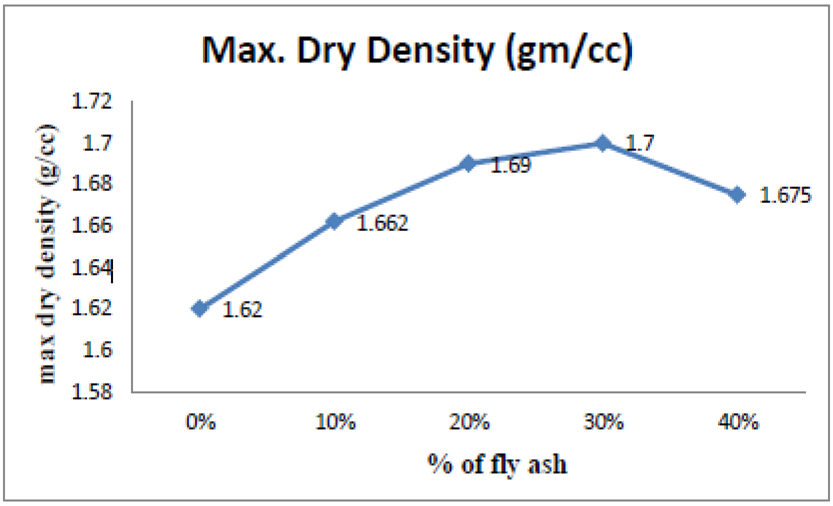

Fig 3 variation of max dry density for increase in fly ash content

From the above graph it is observed that OMC value goes on decreasing upon fly ash replacement and From the above graph it is observed that maximum dry density value is attained at 30% fly ash replacement

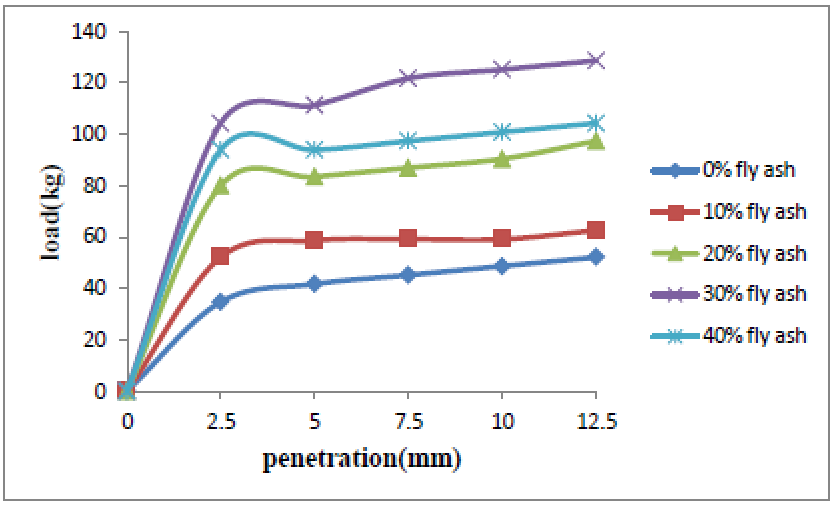

Fig 4 variation of CBR curves for increase in fly ash content

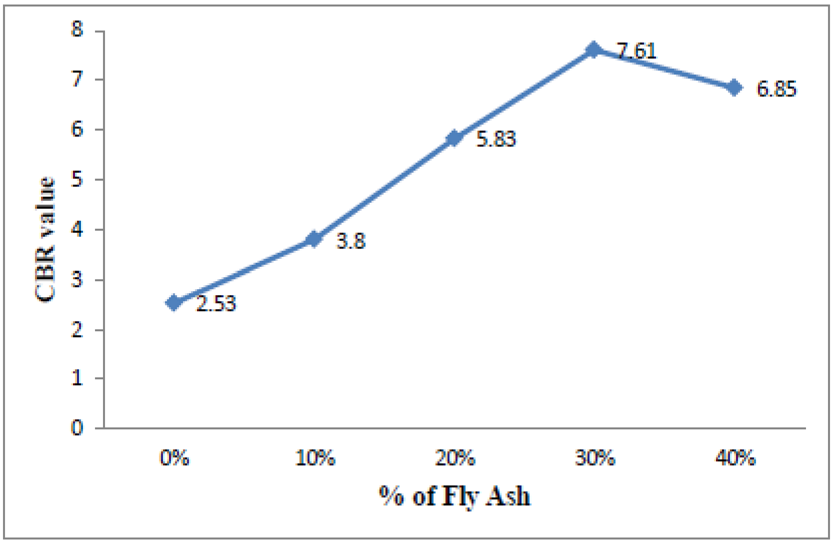

Fig 5 variation of CBR values for increase in fly ash content

From the above it is clear that soil can take greater load up to 30% replacement and From the above graph it is observed that maximum CBR value is attained at 30% fly ash replacement

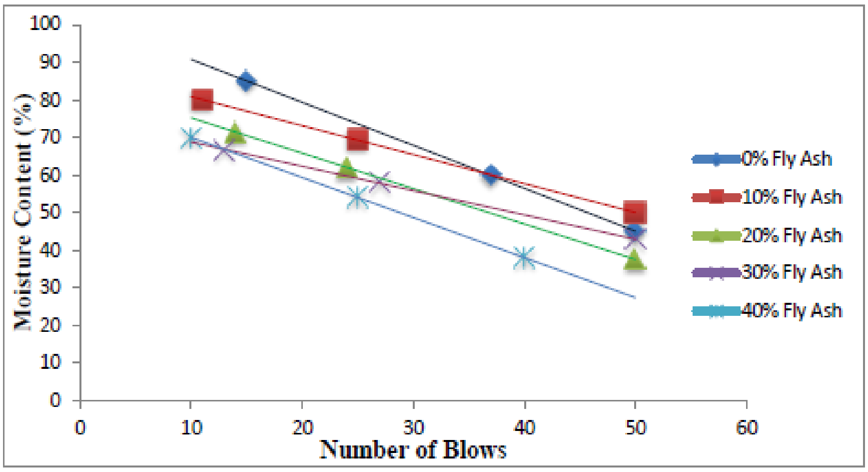

Fig 6 variation of liquid limit curves for increase in fly ash content

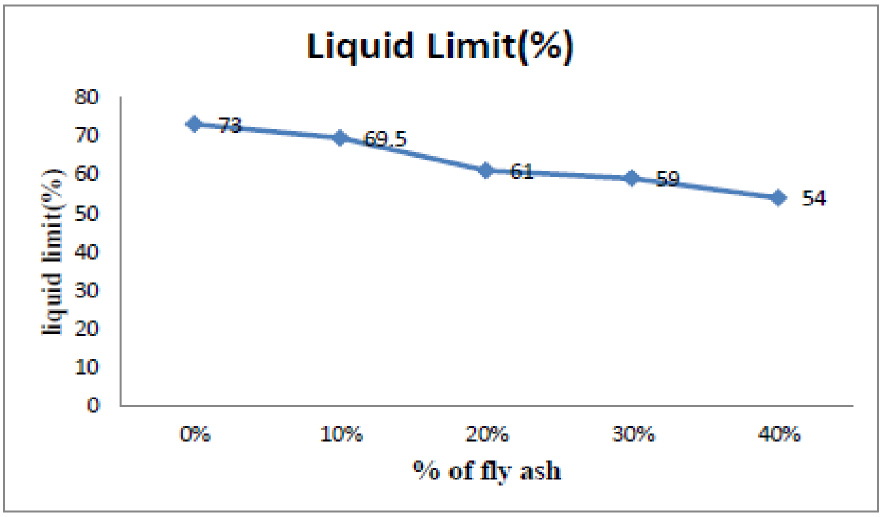

Fig 7 variation of liquid limit values for increase in fly ash content

The above curve shows that liquid limit goes on decreasing upon fly ash replacement and the above graph shows that liquid limit goes on decreasing upon fly ash replacement.

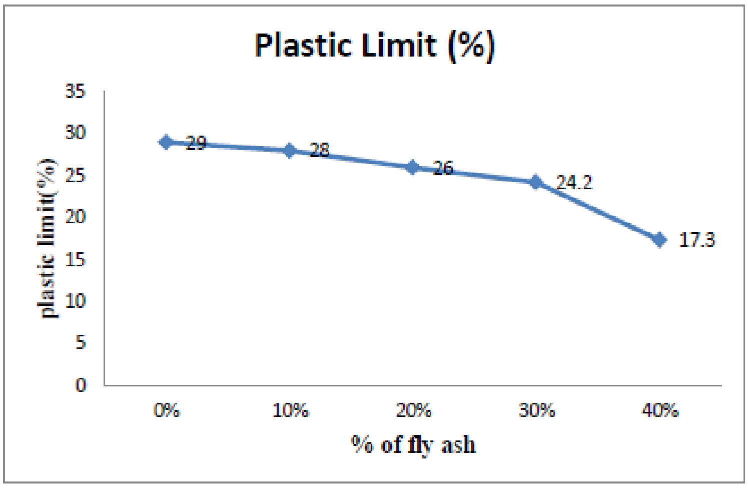

Fig 8 variation of plastic limit for increase in fly ash content

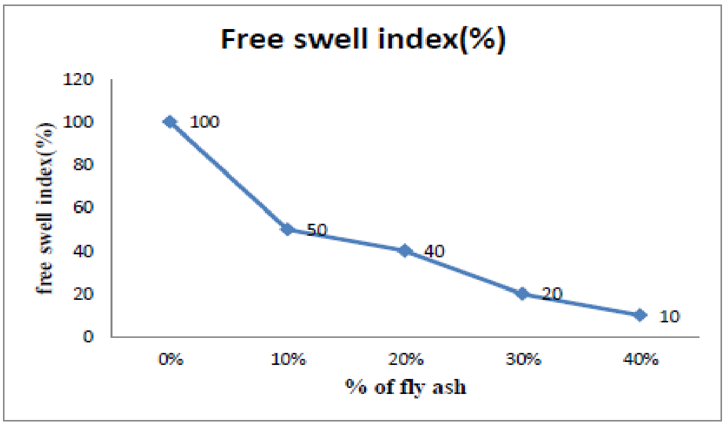

Fig.9 variation of free swell index for increase in fly ash content

The above graph shows that plastic limit goes on decreasing upon fly ash replacement and the above graph shows that FSI goes on decreasing upon fly ash replacement.

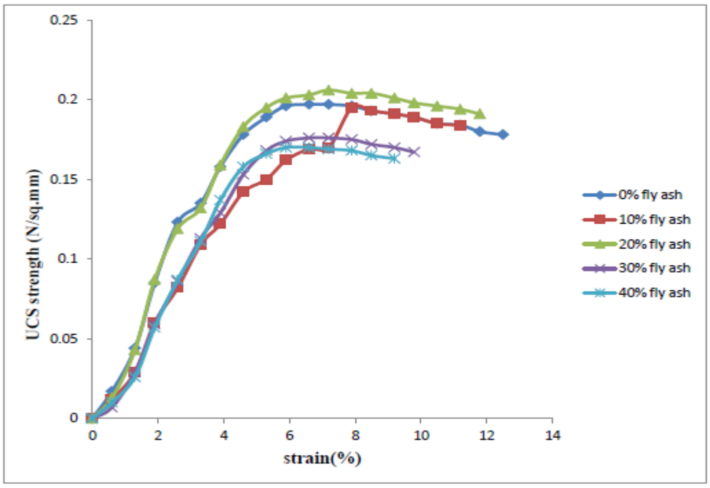

Figure 10 Comparison of UCS test readings in expansive soil, with varying fly ash content

From the above graph it is observed that the peak UCC value is attained at 20% replacement

5. CONCLUSIONS

Based on the results obtained and comparisons made in this paper, the following conclusions can be drawn:

1. By experimental consequences we've got determined that the soil pattern is properly graded clay. The most dry density (MDD) cost of the expansive soil expanded until 30% substitute with fly ash. Then MDD values continuously decreased thereafter. The share of boom of mdd at 30% is 5.Five%.

2. The superior moisture content material (OMC) goes on reducing with growth in fly ash content in soil. It reached the favored value at 30% alternative. The percent of lower in OMC at 30% is 44%.

3. The unconfined compressive energy (UCC) of the soil with variant of fly ash content material decrease to begin with then it reaches the peak price for 20% substitute of soil by fly ash then it diminishes. Within the california bearing ratio (CBR) tests of soil performed with various fly ash content material, the cbr price expanded gradually with the growth in fly ash content material until 30% substitute then it decreased thereafter. The percentage of boom of CBR at 30% is 2 hundred%.

4. The liquid limit and plastic limit of the soil is going on reducing with the increase in fly ash content material. It reached the preferred cost at 30% substitute.

5. The free swell index of the expansive soil decreases swiftly for 10% and 30% replacements. This expansive soil sample can be changed by using fly ash up to 30%.

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EXPERIMENTAL STUDIES ON COIR AND JUTE FIBERS AS REINFORCING MATERIAL IN CONCRETE

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Abstract: Now a day, concrete is that the foremost broadly used in human-made material. The concrete is often recognized by its strength. Because the natural fibers are the effective material to reinforce strength and which can not solely explore a way to improve the properties of concrete. To accomplish this ambition, an investigational study of the compressive strength and flexural strength of concrete composition, Coir fiber reinforced concrete composites (CFRCC) and jute fiber reinforced concrete composites (JFRCC) are conducted. Because the coir and jute are that the regionally accessible natural fiber material. By the being there of coir and jute fiber with additional cement content strengthen the concrete in great scope. Jute, coir and bamboo are examined for their appropriateness for assimilation in cement concrete. The physical properties of those fibers have shown no deterioration during a concrete medium. It is shown that workable and harmonized mixes can be obtained using a special method of proportioning. Whereas compressive and tensile strengths of vegetable fiber concretes are no higher than those of control concrete, their deformation behavior shows improvement in ductility and reduced shrinkage. The impact and fracture toughness of vegetable fiber concretes are also clearly higher. The use of coconut fibers and jute fibers also will lead to higher management of thosee waste fibers. The compressive and flexural strength of concrete with 2% replacement of coir fiber with cement is additional and acquires high value at 0.3% replacement of jute fiber with cement is more.
Index Terms: compressive strength, flexural strength

INTRODUCTION

Concrete reinforcement by natural fibers is a lot of hopeful to indemnify the concrete strength enhancement with non- dangerous impact on environment as well as the effective use of accessible natural possessions. To accomplish this goal, abundant researchers have worn the fiber additionally as yarn terribly effectively as concrete reinforcing material.

Natural fibers are ecological, economical, environmental gracious, and effortlessly accessible. The use of natural fibers during a moderately brittle cement matrix has achieved substantial strength, and toughness of the composite. Natural fiber like coconut fiber has convinced physical and mechanical uniqueness that may be utilized effectively within the development of reinforced concrete material. In most cases, these coconut fibers are deserted as agricultural waste, thus will be simply obtainable in lots of abundance therefore creation them contemptible. The natural jute fiber is the effective material to reinforce concrete strength which will not only discover a way to improve the properties of concrete. It will additionally explore the use of jute and limit the exploitation of polymer which is environmentally detrimental. To resolve the consequence for exploring probable use of jute for obtaining superior concrete with low cost, lacking distressing the surroundings and minimum wellbeing hazard. The primary goal of the project be to conduct experimental studies for improvement of properties of concrete by reinforcing it with coconut and jute fibers.

Objective of Present Investigation:

General

The main objective of the present work was to systematically study the effect of the proportion replacement of cement by coir as 0%, 2%, 4% and 6% respectively and jute fiber as 0%, 0.1%, 0.2%and 0.3% on the strength properties of concrete. The study was carried out on M25 grade concrete with 0.45 water cement ratio. Cubes of standard size 150mm*150mm*150mm (length * breadth * depth) were cast and tested for 7, 14 and 28 days compressive strength. Standard cylinders of size 150mm*150mm*700mm (length * breadth* depth) were cast and tested for 7, 14 and 28 days for flexural strength.

To study the strength characteristics in terms of compressive and flexural strengths, a total of 4 mixes were tried with different percentages of coir and jute fiber. The relative proportions of cement, coarse aggregates, sand and water are obtained by IS – code method. M25 is considered as the reference mix.

Objectives

The specific objectives of the present investigations are as listed below:

1. To evaluate the workability characteristics in terms of compaction slump cone test for M25 grade concrete with different proportions of coir and jute fibers.
2. To evaluate the compressive strength at 7, 14 and 28 days for M25 grade concrete with all the different proportions of coir and jute fibers.
3. To evaluate the flexural strength at 7, 14 and 28 days of M25 grade concrete with all different proportions of coir and jute fibers

LITERATURE REVIEW

1. Kshitija Nadgouda (coir fiber reinforced concrete, january 2015).Reinforcement of concrete is important to enhance its engineering properties. For this study, coconut fibers were used as they're freely offered in massive quantities. The study includes a comparative statement of properties of coconut fiber reinforced concrete with standard concrete supported experiments performed within the laboratory. The use of coconut fibers will also lead to better management of these waste fibers. The addition of coconut fibers improved the flexural strength of concrete by about 12%; they also formed good bonding in the concrete. The study found the optimum fiber content to be 3% (by weight of cement). Further work is required by changing the fiber content and aspect ratio to determine the optimum range of fiber content so that fiber reinforced concrete can be used where high flexural strength is required.
2. Pooja Warke, Shrinkhala Dewangan (Evaluating the performance of jute fiber in concrete, june 2016).The objective of these studies to investigate the properties of concrete by the victimization of jute fiber. A distinct share of jute fiber is used in concrete as 0.2%, 0.3%, 0.4% volume of concrete and analyzes the property of concrete. The compressive test was carried out at concrete ages of 7 and 28 days. As the different proportion of the jute fiber is mixed with concrete and solid cube. The final strength of the cube was casted for 7 days and 28 days curing. The Compressive testing machine is used for testing the compressive strength of the concrete cube. Improving the strength of the structure using

Jute fiber as the raw material in construction .Jute fiber is 100% bio-degradable and recycled and so environmentally friendly with moisture content of 12.6%.Using jute fiber as a natural fiber in concrete .Jute fiber will increases the property of concrete like compressive strength and bending strength, greater resistance to cracking and therefore improved impact strength and toughness. For this purpose, M20 grade concrete was chosen. In concrete use of jute fiber during an appropriate combination might potentially not only improve the overall property of concrete, but may also result in performance synergy.

3. Saandeepa Nivajje, dr. N.R.Krishna Murthy (November 2013), The current manuscript deals with the subject of the addition of natural fibers to concrete to review the strength properties and additionally to look at if there is a reduction in propagation of shrinkage crack problems. Basically natural fibers are of two types. Natural inorganic fibers like Basalt, Asbestos…etc and also the different are the natural organic fibers like coconut, palm, kenaf, jute, sisal, banana, pine, sugarcane, bamboo…etc. The natural fibers are investigated by completely different researchers as construction materials which will be utilized in cement paste/mortar/concrete. This study may include the fiber properties, characteristics and compatibility between themselves and additionally the comparisons and conclusion to be studied for various fiber-cement proportions. But all properties of concrete might not improve for similar proportions of various fibers. Some properties are also improved and the same is also reduced, since each fiber has its own completely different properties. Totally the study deals with comparisons and variations between the various natural fibers.

METHODOLOGY

Experimental investigation was planned to provide sufficient information about the strength characteristics of Coir fiber reinforced concrete and jute fiber reinforced concrete without using any admixtures and comparing the performance of both types of concrete with conventional concrete. Tests were conducted on materials to know their physical properties. Also tests were performed on Coir fiber reinforced concrete and jute fiber reinforced concrete to study its workability. Results were analyzed to derive useful conclusions regarding the strength characteristics of crusher dust concrete. M25 concrete has been used as reference mix.

MATERIALS USED

A. Cement

Cement is a binder, a substance used in construction that sets, hardens and adheres to alternative materials, binding them along. Cement is seldom used exclusively; however it is used to bind sand and gravel (aggregate) along. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete. Cements used in construction are usually inorganic; often lime or calcium silicate based, and can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to set in the presence of water (see hydraulic and non-hydraulic lime plaster). Non-hydraulic cement will not set in wet conditions or underwater; rather, it sets because it dries and reacts with carbon dioxide within the air. It is resistant to attack by chemicals after setting. Hydraulic cements (e.g., Portland cement) set and become adhesive because of a chemical reaction between the dry ingredients and water. The chemical reaction results in mineral hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack. The chemical process for hydraulic cement found by ancient Romans used volcanic ash (pozzolanic) with added lime (calcium oxide).(OPC 53 GRADE)(IS 8112-1989).

Weight of sample taken = 1000gms

TABLE-1 Physical properties of Cement

S.NO.	PROPERTY	VALUE
1	Fineness of cement	1.56%
2	Specific Gravity	2.86
3	Normal consistency	32%
4	Setting time Initial setting time Final setting time	 50 min 560 min

B. Natural Coarse Aggregate

Coarse aggregates are particles are larger than 4.75mm, however typically vary between 9.5mm to 37.5mm in diameter. They can either be from Primary, Secondary or Recycled sources. Primary, or 'virgin', aggregates are either Land- or Marine-Won. Gravel may be a coarse marine-won aggregate; land-won coarse aggregates include gravel and crushed rock. Gravels represent the bulk of coarse aggregate utilized in concrete with crushed stone creating up most of the rest. Secondary aggregates are materials which are the by-products of extractive operations and are derived from an awfully wide selection of materials.

TABLE-2 Classification of Coarse Aggregates

Coarse Aggregate	Size
Fine Gravel	4 mm - 8 mm
Medium Gravel	8 mm - 16 mm
Coarse Gravel	16 mm - 64 mm
Cobbles	64 mm - 256 mm
Boulders	>256 mm

TABLE-3 Physical Properties of Coarse Aggregates

(IS 383, IS 2386 PART III & IV)

S. No	Property	Value
1	Specific gravity	2.92
2	Fineness modulus	5.35
3	Water absorption	9%

C. Fine Aggregate

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. As with coarse aggregates these can be from Primary, Secondary or Recycled sources. When the aggregate is sieved through 4.75mm sieve, the aggregate passed through it called as fine aggregate. Natural sand is generally used as fine aggregate; silt and clay are also come under this category. The soft deposit consisting of sand, silt and clay is termed as loam. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

TABLE-4 Classification of Fine Aggregates

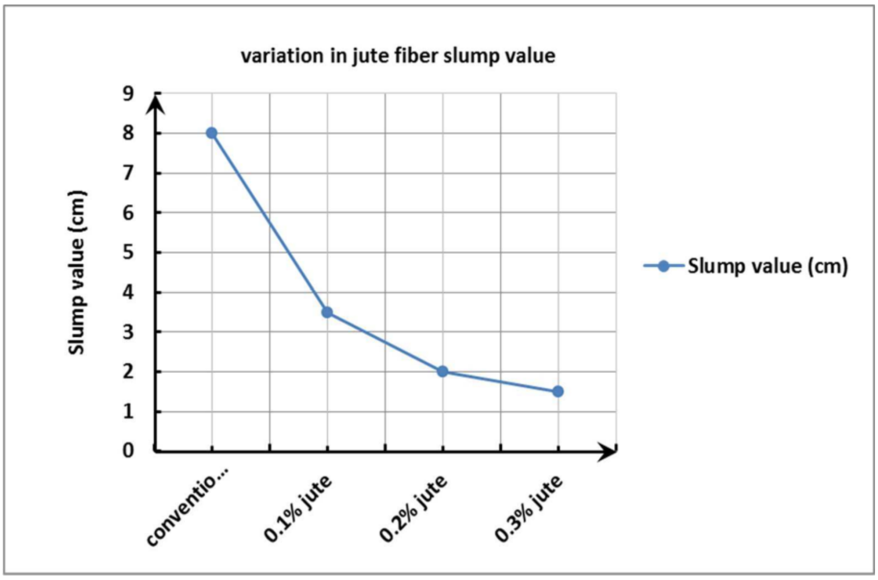
Fine Aggregate	Size
Coarse Sand	2.0 mm - 0.5 mm
Medium Sand	0.5 mm - 0.25 mm
Fine sand	0.25 mm - 0.06 mm
Silt	0.06 mm - 0.002 mm
Clay	< 0.002 mm

TABLE-5 Physical Properties of Fine Aggregates

According to IS 383-1970 this sand confirms to Zone – III

S. No	Property	Value
1	Grading of sand	Zone III as per IS 383
2	Fineness modulus	2.65%

3	Specific gravity	2.47



TEST RESULTS

Workability

The workability of concrete with different proportions of Conventional mix, coir mix and jute mix is determined by slump cone test.

TABLE-6 Slump cone value of M25 grade concrete with different proportions of coir fiber

S.No	Mix	Slump
1	0% coir fiber	8
2	2% coir fiber	2.5
3	4% coir fiber	0
4	6% coir fiber	0

TABLE-7 Slump cone value of M25 grade concrete with different proportions of jute fiber

S.No	Mix	Slump
1	0% jute fiber	8
2	0.1% jute fiber	3.5
3	0.2% jute fiber	2
4	0.3% jute fiber	1.5

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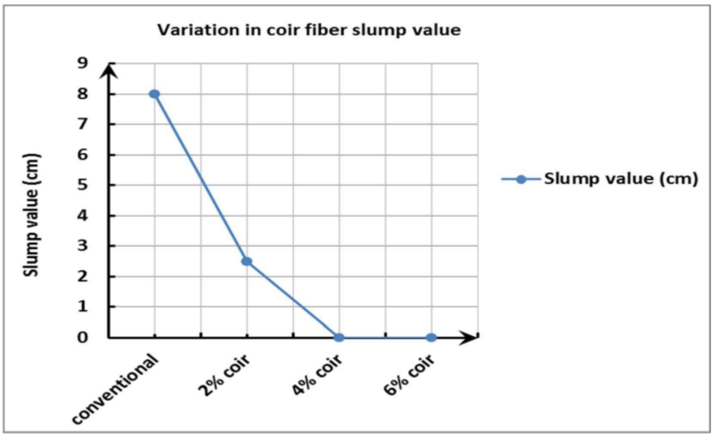


Fig.2 Variation of slump with % of jute mix for M25 grade concrete.

DESTRUCTIVE TESTING

TABLE-8 Values of compressive strength of M25 grade concrete with different proportions of coir fiber.

S.No	Days of test	Conventional cement concrete	2% Coir fiber cement concrete	4% Coir fiber cement concrete	6% Coir fiber cement concrete
1	7 Days	19	20.35	12.6	8.95
2	14 Days	26.3	28.24	14.7	10.9
3	28 Days	29.4	31.46	20.4	11.7

Fig.3 Variation of compressive strength of M25 grade concrete with different proportions of % of coir fiber.

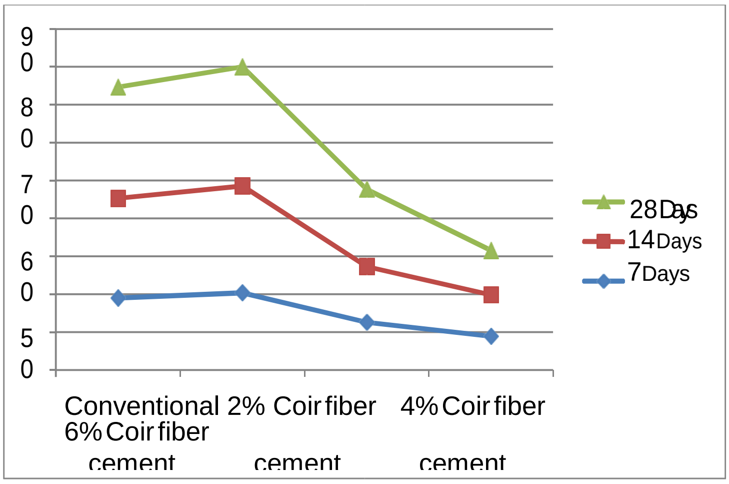
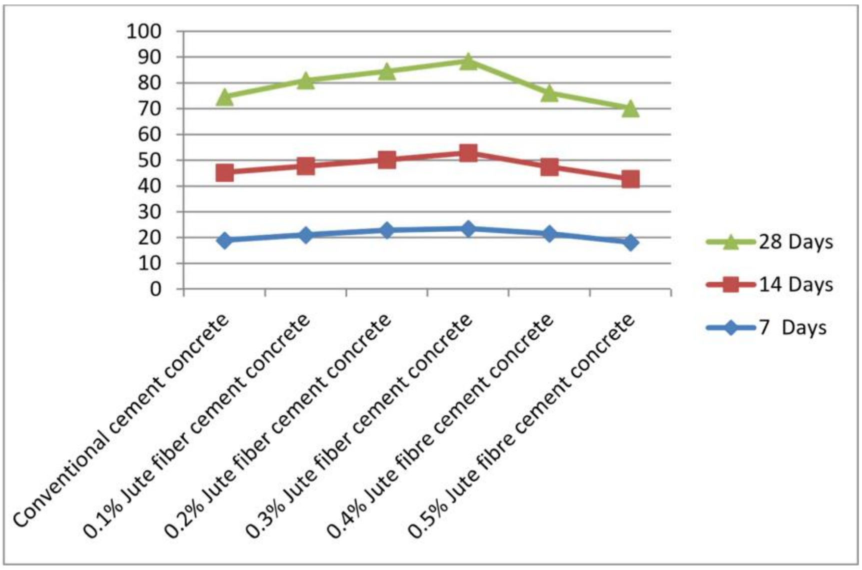


Fig.4 Variation of compressive strength of M25 grade concrete with different proportions of % of jute fiber



FLEXURAL STRENGTH

TABLE-9 Values of flexural strength of M25 grade concrete with different proportions of coir fiber.

S.no	Days of test	Conventional cement concrete	2% Coir fiber cement concrete	4% Coir fiber cement concrete	6% Coir fiber cement concrete
1	7 Days	7.1	7.8	7.69	7.42
2	14 Days	7.67	8.1	7.92	7.73
3	28 Days	8.83	9.53	9.21	8.92

Fig.4 Variation of flexural strength of M25 grade concrete with different proportions of % of coir fiber.

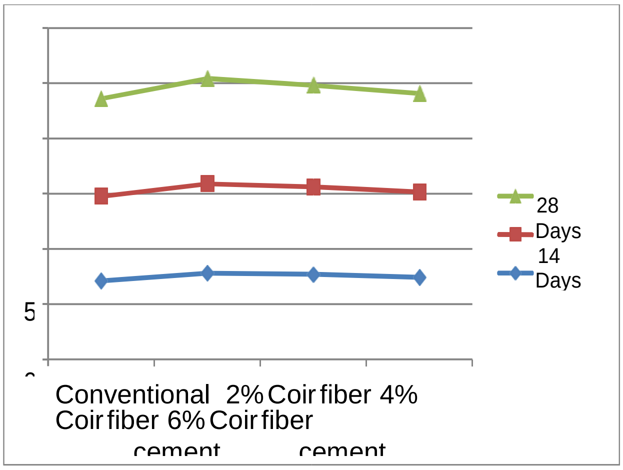
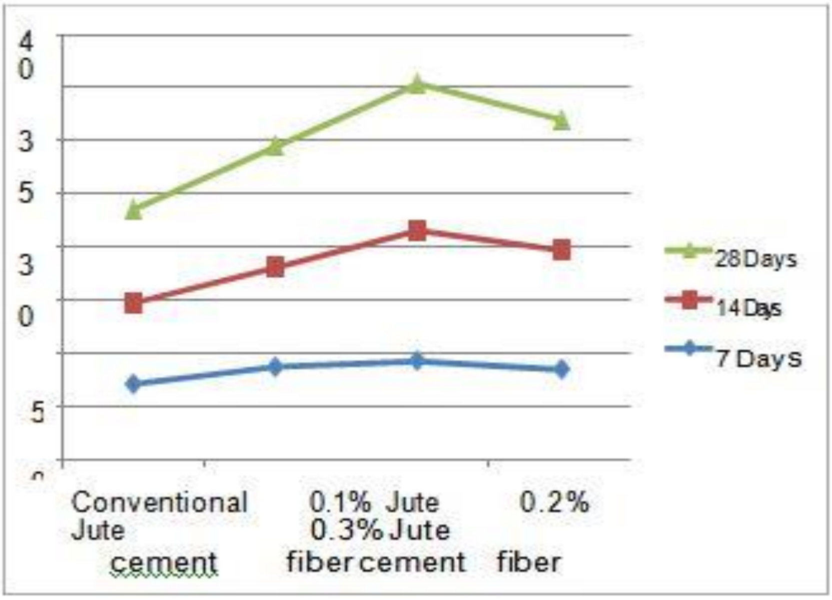


TABLE-10 Values of flexural strength of M25 grade concrete with different proportions of jute fiber.

S.no	Days of test	Conventional cement concrete	0.1% Jute fiber cement concrete	0.2% Jute fiber cement concrete	0.3% Jute fiber cement concrete
1	7 Days	7.1	8.7	9.2	8.42
2	14 Days	7.67	9.41	12.4	11.3
3	28 Days	8.83	11.4	13.8	12.3

Fig.5 Variation of flexural strength of M25 grade concrete with different proportions of % of jute fiber.



CONCLUSIONS

The following conclusions are drawn from the results considering the workability, strength characteristics of concrete made with the replacement of cement with certain percentages of coir and jute fiber in different proportions for M25 grade.

1. Coir and jute fibers are the good partial replacement materials for cement and give more strength depending upon the percentage replacement which helps in maintaining the environment as well as economical balance.
2. From various tests conducted, it can be concluded that the properties of coir and jute fiber concrete gives a better result when compared to nominal mix concrete and also considered as cost efficiency material when compared to the cost of cement.
3. The workability of concrete measured from slump cone decreased as the percentage replacement of coir and jute fibers with cement.
4. Increase in strength is observed for all % replacement of natural sand by crusher dust at all stages.
5. The compressive and flexural strength of concrete with 2% replacement of coir fiber with cement is maximum.
6. The compressive and flexural strength acquires high value at 0.3% replacement of jute fiber with cement is maximum.

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COMPARATIVE BEHAVIORAL STUDY ON PUMICE LIGHTWEIGHT SELF-COMPACTING CONCRETE AND LECA LIGHTWEIGHT SELF COMPACTING CONCRETE

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Abstract: - Lightweight self-compacting concrete (LWSCC) is an advanced concrete that combines the advantages of both lightweight concrete (LWC) and self-compacting concrete (SCC). This concrete provides an excellent solution to decreasing the self-weight of a structure while making pouring easier and removing the construction challenges and complications. LWSCCs were designed using lightweight aggregate (LWA), which replaced coarse aggregates at certain percentages. Two types of LWA used in this study are Light expanded clay aggregate (LECA) and pumice. The grades of the concrete investigated are M20, M30 and M40 with partial replacements of coarse aggregate with LECA and pumice of 10%, 20% and 30%. This paper investigates the comparative behavioral study between Fresh, Hardened, Mechanical properties of light weight self-compacting concrete produced with expanded clay aggregates (LECA) and light weight self-compacting concrete produced with pumice aggregate. The influence of different proportions of replacements is analyzed. Promising results were obtained with obtained flexural strengths split tensile strengths and compressive strengths, varying between 14-32MPa for density range 1500-1800kg/m3.

Index Terms: Lightweight self-compacting concrete (LWSCC), Pumice lightweight aggregate, Light expanded clay aggregate (LECA) Compressive strength, and VMA

I. INTRODUCTION: Light expanded clay aggregate (LECA) is produced in a rotary kiln at the temperature of about 1200OC. LECA consists of small, lightweight, bloated particles of burnt clay. It is a universally accessible and an environment-friendly, entirely natural product with a low cost and high porosity. LECA is a special type of clay pelletized and fired in a rotary kiln at a very high temperature (with grains size 4–10 mm). In this study, LECA was provided from GBC INDIA, Gujarat, India. In Portugal, lightweight expanded clay aggregates (LECA) are typically used in the production of vibrant compressor lightweight concrete, which presently represents 10% of the total volume of vibrant-compressor concrete produced in Portuguese factories. The use of LECA aggregates has increased since it was introduced in 1990's, after the acquisition of the Portuguese factory by the industrial word leader of LECA production. Lightweight concrete expanded clay aggregates exhibit particular properties: favorable thermal and acoustic behavior provided by the volume of voids, although with low mechanical strength. For structural use, it is normal to incorporate ordinary aggregates in the concrete mix to achieve adequate mechanical strength. With the increasing use of lightweight concrete with expanded clay aggregates in precast products for construction, there is a need for a better understanding of for the properties of these concretes in order to more effectively design and optimize the characteristics of these products.

Pumice:

Light weight aggregate concrete (LWAC) has been used successfully for structural purposes for many years, because of their improved properties such as the workability, strength, less dead load and resistance to freezing and thawing of light weight concrete [V. Khonsari and et.al 2010]

The use of light weight aggregates concrete in structures offers many advantages over the conventional normal weight concrete, including an increased strength weight ratio and improved thermal and sound insulation and fire resistances properties [K.Dhir and et.al,1984].

In concrete construction field, the concrete represents a very large proportion of the total load on the structure and there are clearly considerable advantages in reducing its density. One of the ways to reduce the weight of a structure is the use of light weight aggregate concrete [Mouli and Khelali 2008].

II.MATERIALS AND ITS PROPERTIES

This section gives the details of the characteristics of the different materials used in this experimental investigation.

i. Cement

Cement is used as a binding material. In this experimental investigation, Ordinary Portland Cement of Grade 53 is used. The cement is found to be conforming to various specifications of IS 12269-1987. The physical properties of cement are tested, and the results are tabulated in Table I as per IS 4031-1998.

TABLE I.
PHYSICAL PROPERTIES OF CEMENT

Test	Result
Specific gravity	3.10
Standard consistency	34%
Initial setting time	45 min
Final setting time	580 min
Bulk density	1440 kg/ m^3
Fineness of cement	2.37 %

ii. Aggregates

Aggregates are sluggish granular materials such as fine aggregate, gravel, or crushed stone that are mixed along with water and Portland cement to make concrete. They are essential ingredients in making concrete.

iii. Coarse aggregate

In present experimental work coarse aggregate passing through 12mm IS sieve and retaining on 10mm IS sieve is used. Certain care is taken while choosing coarse aggregate and it is seen that it is free from impurities. Characteristic Tests are conducted to find out the properties of the coarse aggregate and are tabulated in Table II.

iv. Coarse aggregate (pumice)

Pumice Lightweight aggregate (PLA) is used as the lightweight aggregate which of size 8 to 12mm. PUMICE is free from impurities. Characteristic tests are also performed on PUMICE and the results are presented in Table II.

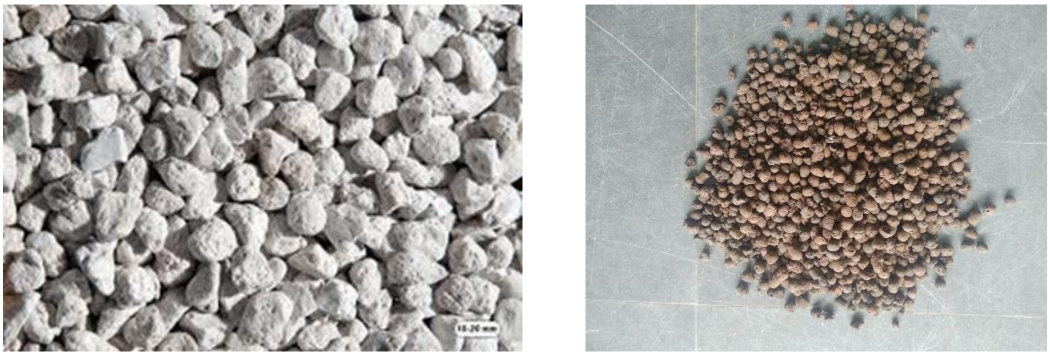

Figure 1. Pumice LECA Lightweight aggregate

TABLE II.
PHYSICAL PROPERTIES OF COARSE AGGREGATE

Property	Coarse aggregate	Pumice
Fineness modulus	6.41	5.84
Specific gravity	2.43	1.04
Bulk density	1420 kg/ m^3	410 kg/ m^3
Water absorption	0.6 %	30 %

iv. Fine aggregate

Fine aggregate used in this experimental work is locally available river sand, care is taken to see that the sand is free from impurities, waste stones and to remain clean. Sand used is confirming to the requirements of IS: 383-1970. Characteristic tests are conducted on fine aggregate and the properties of fine aggregate are tabulated in Table III.

TABLE III.
PHYSICAL PROPERTIES OF FINE AGGREGATE

Test	Result
Fineness modulus	2.83
Specific gravity	2.59
Bulk density	1570 kg/ m3
Water absorption	1%

v. Chemical Admixture

In the present study, CONPLAST SP 430 is used. It is used to improve the workability of the concrete and also especially formulated to give high water reductions up to 25% without loss of workability and reduce permeability to give excellent concrete.

vii. Water

Water is the most important ingredient of concrete which helps to bind the cement content and aggregates. Clean potable water is used for concrete mixes.

III. EXPERIMENTAL INVESTIGATIONS

Mix Design

In the present study, the mix design of the Pumice Lightweight aggregate concrete (PLAC) was done using the rational mix design method. The Pumice lightweight aggregate is replaced in place of coarse aggregate in concrete by replacing 10%,20%,30%&40% of Normal Weight Aggregate in volume fractions. The chemical admixture i.e. SP 430 is used in order to improve workability.

Casting of specimen

The fresh concrete was casted using different percentages i.e.10%,20%,30% & 40%. For each mixture, cube cylinder and prism specimens of size 150x150x150mm, 150x300mm and 100x100x500mm were cast individually. The composition of LWC mixtures is represented in Table IV.

Figure 2. Casting of cube specimens

Curing of specimens

All the casted concrete specimens were cured by placing the specimens in the curing tank containing water for a period of 28 days. The LECA was also cured using vacuum curing method by placing it in a vacuum chamber for 24 hours and then it is used in the casting of LWC.

Figure 3 Curing of cube specimens

Compressive Strength

Cubes of size 150x150x150mm were cast and allowed for curing in curing chamber for 28 days and 56 days and tested in Automatic compression testing machine of 2000KN-capacity.

Figure 4. Compressive strength test and Split tensile test of PUMICE lightweight aggregate concrete cube and cylindrical specimen respectively with Automatic compression testing machine of 2000kN capacity

TABLE - IV
Mix proportions of NWSCC

Type of mix	Mix proportions	QUANTITIES kg/m^3					
		Cement	Flyash	Fine aggregate	Coarse aggregate	Water	SP
NWSCC-M20	1:1.2:3.4:2.6:0.9:0.021	258	310	900	685	240	5.67
NWSCC-M30	1:0.8:2.5:1.9:0.5:0.022	360	300	900	700	180	8.05
NWSCC-M40	1:0.7:1.8:1.4:0.51:0.026	468	350	885	700	240	12.2
NWSCC-M60	1:0.4:1.2:1.1:0.39:0.013	660	310	850	730	260	9.02

TABLE IV.
Replacement of coarse aggregate in kg/m^3

Type of mix	Coarse Aggregate Replacement kg/m^3							
	Gravel 90%	LECA 10%	Gravel 80%	LECA 20%	Gravel 70%	LECA 30%	Gravel 60%	LECA 40%
LWSCC-M20	614.5	22.7	546.2	45.5	477.9	68.2	409.6	91.0
LWSCC-M30	629.8	23.3	559.8	46.6	489.8	69.9	419.8	93.3
LWSCC-M40	629.8	23.3	559.8	46.6	489.8	69.9	419.8	93.3
LWSCC-M60	656.1	24.3	583.2	48.6	510.3	72.9	437.4	97.2

TABLE VI.
Hardened Properties of NWSCC and LWSCC produced with pumice at 7days& 28 days

S.No.	Grade of concrete	Designation	Cube Compressive		Prism flexural strength Mpa		Cylinder split tensile strength	
			7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
1	20	NSCC	18.3	27.2	3.67	5.10	4.3	6.25
2		10%	18.05	27.10	3.61	5.06	4.13	6.07
3		20%	17.90	26.50	3.50	4.95	4.01	5.90
4		30%	15.10	21.6	2.80	3.17	3.28	5.10
5		40%	14.7	20.6	2.20	2.98	3.12	4.85
6	30	NSCC	23.95	38.90	3.9	6.1	6.55	8.37
7		10%	23.35	37.85	3.85	5.98	6.40	8.11
8		20%	23.05	35.67	3.60	5.80	6.25	7.96
9		30%	21.25	30.18	3.10	5.20	5.92	7.41
10		40%	19.35	28.37	3.01	4.97	5.61	7.17
11	40	NSCC	27.55	50.8	4.65	7.1	7.45	9.65
12		10%	27.40	49.50	4.61	7.02	7.22	9.39
13		20%	26.97	46.13	4.25	6.91	7.03	9.12
14		30%	23.72	40.28	4.07	6.38	6.81	8.91
15		40%	23.16	38.63	4.72	3.89	6.34	8.73

TABLE- VII
Densities and compressive strength of NWSCC AND LWSCC

Type of mixes	Grade of Concrete	Coarse Aggregate %		Average Densities kg/m^3	Compressive strength MPa	
		Gravel %	LECA %		7-Days	28-Days
NWSCC	M20	100	-	2430	21.8	27.0
	M30	100	-	2450	24.7	38.8
	M40	100	-	2440	33.5	51.5
	M60	100	-	2460	46.9	68.8
LWSCC	M20	90	10	2303	13.3	21.3
	M20	80	20	2200	13.4	20.5
	M20	70	30	2076	12.6	20.4
	M20	60	40	1975	11.4	20.2
	M30	90	10	2313	24.6	37.3
	M30	80	20	2218	22.9	35.3
	M30	70	30	2086	18.9	33
	M30	60	40	1991	13	24.3
	M40	90	10	2286	31.9	49.1
	M40	80	20	2193	25.2	40.1
	M40	70	30	2083	25.1	37.8
	M40	60	40	1940	23.4	34.8

TABLE- VIII

Grade of concrete	Fresh Properties			Remarks	Designation
	Slump flowT50cm Test Sec	V-Funnel Test Sec	L-Box Test H2/H1		
20	4.05	6.89	0.88	RS	NSCC
	3.89	7.02	0.983	RS	10%
	3.96	7.05	0.9	RS	20%
	4.07	7.23	0.86	RS	30%
	4.12	7.48	0.79	RNS	40%
30	2.23	6.17	0.9	RNS	NSCC
	2.78	8.23	0.78	RNS	10%
	2.7	6.76	0.94	RS	20%
	3.2	7.58	0.915	RS	30%
	3.78	8.27	0.97	RS	40%
40	3.59	7.53	0.956	RS	NSCC
	3.56	7.12	0.92	RS	10%
	3.98	7.98	0.88	RS	20%
	3.03	8.01	1	RS	30%
	3.42	8.64	0.79	RNS	40%

Fresh and hardened properties of NWSCC and LWSCC

TABLE IX.
Fresh and Hardened Properties of NWSCC and LWSCC

Type of mixes	Grade of Concrete	Coarse Aggregate %		Fresh properties			Hardened properties	
		Gravel %	LECA %	T_{50} cm (2-5) sec	V-Funnel (6-12) sec	L-box (H_2/H_1) mm	7 days (MPa)	28 days (MPa)
NWSCC	M20	100	-	4	7	0.85	21.85	27.0
	M30	100	-	5	8	1	24.7	38.8
	M40	100	-	4	11	9.2	33.5	51.5
	M60	100	-	3.9	10	8.9	46.9	68.8
LWSCC	M20	90	10	4.2	9	1	13.3	21.3
	M20	80	20	4.2	11	0.92	13.4	20.5
	M20	70	30	4.4	8	0.92	12.6	20.4
	M20	60	40	4.1	12	0.89	11.46	20.2
	M30	90	10	4.2	11	0.95	24.6	37.3
	M30	80	20	4.1	11.5	0.93	22.9	35.5
	M30	70	30	4	12	0.92	18.9	33.0
	M30	60	40	4.3	9	0.91	13.0	24.3
	M40	90	10	3.4	9	1	31.9	49.1
	M40	80	20	3.9	10.2	0.89	25.2	40.1
	M40	70	30	4.3	9	0.89	25.1	37.8
	M40	60	40	4.7	11.2	1	23.4	34.8

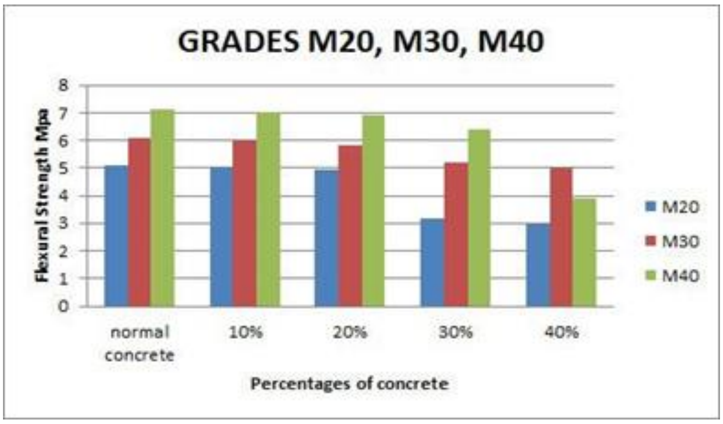

Figure 5. Variation of Flexural strength for NWSCC&LWSCC at different grades (M20, M30, M40) at the age of 28 days.

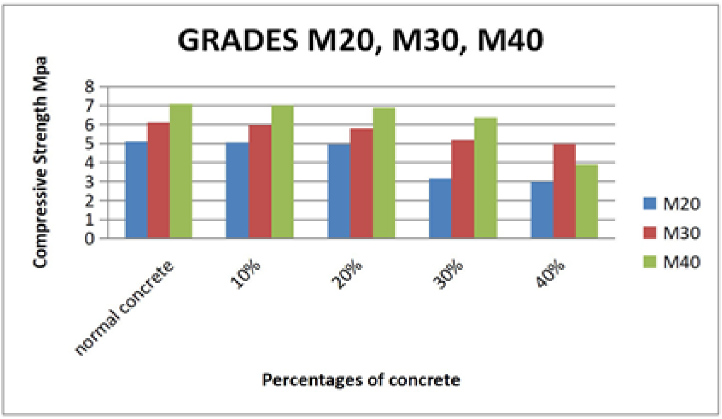

Figure 6.a Variation of Compressive strength for NWSCC & LWSCC at different grades (M20, M30, M40) at the age of 28 days.

IV. RESULTS

For M20, M30, and M40 and grade of concretes the fresh properties were satisfied. For M20, M30, and M40 Grade of Conventional self-compacting concrete the compressive strength for 7 days were 18.3, 23.95, and 27.55 N/mm^2 and 28 days were 27.2, 38.90 and 50.8 N/mm^2. For M20, M30, and M40 Grade of concrete the flexural strength for 7 days were 3.67,3.90 and 4.65 N/mm^2 and 28 days were 3.10,6.10 and 7.10 N/mm^2. For M20, M30, and M40 Grade of concrete the split tensile strength for 7 days were 4.3, 6.55, and 7.45 N/mm^2 and 28 days were 6.2, 38.90 and 50.8 N/mm^2. The densities of concrete are decreasing as the increasing in the percentage replacement of CA with PUMICE. The mechanical properties it was observed that for M20 grade of concrete the replacement of coarse aggregate by 0%, 10%, 20%, 30% and 40% with PUMICE the average compressive strength for 7 and 28 days in MPa were 18.05, 17.90, 15.10, 14.70 and 27.10 N/mm^2, 26.50, 21.60, 20.60 N/mm^2. It was observed that for M30 grade of concrete the replacement of CA with 10%, 20%, 30% and 40% with PUMICE the average compressive strength for 7 and 28 days in MPa were 23.35, 23.05, 21.25, and 19.35 N/mm^2 and 37.85, 35.67, 30.18 and 28.37 N/mm^2. It was observed that for M40 grade of concrete the replacement of CA with 10%, 20%, 30% and 40% with PUMICE the average compressive strength for 7 and 28 days in MPa were 27.40, 26.97, 23.72, 23.16 N/mm^2 and 49.50, 46.13, 40.28, 38.63 N/mm^2.

It was observed that for M20 grade of concrete the replacement of CA with 10%, 20%, 30% and 40% with PUMICE the average flexural strength for 7 and 28 days in MPa were 3.61, 3.50, 2.80, and 2.20 N/mm^2 and 5.06, 4.95, 3.17 and 2.98 N/mm^2 It was observed that for M30 grade of concrete the replacement of CA with 10%, 20%, 30% and 40% with PUMICE the average flexural strength for 7 and 28 days in MPa were 3.85, 3.60, 3.10, and 3.01 N/mm^2. and 5.98, 5.80, 5.20, and 4.97 N/mm^2. It was observed that for M40 grade of concrete the replacement of coarse aggregate with 10%, 20%, 30% and 40% with PUMICE the average flexural strength for 7 and 28 days in MPa were 4.61, 4.25, 4.07, and 4.72 N/mm^2. and 7.02, 6.91, 6.38, and 3.89 N/mm^2.

It was observed that for M20 grade of concrete the replacement of CA with 10%, 20%, 30% and 40% with PUMICE the average Split tensile strength for 7 and 28 days in MPa were 4.13, 4.01, 3.28, and 3.12 N/mm^2 and 6.07, 5.90, 5.10 and 4.85 N/mm^2 It was observed that for M30 grade of concrete the replacement of coarse aggregate with 10%, 20%, 30% and 40% with PUMICE the average Split tensile strength for 7 and 28 days in MPa were 6.55, 6.40, 6.25, and 5.92 N/mm^2. and 8.11, 7.96, 7.41, and 7.17 N/mm^2. It was observed that for M40 grade of concrete the replacement of CA with 10%, 20%, 30% and 40% with PUMICE the average Split tensile strength for 7 and 28 days in MPa were 7.22, 7.03, 6.81, and 6.34 N/mm^2. and 9.39, 9.12, 8.91, and 8.73 N/mm^2.

V. CONCLUSIONS

The following conclusions are drawn from the Experimental Investigations

1. The filling ability, passing ability, and segregation resistance of all LWSCC mixes produced with PUMICE and LECA are in conformity with EFNARC guidelines.
2. The spherical shape of PUMICE has significantly improved rheological properties of the fresh concrete mix.
3. The increase in the percentage of pumice coarse aggregate and LECA showed a reduction on both compressive and flexural strengths of concrete.
4. The compressive strength and flexural strengths of pumice aggregate lightweight concrete (LWSCC) are found to be optimum for 20% replacement of pumice aggregate.
5. Pumice aggregate absorbs additional water when compared to the normal coarse aggregate reducing workability. This problem has been overcome by a higher dosage of SP.
6. Due to the less density pumice the aggregate was found to be segregating and floating on the surface of self- compacting concrete, which needs to be corrected with an appropriate dosage of superplasticizers and viscosity modifying admixture.
7. The compressive strength of lightweight SCC with pumice aggregate was found to increase when pumice is immersed in water for 24 hours before making concrete
8. Density of concrete is found to decrease with the increase in the percentage replacement of normal aggregate with LECA.
9. The density of light weight aggregate varied from 1870 Kg/m3 to 1950 Kg/m3, which is less than the weight of conventional concrete having a density of 2450 Kg/m3 as measured in lab.
10. Due to light weight, LECA was found to be floating on the surface of the concrete causing problems for the flow of SCC.
11. The passing ability of SCC with LECA was found to decrease with increase in the percentage of LECA due to its water absorption. However, this can be compensated by higher dosage of super plasticizer.
12. Compressive strength of light weight SCC with LECA was found to increase when LECA is immersed in water for 24 hours before making concrete.

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PAVEMENT OVERLAY DESIGN USING FALLING WEIGHT DEFLECTOMETER

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Abstract - Pavement evaluation is a technique of assessing the condition of a pavement, both structurally and surface characteristics. Pavements which have been subjected to traffic, deform elastically under load which depends on type subgrade soil and its compaction level, pavement thickness and its composition, drainage conditions, pavement surface temperature and wheel load. There are number of different types of pavement deflection testing equipment which are being used all over the world. The most common types are Benkelman Beam Deflection (BBD), Falling Weight Deflectometer (FWD) and Dynamic Cone Penetrometer. BBD test widely used method in which rebound deflection is measured on static loading and there by evaluating strength of the pavement. However with limitations and practical difficulties of BBD, FWD was chosen for the study. The deflections of the pavement are recorded due to the dynamic loading and studied for further strength determination. A 4-lane National Highway has been selected and tested for residual strength and it is designed for overlay as per IRC:115-2014 & IRC:37-2012 using FWD equipment and with the assistance of KGPBACK and IIT PAVE software's. An overlay of 50 mm on one direction and 100 mm on opposite direction was recommended to meet the functional and structural requirement respectively.

Key words: Falling Weight Deflectometer (FWD), Pavement overlay, KGPBACK, IIT PAVE, IRC:115-2014 and IRC:37-2012.

Introduction

The objective of the study is to evolve structural condition of the pavement using Falling Weight Deflectometer and subsequent analysis is carried out to ascertain the relative performance of the pavement in the perspective of evaluating residual life. The load-deflection data from the FWD was inferred through the analytical techniques by back calculation to estimate the elastic moduli of the pavement layers. Thus calculated moduli was therefore used for the strength evaluation of different layers of pavement and the estimation of strength requirement of pavement. The procedures for the test and evaluation of structural condition of pavements is detailed in IRC- 115:2014

Design Methodology

Performance of flexible pavements can be evaluated by subjecting the pavement to external loads such that it simulate the traffic loading and recording the response of pavement to such loading by measuring the elastic deflection under such loads. For the reason, the Falling Weight Deflectometer was chosen as per the guidelines in IRC:115_2014. Falling Weight Deflectometer, which is closely simulates the duration and amplitude of the load pulses produced by moving wheel loads. The basic working principle of the impulse loading equipment is to drop a mass on the pavement to produce an impulse load and measure the surface deflections. The mass is dropped on a spring system, which in turn transmits the load to the pavement through a loading plate. The resulting bowl characteristics are observed and used in the back-calculation of pavement material properties.

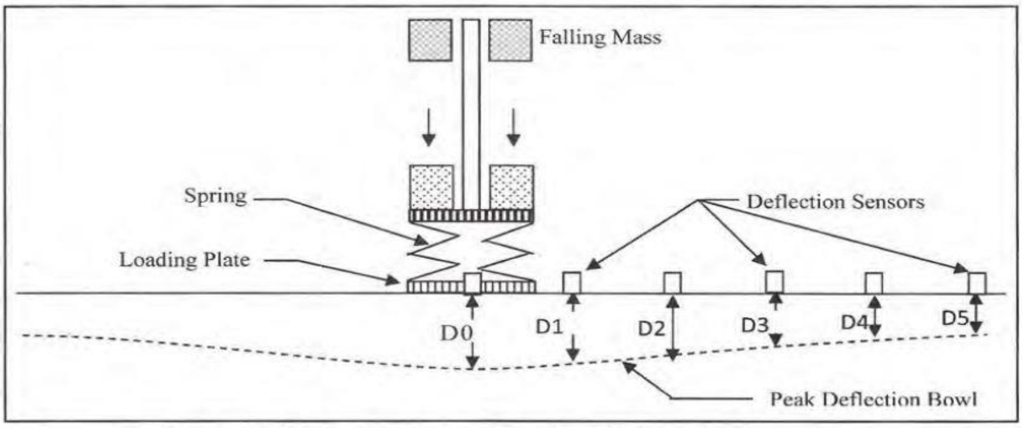

Fig 1. Working Principle of FWD

The FWD test data was collected from different load drops at each test point primarily consisted of peak load, peak deflections at different radial locations. Unrealistic deflection values and obviously enormous data are removed.

The target peak load was applied on bituminous pavement is 40kN (+/- 4kN), which corresponds to the load on one dual wheel set of an 80kN standard axle load. But in practice applied peak load always may not be exactly 40kN, hence the deflection values measured by geophones should be normalized to equivalent 40kN loading. The normalization of deflections are done linearly.

KGPBACK is the Back calculation technique used to calculate the elastic moduli of existing pavement layers. Normalized surface deflections, along with other inputs such as radial distances at which deflections are measured, layer thicknesses, Poison's ratio values of different layers, target load and loading plate radius, are used to back-calculate the elastic moduli of different layers of the existing pavement. Elasticity moduli values were corrected for temperature and seasonal variation which is further used for the estimation of the design Elastic Moduli (E) values. As per IRC guidelines 15th percentile of E values are considered for the project study.

For areas in India having a tropical climate, the temperature corrections has to be applied for the temperatures more than the standard pavement temperature which is 35^{0}C. The temperature corrections are applied for the back calculated modulus obtained from of bituminous layer using below mentioned equation.

$$E_{T1} = \lambda \, E_{T2}$$

Where, λ is temperature correction factor, is given as $(1\text{-}0.238\ln T_1)/\ (1\text{-}0.238\ln T_2)$

E_{T1} is back-calculated modulus (MPa) at temperature T_1 (^{0}C)

E_{T2} is back-calculated modulus (MPa) at temperature T_2 (^{0}C)

Seasonal corrections for subgrade and granular moduli were also applied using the following relationships developed for different seasons (winter/ summer/ monsoon) as per IRC: 115-2014.

$E_{sub\ mon} = 3.351 * (E_{sub\_win})^{0.7688} – 28.9$

$E_{sub\ mon} = 0.8554 * (E_{sub\_sum})^{0.7688} – 8.461$

$E_{granu\_mon} = - 0.0003 * (E_{granu\_Sum})^2 + 0.9584 * (E_{granu\_Sum}) – 32.989$

$E_{granu\_mon} = 10.5523 * (E_{granu\_win})^{0.624} -- 113$

The results from the above analysis along the physical and load characteristics of the pavement were given as inputs to the IIT PAVE software to obtain the peak strains at critical locations of the pavement. These strains are later used to find residual fatigue and rutting strengths of the pavement.

The layer moduli were used to analyse the pavement for critical strains which are indicators of pavement performance in terms of rutting and fatigue cracking as suggested by IRC. A diagram with different layers of flexible pavement and critical strain locations is shown in following figure.

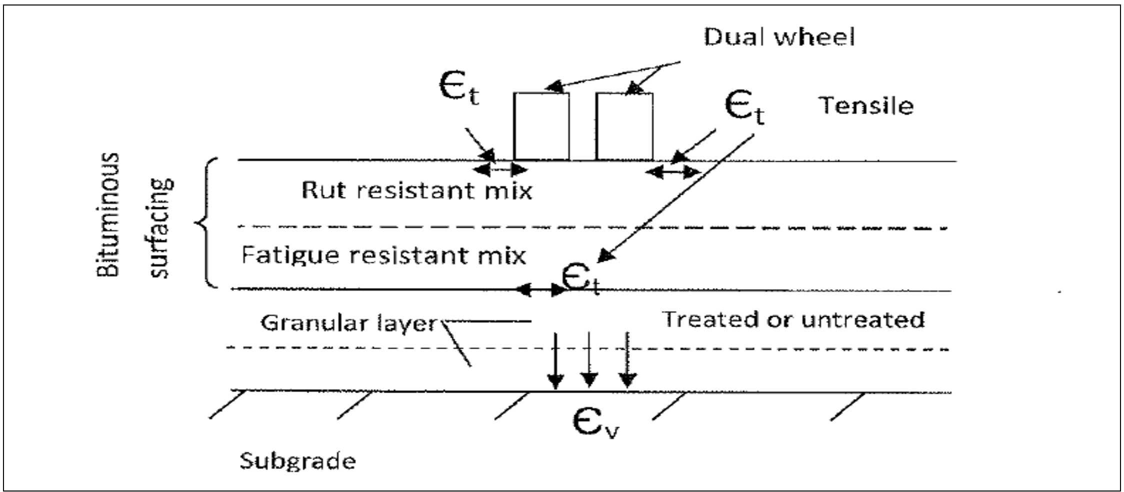

Fig 2. Different layers of flexible pavement & Critical Strain locations

The fatigue (or fracture) life in Million Standard Axles (MSA) of the bituminous layer and the number of load repetitions in terms of standard axles that cause fatigue denotes the fatigue life of the pavement. The fatigue model for 90 percent reliability is given in following equation.

$$N_f = 0.711 * 10^{-0.4} * [1/\varepsilon_t]^{3.89} * [1/M_R]^{0.854}$$

Where, N_f is Fatigue life in number of standard axles

ε_t is Maximum tensile strain at the bottom of bituminous layer

M_R is resilient modulus of the bituminous layer.

Rutting life in Million Standard Axles (MSA) is the permanent deformation in pavement usually occurring longitudinally along the wheel path. Rutting model for 90 percent reliability level was given in following equation.

$$N = 1.41*10^{-8} * [1/\varepsilon_v]^{4.5337}$$

Where, N is Number of cumulative standard axles

ε_v is Vertical strain in the subgrade

Thus the obtained fatigue and rutting life of the pavements are compared with the design strength to arrive the design thickness of the pavement overlay.

Pavement Characteristics and Deflection Measurement Scheme

In this study, the pavement of interest is four lane dual carriageway from NH5. The project stretch from Km. 951.500 to Km 1022.500 both on LHS and RHS at 250m spacing on outer wheel path of outer lane and at 500 m spacing on outer wheel path of inner lane. Deflections obtained on each side of the carriageway has been normalized to correspond standard target load of 40kN as per guidelines.

Pavement layer thicknesses are essential inputs to the process of back-calculation of layer moduli and, in turn, to the estimation of remaining life and overlay requirements of the in-service pavement. A pit of size 0.6m x 0.6m was excavated at an interval of 10km as the records suggest the uniformity of the pavement composition. The total crust thicknesses of the pavement measured along the chainage varies 660 mm to 890 mm with bituminous layer of varying thickness from 200 to 360 mm and a granular layer of thickness 450 mm to 690 mm.

Results and Discussion

The FWD test is calibrated to ensure the deflection values given by the sensors are reliable. The mean and standard deviation of deflections are calculated for twelve drops for each geophone separately. As per IRC:115-2014, the standard deviation of the peak load should be less than 5 percent of the mean value of the peak load.

The measured load deflection data was normalized by removing the erroneous output and processed by applying all temperature and seasonal corrections to arrive at representative moduli of each layer by back calculation through KGPBACK. The representative moduli of bituminous, granular and subgrade layers of LHS and RHS with all corrections applied are shown graphically in the below figure.

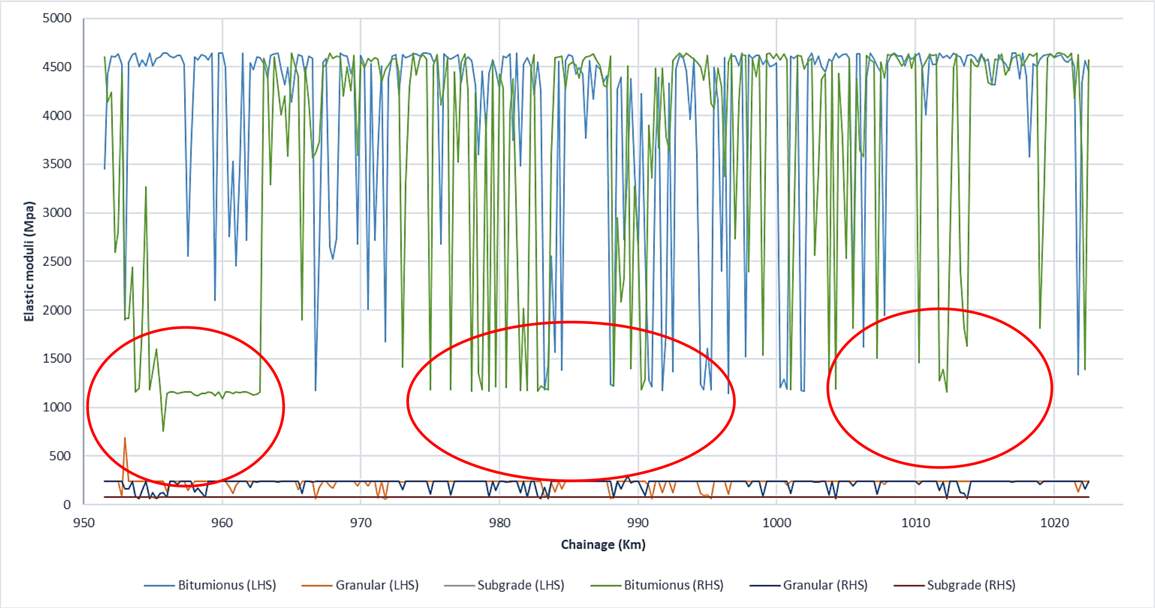

Fig 3. Elastic moduli of different layers of pavement

It is clear from the above graphical representation, the RHS bituminous layer has very low values of moduli. Selection of 15th percentile modulus values (15% of the values will be less than this value) of each of the three layers considered for analysis. The design 15th percentile values are mentioned below table.

Table 1: 15th Percentile Back Calculated Modulus Values on LHS and RHS Side

Side	15th Percentile of Moduli for the design		
	Bituminous (Mpa)	**Granular (Mpa)**	**Subgrade (Mpa)**
LHS	2562.15	223.2669	77
RHS	1198.46	161.65	77

With the above elastic modulus, physical and load characteristics of the pavement, the critical strain values of the pavement were obtained from the IITPAVE and those strain results were used to calculate the fatigue and rutting life of the bitumen layer as shown in the below table.

Table 2: Residual Life of pavement on RHS Side

Side	Analysis of pavement using IITPAVE		Remaining Life of Pavement	
	Horz. Tensile Strain (microns)	**Vert. Comp. Strain (microns)**	**Fatigue (MSA)**	**Rutting (MSA)**
LHS	114.40	163.20	187.78	2087.42
RHS	195.00	198.80	20.61	853.27

As the residual strength of the pavement is more than the required design strength there is no requirement for structural overlay on the LHS. However an overlay of 50mm is suggested for functional requirement which covers surface defects like cracks, potholes, roughness, etc. Along RHS, the residual strength of the pavement is 20.61 MSA which is much less than the design requirement of the pavement. A structural overlay is to be designed to meet the design strength. A trial of 100mm overlay is used on IITPAVE software along with other properties as input. Based on the design life of pavement, the residual life of the pavement is re-calculated as shown in below table.

Table3: Residual & Design life of pavement

Side	Design strength (MSA)	Residual strength (MSA)	Design overlay strength (MSA)	Overlay Thickness(mm)	Strength after overlay (MSA)
LHS	170	187.78	Not required	50	188
RHS	150	20.61	130	100	159.18

To summarise the results, a thickness of 50mm of functional overlay on LHS side and a thickness of 100 structural overlay on RHS side was arrived to meet design strength and foundational requirement of the pavement.

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IMPACT RESISTANCE OF GEOPOLYMER CONCRETE MADE WITH REPLACEMENT OF COARSE AGGREGATE BY RECYCLED AGGREGATE

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Abstract: Concrete is the most used construction material in the world. It is produced by using the ordinary Portland cement(OPC), coarse aggregate, fine aggregate and water. The production of one ton of OPC liberates one ton of carbon dioxide into the atmosphere that can be occurs 7 to 8 % of global warming. at the same time availability of natural coarse aggregate getting reducing day by day and construction and demolition waste is the major issue in India. So geopolymer and recycled aggregate are the good alternatives for the ordinary Portland cement and natural coarse aggregate respectively, since replacement of the natural coarse aggregate with recycled aggregate to reduce an impact on landfills and cost of the project. Geopolymer concrete is the innovative and eco-friendly concrete, it is produced by chemical action of inorganic molecules and made up of fly ash, ground granulated blast furnace slag GGBS, fine aggregate, coarse aggregate and an alkaline solution of sodium hydroxide and sodium silicate. NaOH and Na_2SiO_3 solution is used to synthesis the geopolymer in this study. The main aim of this paper is to study the impact resistance of geopolymer concrete of grade G40 when natural coarse aggregate is replaced with recycled coarse aggregate in different proportions such as 10%, 20%, 30%, 40% and 50% and also to compare the results of geopolymer concrete made with recycled coarse aggregates with geopolymer concrete of natural coarse aggregate and controlled concrete manufactured with recycled coarse aggregates and controlled concrete of natural coarse aggregates of respective grade. It has been observed that an impact resistance is enhanced in geopolymer concrete, both in natural coarse aggregate and recycled coarse aggregate up to 30% replacement when it is compared with the respective grade of controlled concrete.

Key words: Geopolymer Concrete, Recycled Aggregate, Impact Resistance, Alkaline Solutions, Controlled Concrete.

1. INTRODUCTION

Concrete is the only construction material which is used world and its consumption is second only to water. Production of cement is not only energy intensive, but also responsible for emission of carbon dioxide (CO2) in large quantity. 1 ton of cement releases 1 ton of carbon dioxide into atmosphere.

Increased focus is also being placed on recycling as the world's natural resources are being depleted and the amount of waste being disposed of into landfill is increasing globally. Therefore, as the industrial development process continues, the re-use of construction and demolition waste is becoming increasingly important and various solutions have been researched for high-volume use of recycled concrete.

Geopolymer is a promising alternative binder to Portland cement. It is produced mostly from by- product materials such as fly ash and blast furnace slag. There are many efforts are being made to reduce the use of Portland cement in concrete by finding alternative binders to

Portland cement this include the utilization of supplementary cementing materials fly ash, granulated blast furnace slag, rice-husk ash and metakaolin. In 1972, Joseph Davidovits coined the name ‘‘geopolymers’’ to describe the zeolite like polymers. Geopolymers are the alumina-silicate polymers which consist of amorphous and three dimensional structures formed from the geopolymerisation of alumina-silicate monomers in alkaline solution. Investigations have been carried out on calcined clays (e.g., metakaolin) or industrial wastes (e.g., fly ash or metallurgical slag). A reaction pathway involving the polycondensation of orthosialiate ions (hypothetical monomer) is proposed by Davidovits.
This paper presents experimental results of geopolymer concrete of grade G40 when natural coarse aggregate is replaced with recycled aggregate in different proportions such as 10%, 20%, 30%, 40%,50% andalso to compare the results of geopolymer concrete made with recycled coarse aggregates with geopolymer concrete of natural coarse aggregate and controlled concrete of respective grade.

2. MATERIALS

The materials used in this study are ordinary Portland cement(OPC), coarse aggregate, fine aggregate, fly ash, ground granulated blast furnace slag(GGBS), recycled aggregate, sodium hydroxide, sodium silicate, super plasticizer, water.

2.1 Ordinary Portland Cement

In this experimental investigations, 53-grade of ordinary Portland cement is used. The cement thus procured was tested for physical properties in accordance with the IS: 4031-1968 and found to be conforming various specifications of IS 12629-1987.

2.2 Fine Aggregate

In the present investigation, fine aggregate used is obtained from local sources. The sand is made free from clay matter, silt, and organic impurities and sieved on 4.75mm IS sieve. The physical properties of fine aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS: 2386. Grain size distribution of sand shows it is close to Zone II of IS 383-1970.

2.3 Coarse Aggregate

The crushed angular aggregate of 20mm maximum size obtained from the local crushing plants is used as coarse aggregate in the present study. The physical properties of coarse aggregate such as specific gravity, bulk density, flakiness and elongation index are tested in accordance with IS: 2386-1963.

2.4 Fly Ash

In the present study of work, the Class F-fly ash i.e., low calcium fly is ash used, which is obtained from Vijayawada thermal power station in Andhra Pradesh.

2.5 Ground Granulated Blast Furnace Slag

Ground Granulated Blast Furnace Slag (GGBS) is a byproduct of the steel industry. Blast furnace slag is defined as “the non-metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition simultaneously with iron in a blast furnace”. About 15% by mass of binders was replaced with GGBS.

2.6 Recycled Aggregate Concrete(RAC)

Construction and demolition waste contributes up to 40 percent of all waste generated worldwide. The majority of recycled aggregate that is used in Australia is recycled concrete aggregate (RCA) produced from construction and demolition waste, as it is the most suitable replacement of natural coarse aggregate. Utilizing recycled aggregate can result in around 60 percent less waste and 50 percentages less mineral depletion per cubic metre of concrete produced. The strength of ordinary Portland cement concrete utilizing recycled aggregate depends largely on the percentage of recycled aggregate used.

2.7 Water

Water free from chemicals, oils and other forms of impurities is used for mixing of concrete as per IS: 456:2000.

2.8 Sodium Hydroxide

Sodium Hydroxide is one of the major ingredients of geopolymer concrete. The following are the specifications of Sodium hydroxide pellets and this material is procured from the local laboratory chemical vendors in Hyderabad. Specifications are tabulated in table 1 as given by the suppliers.

Table 1: Shows Physical properties of NaOH

Molar mass	40 gm/mol
Appearance	White solid
Density	2.1 gr/cc
Melting point	318 ^{o}C
Boiling point	1390 ^{o}C
Amount of heat liberated when dissolved in water	266 l/gr

2.8 Sodium Silicate Solution

Sodium silicate solution is a type of alkaline liquid plays an important role in the polymerization process. This material is procured from the local laboratory chemical vendors in Hyderabad. Specifications are tabulated in table 2 as given by the suppliers.

Table 2: Properties of Na_2SiO_3 Solution

Specific gravity	1.57
Molar mass	122.06 gm/mol
Na2O (by mass)	14.35%
SiO2 (by mass)	30.00%
Water (by mass)	55.00%
Weight ratio (SiO2 to Na2O)	2.09
Molarity ratio	0.97

2.10 Super Plasticizer

Super plasticizer GLENIUM B233 of Fosroc chemical India Ltd. was used as water reducing admixture, it increases workability.

3. EXPERIMENTAL INVESTIGATION

3.1 General

The main aim of this study is to find an impact strength of Geopolymer concrete of grade G40 and conventional concrete of grade M40 with partial replacement of natural coarse aggregate with recycled coarse aggregate. In this work replacement of natural coarse aggregate is varied by 10%, 20%, 30%, 40% and 50% with recycled coarse aggregate and also to compare the results of Geopolymer concrete made with recycled coarse aggregates (RAGPC) with Geopolymer concrete of natural coarse aggregate (GPC) and controlled concrete manufactured with recycled aggregates (RAC) and controlled concrete of natural coarse aggregates (CC) of respective grade.

3.2 Mixing and Curing

Geopolymer concrete is prepared by using the same procedure whatever is used in the conventional concrete. In the laboratory, the fly ash and the aggregates were mixed together in dry by using a pan mixer for about two minutes, then the alkaline liquid was mixed with the super plasticizer and extra water if any. The liquid component of the mixture was then added to the dry material and the mixing continued usually for another two minutes. The fresh concrete was cast and compacted by the usual methods used in the case of conventional concrete. The workability of the fresh concrete was measured by means of the conventional slump test.in this study samples were cast and after one-day rest period, the specimens were cured in an oven at 60^{o}C for 24 hours and the remaining period in sun light until testing is done. The samples were cast testing at 3days and 7 days and 28 days to analyze the compressive strength and impact strength. The samples were casted and tested at 3, 7 and 28 days to find the compressive strength and impact strength of the geopolymer concrete and conventional concrete.

3.3 Compression Test

The compression test is conducted on the cubes 100x100x100 at 3 days, 7 days and 28 days' accordance with the IS 516-1969.

3.4 Impact Test

The test specimens of prisms 100 mm x 100 mm x 500 mm were casted for geopolymer concrete of G40 and conventional concrete of M40. The load is applied as an impact blow from a swinging weighted pendulum hammer that is released from a raised position of 20° with the vertical. The specimen is firmly positioned at the base as shown in Fig 1. The blows were repeated in above manner till first crack appears. The crack propagation for each blow after first crack was marked on the specimen. The number of blows required for the crack propagation from one edge to other on the tension face was recorded. The experiment was continued till the spalling of mortar occurs on the compression face of the specimen. The impact strength is expressed in terms of number of blows required to break the specimen.
Mass of the pendulum hammer =10 kg; g=9.8 m/sec2
L=length of pendulum= 1.83 m; h=L(1-cosϴ) where ϴ=20°
Energy for one blow,E = mgh = 10*9.8*0.11= 10.78 Joule

Fig 1: Shows Impact Test Apparatus

4. TEST RESULTS

4.1 Compressive Strength

4.1.1 Compressive Strength of CC and GPC

Compressive strength test is the direct measure of the strength of concrete. Compressive strength test has been conducted on the cubes of sizes 100mmx100mmx100mm accordance with IS 516-1969.

Table 3: Compressive strength of CC & GPC

	CC (N/mm^2)	**GPC (N/mm^2)**
3 days	28.75	46.71
7 days	40.25	53.91
28 days	56.72	58.30

4.1.2 Compressive Strength of Conventional Concrete made with RecycledAggregate (RAC)

Compressive strength test is performed on conventional concrete made with recycled aggregate at varying percentages i.e., 10%, 20%, 30%, 40% & 50%. In this regard, the compressive strength value has been slightly decreasing up to 30% of replacement with recycled aggregate and thereon it started to decrease drastically. From the results given in table 4, it can be inferred that, 30% replacement is the optimum percentage of utilization of recycled aggregate in the concrete, because at this percentage the strength is higher than target mean strength.

Table 4: Compressive strength of Conventional Concrete made with varying percentages of Recycled aggregate (RAC)

	0%	10%	20%	**30%**	40%	50%
3 days(N/mm^2)	28.45	26.80	24.91	**24.56**	23.26	21.98
7 days(N/mm^2)	39.50	37.66	35.50	**34.65**	32.70	31.50
28 days(N/mm^2)	56.72	53.81	51.04	**49.75**	46.72	45.08

4.1.3 Compressive Strength of Geopolymer Concrete made with Recycled Aggregate (RAGPC)

Compressive strength test is performed on geopolymer concrete made with recycled aggregate at varying percentages i.e., 10%, 20%, 30%, 40% & 50%. In this regard, the compressive strength value has been slightly decreasing up to 30% of replacement with recycled aggregate and thereon it started to decrease drastically. From the results given in table 5, it can be inferred that, 30% replacement is the optimum percentage of utilization of recycled aggregate in the concrete, because at this percentage the strength is higher than target meanstrength.

Table 5: Compressive strength of Geopolymer Concrete made with varying percentages of Recycled aggregate (RAGPC)

	0%	10%	20%	**30%**	40%	50%
3 days(N/mm^2)	46.71	45.56	43.65	**40.77**	38.24	38.02
7 days(N/mm^2)	53.91	51.18	48.44	**46.31**	43.98	42.72
28 days(N/mm^2)	58.30	56.25	53.24	**50.34**	47.81	46.95

4.1.4 Comparison of Compressive Strength Test Results

From Table 6, it is evident that the strength of Geopolymer concrete is more than that of Conventional concrete. When the conventional and geopolymer concrete replaced with recycled aggregate the strengths have been slightly decreased up to 30% and thereon deceased drastically. In recycled aggregate concrete and recycled aggregate geopolymer concrete, the strength has been decreased slightly but still it is more than target mean strength, so optimum strength results at 30% replacement of recycled aggregate geopolymer concrete can be considered.

Table 6: Comparison of Compressive Strength Test Results

	CC	GPC	RAC	RAGPC
3 days (N/mm^2)	28.75	46.71	24.17	40.15
7 days (N/mm^2)	40.25	53.91	34.52	46.31
28 days (N/mm^2)	56.72	58.30	49.75	50.34

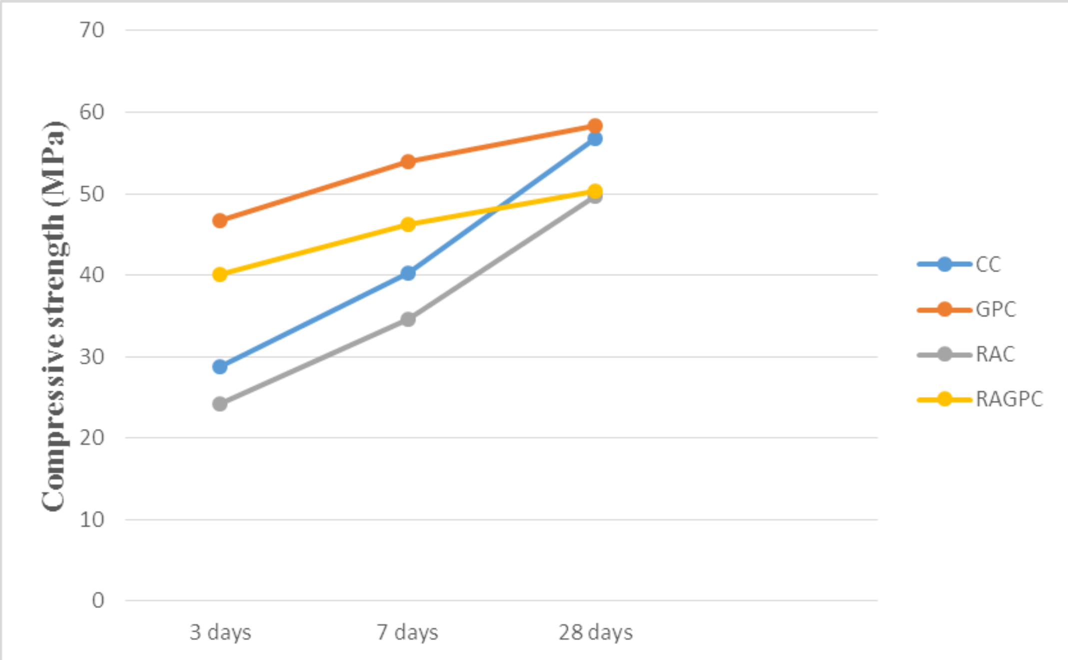

Fig 2: Comparison of Compressive Strength Test Results

4.2 Impact Test

The test results of the impact strength at 3, 7 and 28 days of Geopolymer concrete made with recycled coarse aggregates (RAGPC) with Geopolymer concrete of natural coarse aggregate (GPC) and controlled concrete manufactured with recycled aggregates (RAC) and controlled concrete of natural coarse aggregates (CC) of respective grade were shown in below tables.

4.2.1 Comparison of Impact Strength Test Results

Table 7: Comparison of Impact Strength Test Results in Number of Blows

	CC	GPC	RAC (30%)	RAGPC (30%)
3 days (N/mm2)	11	17	10	15
7 days (N/mm2)	14	20	14	18
28 days (N/mm2)	19	22	18	20

Table 8: Increase in Percentage of Impact Resistance in Number of Blows of Geopolymer Concrete (G40) over Controlled Concrete (M40)

	0%	**30%**
G40 3 days(N/mm^2)	17	**15**
M40 3 days(N/mm^2)	11	**10**
Increase in %	**54.54**	**50**
G40 7 days(N/mm^2)	20	**18**
M40 7 days(N/mm^2)	14	**13**
Increase in %	**42.85**	**38.57**
G40 28 days(N/mm^2)	24	**20**
M40 28 days(N/mm^2)	21	**18**
Increase in %	**14.28**	**11.11**

From the table 8, it is observed that there was a significant increase in the 3 days impact strength by 54.54% and 50% in geopolymer concrete for 0% and 30% as compared to controlled concrete of 0% and 30% respectively. There is a relative increase in the 7 days impact strength by 42.85% and 38.57% in geopolymer concrete for 0% and 30% as compared to controlled concrete of 0% and 30% respectively and there is a slight increase in the 28 days impact strength by 14.28% and 11.11% in geopolymer concrete for 0% and 30% as compared to controlled concrete of 0% and 30% respectively. The percentage of impact strength increases in the early age is due to polymerization of alkaline liquid with fly ash and GGBS under oven curing at optimum temperature i.e.60^{o}C.

Table 9: **Energy Consumption and Ductility Index Geopolymer Concrete (G40)and Controlled Concrete (M40)**

Type of Concrete	Recycled Aggregate percentage	No. of Blows for First Crack	No. of Blows for Ultimate Failure	Energy Consumed for First Crack (Joule) E1	Energy Consumed for Ultimate Failure(Joule) E2	Ductility Index E2/E1
Controlled Concrete	0%	15	19	161.7	204.82	1.27
	30%	14	18	150.92	194.04	1.28
Geopolymer Concrete	0%	18	22	194.04	237.16	1.22
	30%	16	20	172.48	215.6	1.25

From the table 9, it is observed that more energy consumption is required in geopolymer concrete specimens compared to that of controlled concrete specimens of both the grades. The ductility index of geopolymer concrete specimens is slightly higher than that of controlled concrete specimens of both the grades confirming that geopolymer concrete is slightly ductile than controlled concrete.

5. CONCLUSIONS

The following specific conclusions can be drawn from the present experimental investigation:

i. From the results, it is concluded that the compressive and impact strength of Geopolymer concrete made with Natural Aggregate (GPA) is 2.79% and 14.28% more than that of Conventional concrete made with Natural Aggregate (CC) respectively.

ii. It is observed that the compressive and impact strength of Conventional concrete with Recycled Aggregate (RAC) is 12.29% and 5.26% less than that of Conventional concrete with Natural Aggregate (CC) respectively at 30% replacement. However it can be considerable, since compressive strength is still higher than the target mean strength.

iii. The compressive and impact strength of Geopolymer concrete made with Recycled Aggregate (RAGPC) is 13.65% and 9.09% less than that of Geopolymer concrete made with Natural Aggregate (GPC) respectively at 30% replacement. However it can be considerable, since compressive strengthis still higher than the target meanstrength

iv. The replacement of recycled aggregate in concrete gives better results till 30% replacement, so it is an alternative solution for disposal of C & D waste.

v. The energy consumption and ductility index of geopolymer and controlled concrete is almost same confirming that both concretes having same ductility.

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EXPERIMENTAL INVESTIGATION ON PERVIOUS CONCRETE

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Abstract- Mix of concrete is modified as pervious where water can percolate in to the Gorund Pervious concrete is a concrete which consists of coarse aggregates and cement paste, water with absence of fine aggregates. The Pervious concrete also is called as no fine concrete. Pervious concrete allows water from precipitation and other sources to pass directly through thereby reducing the runoff from the site and allowing the ground water recharge. In many projects, water logging of paring and walking is a major issue, especially during monsoon seasons, as pavements and floors as impermeable. It differs from conventional concrete because it doesn't have any fine aggregates to increase the rate of infiltration. A sample sized aggregates which pass through 20mm sieve and retained on 10mm sieve are considered. Cement of OPC 53 grade is used. The research on different mixes is done. Two mixes M1, M2 without admixtures and three mixes M3, M4, and M5 with addition of silica fumes of 5% and 10% of volume of concrete are tested. These concrete cubes are casted, cured and tested for compressive strength and flexure strength. Compressive strength of different mixes range from 3.5 to 28Mpa. Flexural strength varies 1 to 15Mpa.The behavior of Pervious concrete is observed and studied with addition of silica fumes.

1.1 INTRODUCTION

Pervious cement can be utilized for various applications, however its essential use is in street asphalt, for example, in rustic zones. This report will concentrate on the asphalt utilizations of the solid. Which additionally has been alluded to as permeable concrete, penetrable cement, no fines solid, hole reviewed concrete and upgraded porosity concrete. Pervious cement is a zero droop, open reviewed material comprising of bond, coarse total, admixtures and water pervious solid substance no fine total, for example, sand, it is some of the time alluded to as "no fines" concrete. It will create a solidified material with associated pores running in size from 2 to 8 mm with compressive quality 2.8MPa to 28MPa. Pervious solid asphalt in country territories is a one of a kind and successful intends to accomplish significant ecological issues and bolster green, manageable development. By catching tempest water and enabling it to saturate the ground, permeable cement is instrumental in reviving groundwater, decreasing tempest water overflow.

Fig 1 and 2 showing the porous concrete

1.2 Significance of Pervious Concrete in Rural Road Pavement

In provincial regions bigger measure of water winds up falling on impenetrable surfaces, for example, parking areas, carports, walkways, and roads instead of dousing into the dirt. This makes an irregularity in the common biological system and prompts a large group of issues including disintegration, floods, ground water level exhaustion and contamination of streams, as water hurrying crosswise over asphalt surfaces grabs everything from oil and oil spills to de-icing salts and substance manures. A straightforward answer for maintain a strategic distance from these issues is to quit developing impenetrable surfaces that square common water penetration into the dirt. As opposed to building them with traditional solid, we ought to switch Pervious Concrete or Porous Pavement, a material that offers the inalienable sturdiness and miscreant cycle expenses of a run of the mill solid asphalt while holding tempest water spillover and renewing nearby watershed frameworks. Rather than avoiding penetration of water into the dirt, pervious asphalt helps the procedure by catching water in a system of voids and enabling it to permeate into the fundamental soil.

3 METHODOLOGY:

Cubes of different grades has casted in the concrete laboratory and Tested for the Calculating strength.

1. Measure the dry extent of fixings (Cement, Sand and Coarse Aggregate) according to the plan necessities. The Ingredients ought to be adequate enough to cast test solid shapes
2. Thoroughly blend the dry fixings to acquire uniform blend
3. Add structure amount of water to the dry extent (water-concrete proportion) and blend well to acquire uniform surface

Fig 3 showing the pervious concrete Casted in the laboratory

Fig.4 concrete laid on parking

4.Fill the solid to the shape with the assistance of vibrator for careful compaction
5.Finish the highest point of the solid by trowel and tapped well till the bond slurry comes to the highest point of the shapes. Finally prepare the cubes of required standard size.
6. Mix proportionality cement coursese aggregate and silica in various propotions and tested for the compressive and flexural strength.

4. MATERIALS USED

4.1 PROPERTIES OF MATERIALS

CEMENT: Pervious solid uses indistinguishable materials from typical customary cement. It is a decent restricting material. It sets, solidifies, and clings to different materials to tie them together. The most normally utilized bond for pervious cement is Ordinary Portland Cement of 53grade.

COARSE AGGREGATE: The porosity in PC is made by the end of fine total and the utilization of coarse total with a tight or uniform reviewing to permit moderately low molecule . pressing.Aggregate grading generally used in PC are typically either single-sized coarse aggregate or grading between 10mm and 20mm. PC made with single-sized aggregate has high permeability, but low strength development.

WATER: Water-to-cement ratios between 0.27 and 0.36 are used routinely with proper inclusion of chemical admixtures, and those as high as 0.40 have been used successfully. Along these lines, by directing the slump cone test for PC we got the W/C proportion for blend extent of 1:6 as 0.3 and that for blend extent 1:8 as 0.4 and the slump we watch for PC will dependably be a breakdown slump.

SILICA FUME: Silica fume, also known as micro silica, is an polymorph of silicon dioxide, silica. It is very fine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of cylindrical particles with an mean particle diameter of 150nm with fineness.

Table 1. Physical properties of silica fume.

S.NO	PROPERTIES	Observed value
1	Colour	Light grey
2	Fineness	Below 45 microns
3	Specific gravity	2.17
4	Bulk density	550 to 700kg/m3
5	Moisture content	0.1 to 3%

Table 2.0 Chemical properties of silica fume:

S.NO	Component	Quantity
1	SiO2	90-94%
2	Al2O3	0.06%
3	Carbon	1%
4	CaO	0.10%
5	MgO	0.10%
6	FeO	0.02%
7	TiO2	0.03%
8	LOI&lt	5%

CODE BOOK REFERRED FOR MATERIALS
The code book used for OPC 53 grade cement is IS 1489:1991.
The code for using Coarse aggregates of sizes 10mm to 20mm is IS 2386-1963.

5.0 LITERATURE REVIEW

1.M. Karthik (2017) on One day National Conference on &quota; Recent Innovations in Science, Technology and Engineering& quot; at NIT, Jammu and Kashmir examined the impact of various total sizes (10mm, 12.5,16mm and 20 mm) on solidified properties of no-fine cements and the outcomes demonstrated that compressive quality diminishes with an expansion in totals measure.

2 Dev Pratap Mani Tripathi (2017) on worldwide diary of designing exploration and innovation contemplated that by utilizing the normal material and strategy, the quality of the pervious cement is low.

3. Vikram and Mahla (2016) R.P on worldwide diary for research in connected science and designing innovation considered that by utilizing littler total and silica smolder in the past solid quality can be expanded incredibly. Additionally, by expanding the bond glue fastener territory and upgrading the quality of concrete folio pervious solid quality can likewise be expanded. The pervious asphalt materials that made out of a surface layer and aa base layer were made. The compressive quality of the pervious cement can achieve 50 MPa and the flexural quality 6MPa.Vinayak Kharbikar (2015) Kevern International diary of development examine and creative thoughts in instruction contemplated that by utilizing polypropylene fiber in the pervious cement flexural quality can be expanded significantly.,

According to Bala guru (1988) the uniaxial compression test, Khajuria and Balaguru , (1989) .in some instances, if more water is added to fiber concrete to improve its workability, Bentur, (2007). (Hasan Et Al., 2011 Roesler Et Al. (2006) is also referred for this studied area.

6.0 TESTS CONDUCTED

6.1.1 Determine fineness of cement

Report the value of fineness, to the nearest 0.1 percent, as the residue on the 90µm sieve.

6.1.2 Specific gravity of cement

Calculations:

Specific gravity (Sg)=(W2_W1)/((W2_W1)_(W3_W4)*0.79)

where, Specific gravity of Kerosene = 0.79 g/cc

6.1.3 Soundness

Soundness of cement is determined by Le- Chatelier method as per IS:4031(Part1)-1988

6.1.4 Consistency

consistency of cement is that consistency at which the Vicat plunger penetrates to a point 5-7mm from the bottom of Vicat mould.

6.1.5 Initial and Final Setting time

Consistency of cement is that consistency at which the Vicat plunger

Penetrates to a point 5-7mm from the bottom of Vicat mould.

7.0 EXPERIMENTAL INVESTIGATION

7 .1 Pervious Concrete Mix Design

The mix design obtained from conventional method of concrete mix design was not applicable for designing the PC since mixes were assumed with zero fines. So the design of pervious mix was adopted as per the ACI 552.1– 08 codes in which the quantities of PC (optimum) were mentioned. The optimum values from codes were

Figure 5.1: Curing and casting

Figure 5.2. Cured moulds

7.2 Percentage strength of concrete at various ages: the strength of concrete increases with age. Below shows the strength of concrete at different ages in comparison with the strength at 28 days after casting

Table 3 showing the age and related percentage in strength

Age	Strength percent
1 day	16%
3 days	50%
7 days	60%
28 days	85% to 90%

Table 4: compressive strength of different grades of concrete

Grade of concrete	Minimum compressive Strength N/mm^2 at 7 days	Specified characteristic Compressive strength N/mm^2 at 28 days
M15	10	15
M20	13.5	20
M25	17	25
M30	20	30
M40	27	40
M45	30	45

8 .0 Calculation:

Compressive Strength of concrete = Maximum compressive load / Cross Sectional Area

Cross sectional Area = 150mm X 150mm = 22500 mm^2 or 225 cm^2

Compressive Strength =Load/Cross sectional area

9.0 . EXPERIMENTAL RESULTS

From the experimental investigation the following results are drawn:

Mix proportions (cement + C.A) and W/C ratio= 20 % =0.20

Table 5 : compressive strength results without admixture:

Mix proportions	Compressive strength (MPa)		
	3 days	7 days	28 days
M1(1:6)	10.74	12.29	18.45
M2(1:8)	4.22	7.23	10.85

Table 6 : Flexural strength test results

Mix proportions	Flexural test MPa)		
	3 days	7 days	28 days
M1(1:6)	1.5	2.5	3.75
M2(1:8)	1	1.25	1.875

Mix proportions (cement + C.A + Silica fumes) and W/C Ration =0.30

Table 7 Compressive strength results:

Mix proportions	Percentage of silica fumes	
	5%	10%
	Compressive strength (MPa) 28 days	Compressive strength 28 days
M3	16.	18.09
M4	19.34	21.67
M5	26.09	28.07

Table: 8 Flexural strength test results

Mix proportions	Percentage of silica fumes	
	5%	10%
	Flexural strength (MPa) 28 days	Flexural strength (MPa) 28 days
M3	2.81	3.02
M4	3.07	3.23
M5	3.57	3.70

10.0. CONCLUSION

1. The mix proportion M5(1:6) has got a high compressive strength
2. The mix proportion M1(1:6) has got a high flexural strength
3. There was an increase in compressive strength with increase in silica fume and Max compressive strength of Pervious concrete was 28.07 Mpa at 28 days of age found in mix proportion M5(1:6)
4. The Max flexural strength of Pervious concrete was 3.75 Mpa at 28 days of age found in mix proportion M1(1:6)

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PERFORMANCE COMPARISION OF FRC WITH AND WITHOUT MINERAL ADMIXTURES

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Abstract - The consumption and hence the production of Ordinary Portland Cement (OPC) is increasing year by year world over. Further, the production of every tonne of OPC generates one tonne of green house gases, (CO_2) which results in Global Warming. Usage of OPC is more in construction industry as it is a major ingredient in Concrete. As the usage of Concrete is increasing year by year, more and more is the OPC production and hence the environment is getting polluted; added to this undesirable scenario, the natural resources like lime stone used to manufacture cement and river sand are getting depleted year by year. In order to prevent the usage of large amounts of OPC in Concrete, mineral admixtures like Ground Granulated Blast furnace Slag (GGBS), Fly Ash (FA)and Metakaolin (MK) which are pozzolanic and cementitious in nature are adopted to replace certain percentages of OPC. Manufactured Sand (M-sand) is adopted to replace river sand. Strength as well as durability properties of FRC (@1% steel fiber by weight of binder) made with 100% OPC with different water binder ratios and concrete grades M25, M30, M35, and M40 were found. And then FRC made with 50% OPC and 50% mineral admixtures like fly ash, Metakaolin and GGBS in different combinations were tested for strength and subjected to durability tests. It is observed during the analysis of tests FRC with mineral admixtures has performed better than that of FRC made with 100% OPC.

Keywords: Concrete, Fly Ash, GGBS, Metakaolin, steel fiber, compressive strength, split tensile strength, Water absorption and Sorptivity test.

I. INTRODUCTION

Concrete is one of the most commonly adopted material for construction. Durability, potential to sustain extreme weather conditions and ability to be molded in to any shape made this material widely acceptable. Concrete comprise of cement, fine aggregate, coarse aggregate and water. Though cement generally comprises 12% of Concrete mass [1], about 250 million tons of cement produced in India yearly. This in turn produces 220 million tons of CO_2 approximately which cause environmental pollution and global warming. To overcome this, comprehensive approach is to be developed to use more and more pozzolanic mineral admixtures in Concrete. Most of the pozzolanic mineral admixtures are by-products and their usage in concrete could decrease consumption of cement in construction. Hence this could reduce environmental pollution and global warming to large extent. On the other hand, it became necessary to replace natural sand in Concrete by alternate material without compromising on the quality of Concrete as the available sources of natural sand are getting depleted and transportation of good quality sand from long distances may increase cost of construction. The past researches have shown that Fly Ash, Ground Granulated Blast-Furnace Slag (GGBS) could give better result on replacing Ordinary Portland Cement (OPC)[1]. And further, natural sand can be replaced completely by manufactured sand (M-Sand) in Concrete [1] to get same results as natural sand. Steel Fibers are generally added to improve cracking resistance due to plastic and drying shrinkage. Addition of Steel Fibers increases mechanical properties like compressive strength, split tensile strength and flexural strength [2].

II. MATERIALS

Cement

Cement used in this study is ordinary Portland cement of 53 grade confirming to IS: 2269-1987 specifications.

Fine aggregates

Manufacturing sand is used instead of river sand in this investigation as fine aggregate which is having specific gravity of 2.6, fineness modulus of 3.10.

Coarse aggregates

Crushed angular aggregate used in this study confirming to IS: 383-1970.Which was bought from the quarry nearby and the size of coarse aggregate used is 20 mm which is free from deleterious materials. Coarse aggregate used has specific gravity is 2.64 and bulk density of 1592 kg/mm^3.

Fibers: The fibers used are hooked end steel fibers. Which are randomly oriented and having aspect ratio of 40.In this study steel fibers@1% by weight of binder are used in all concrete mixes

Fly ash: Color-Dark gray, Bulk Density-1041 kg/m^3,Sp.gravity-2.2

GGBS: Color-off White, Bulk density-1280 kg/m^3, Sp.gravity-2.8

Metakaolin: Color-Off white, Bulk Density-790 kg/m^3,Sp.gravity-2.6

Super plasticizer

Super plasticizer used in the study is MasterRheobuild920SH. (0.1%) by weight of cement based on Naphthalene formaldehyde polymers with following properties as per IS: 9103-1999[3].

III. EXPERIMENTAL INVESTIGATION

GENERAL

Experimental investigation is made by replacing cement by GGBS, Metakaolin and Fly ash in fiber reinforced concrete with 1% steel fibers with varied water binder ratios, concrete grades and mineral admixture proportions. Behaviour of RCC structural elements like Beams and Columns made with 50% replacement of OPC with Fly Ash was similar to that of samples made with 100% OPC, as stated by Dr N Sanjeev in his PhD thesis [3] .Durability properties are established by conducting Water absorption and Sorptivity tests additionally some of the Mechanical properties compressive strength, Split tensile strength are determined.

TESTS

Sorptivity

To determine the cumulative change in volume of water absorbed per unit area against square root of time as per ASTM C1585. Specimens are made about a Size of 100mm diameter and 50mm depth which were oven dried at 110°C for 24 hrs after curing for about 28 days. Sealant or tape are used to seal the sides of specimens but the suction face and face opposite to are not sealed .it is a placed in a container containing water about 5 to 10mm height of water .

Rate of water absorption =K

K is the slope of **I vs** $\sqrt{t}$

I = W/(A×d)

W= amount of water absorbed in Kg

A=Area of cross section contact with water; d=density of medium in which it is immersed (1000Kg/m^3 for water)

Water absorption

Sizes of 100mm×100mm×100mm concrete cubes are used to determine the water absorption. Specimens are dried at 110°C for 24 hrs after curing for about 28 days. Specimens are placed in container and it was fully immersed in such a way that height of water above the specimen after immersion is 2cm. Weights are noted at different intervals of time.

Mi%=100× (mi-mo)/mo

mi=weight of wet sample at time t

mo=weight of dry sample.

Compressive strength

Cubes of 15 cm X 15 cm X 15 cm are commonly used. These specimens are tested by compression testing machine after 7 days or 28 days curing according to IS 516-1969 [4]. A loading rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Split tensile strength

Size of 150mm diameter and 300mm height cylinder is used to determine the tensile strength and it is the standard method and performed in accordance with IS 5816-1970.

IV. MIX DESIGN

The Concrete mix of M25 grade is designed as per IS 10262-2009[5].The partial replacements of OPC with Mineral Admixtures are done based on weight basis.

Grade	water	cement	Fine aggregate	Coarse aggregate
M25	0.45	1	2.39	3.17
M30	0.43	1	2.17	3
M35	0.42	1	2.13	2.86
M40	0.4	1	1.98	2.79

V. CONCRETE MIXES AND TEST RESULTS

C1: M25 Grade, OPC 100%+ M-Sand +Coarse aggregate + Fibers(1% of weight of OPC)

C2: M30 Grade, OPC 100%+ M-Sand +Coarse aggregate + Fibers(1% of weight of OPC)

C3: M35 Grade, OPC 100%+ M-Sand +Coarse aggregate + Fibers(1% of weight of OPC)

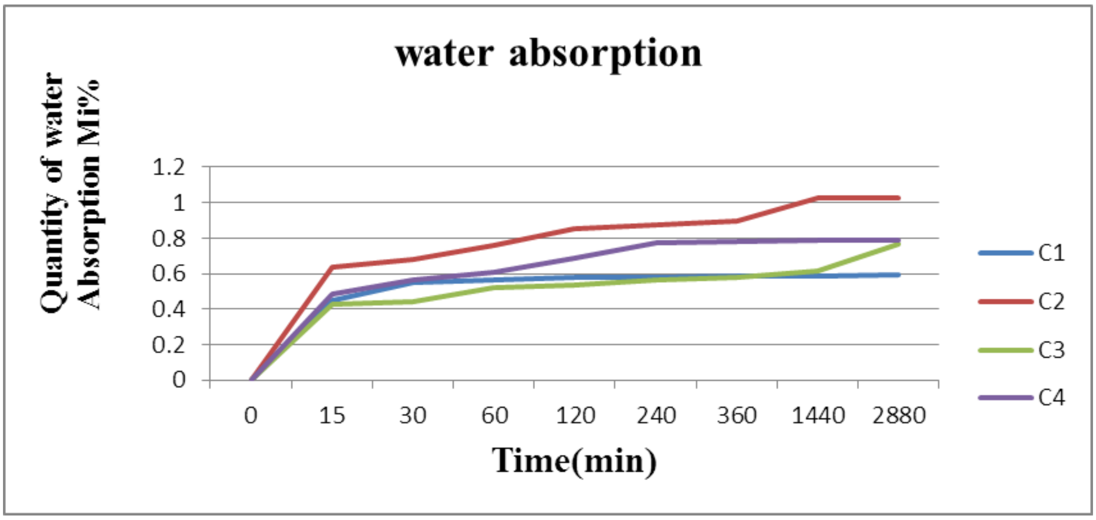
C4: M40 Grade, OPC 100%+ M-Sand +Coarse aggregate + Fibers(1% of weight of OPC)

(i) Mechanical properties: Compressive strength and split tensile strength test results for FRC with 100% OPC are shown in table 1.

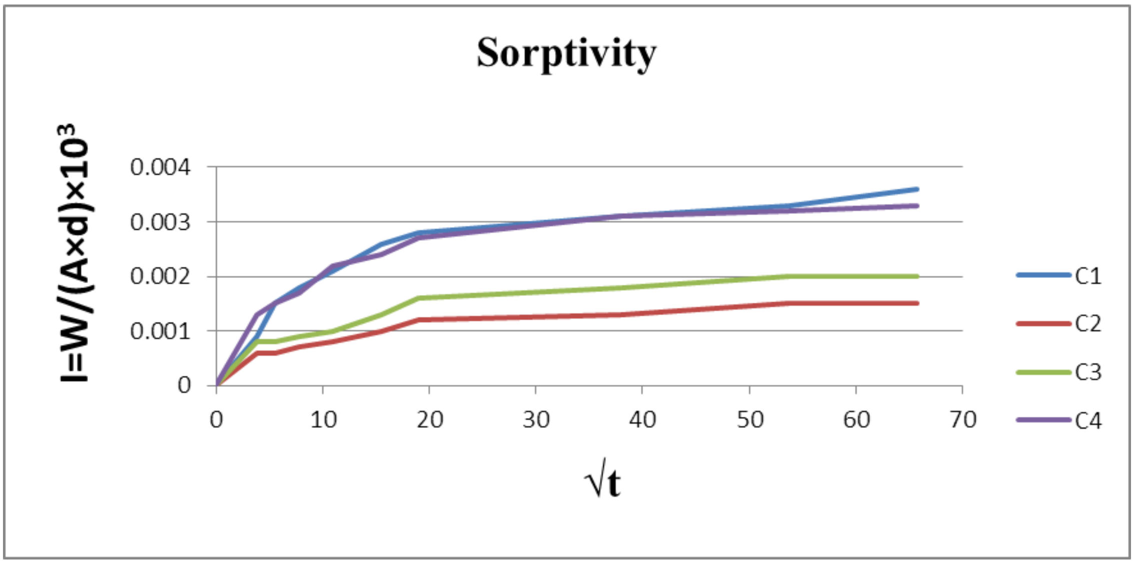
TABLE 1

Grade of concrete	MIX	Compressive strength		Split tensile strength	
		7days	28days	7days	28days
25	C1	26.8	36	2.6	3.57
30	C2	33.23	48.14	3.1	4.1
35	C3	34.37	49.3	2.86	4.17
40	C4	36	53.37	4.46	6.16

(ii) **Durability properties:** Water absorption and Sorptivity values for FRC with 100% OPC are represented graphically vide Fig(1)and Fig(2).



Fig(1)



Fig(2)

M1: OPC 85% + 5%GGBS +5% Fly ash + 5%Metakaolin +Fine Aggregate (M sand) + Coarse Aggregate + Fibers (1% of weight of binder).

M2: 70% OPC + 15% Fly Ash + 15% GGBS + Fine Aggregate (M sand) + Coarse Aggregate + Fibers (1% of weight of cementitious material)

M3: 70% OPC + 15% Fly Ash + 15% Metakaolin + Fine Aggregate (M sand) + Coarse Aggregate + Fibers (1% of weight of cementitious material)

M4: OPC 70%+ + 15%GGBS +15%Metakaolin +Fine aggregate (M sand) +Coarse Aggregate +Fibers (1% of weight of cementitious material)

(iii) Mechanical properties: Compressive strength and split tensile strength test results for different Mixes (M1, M2, M3, M4) are shown in table 2.

TABLE 2

Grade of concrete	MIX	Water binder ratio	Compressive strength		Split tensile strength	
			7 days	28days	7days	28days
25	M1	0.45	25.48	44.2	2.4	4.6
30	M2	0.43	28.02	42.85	2.5	3.7
35	M3	0.42	29.85	45.2	2.49	3.77
40	M4	0.4	37.92	55.51	3.73	6.67

(iv) Durability properties: Water absorption and Sorptivity values for different Mixes (M1, M2, M3, M4) represented graphically vide Fig(3)and Fig(4).

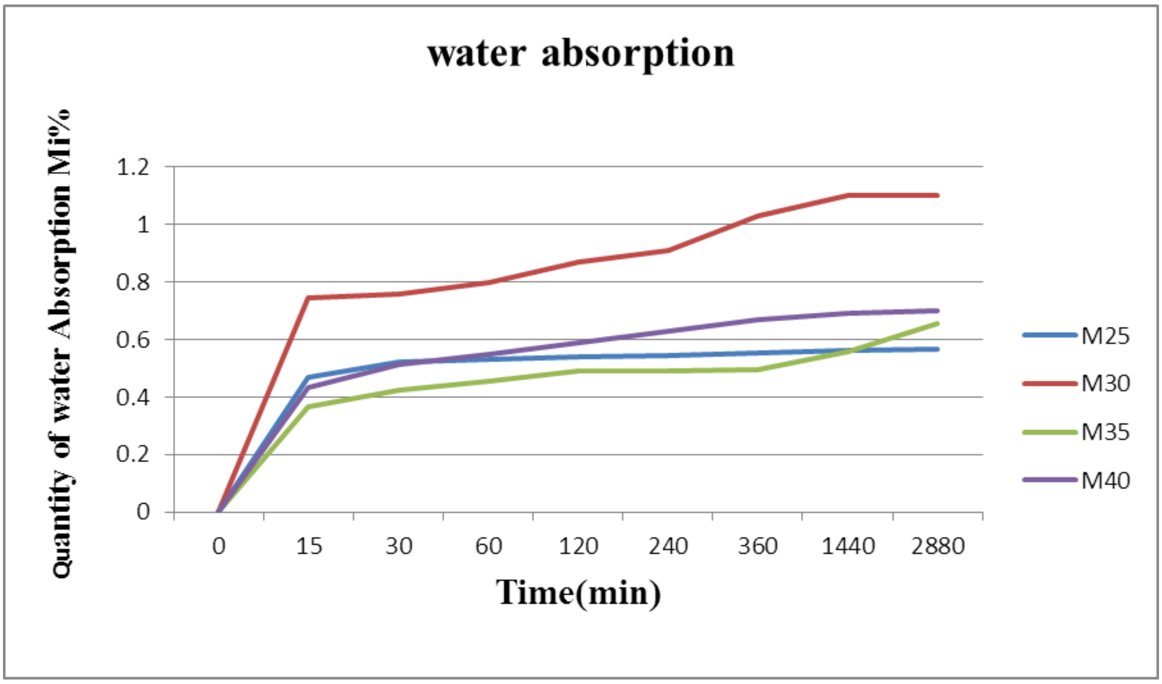


Fig (3)

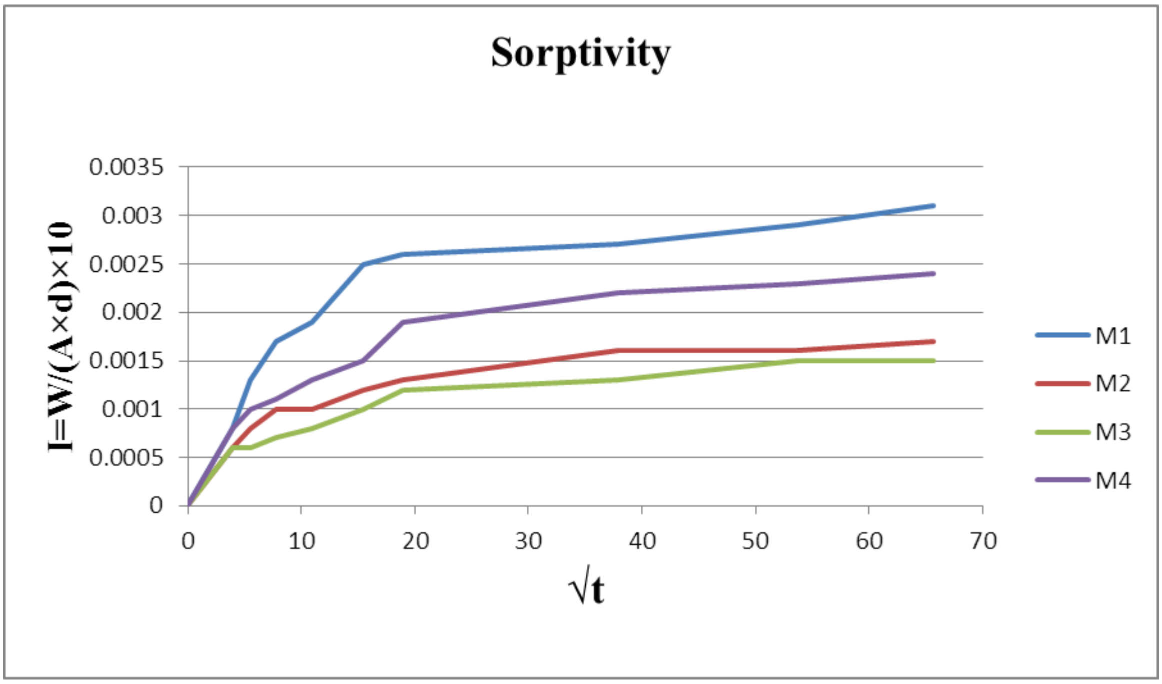


Fig (4)

However tests were conducted on samples prepared with only OPC without using the fibers to compare the results with FRC. Concrete mixes for M40 grade concrete with water binder ratio 0.46 are appended below

A0: OPC (100%) +Fine Aggregate(M-Sand)+Coarse Aggregate

A1: OPC 85%+5% Flyash+5%GGBS+5%MetaKaolin+Fine Aggregate +Course Aggregate

A2: OPC 70%+10%Flyash+10%GGBS+10%MetaKaolin+FineAggregate+CoarseAggregate

A3: OPC 55%+15%Flyash+15%GGBS+15%MetaKaolin+FineAggregate+CoarseAggregate

Table 3: Compressive, Split tensile strength values of various mixes

TABLE 3

MIX	**COMPRESSIVE STRENGTH(N/mm^2)**		**SPLIT TENSILE STRENGTH(N/mm^2)**	
	7 days	**28 days**	**7 days**	**28 days**
A0	36.04	50.73	2.32	3.29
A1	37.92	51.42	2.74	3.61
A2	38.91	53.45	3.04	3.74
A3	39.31	56.41	3.29	4.06

VI. CONCLUSIONS

1. Maximum Compressive strength were attained for Mix M1 at 15% replacement and its 28 days compressive strength is 23% more than that off controlled concrete.
2. Mixes M2,M3,M4 attained maximum compressive strengths at 30% replacement,28 days compressive strength of M2,M3,M4 is 13% ,4.5%,10.5% more than the target mean strength.
3. Maximum Split tensile strength were attained for Mix M1 at 15% replacement. Whereas for Mixes M2, M3, M4 attained maximum Split tensile strength at 30% replacement.
4. In the present Study for Mixes M1, M3, M4 there was significant improvement in the durability properties like water absorption and Sorptivity.
5. For mix M2 there was no significant improvement in the durability properties like water absorption and Sorptivity

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AN EXPERIMENTAL STUDIES ON MECHANICAL PROPERTIES OF M30 GRADE CONCRETE WITH PARTIAL REPLACEMENTS OF CEMENT BY DOLOMITE AND FINE AGGREGATE BY COPPER SLAG

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Abstract: Concrete plays an important role in every construction. This paper is an experimental investigation to study the mechanical properties of the concrete with partial replacement of cement by dolomite powder and fine aggregate by copper slag. The cement content replaced with dolomite and fine aggregate replaced with copper slag from 5% to 25% at regular intervals of 5%. In the designed mix proportion of M30 grade concrete is 1:2.17:2.95. The Superplastisizer Master Rheobuild 920SH of 0.5% dosage used as chemical admixture is added to the concrete to maintain 0.45 the water-cement ratio. The concrete cubes, cylinders were casted. The various mechanical properties such as compressive strength, split tensile strength, were tested after 3 days, 7 days and 28 days of curing from 5 to 25% at regular intervals of 5% replacement of cement with dolomite powder and 10% to 50% at regular intervals of 10% replacement of fine aggregate with copper slag.

Keywords: Concrete, Cement, Dolomite powder, Fine aggregate, Copper slag, Compressive strength, Split tensile strength

1. INTRODUCTION

Concrete is an adaptable designing material utilized in most of the construction. It is fundamentally made out of cement, water, fine aggregate and coarse aggregate. It is eventually noticed that, concrete is very crucial as it is made in such a way that it is economical, highly durable with good workability and it can be made it into any form and size with high compressive strength. The usage of supplementary solidifying materials like dolomite powder, egg shell, rice husk, silica fume, sugarcane bagasse, metakaolin, fly ash and so on which are natural pozzolans and so forth in concrete generation is one of the answers for reducing the cement content in concrete and therefore reducing the CO_2 content into the environment. Along these lines, conditions for additional protective and eco-pleasing establishing material have increased eagerness for inadequate bond replacement material. The excavation of sand from the river beds lessen the water head, therefore less pervasion of water into the ground resulting lower ground water level. Along these lines, conditions for additional protective and eco-pleasing waste materials have increased eagerness for inadequate replacement of fine aggregate. By using with different mineral admixtures in concrete like dolomite, copper slag not only improves mechanical properties but also other properties like workability.

2. MATERIALS

The materials utilized for this trial work are cement, water, fine aggregate (river sand), coarse aggregate 20mm, Dolomite powder, Copper slag and water.

2.1 Cement

Cement used for all the concrete mixes in this experimental work is Ordinary Portland Cement. Fresh and no lumps were present in the cement used in this trial work. Cement was tested as per IS: 12269-1987. OPC 53 grade was used in this experimental work.

Table: 1

CHARACTERISTICS	OBSERVED VALUE
Normal consistency	32%
Initial setting time	65 min
Final setting time	270 min
Specific gravity	3.15
Compressive strength at 28 days	53 Mpa

2.2 Fine Aggregate

Aggregate passing through 4.75mm sieve and held on 75micron sieve is named as fine aggregate. Fine aggregate was tested as per IS:383-1970.

Table: 2

CHARACTERISTICS	OBSERVED VALUES
Grade zone	II
Specific gravity	2.6
Fineness modulus	2.2

2.3 Coarse Aggregate

Coarse aggregate used in this experimental work is an angular shaped aggregate. The aggregates passing through the 20mm sieve and were held on 10mm sieve. Coarse aggregate was tested as per IS 383-1970.

Table: 3

CHARACTERISTICS	OBSERVED VALUES
Water absorption	0.5
Specific gravity	2.68
Fineness modulus	6.8

2.4 Dolomite Powder

The dolomite is an anhydrous carbonate mineral created out of calcium magnesium carbonate. Dolomite powder is obtained by crushing the dolomite mineral.

2.5 Copper Slag

Copper slag is a by-product of copper extraction by smelting process. During smelting, impurities become scoria that floats on the liquified metal. Scoria that's quenched in water produces angular granules that are disposed of as wastes are utilized in concrete for construction.

Copper Slag used for this experimental work was collected from Sri Srinivasa Metalizers, Cherlapalli. The particle shape is multifaced. Its appearance is black and glassy. The specific gravity of the copper slag was found to be 3.15.

2.6 Super Plasticizer

Superplastisizer Master Rheobuild 920SH was used in this experimental work to improve the workability of the concrete.

Table: 4

CHARACTERISTICS	OBESRVATION
State	Liquid
Colour	Dark
Density	1.2
Chemical name	Naphthalene formaldehyde polymer
pH	8.40

3. CHEMICAL COMPOSITION OF THE MATERIALS

3.1 Dolomite

Carbonate, Calcium Carbonate, Magnesium Carbonate, Insoluble Acid and Silicon-dioxide are the chemicals present in dolomite powder.

Chemical Composition:

Table: 5

CHEMICAL	PERCENTAGE
Total Carbonate	97.4%
$CaCO_3$	59.5%
$MgCO_3$	31.9%
Acid Insoluble	8.7%
SiO_2	4.1%

3.2 Copper Slag

Aluminium Oxide, Ferric Oxide, Silicon-dioxide, Calcium oxide, Magnesium Oxide are the chemicals present in copper slag.

Chemical Composition:

Table: 6

CHEMICAL	PERCENTAGE
SiO_2	33-35%
Fe_2O_3	40-44%
Al_2O_3	4-6%
CaO	0.8-1.5%
MgO	1-2%

4. EXPERIMENTAL WORK

4.1 Mix Design

The mix design techniques utilized in various nations are mostly dependent on the empirical relationships, charts and graphs created from extensive trial examinations. A properly designed concrete mix should have least cement content without relinquishing quality so as to make in concrete mix. The aim of contemplating the different properties of the material of concrete, plastic concrete and hardened concrete, is to empower a concrete technologist to design a concrete blend for a specific strength and durability.

4.2 Mix Proportion

In this experimental study, M30 grade of concrete was used and the mix proportions for cement, fine aggregate and coarse aggregate was taken as 1:2.17:2.95 which was designed as per IS:10262-2009, with a water-cement ratio as 0.45.

4.3 Concrete Mixes

M1: 100% OPC + Fine Aggregate (river sand) + Coarse Aggregate

M2: (95% OPC + 5% Dolomite Powder) +(90% Fine Aggregate (river sand) + 10% Copper Slag) + Coarse Aggregate

M3: (90% OPC + 10% Dolomite Powder) + (80% Fine Aggregate (river sand) + 20% Copper Slag) + Coarse Aggregate

M4: (85% OPC + 15% Dolomite Powder) + (70% Fine Aggregate (river sand) + 30% Copper Slag) + Coarse Aggregate

M5: (80% OPC + 20% Dolomite Powder) + (60% Fine Aggregate (river sand) + 40% Copper Slag) + Coarse Aggregate

M6: (75% OPC + 25% Dolomite Powder) + (50 % Fine Aggregate (river sand) + 50% Copper Slag) + Coarse Aggregate

4.4 Batching and Mixing

Weigh batching was done with the assistance of electronic scales. Batching was performed for each of the combination proportions. Tilting concrete mixture was used for mixing of concrete ingredients for about 2-3 minutes.

Placing and Compaction: First the cube, cylinder and beam moulds are cleaned and then oil is applied to them to avoid the bond between the moulds and the concrete. Placing of concrete into the mould is done in 3 layers with 25 blows given to each layer with the help of tamping rod. The air trapped in the fresh concrete which was put in the moulds is removed by the table vibrator.

4.5 Demoulding

The fresh concrete is allowed to set for 24 hours after it is placed in the moulds. Then they were marked with specific identification like M1, M2, M3 etc., for varying replacement percentages of dolomite and copper slag and were put in the curing tank at ambient temperature. The hardened concrete specimens were removed from the curing tank after 3, 7 and 28 days for testing.

4.6 Compressive strength

The cubes of size 150mm x 150mm x 150mm were used to conduct the compression test in accordance with IS:516-1959. Three samples were used to test the compressive strength test after 3, 7 and 28 days curing.

4.7 Spilt Tensile Strength Test

Spilt tensile strength test was performed according to IS 5816-1970, a standard test to get the tensile strength in indirect manner.

5. Test Results

5.1 Compression Test

The Compressive strength for 3, 7 and 28days values are shown graphically in **fig.1** below. It was observed that the compressive strength was optimum when 10% of cement replaced with dolomite powder and 20% of fine aggregate replaced with copper slag. It was also observed that 20% of cement replaced with dolomite powder and 40% of fine aggregate replaced with copper slag can be replaced which gives strength at par with conventional mix.

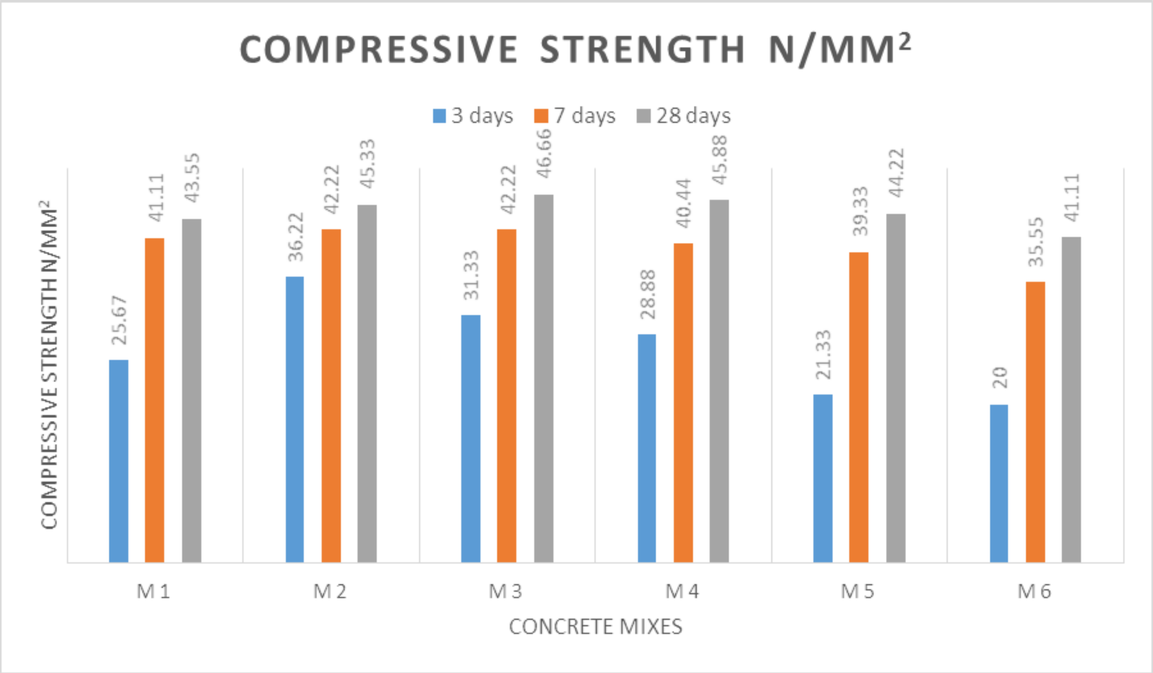

Fig (1)

5.2 Split Tensile Test

The split tensile strength for 3, 7 and 28days values are shown graphically in **fig.2** below. It was observed that the split tensile strength was reduce gradually.

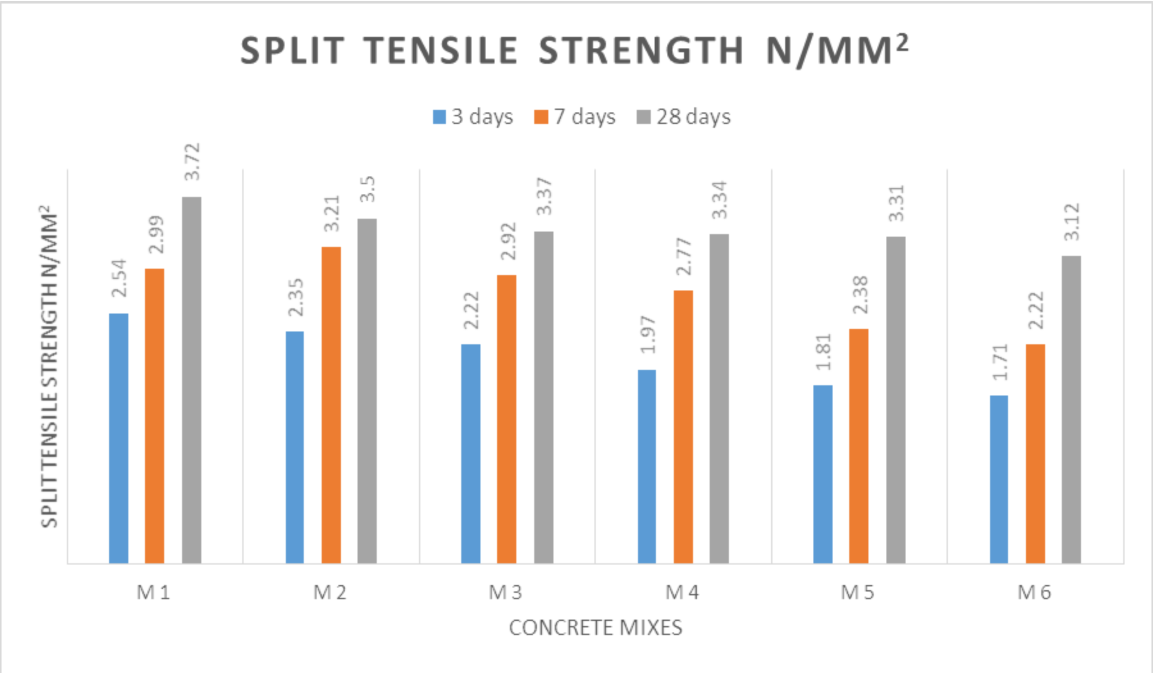

Fig (2)

6. CONCLUSION

- The partial replacement of cement with dolomite and copper slag with fine aggregate has increased the compressive strength
- The optimum compressive strength is observed at mix M3 i.e., at 10% replacement of cement with dolomite and 20% replacement of fine aggregate with copper slag.
- It was also observed that upto M5 i.e., at 20% dolomite and 40% copper slag can be replaced which gives compressive strength at par with conventional mix.
- The split tensile strength is observed to be gradually decreasing with the increase of replacement of dolomite and copper slag maybe due to reduce of interlocking between the ingredients of concrete mix.

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List of codes

1) Indian standard code of practice for plain and reinforced concrete, IS-456:2000, 4th revision.
2) Indian standard recommended guidelines for concrete mix design, IS 10262:2009.
3) IS 12269- 1987: Specifications of 53 grade OPC
4) Indian standard specifications for coarse and fine aggregate from natural sources for concrete IS 383-1970
5) IS 2386-1963: Methods of testing aggregates for concrete
6) IS 516-1959: Methods of test for strength of concrete.

EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF M35 GRADE CONCRETE WITH PARTIAL REPLACEMENT OF FINE AGGREGATE BY COPPER SLAG

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Abstract - In present situation, fast urbanization has made a gigantic interest for regular sand consequently made it considerably more costly. Elective materials in all types of constructions are acquainted with decrease the weight on normal materials, furthur maintaining the economical status of project. While additionally dealing with the encompassing condition. Squander Materials like Stone residue, Copper Slag, Carbonate Sand ,Flyash and so forth having silica sythesis (SiO_2) could be utilized as a substitution for Fine aggregate in a concrete mix. In the process of manufacturing copper the biproduct Copper slag is produced in an heavy quantity.Copper slag has an high specific gravity and has glassy granular texture .Copper slag contains the same particle sizes as of fine aggregate so that it can be used as a replacement for fine aggregate in concrete mix .Here in this paper the main objective is to consider the utilization of Copper slag as an elective substitution material of Fine aggregate. Additionally examines the after effect of substitution of Fine aggregate with Copper slag on mechanical characteristics of cement concrete such as Compressive strength and Flexural strength.

Keywords: Concrete ,Fine aggregate, Copper slag ,Compressive strength and Split Tensile strength.

INTRODUCTION

In the present situation, because of constant development in populace and Industrialization there is enormous necessity of aggregates generally for construction industry due to excessive usage of natural sand it is causing disturbances to nature and also became more expensive. So the researchers created plans for managing the waste coming from various Industries. such as substituting the fine aggregates by other materials to reach the explicit needs. Rapid industrialization producing the heavy quantity of waste and substantially natural resources are also getting depleted The eco agreeable and dependable advancement for development comprise the utilization of non customary and diverse waste materials, and reusing of waste material for diminishing emanations in conditions and diminishing the utilization of natural resources .Copper slag has nearly same features as the fine aggregate .Copper slag is one of those materials which is disposed in to land as a waste material and which is produced as a by product during the refining of copper. Here about 2.2 to 2.5 tons of waste is produced. Now this waste slag can be used as a replacement for the aggregates in concrete. Usage of copper slag as a partial replacement for fine aggregate ,the cost of the construction can also be reduced .About 25%to30% of sand is present in copper slag which is the main component in natural sand and a negligible amount of copper(0.2%) is also present in the copper slag. In this present investigation the mechanical properties of M35 grade concrete were tested when fine aggregate partially replaced with copper slag ,i.e.,10%to50% at a regular interval of 10%.

2.MATERIALS

2.1Cement

The ordinary Portland cement of 53 grade is used through out the investigation confining to IS:12269-1987. Test results are mentioned in Table1

Table : 1

CHARACTERISTICS	OBSERVED VALUE
Normal consistency	32%
Initial setting time	65 min
Final setting time	270 min
Specific gravity	3.15
Compressive strength at 28 days	53 Mpa

2.2Water

Portable water which is available in the premises of the lab is used for the curing and the experimental procedures which are free from the organic matter and dissolved salts.

2.3Coarse aggregate

Locally available Crushed angular aggregate of size 20mm were used confining to IS 383:1970. Confining to IS 2386:1963 physical properties like specific gravity and water absorption were tested. Test results are mentioned in Table 2.

Table: 2

CHARACTERISTICS	OBSERVED VALUES
Water absorption	0.5
Specific gravity	2.64
Fineness modulus	6.8

2.4 Fine aggregate

Locally available fresh sand confining to IS 383:1970. Which is free from organic matter. confining to IS 2386:1963 physical properties like specific gravity and water absorption were tested. Test results are mentioned in Table 3.

Table:3

CHARACTERISTICS	OBSERVED VALUES
Grade zone	II
Specific gravity	2.6
Fineness modulus	2.2

2.5 Copper slag

Copper slag used here was collected from the Sri Sai Metalizers located at Hyderabad. The physical and chemical properties of copper slag are mentioned in Table 4 and Table 5 .

Table:4

PHYSICAL PROPERTIES	COPPER SLAG
Particle shape	Multifaceted
Appearance	Black and glassy
Specific gravity	3.15

Table: 5

Chemical component	%of chemical component
SiO_2	33-35%
Fe_2O_3	40-44%
Al_2O_3	4-6%
CaO	0.8-1.5%
MgO	1-2%

2.6Super plasticizer

Superplastisizer Master Rheobuild 920SH was used to improve the workability of concrete.The properties of Admixture are mentioned in Table 6

Table :6

State	Liquid
Colour	Dark
Density	1.2
Chemical name	Naphthalene formaldehyde polymer
Ph	8.40

3.EXPERIMENTAL INVESTIGATION

Experimental investigation was performed on partial replacement of fine aggregate with copper slag to study the mechanical properties of M35 grade concrete. The Replacement of fine aggregate with copper slag is done at different percentages from 0% to 50%at a regular interval of 10% by mass. The materials like cement, coarse aggregate, fine aggregate and copper slag were tested in laboratory for suitability and used in mix design.

3.1 Mix proportion

The mix proportion of M35 grade concrete for the present investigation designed as per IS 10262-2009.The mix proportion used are 1:2.1:2.86 at w/c 0.17.

3.2 Compressive Strength Test

The cube specimen of size 150mm x 150mm x 150mm were casted ,cured and tested for compressive strength test in accordance with IS 516-1969.After 3 days 7 days and 28 days and for every test 3 samples were tested.

3.3 Split tensile Test

The cylinder specimen of size 150mm dia x 300mm in height were casted,cured and tested for split tensile strength test in accordance with IS 5816-1970.After 3 days 7 days and 28 days and for every test 3 samples were tested.

3.4 Flexural Strength Test.

The specimen of size 400mm x 100mm x 100 mm were casted cure and tested for flexural strength .After 3 days 7 days and 28 days and for every test 3 samples were tested.

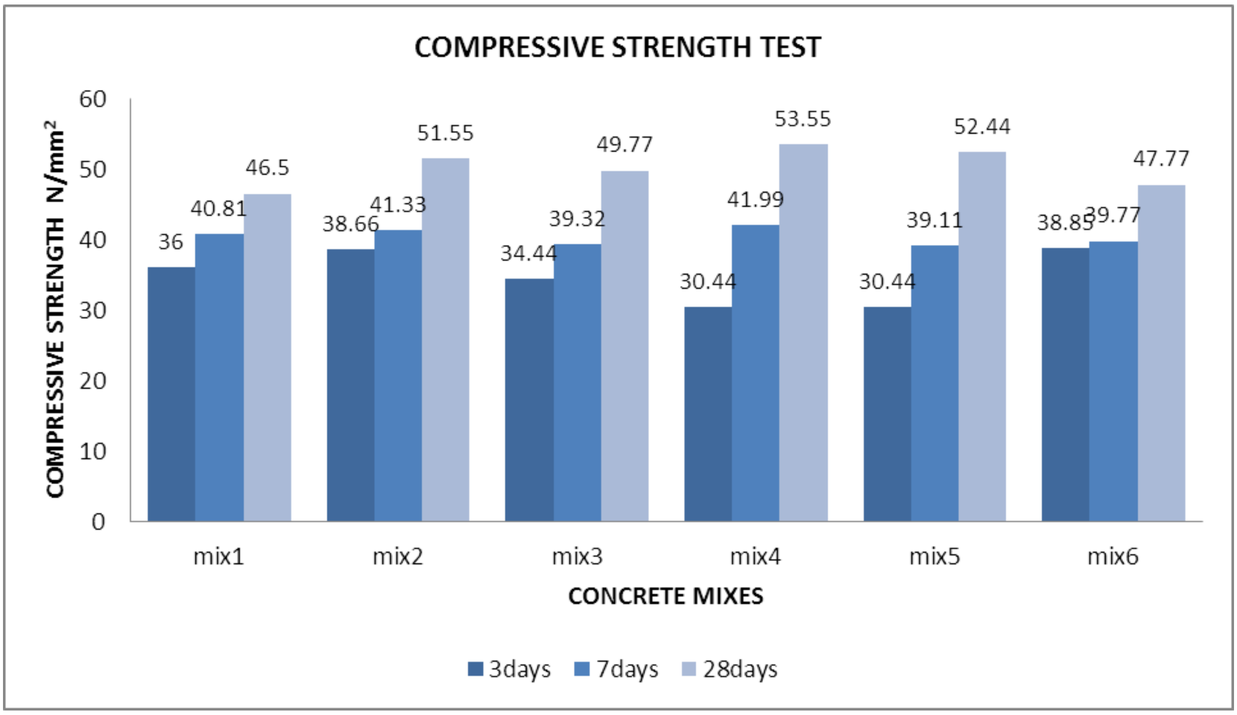
3.5 Concrete mix

MIX 1: OPC +(100% fine aggregate + 0%copperslag)+coarse aggregate
MIX2: OPC +(90% fine aggregate +10%copperslag)+coarse aggregate
MIX3: OPC +(80%fine aggregate +20%copperslag)+coarse aggregate
MIX4: OPC +(70% fine aggregate +30%copperslag)+coarse aggregate
MIX5: OPC +(60% fine aggregate +40%copperslag)+coarse aggregate.
MIX6: OPC +(50% fine aggregate +50% copperslag)+ coarse aggregate.

4.TEST RESULTS

4.1 Compressive strength

The compressive strength values for all the mixes at 3 days ,7 days and 28 days age are shown graphically in fig 1. It is observed that 40 % replacement is optimum among all replacement and compressive strength for 40%replacement is 23% more than the target mean strength at 28 days .



Fig(1)

4.2 Spilt Tensile Strength

Split tensile strength values for all the mixes at 3 days,7days and 28 days are shown graphically in Fig 2. It is observed that 40% replacement is optimum among all the replacements.

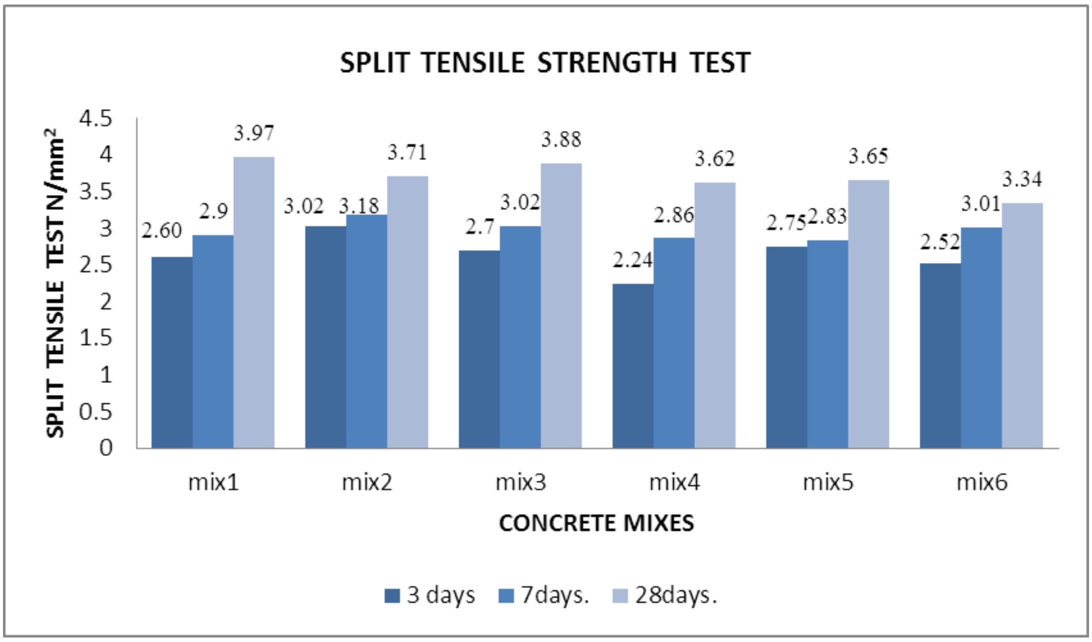


Fig (2)

5. CONCLUSION

The following are the conclusions for the experimental investigations .

1. Considerable increase in compressive strength was seen when the copper slag is used in permissible limits.
2. Upto 50% of replacement of fine aggregate copper slag shows better results when compared with conventional concrete.
3. With 30% replacement of fine aggregate with copper slag showed the 23% increasd in compressive strength.
4. By experimental results it is observed that the split tensile strength decreased at small percentages it may be due to lesser interlocking capacity between concrete ingredients
5. The increase in compressive strength is mainly due to the toughness and the glassy surface of the copper slag.
6. The workability is also seen increased depending on the percentages of copper slag used.
7. By this investigation it is clear that the copper slag can be used as a elective replacement material for fineaggregate upto 50% helps in keeping up the ecological and economical balance.

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List of codes.

1. Indian standard code of practice for plain and reinforced concrete, IS-456:2000, 4th revision.
2. Indian standard recommended guidelines for concrete mix design, IS 10262:2009.
3. IS 12269- 1987: specifications of 53 grade OPC
4.Indian standard specifications for coarse and fine aggregate from natural sources for concrete IS 383-1970
5.IS 2386-1963 : methods of testing aggregates for concrete
6.IS 516-1959: methods of test for strength of concrete.

EXPERIMENTAL STUDY ON COMPRESSIVE STRENGTH, WATER RETENTION AND WATER ABSORPTION OF SELF CURING CONCRETE WITH DIFFERENT CURING CONDITIONS

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Abstract - Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. However good curing is not always practical in many cases. Therefore the need to develop self-curing agents attracted several researchers. The concept of several self-curing agents is to reduce water evaporation from concrete. And hence increase the water retention capacity of concrete compared to conventional concrete. The use of self-curing agent is very important from the point view that water resources are getting valuable every day.

This project summarizes various aspects of self-curing of concrete which can be of valuable assistance in adopting good construction practices at site. M25 grade concrete cube specimens prepared based on the standards and availability of materials without and with 30% of flyash and quarry dust replaced as cement and fine aggregate and cubes cured by covering them with a external self-curing compound BONDIT CURE WB, air dried and normal water. These specimens are then tested after 7,14 and 28 days to obtain the compressive strength in three different conditions. The compressive strength of concrete cubes is calculated and compressive strength of self-curing concrete is compared with the different conditions. At the end of curing period of 7,14 and 28 days the amount of water retained in self cured concrete cubes is calculated and compared with the air dried cubes. Water absorption test is conducted on air dried concrete and self-cured concrete cubes and the amount of water is absorbed is calculate and compared.

KEY WORDS
Workability, Water absorption, Water retention, BONDIT CURE WB

INTRODUCTION

The concept of self-curing is to reduce the water evaporation from concrete and hence increase the water retention capacity of the concrete compared to conventional concrete. Efficient curing improves the strength and durability of concrete. Concrete curing compounds is considered to be most important since curing of concrete is a major challenge in the construction industry. Enough water needs to be present in a concrete mix for the hydration of cement to take place. When the concrete is exposed, water evaporates from its surface, The factors those influences the evaporation are atmospheric temperature, wind velocity, relative humidity, type of cement, initial temperature of the concrete and more importantly free w/c ratio of the mix.

PROPERTIES OF MATERIALS

S.No	Material	proerty	values	Specified limits as per IS code
1	Cement	Fineness	5%	≤10%
		Consistency	33%	≥30 min
		Specific gravity	3.15	2.90 to 3.15
		Initial setting time	30min	≥30 min
		Final setting time	600min	≤600min
2	Fly ash	Specific gravity-2.2	2.2	2.1 to 3.0
3	Fine aggregate (Natural sand and Crusher sand)	Specific Gravity	2.55	2.5 to2.8
		Fineness modulus	2.46	2.4 to 2.8
4	Coarse aggregate	Specific Gravity-2.65	2.65	2.5 to 3.0
		Fineness modulus	6.1	5.5 to 8.0

EXPERIMENTAL INVESTIGATIONS

SLUMP TEST ON FRESH CONCRETE

The object of the test is to find out the workability of freshly mixed cement concrete. The slump test is a means of assessing the consistency of fresh concrete. It is used, indirectly, as a means of checking that the correct amount of water has been added to the mix.

COMPRESSIVE STRENGTH

The cube specimens were tested on compression testing machine of capacity 2000KN. The bearing surface of machine was wiped off clean and sand or other material removed from the surface of the specimen. The specimen was placed in machine in such a manner that the load was applied to opposite sides of the cubes as casted that is, not top and bottom. The axis of the specimen was carefully aligned at the centre of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. The compressive strength of concrete cubes were determined after 7, 14 and 28days.

Compressive strength = ultimate load/bearing area.

WATER RETENTION

The specimens were prepared and initial weights of all cubes taken. After completion of every curing stage again weights of al lcubes taken and noted it as final weights. The amount of water retained in air dried cubes and self cured cubes is calculated and compared.

WATER ABSORPTION

The specimens were prepared and initial weights of all cubes taken. After completion of 7,14 and 28 days of curing period concrete cubes are immersed in water for 24 hours. The amount water absorbed by the concrete cubes are calculated by its initial weight. The amount of water absorption in air dried cubes and self cured cubes is calculated and compared.

MIX PROPRTIONS

Concrete design strength (MPa)	Cement	Fine aggregate (30%of quarry dust)	Coarse aggregate (10mm+20mm)	w/c ratio
25(without flyash)	425.73	(191+445)	563+563	0.45
25(with flyash)	298+ 128	(187+436)	551+551	0.45

TEST RESULTS AND DISCUSSIONS

1. Slump retention test of concrete

Table.1.Slump test retention values

s.no.	Design compressive strength(MPa)	Dosage of mineral admixture(percentage)	Slump (mm)
1	25	0	78
2	25	30	86

From the obtained results for conventional concrete slump value is more than the designed slump and for non-conventional concrete slump is more than the conventional concrete. As 30% of flyash replaced as cement in concrete, it has finer and rounded particles so it consumes lesser water then workability increases.

2. COMPRESSIVE STRENGTH

The specimens were prepared after completion of requrierd curing period the specimens were tested for compressive strength. They were tested in a Compression Testing Machine. The rate of loading was maintained as per the requirements given in the code of practice (IS: 516-1969). Three specimens of 150mm cubes were tested for required age and the average value of compressive strength was calculated. The results of compressive strength test were tabulated in table.

Table.2. compressive strength results for M_{25} Grade of concrete

Compressive strength of concrete in N/mm^2						
Curing period in days	Air dry		Water curing		Self-curing	
	cement	Cement+flyash	cement	Cement+flyash	Cement	Cement+flyash
7	16.59	17.18	23.25	23.65	24	24.59
14	22.96	23.55	29.63	31.40	31.35	32.29
28	27.10	28.01	31.55	32.88	36.78	38.67

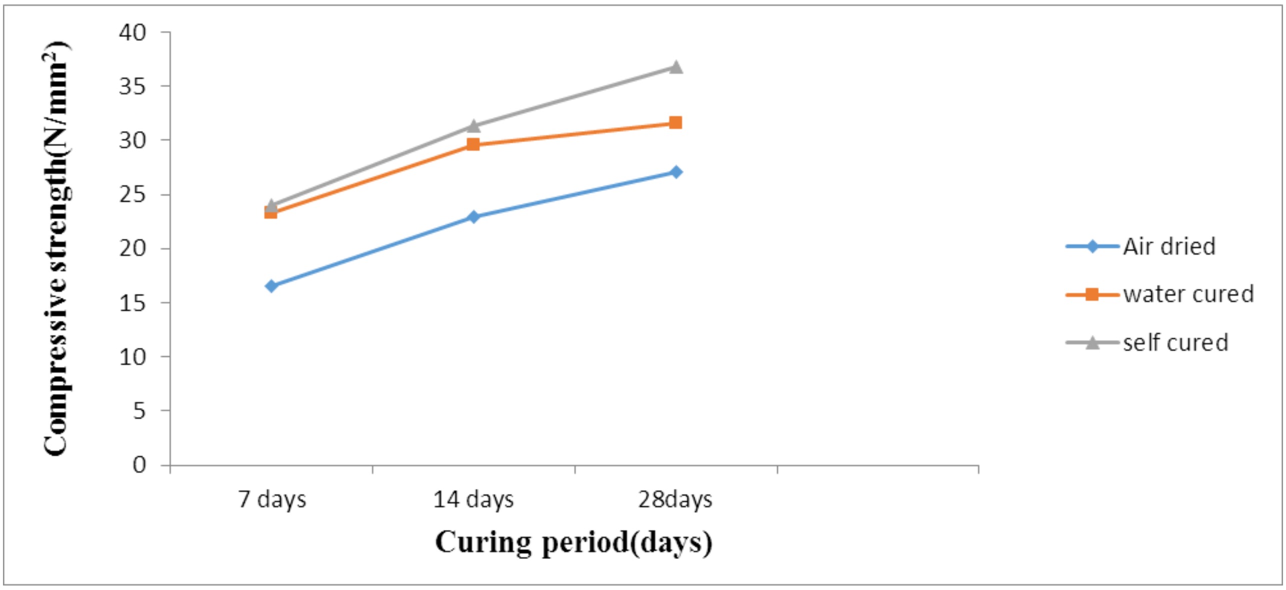

Fig.1.Plot of Curing Period v/s Compressive Strength (N/mm^2) without replacement

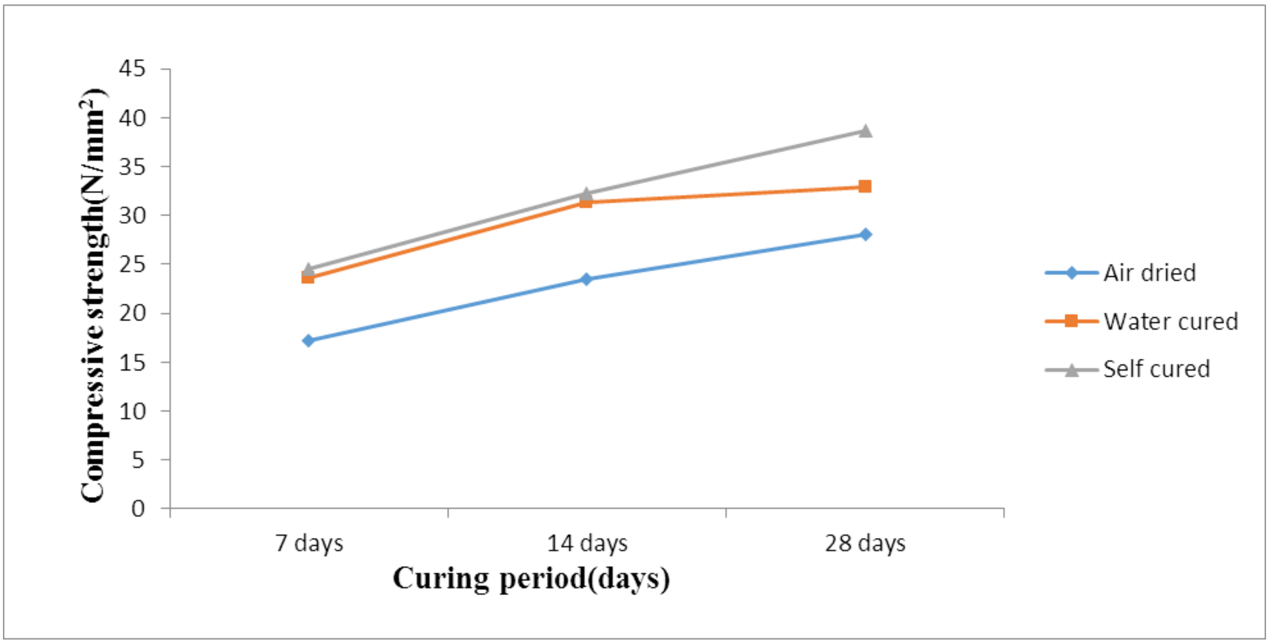

Fig.2. Plot Of Curing Period v/s Compressive Strength (N/mm^2) 30% Partial replacement Of flyash

From the obtained results observed that compressive Strength of air dried concrete cubes are lesser than compressive strength of water cured, self cured concrete cubes and after completion of 28 days curing period is also lesser than the designed target strength. Because of lack of curing, the amount of water present in the cubes evaporated. So the compressive strength of air dried cubes is less. It shows the curing of concrete is necessary.

The compressive strength of water cured concrete cubes is lesser than the compressive strength of the self cured concrete cubes and m,ore than the strength of the air dried cubes. And it gained designed target strength of after 28 days of curing period. After 7 days curing period it gains 66% of designed target strength, After 14 days curing period it gains 91% of designed target strength and After 28days curing period it gains 99% of designed target strength.

The compressive strength of self cured concrete cubes is higher than all and it gained more than the designed target strength after 28 days of curing period.

After completion of 7 days curing period the compressive strength of self cured concrete is 3% and 3.9% is more than the water cured concrete cubes without and with replacement.

After completion of 14 days curing period the compressive strength of self cured concrete is 5.8% and 6.4% is more than the water cured concrete cubes without and with replacement.

28 days curing period the compressive strength of self cured concrete is 16.5% and 17.5% is more than the water cured concrete cubes without and with replacement. Because application self curing agent on concrete cubes it arrests the water loss from the concrete and the amount of water present in the concrete is efficiently utilized for the complete hydration process. So it is used for getting strength more than the designed target strength.

From the obtained results also observed that compressive strength of non conventional concrete is higher than the compressive strength of conventional concrete at every stage of curing period and air dried, water cured and self cured concrete. Initially after preparation of air dried concrete cubes taken the weights

3.WATER RETENTION

The specimens were prepared and initial weights of all cubes taken. After completion of every curing stage again weights of all cubes taken and noted it as final weights. The amount of water retained in air dried cubes and self cured cubes is calculated and compared.

Table.3. Water retention results (M_{25} Grade concrete)

		Initial weights(Kgs)			**Final weights(Kgs)**			**Weight loss(Kgs)**		
					7days	**14days**	**28days**	**7days**	**14days**	**28days**
Air dried	Cement	8.92	8.93	8.94	7.94	7.86	7.82	0.98	1.07	1.12
	Cement+flyash	8.72	8.74	8.86	7.96	7.98	7.88	0.76	0.76	0.98
Self cured	Cement	8.80	8.88	8.96	8.58	8.61	8.66	0.22	0.27	0.30
	Cement+flyash	8.73	8.74	8.78	8.56	8.57	8.58	0.17	0.17	0.20

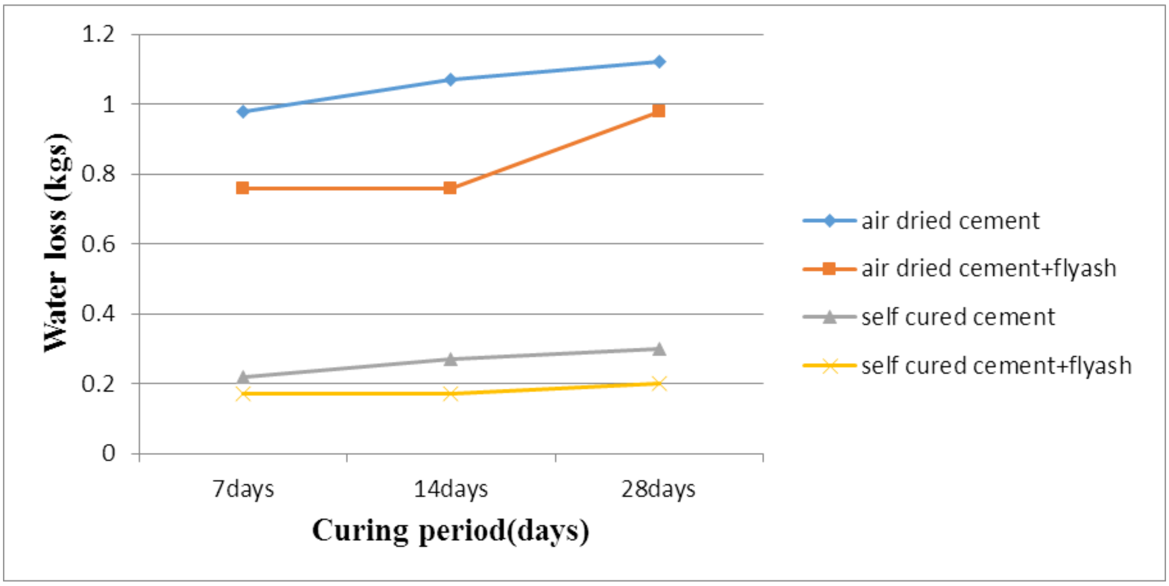

Fig.3.Plot of Curing period v/s water retention

From the obtained results observed that the weight loss of the air dried concrete cubes is more than the self cured concrete cubes. Because of lack of curing the amount of water present in the air dried cubes evaporated. The external application of self curing agent acts as a barrier to prevents the loss of water from the cubes.

4.WATER ABSORPTION

The specimens were prepared and initial weights of all cubes taken. After completion of every curing stage again weights of all cubes taken and noted it as final weights. The amount of water rabsorption in air dried cubes and self cured cubes is calculated and compared.

Table.3. water absorption results (M_{25} Grade concrete)

days	Air Dried				Self Cured			
	Cement		Cement+Fly Ash		Cement		Cement+Fly Ash	
	Initial weight	Final weight	Initial weight	Final weight	Initial weight	Final weight	Initial weight	Final weight
7	8.92	9.16	8.72	9.00	8.80	8.90	8.73	8.84
14	8.93	9.33	8.74	9.18	8.88	9.02	8.74	8.89
28	8.94	9.45	8.86	9.30	8.96	9.14	8.78	8.97

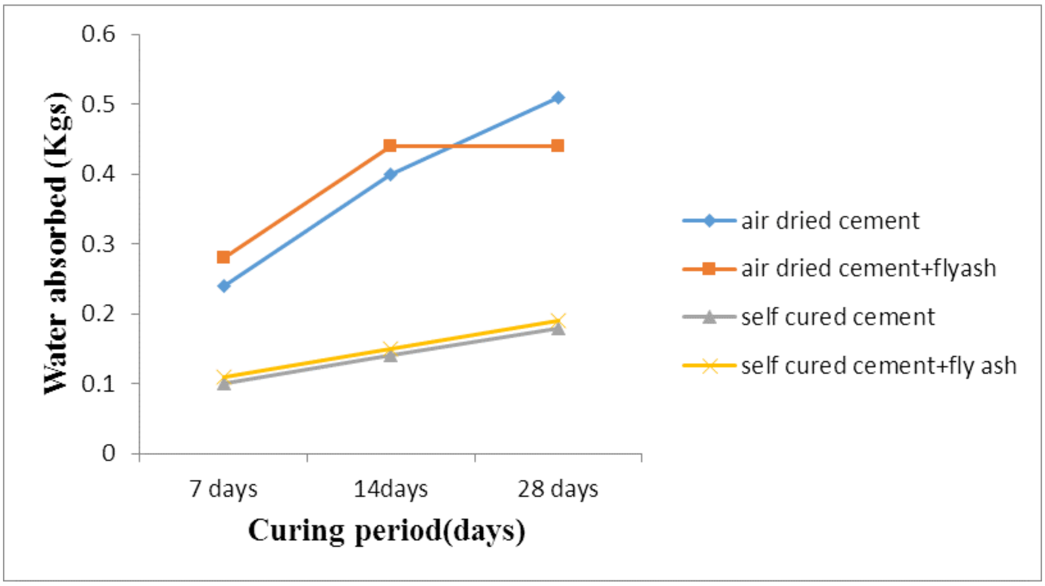

Fig.4.Plot of Curing period vs water absorbed

From the obtained results we observed that water absorbtion of air dried concrete increases with increase in curing period. And water absorption is more in the case of air dried concrete. In self curing concrete the water absorption is less because external application of self curing agent. Itforms a thin layer and prevents the entry of water into the concrete.

CONCLUSIONS

1. Compressive strength of self curing concrete after 28 days curing period is more than the compressive strength of water cured concrete by 16.5% and 17.5% without and with replacement flyash and quarry dust respectively. Because of external self curing compound complete hydration takes place in concrete and it gives more strength.
2. Compressive strength of air dried concrete cubes is lesser than the designed target strength because lack of curing.
3. The amount water retained in self cured concrete is more than the air dried concrete. Beacause the external self curing compound forms a thin layer and it arrests the evaporation of water from the concrete.
4. Water absorption capacity of air dried concrete increases with age of curing and it is more than the water absorption in self curing concrete.

ACKNOLEDGEMENT

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36	Mr. G. Sateesh Kumar	Assistant Professor	Structural Engg

List of Consultancy and Research Projects

(Last 5 yrs.)

Year	Client Name	Amount (Rs.)	Work Description/ Research Project Title	Nature of the Work	Status	Principle Investigator / Person In-Charge
2019-20	JNTUH TEQIP III	Rs. 2,99,000 Duration-1 yr.	Microbially Induced Calcite Precipitation for Crack Remediation in Concrete Structures	Collaborative Research Project	Ongoing Start Date-Aug 2019	Dr.V Srinivasa Reddy
	Aakruthi Consultants	Rs. 10000	Concrete Mix Designs and Proof-Checking (NDT)	Consultancy	Completed	Dr.V Srinivasa Reddy
	Aakruthi Consultants	Rs. 5000	Core Testing	Consultancy	Completed	Dr.V Srinivasa Reddy
	Greater Hyderabad Municipal Corporation (GHMC)	Rs.1,00,000	Third party quality control works	Consultancy	Ongoing Start Date-Aug 2019	Dr. V Mallikarjuna Reddy
2018-19	SS Civil Construction Contractors	Rs.3000	Cube Testing	Consultancy	Completed	Dr.V Srinivasa Reddy
	R K Engineers	Rs.10,000	Concrete Mix Design	Consultancy	Completed	Dr.V Srinivasa Reddy
	NCC Ltd.	Rs.7,50,000 Duration- 5 yrs.	Characterization And Performance Evaluation Of Ultra-High Strength Steel Fibre Reinforced Reactive Powder Concrete For Structural Applications	Research funded by Industry	**Ongoing** Start Date: Feb 2019	Dr.V Srinivasa Reddy
	AICTE	Rs.9,65,000	Modernization & Removal Of Obsolescence	MODROBS	**Ongoing** Start Date: Jan 2019	Dr. GVV Satyanarayana
	Greater Hyderabad Municipal Corporation (GHMC)	Rs. 21,00,000	Third party quality control works	Consultancy	Completed	Dr. V Mallikarjuna Reddy
	Vasupradha Consultants LLP, New Delhi	Rs. 34,500	Testing Materials	Consultancy	Completed	Dr. C Lavanya

	Texas A&M University , USA	Rs. 10,65,289	Training Program for teachers from Afghanistan	Consultancy	Completed	Dr. V Mallikarjuna Reddy
2017-18	The Centre on Conflict and Development (ConDev) Texas A&M University , USA	Rs.13,50,000	Training Program for teachers from Afghanistan	Consultancy	Completed	Dr. V Mallikarjuna Reddy
	Pachayat Raj, Kandukur, Andhra Pradesh	Rs.2,00,000 Duration- 2 yrs.	Rehabilitation of Concrete with Bacteria (Bacterial Concrete)	Research funded by Industry	**Ongoing** Start Date: Sep 2017	Dr.V Srinivasa Reddy
	LANCO Technology Park	Rs.2,00,000 Duration- 2 yrs.	Studies on the properties of nano-silica based self-compacting concrete	Research funded by Industry	. **Ongoing** Start Date: Oct 2017	Dr.V Srinivasa Reddy
	Ganges Valley school, Bachupally Hyderabad	Rs.30,273	Road Work for Ganges Valley school	Consultancy	Completed	Dr. V Mallikarjuna Reddy/ Dr. GVV Satyanarayana
2016-17	GRIET Hyderabad	Rs.6230	False Ceiling for Sheds	Consultancy	Completed	Dr. V Mallikarjuna Reddy
2015-16	Ganges Valley school, Bachupally Hyderabad	Rs.16,431	Badminton flooring, Ganges Valley school,	Consultancy	Completed	Dr.V Srinivasa Reddy
		Rs.27,852	Construction of Ganges Valley Building	Consultancy	Completed	Dr. Hussain/ Dr. GVSK Prasad/ Dr.V Mallikarajuna Reddy/ Mr. CVS Narayana
2014-15	Ganges Valley school, Bachupally Hyderabad	Rs.10,30,557	Construction of Ganges Valley Building	Consultancy	Completed	Dr. Hussain/ Mr. SP Raju/ Ms. C Lavanya/ Mr. P Sirisha

Consultancy Services offered by the

Department of Civil Engineering

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY

ARCHITECTURAL

- Preparation of conceptual and schematic sketches and layout based on the clients requirement and to suit the site conditions, terrain, environment and presentation of the same for the approval from the clients.
- Drafting specifications and selection of finishes, materials etc., to suit the clients functional requirements, workable intricacy, Epicurean outcome and aesthetic appeal.
- Preparation of drawings for getting approval from the local authorities and financial institutions.
- Preparation of detailed architectural working drawings for all items including elevations, sections, blowup details etc., for execution process.
- Revising the drawings, if any changes are required either due to site problems or due to change in functional demand during the progress of the work.
- Selection and choosing of right type of material and finish viz., floor covering, wall and ceiling finish, textures and shades, cladding etc.

STRUCTURAL ENGINEERING

Design & Detailing – Concrete:

- Preliminary design and quantity estimation at pre–bid stage
- Foundation design and load data for other engineering activities
- Preparation of technical specifications for bids
- General Arrangement and reinforced concrete detail drawings for all concrete structures related to project with comprehensive bending schedules
- High strength/ High performance concrete mix designs and development
- Material testing (concrete cube specimens, Bricks, tiles etc)
- NDT testing
- Concrete Samples mechanical and durability property determination
- Proof checking
- Aggregates testing
- Onsite inspections and testing
- Repair, Retrofitting and Rehabilitation of concrete and steel structures

Design & Detailing – Steel:

- Preliminary design and quantity estimation at pre–bid stage
- Preparation of technical specifications for bids
- Scheme Drawings
- Fabrication drawings
- Development views for profile cuttings
- Material takeoff for structural steel procurement

Peer review:

- We also undertake peer review work for analysis and design carried out by others
- We do this by verifying the structural model & results of others or by doing a completely independent analysis depending on the client's requirement

PROJECT MANAGEMENT

- Preparation of Bar chart / CPM / Pert
- Full time supervision of the projects, material supply schedule
- Checking of structural design (if required by the client)
- Quality control

STRUCTURAL PROOF CONSULTANCY

- Verifying proposed structural system at conceptual stage. Scrutiny & review of Design calculations & drawings
- Preparation of Detailed Report with Recommendations

ESTIMATION, TENDERING & BAR BENDING SCHEDULE

- Preparation of Specifications, Estimates & Tender Documents
- Preparation of Bill of Quantities.
- Preparation of Bar Bending Schedule.