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CHALLENGES IN FINE COAL PROCESSING, DEWATERING, AND DISPOSAL

NEERAJ SINGH

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Preface

Coal mining and preparation have had a long history in the United States and the world, serving as the engine of growth for many industries. Today, new sources of energy, increased environmental awareness and more stringent regulations from the U.S. Environmental Protection Agency and other organizations are changing the way coal is found, extracted and used. As a result, fine coal cleaning, dewatering and refuse disposal are now at a major crossroads.The increased level of fines, and near-density material in the inferior seams being mined today, necessitates the development of more efficient fine coal cleaning devices. This in turn requires improvements in traditional dewatering techniques to address the need for acceptable moisture levels in plant products. Moreover, the larger volume of fine refuse being generated, coupled with harsher disposal regulations, require upgraded treatment options.

Editor

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Chapter 1

Influence of Fly Ash, Bottom Ash, and Light Expanded Clay Aggregate on Concrete

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ABSTRACT

Invention of new methods in strengthening concrete is under work for decades. Developing countries like India use the extensive reinforced construction works materials such as fly ash and bottom ash and other ingredients in RCC construction. In the construction industry, major attention has been devoted to the use of fly ash and bottom ash as cement and fine aggregate replacements. In addition, light expanded clay aggregate has been introduced instead of coarse aggregate to make concrete have light weight. This paper presents the results of a real-

time work carried out to form light weight concrete made with fly ash, bottom ash, and light expanded clay aggregate as mineral admixtures. Experimental investigation on concrete mix M_{20} is done by replacement of cement with fly ash, fine aggregate with bottom ash, and coarse aggregate with light expanded clay aggregate at the rates of 5%, 10%, 15%, 20%, 25%, 30%, and 35% in each mix and their compressive strength and split tensile strength of concrete were discussed for 7, 28, and 56 days and flexural strength has been discussed for 7, 28, and 56 days depending on the optimum dosage of replacement in compressive strength and split tensile strength of concrete.

INTRODUCTION

High performance concrete indicates an exceptional form of concrete endowed with astonishing proficiency and strength essentials which are unequipped with periodical assessment on a regular basis by way of traditional materials and standard mixing, placing, and curing techniques [1]. Ordinary Portland cement (OPC) has grabbed an unenviable and undefeatable position as a significant material in the generation of concrete and meticulously releases its designed obligation as an extraordinary binder to join all the gathered materials. With the purpose of attaining, there is a dire need of the burning of mammoth measure of fuel and rot of limestone [2]. A few grades of ordinary Portland cement (OPC) are accessible tailor made to suit the particular nation code categorization. In this respect, Bureau of Indian Standard (BIS) exquisitely does the capacity of categorizing three separate grades of OPC, for example, 33, 43, and 53, which have chronically been widely utilized in construction industry [3]. The strength, sturdiness, and different attributes of concrete rely on the properties of its ingredients, the proportion of the mix, the strategy of compaction, and different controls amid placing, compaction, and curing [4]. Concrete containing wastes can help construction manageable quality and contribute to the advancement of the civil engineering region by employing industrial waste, minimizing the utilization of natural assets, and producing more effective materials [5]. The Portland cement concrete resorts to the employment of fly ash when the loss-on-ignition (LOI) qualities fall inside the area of 6%. The fly ash is home to the crystalline and amorphous components

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together with unburnt carbon. It grasps differing measures of unburnt carbon, which is prone to reach the tune of 17% [6]. Fly ash is regularly alluded to as pond ash and over the long haul the water is permitted to drain away. Both techniques viably prompt to dumping of the fly ash in landfills on open land. The chemical composition of fly ash remains changes relying on the type of coal utilized as a part of combustion, combustion conditions, and evacuation productivity of air contamination control device [7]. The effect of fly ash substance and substitution of trampled sand stone total with concrete squandrs and marble squanders employed prefabricated concrete interlocking squares [8]. With an eye on the power of concrete edifices, modern concrete methodology set down extraordinary steps to chop down summit and differential temperatures by deploying materials with the minimized level of release of heat to steer clear of or then again bring down thermal splitting prompting the prevention of the decomposition of the concrete [9]. Production of concrete is done in exceedingly high and imperceptibly low temperatures of concrete to understand the workability and compressive quality [10]. The statistical model and the kinetic property of flexural, breaking tensile furthermore modulus of versatility as per the compressive stability stemmed from the unwarranted coefficient of correlation [11]. Concrete generated out of minute total and superior void ratio is known to be enriched with a brilliant expertise to exile the materials [12]. In India, the power division focused around coal based thermal power stations produces a colossal quantity of fly ash assessed around 11 crore tonnes every annum. The consumption of fly ash is assessed to be around 30% for the purpose of various engineering properties essentials [13]. Ignition of coal to deliver power in a boiler yields around 80% of the unburned material or ash, which is entrained in the flue gas and is entrapped and reclaimed in the shape of fly ash. The residual 20% of the ash helps dry base ash [14]. At the point when pulverized coal is blazed in a dry bottom boiler, around 80 to 90% of the unburned material or ash is entrained in the flue gas and is trapped and recovered as fly ash. The residual 10–20% of the ash is indicated to dry bottom ash, sand size, material which is assembled in water-filled containers at the base of the furnace [15]. Coal bottom ash in concrete is created by the method of fractional, almost-aggregate, and total substitution of fine aggregates in concrete [16]. On the other hand, lightweight concrete is awkward to make a case belong to a unique category material. However, LWC (light weight concrete) has clear edges, and the plunge in the total expense created by the lower dead loads is constantly overshot by the raised production outlay [17]. As a matter of fact, lightweight concrete has surfaced as the agreeable favorite as against the standard concrete in the perspective of a multitude of unrivaled attributes. The dip in dead weight generally brings about cutbacks in production outlay [18]. The self-compacting normal weight aggregate concrete (SCNC) is to be the favorite for the purpose of development. The surge in the construction expense of SCLC fares positively with that for SCNC [19]. Lightweight aggregate concrete deadweight is assessed to be around 15%~30% lighter than standard concrete, which sufficiently fulfills the mechanical attributes that roadway support requires on the specified density degree [20]. Rising utilization of light weight concrete (LWC) brought the requirement for the artificial lightweight total production, which may be accomplished by cold bonding assembling methodology. Production of artificial fly lightweight aggregates with cold bonding process needs much less energy consumption when contrasted with sintering [21]. Lightweight concrete made with natural or artificial lightweight aggregates is accessible in numerous parts of the world. It can be utilized as a part of creating concrete in an extensive variety of unit weights and suitable qualities for different applications [22]. Lightweight aggregates concrete livens up its potency to thwart nearby harm activated by ballistic loading. Lower modulus of flexibility and higher tensile strain limit outfits lightweight concrete opposite standard weight concrete with superior impact resistance [23]. Light concrete material is more and more prescribed by the builders to reach a supportable improvement due to its great strength and thermal properties [24]. The adhesive strength is accomplished from solidity in the binder and interlocking traits of the aggregates, which are constantly focused around angularity, levelness, and extension [25]. Light expanded clay aggregate (LECA), generally, includes tiny, lightweight, bloated particles of burnt clay The hundreds and thousands of tiny, air-filled depressions successfully empower LECA with its sterling strength and thermal insulation qualities. The average water absorption of LECA total (0–25 mm) is thought to associate with 18 percent of volume in saturated status amid the time of 3 days. The ordinary Portland cement (OPC) is partially substituted by the fly ash, fine aggregate interchanged by bottom ash, and coarse aggregate supplanted by light expanded clay aggregate (LECA) by weights of 5%, 10%, 15%, 20%, 25%, 30%, and 35%, separately. The compressive strength, split tensile strength, and flexural strength are successfully assessed by means of determined input values in concurrent investigation.

EXPERIMENTAL PROGRAM

The objective of the work is to evaluate the compressive strength (CS), split tensile strength (STS), and flexural strength (FS) of the concrete. In this concrete mix, ordinary Portland cement ($OPC_{43grade}$) is replaced by fly ash, the fine aggregate is replaced by bottom ash, and the coarse aggregate is replaced by light expanded clay aggregate (LECA) by weights of 5%, 10%, 15%, 20%, 25%, 30%, and 35%, respectively. For increasing the strength in cement, these materials are to be added. In the experimental investigation, the concrete cube or cylinder is used to analyze the properties of the concrete with all materials. Each weight (5%, 10%, 15%, 20%, 25%, 30%, or 35%) of a material conducted the test on 7 days, 28 days, and 56 days. The parameters involved in evaluating the performance of concrete are compressive strength (CS), split tensile strength (STS), and flexural strength (FS) that are attained from real time experiments. Then finding the flexural strength has been discussed for 7, 28, and 56 days depending on the load for the optimum dosage of replacement in compressive strength and split tensile strength of concrete.

Materials Used

Names of materials used in this research and their performance are listed in this section. The resources are ordinary Portland cement, fly ash, bottom ash, fine aggregate, coarse aggregate and light expanded clay aggregate (LECA).

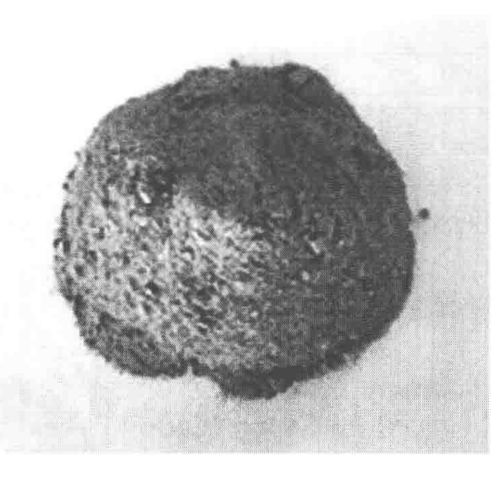
Ordinary Portland Cement

Ordinary Portland cement is the basic form of cement where 95% of it is clinker and 5% is gypsum which is added as an additive to enhance the setting time of the cement to a workable 30 minutes odd or so. Gypsum controls initial setting time of the cement. If gypsum is not added, cement would be set as soon as water is added in cement.

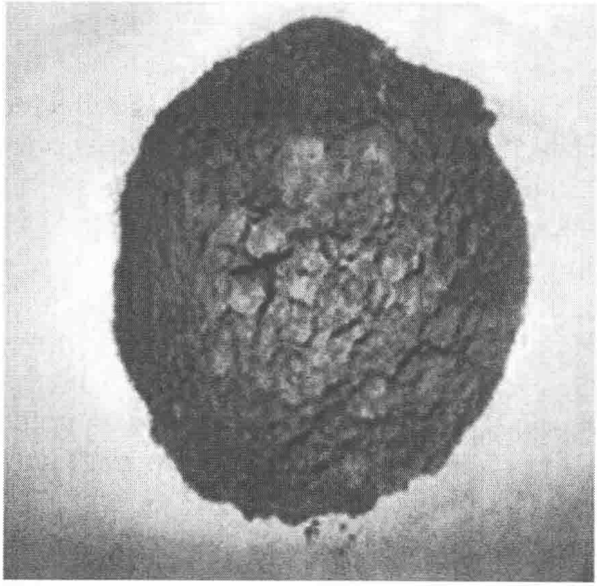
Different grades (33, 43, and 53) of OPC have been classified by the Bureau of Indian Standards (BIS). It is manufactured in larger quantities when compared with the other types of cement and it is admirably suited for use in general concrete construction where there is no exposure to sulphates in the soil or in ground water. In this research, the cement ($OPC_{43grade}$) that has a specific gravity of 3.15 and initial and final setting times of the cement of 50 minutes and 450 minutes has been used.

Fly Ash

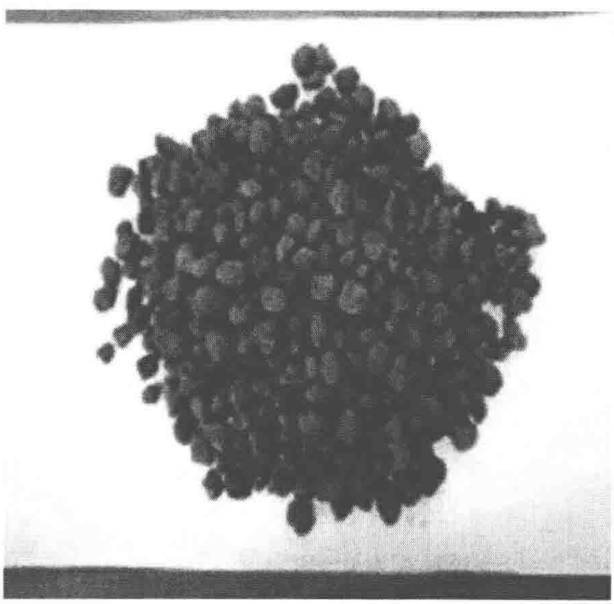
The most common type of coal-burning furnace in the electric utility industry, about 80% of the unburned material or ash, is entrained in the flue gas and is captured and recovered as fly ash. Fly ash was collected from Thoothukudi Thermal Power Plant, Tamil Nadu, India The increasing scarcity of raw materials and the urgent need to protect the environment against pollution have accentuated the significance of developing new building materials based on industrial waste generated from coal fired thermal power station which is creating unmanageable disposal problems due to its potential to pollute the environment. As the cost of disposing of fly ash continues to rise, strategies for the recycling of fly ash are environmentally and economically critical. For the source materials the two emerging areas for the recycling of coal fly ash are used as shown in Figure 1(a).



(a)



(b)



(c)

Figure 1: Materials (a) Fly ash, (b) Bottom ash, (c) LECA.

Bottom Ash

The remaining 20% of the unburned material is collected at the bottom of the combustion chamber in a water-filled hopper and is removed by means of high-pressure water jets to a decanting basin for dewatering and is recovered as bottom ash as shown in Figure 1(b). Coal bottom ash was obtained from Thoothukudi Thermal Power Plant, Tamil Nadu, India The fly ash was obtained directly from the bottom of the electrostatic precipitator into a sack because of its powdery and dusty nature, while the coal bottom ash is transported from the bottom of the boiler to an ash pond as liquid slurry where the sample was collected. Bottom ash is lighter and more brittle and it is dark gray material with a grain size similar to that of sand.

Fine Aggregate

According to the Indian standards natural sand is a form of silica (SiO_2) that has maximum particle size of 4.75 mm and it was used as fine aggregate. The minimum particle size of fine aggregate is 0.075 mm. It is formed by decomposition of sand stones due to various weathering actions. Fine aggregate prevents shrinkage of the mortar and concrete. The specific gravity and fineness modulus of coarse aggregate were 2.67 and 2.3.

Fine aggregate is an inert or chemically inactive material, most of which passes through a 4.75 mm IS sieve and contains no more than 5 percent of coarser material. It may be classified as follows:

- Natural sand: fine aggregate that results from the natural disintegration of rocks and has been deposited by streams or glacial agencies;
- Crushed stone sand: fine aggregate produced by crushing hard stone;
- Crushed gravel sand: fine aggregate produced by crushing natural gravel.

It reduces the porosity of the final mass and considerably increases its strength. Usually, natural river sand is used as a fine aggregate. However, at places, where natural sand is not available economically, finely crushed stone may be used as a fine aggregate.

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