EXPERIMENTAL BEHAVIOUR ON REINFORCEMENT CONCRETE BY USING STEEL AND COPPER

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Abstract - The motivation for such replacement is typically cost—copper is available in many industrial locations, whereas steel reinforcement is relatively more expensive—and more recently, the drive to find more sustainable alternatives in the construction industry. This review addresses such 'Copper-reinforced concrete' and assesses its structural and environmental performance as an alternative to steel reinforced concrete. A prototype three bay portal frame, that would not be uncommon in regions of the world where copper-reinforced concrete may be considered, is used to illustrate copper reinforced concrete design and as a basis for a life cycle assessment of the same. The authors conclude that, copper is a material with extraordinary mechanical properties, its use in copper-reinforced concrete is an considered concept, having significant durability, strength and stiffness issues, and meet the environmentally friendly credentials often attributed to it.

Key Words: Copper rod, Reinforcement, Structure, Sustainable, New Technology….

1. INTRODUCTION

1.1 General

Copper is a chemical element with the symbol **Cu** (from Latin: *cuprum*) and atomic number 29. It is a soft, malleable, and ductile metal with very high thermal and electrical conductivity. A freshly exposed surface of pure copper has a pinkish-orange color. Copper is used as a conductor of heat and electricity, as a building material, and as a constituent of various metal alloys, such as sterling silver used in jewelry, cupronickel used to make marine hardware and coins, and constantan used in strain gauges and thermocouples for temperature measurement.

Copper used in buildings, usually for roofing, oxidizes to form a green verdigris (or patina). Copper is sometimes used in decorative art, both in its elemental metal form and in compounds as pigments. Copper compounds are used as bacteriostatic agents, fungicides, and wood preservatives.

Copper is essential to all living organisms as a trace dietary mineral because it is a key constituent of the respiratory enzyme complex cytochromecoxidase. In molluscs and crustaceans, copper is a constituent of the blood pigment hemocyanin, replaced by the iron-complexed hemoglobin in fish and other vertebrates. In humans, copper is found mainly in the liver, muscle, and bone.

Copper slag as a replacement of fine aggregate and coarse aggregate is its engineering factor, economic factor and environmental factor. Engineering factor is that copper slag contains required chemical properties for using it as a replacement material. Economic factor is that its cost is comparatively less than that of other waste material. Environmental factor is that production of copper slag does not produce any hazardous gases.

From copper smelting process, copper slag is produced as a by-product. Per unit production of copper, approximately 2.3- 3.0 ton of copper slag is generated as a by-product. In India, entire copper slag is generated by three states of the India namely Madhya Pradesh, Rajasthan, Jharkhand.

1.2 OBJECTIVES

The main objectives of this system are,

- The main objectives of the project is to study the addition of copper rod as reinforcement In M30 grade of concrete.
- It has been planned to add copper in the ratio of 1,1.5,2,2.5 percentage respectively.
- It has been aimed to conduct compressive strength test, tensive strength test, flexural test in reinforcement concrete.

2. LITERATURE REVIEW

Binaya Patnaik., *Department of Civil Engineering, GITAM University, Hyderabad.* This paper presents a study of the mechanical properties of copper slag fibre reinforced concrete considering the effect of fibre content (0%, 0.5%, 1%, and 1.5%). Also an attempt has been made to establish the relationship between different mechanical and non-destructive test properties of concrete. Furthermore a mathematical model was proposed to determine different strength properties of copper slag concrete with variation of fibre content in it. The suggested model successfully epitomizes the rise of tensile and flexure strength properties of copper slag concrete with increase in fibre content, however a different pattern has been observed in case of compressive strength. In the present experimental investigation, concretes of grade M20 and M30 were used with crimped steel fibres having an Aspect Ratio of 60.

”Poriya Dhanes *. **BVM Engineering College Vidyanagar (Gujarat), India.*** With increase in the population day by day, consumption of the resources also increases. With this, the waste material production also increases. Manufacturing process of copper production produces enormous amount of the copper slag which contains required chemical properties, so it can be used as construction material. This paper contains information regarding survey of copper slag manufacturing process and different uses of copper slag. This paper reviews the use of industrial waste material ‘copper slag’ in the construction work as a replacement of cement, sand and aggregate to reduce the cost of construction and simultaneously to reduce environmental effect due to the land filling of copper slag. As well as construction is the only industry where the waste materials can be utilized successfully

Prayush Parekh ***,Associate Professor and Head of Department, Department of Civil Engineering,Indira College of Engineering and Management, Pune, (India)***Bamboo is the one of the material which is used as construction material from ancient times. It was used as reinforcement with mud and as formwork also. Concrete have high compressive strength but has low tensile strength due to this, it is often reinforced with steel bars. In this study we are trying to found out the properties of bamboo from previous research papers.

Abhinav.*, M. Tech (Research Scholar), Department of Civil Engineering, Integral University, Lucknow (UP).*In present scenario, alternative materials in all forms of constructions is introduced to reduce the pressure on good quality natural materials, which will balance the economical purpose of the project while also taking care of the surrounding environment. A large amount of by-product or wastes such as fly-ash, copper slag, silica fume etc. are generated by industries, which causes environmental as well as health problems due to dumping and disposal. Copper slag is a by-product produced during smelting of copper. Each ton of copper produced, produces around 2.2 tons of copper slag. Copper slag can be utilized as fine aggregate in cement mortars, normal concrete and also as aggregates (coarse) in concrete (high strength). As fine aggregate in cementmortar, copper slag provides good interlocking which leads to better volumetric and mechanicalquality of different mixes. It was reported that about 50% substitution of copper slag incement mortar increased the compressing strength highly, slightly increased the density andsignificantly increased the workability. This paper present literature review on replacement of fine aggregate by copper slag which includes current and future trends of research.

Aleksandra Franczak, Joanna Karwan-Baczewska,Copper matrix composites containing ceramic particles such as carbides, borides, or nitrides have attracted much attention over the last few years. The increased interest in such materials has mainly been created by their high electrical and thermal conductivity, good mechanical and tribological properties, and microstructural stability. Among other nitrides, the titanium nitride seems to be considered as an attractive reinforcement due to its high hardness, excellent electrical conductivity, and stability at high temperatures. Moreover, its good corrosion resistance proves the uniqueness of the TiN particles above any other nitrides. In this work, Cu-10 wt.% TiN composite powders were produced by mechanical alloying and sintered by the spark plasma sintering (SPS) technique under different temperatures. The morphology and powder particle size after mechanical synthesis were inspected by a scanning electron microscopy (SEM) for all of the powder samples; chemical composition analyses (EDS) were also performed. The hydrostatic method was used to measure the density of the composite samples to analyze the influence of milling time on the process of consolidation in the composite powders.

P. Priyadharshini*, SVS college of engineering, Coimbatore-642109,* Development of self-compacting concrete (SCC) is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-place concrete. since, common river sand is expensive and also large scale depletion of these sources creates environmental problems, a substitute or replacement product for concrete industry is the need of the hour. In such a situation, the Copper Slag can be an economic alternative to the river sand, which is an industrial by-product obtained from the manufacturing of copper. SCC was added with relatively short, discrete, and discontinuous glass fibres to produce Glass Fibre Reinforced Self Compacting Concrete (GFRSCC), to avoid cracking on loading due to low tensile strength of concrete. The use of glass fibres in SCC improves the engineering properties such as tensile strength, ductility, post crack resistance and energy absorption capacity. This work aims at the partial replacement of sand by copper slag and the strength variations observed by the incorporation of glass fibres are studied and compared with the strength properties of control mix SCC. Mix proportioning has to be done for M30 SCC and Self Compactability is checked by various flow tests of slump flow test, J-ring test, U-box, V-funnel and L- Box. Sand is replaced with copper slag in proportions of 0%, 20%, 30%, 40%, 50%, 60% with constant proportion of glass fibre i.e., by 0.1% by volume of concrete. All the trial mixes are planned to be tested and then the optimum mix which gives the maximum strength criteria is to be found out.

Sebastian Kaminski Received: 20 January 2018/Accepted: 16 July 2018. The use of small diameter whole-culm (bars) and/or split bamboo (a.k.a. splints or round strips) has often been proposed as an alternative to relatively expensive reinforcing steel in reinforced concrete. The motivation for such replacement is typically cost—bamboo is readily available in many tropical and sub-tropical locations, whereas steel reinforcement is relatively more expensive—and more recently, the drive to find more sustainable alternatives in the construction industry. This review addresses such 'bamboo-reinforced concrete' and assesses its structural and environmental performance as an alternative to steel reinforced concrete.

A prototype three bay portal frame, that would not be uncommon in regions of the world where bamboo reinforced concrete may be considered, is used to illustrate bamboo reinforced concrete design and as a basis for a life cycle assessment of the same. The authors conclude that, although bamboo is a material with extraordinary mechanical properties, its use in bamboo-reinforced concrete is an ill-considered concept, having significant durability, strength and stiffness issues, and does not meet the environmentally friendly credentials often attributed to it.

Mohd. Ahmed.*, 7 February 2015 © King Fahd University of Petroleum & Minerals 2015.* The various methods, developed for concrete mix design, are not universal because design mixes are specific to regional climate, local materials, and exposure. The new-generation mix design method should be developed based on the performance criteria. The concrete strength obtained from the designed concrete mix and minimum cement content should not be considered the only parameter for suitability of concrete mix for harsh environment region. The durability and quality parameters in a cost-effective way should be included into the mix design methods for extreme climate. The strength and relative proportion of ingredient should be given consideration for the concrete coherent mix. This paper presents the basic principles and comparative study of some popular concrete mix design methods namely fineness modulus method, ACI mix design method, and DOE method from qualitative and cost-effective point of view. It is clear from the study that the mix design methods need some adjustment in their basic design parameters for quality and cost-effectiveness. The durability indicators, in terms of denseness indicator, i.e., mix density and fine aggregate-to-total aggregate ratio, quality indicator, i.e., total aggregate-to-cement and fine aggregate-to-cementratio,and other cementing material/mineral admixtures in addition to minimum cement content are suggested for severe environment. It is anticipated that with detailed experimental investigation on various suggested design factors focusing more on local challenges, present study will pave the way for the development of performance-based extreme environment design mix principles

Glenn T. Eavenson. The effects of variations in copper content on the metallurgical, mechanical, and fracture properties of pearlitic rail steels with a base composition (in wt pct) of 0.9 C, 1.0 Mn, 0.35 Si, and 0.01 Ti were evaluated. Six industrial heats with copper content ranging from (in wt pct) 0.07 to 0.85 were cast, re-heated, rolled and air-quenched with identical industrial processing parameters to produce full rails of the 136RE section. The materials were tested to determine the influence of copper content on austenitic grain size, pearlitic interlamellar spacing, microstructure, hardenability, hardness profile, tensile and yield strength, Charpy U-notch impact toughness, K1c fracture toughness, and fatigue crack growth rate according to standard ASTM testing methodologies. The austenitic grain size, as determined by the McQuaid-Ehn method, suggested that copper does not influence the austenite grain growth characteristics in the temperature range of the test for the steels evaluated. Jominy end-quench hardenability testing showed that copper acts to delay pearlite transformation to a small degree. Pearlite interlamellar spacing measurements, determined via scanning electron microscopy, indicated that increased copper content refines the interlamellar spacing, which agrees with the Jominy hardenability data. The refinement in pearlite interlamellar spacing with increasing copper content increased hardness and strength according to a Hall-Petch type relationship. Both the impact toughness and fatigue crack growth rates were essentially independent of copper content. There was a slight decrease in fracture toughness with increasing copper content most likely due to the increase in yield strength with increasing copper content. Nonetheless, copper does not diminish the strength-toughness balance in pearlitic rail steels, and copper appears to primarily act as another hardenability element during the production of steel rails. The results of this study suggest that the current maximum allowable copper content of 0.4 wt pct specified by the American Railway Engineering and Maintenance-of-

Way Association (AREMA) may be too restrictive for modern steel rail production technology.

Dr. Sivanthi,*et.al., Aditanar College of Engineering, Tiruchendur-628215, Tamilnadu, India.* This paper reports the effect of concrete using copper slag as fine aggregate replacement. In this project work, the concrete grade M40 was selected and IS method was used for mix design. The properties of material for cement, fine aggregate, coarse aggregate and copper slag were studied for mix design. The various strength of concrete like compressive, flexural and split tensile were studied and non-destructive test such as rebound hammer test and ultrasonic pulse velocity measurement were studied for various replacements of fine aggregate using copper slag that are 0%, 20%, 40%, 60%, 80% and 100%. The maximum compressive strength of concrete attained at 40% replacement of fine aggregate at 7 and 28 days. The split tensile strength and the flexural strength were also obtained higher strength at 40% replacement level at 28 days. The rebound hammer test showed higher compressive strength at 40% fine aggregate replacement, this is due to uniformity of concrete. The pulse wave velocity is higher for the 40% fine aggregate replacement, it is understood that the density of the mix is high and free from pores.

"K Rajasekhar, *Department of Civil Engineering, Andhra University, Visakhapatnam – 03.* One of the major challenges in our present society is the protection of environment. Some of the important elements in this respect are the reduction in the consumption of energy and natural raw materials and consumption of waste materials must be increased. This experimental study is to investigate the effect of using copper slag as a replacement of fine aggregate on the strength properties. The common management options for copper slag are recycling, recovering of metal, production of value added products such as abrasive tools, roofing granules, cutting tools, abrasive tiles, glass, rail road ballast, asphalt pavements. Despite increasing reusing of copper slag, the huge amounts of its annual production is disposed in dumps or stockpiles. In the present study experimental investigation has been carried out on M25 grade concrete is used and tests were conducted for various percentage replacement of fine aggregate with copper slag in concrete. The obtained results were compared with those of control concrete made with ordinary portland cement and sand. The use of copper slag in concrete provides potential environment as well as economic benefits for all related industries, particularly in areas where a considerable amount of copper slag is produced. This study reviews the characteristics of copper slag and its effect on the engineering properties of M25 grade concrete.

3. ADVANTAGES OF COPPER

Strong, long lasting, copper tube is the leading choice of modern contractors for plumbing, heating and cooling installations in all kinds of residential and commercial buildings. The primary reasons for this are:

- **COPPER IS ECONOMICAL**

  The combination of easy handling, forming and joining permits savings in installation time, material and overall costs. Long-term performance and reliability mean fewer callbacks, and that makes copper the ideal, cost-effective tubing material.

- **COPPER IS LIGHTWEIGHT**

  Copper tube does not require the heavy thickness of ferrous or threaded pipe of the same internal diameter. This means copper costs less to transport, handles more easily and, when installed, takes less space.

- **COPPER IS FORMABLE**

  The copper tube can be bent and formed, it is frequently possible to eliminate elbows and joints. Smooth bends permit the tube to follow contours and corners of almost any angle. With soft temper tube, particularly when used for renovation or modernization projects, much less wall and ceiling space is needed.

- **COPPER IS EASY TO JOIN**

  Copper tube can be joined with capillary fittings. These fittings save material and make smooth, neat, strong and leak-proof joints. No extra thickness or weight is necessary to compensate for material removed by threading.

- **COPPER IS SAFE**

  Copper tube will not burn or support combustion or decompose to toxic gases. Therefore, it will not carry fire through floors, walls and ceilings. Volatile organic compounds are not required for installation.

- **COPPER IS DEPENDABLE**

Copper tube is manufactured to well-defined composition standards and marked with permanent identification so you know exactly what it is and who made it. It is accepted by virtually every plumbing code.

- **COPPER IS LONG-LASTING**

It has excellent resistance to corrosion and scaling, high mechanical strength, high-temperature resistance and lifetime resistance to UV degradation. Copper assures long, trouble-free service, which translates to satisfied customers and systems that last.

- **COPPER IS 100% RECYCLABLE**

Copper stands alone as an engineering material that can be recycled over and over without degradation in content or properties. This combined with copper's proven durability means that no copper used in a building today needs to enter a landfill.

4. DISADVANTAGES OF COPPER

The development of fiber optic cable, the future of copper wiring is in doubt. Copper has substantial disadvantages over fiber optic cable and, while copper remains very important, if not dominant, fiber optic systems are taking over, leaving copper in a poor position due to its many disadvantages. Most major firms in the semiconductor industry refuse to use copper due to its spotty track record. Many refuse to use it in automotive wiring due to its penchant for corrosion and general unreliability.

- **COST**

Copper costs far more than fiber optic cable. Copper itself is based largely on Latin American foreign trade and therefore is a volatile market relative to domestically produced fiber optic systems. Part of the cost problem of copper wire is both that it is very expensive to store (due to the fact that it cannot be exposed to oxygen) and that it is heavier, leading to higher shipping costs.

- **CORROSION**

One of the most serious disadvantages of copper wire is its susceptibility to corrosion, that is, oxidation. It has a shorter life expectancy than fiber optic cable as a result of this. Therefore, the problem of copper storage is related to its penchant to be oxidized at relatively normal temperatures.

- **SHOCK HAZARD**

Fiber optic cable has a lower shock hazard than copper wire. Copper is susceptible to a great degree of electrical interference, leading to a less clear signal than fiber optics. Copper wire, in short, is more dangerous than fiber optic cable.

- **BONDING**

Copper is being rejected by the semi-conductor industry as being unreliable as a bonding agent. In a recent study conducted by SEMI, the main research arm of the semiconductor industry, most respondents in the field held that copper wire as a bonding agent was unreliable, unproven and inefficient. Further, many in the field held in the survey that they thought copper was unsuited for many complex wiring projects.

5. MATERIALS

Materials: In this research study, the ordinary Portland cement (OPC) 53 grade is used and the compressive strength of 28 days shall be minimum 53 MPa for this cement. Specific gravity of cement is 3.14. Coarse aggregate used in the present study are of crushed angular shape because angular aggregate gives higher strength. They are grey in color. The aggregates sizes vary from 10mm to 20mm. Fine aggregate sizes vary from 0.25mm to 0.06mm. Fine and coarse aggregate was used with specific gravity of 2.65 and 2.68 respectively. Locally available portable water (drinking water) having the pH value of 7.0 preferable and the pH value of water should not less than 6.

In this study, Hydraulic Lime is used as a partial replacement of cement to prepare lime concrete and lime mortar. Amount of lime used in this study is 0, 25, 50 and 75% by weight of cement.

6. MIX DESIGN:

The study uses the design mix M30 grade of concrete using 43 grades OPC in the study. The Mix design was performed as per IS 10262: 2009. The water cement ration for mix is 0.43. The following mix proportion was obtained from the mix design.

Table -1: MIX DESIGN(CEMENT;SAND;AGGREGATE)

CEMENT	SAND	AGGREGATE
368	645.5	1264.04
1	1.754	3.4

7. Casting & Curing:

For compressive strength the standard size of cube mould is 150 mm × 150 mm × 150 mm used. Amount of lime used in this study is 5, 10, 15, 25 and 35% by weight of cement. After casting, each cube should be marked with a legible identification on the top of cubes. Leave the sample undisturbed for 24 hours. After the 24 hours, the moulds are opened and immersed in water for curing till the day of testing. Ponding method was used for curing. Testing is done after 3, 7, 28 days. Three cubes were prepared for each specimen.

8. Compressive Strength:

Compressive strength is the maximum compressive stress that under a gradually applied load, a given solid material can sustain without fracture. Compressive strength is carried on cubes i.e. 150 mm × 150 mm × 150 mm specimens. Concrete's compressive strength mostly depends on the concrete mix design, quality of concrete, cement strength, water cement ratio, curing etc. It is also affected by the other factors such as mixing of concrete, placing of concrete, curing of concrete as well as quality of concrete ingredients. The compressive strength of concrete was found by universal testing machine of 1000 kN capacity.

Compressive Strength = P/A
Where, P = Compressive load in kN and A = Area of cube.

9. Result discussion:

Density test of copper reinforced concrete

Three cubes were made for each gradation ie 1%, 1.5%, 2%, and 2.5% of CA was replaced by fly ash. The density test of concrete for each gradation was conducted. Here partially structural light weight concrete was produced. The shows that results the density of concrete decrease with increase of fly ash in concrete.

Density test results of conventional and copper reinforcement concrete

Specimen	Density of copper reinforcement concrete in kg/m³	% of weight reduction of copper reinforcement concrete
Conventional concrete	2540	0
Fly ash 1%	2322	9
Fly ash 1.5%	2259	11
Fly ash 2%	2157	15
Fly ash 2.5%	2014	21

10. CONCLUSION:

The experimental results of four beams are presented in this report. The comparison of mechanical properties and structural behavior of the CRC beams are discussed. The crack width, deflection, ultimate load of all the beams are compared. The compressive strengths obtained for the 2.5 % of fly ash replacement was 21.33 N/mm^2 which weighter than the target strength of 20 N/mm^2 and it can be produced as structural grade concrete of grade 30. The both compressive strength and split tensile strength results clearly showed 2.5 % of fly ash replacement is optimum. The ultimate loadand ultimate moment capacity of the steel reinforcement beams was higher to the copper reinforced beams due to lower stiffness and lower modulus of elasticity of the beam.

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