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Manufacture of Fly Ash Brick using Steel Slag and Tapioca Powder

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Abstract- In fast growing today's world development of new building materials and processing and utilization of industrial waste is being important to be reduced for achieving safe environment and conservation of scarce resources and materials. Although the use of fly ash has many advantages, its low hydration at early stage causes the strength to be low. In this study, the experimental investigation was carried out to find the optimum mix percentage of some other materials with fly ash brick. However the brick specimen of size 230mm x 110mm x 70 mm were cast for different mix percentage of Fly ash (45%), Gypsum (5%), Lime (10%), Quarry dust (20 to 30%) and SSTP Mix (10 to 20% (mix made of Steel Slag–50%)) and Tapioca powder50%)). The bricks produced in this project were about 12% lighter than clay bricks. Steel Slag and Tapioca powder mix compressive strength were studied for different mix proportions. The result shows the variation of compressive strength for different mix proportions of materials mentioned earlier at different curing ages. From the results it was inferred that, the maximum optimized compressive strength is obtained for optimal mix percentage of Fly ash – 45%, Lime – 10%, Gypsum – 5%, Quarry dust 25% and SSTP Mix –15%.

Keywords: - Fly ash (45%), Gypsum (5%), Lime (10%), Quarry dust (20 to 30%) , SSTP Mix

I. INTRODUCTION

Fly ash refers to the ash produced during combustion of coal. It is the fine powder formed from the mineral matter in coal, consisting of the non- combustible matter in coal plus a small amount of carbon that remains from incomplete combustion. Fly ash is being accumulated as waste material in large quantities near thermal power plants.

As the power requirements of the country goes up, the amount of waste produced will also increase enormously creating problems for its safe disposal due to lack of adequate disposal facilities. Its use in manufacture of bricks will be helpful in its disposal and also help in controlling pollution. It is supplied free of cost to entrepreneurs. The country consumes about 180 billion tonnes bricks, exhausting approximately 340 billion tonnes of clay every year and about 5000 acres of top soil land is made unfertile for a long period. Fly Ash bricks are made of fly ash, lime, gypsum and sand. These can be extensively used in all building constructional activities similar to that of common burnt clay bricks. The fly ash bricks are comparatively lighter in weight and stronger than common clay bricks.

Since fly ash is being accumulated as waste material in large quantity near thermal power plants and creating serious environmental pollution problems, its utilization as main raw material in the manufacture of bricks will not only create sample opportunities for its proper and useful disposal but also help in environmental pollution control to a greater extent in the surrounding areas of power plants. In view of superior quality and eco-friendly nature, and government support the demand for Fly Ash Bricks has picked up.

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II. MATERIALS USED

1. Fly Ash:

Fly ash is a fine powder which is a byproduct from burning pulverized coal in electric generation power plants. Fly ash is a pozzolan, a substance containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water it forms a compound similar to Portland cement. The fly ash produced by coal-fired power plants provide an excellent prime material used in blended cement, mosaic tiles, and hollow blocks among others.

Fly ash can be an expensive replacement for Portland cement in concrete although using it improves strength, segregation, and ease of pumping concrete. The rate of substitution typically specified is 1 to 1 ½ pounds of fly ash to 1 pound of cement. Nonetheless, the amount of fine aggregate should be reduced to accommodate fly ash additional volume.

Fly ash can be used as prime material in blocks, paving or bricks; however, one the most important applications is PCC pavement. PCC pavements use a large amount of concrete and substituting fly ash provides significant economic benefits. Fly ash has also been used for paving roads and as embankment and mine fills, and its gaining acceptance by the Federal government, specifically the Federal Highway Administration (FHA).Smaller builders and housing contractors are not that familiar with fly ash products which could have different properties depending on where and how it was obtained.

Fig 1. Fly Ash.

2. Quarry Dust:

Manufactured sand is a substitute of river for construction purposes sand produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (Quarry dust) is less than 4.75mm. Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the word. Due to the depletion of good quality river sand for the use of construction, the use of manufactured sand has been increased. Another reason for use of quarry dust is its availability and transportation cost.

Since this sand can be crushed from hard granite rocks, it can be readily available at the nearby place, reducing the cost of transportation from far-off rive sand bed. Thus, the cost of construction can be controlled by the use of manufactured sand as an alternative material for construction. The other advantage of using quarry dust is, it can be dust free, the sizes of quarry dust can be controlled easily so that it meets the required grading for the given construction. It is well graded in the required proportion.

Fig 2. Quarry Dust.

It does not contain organic and soluble compound that affects the setting time and properties of cement, thus the required strength of concrete can be maintained. It does not have the presence of impurities such as clay, dust and silt coatings, increase water requirement as in the case of river sand which impair bond between cement paste and aggregate. Thus, increased quality and durability of concrete. Quarry dust is obtained from specific hard rock (granite) using the state-of-the-art International technology, thus the required property of sand is

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obtained. Quarry dust is cubical in shape and is manufactured using technology like High Carbon steel hit rock and then rock on rock process which is synonymous to that of natural process undergoing in river sand information. Modern and imported machines are used to produce quarry dust to ensure required grading zone for the sand.

3. Gypsum:

Gypsum is a soft sulfate mineral composed of calcium sulfate dehydrate, with the chemical formula CaSO.2H2O, it is widely mined and is used as a fertilizer, and as the main constituent in many forms of plaster, blackboard chalk and wallboard. Natural gypsum occurs in sedimentary rock formations, and is found in over 85 countries. The United States, Canada and Mexico have some of the largest reserves of high-quality gypsum. Gypsum is mined in 17 states. Iowa, Texas, Utah, and New Mexico are particularly important producers.

One hundred pounds of gypsum rock contains approximately 21 pounds (or 10 quarts) of chemically combined water. Gypsum rock is mined or quarried, crushed and ground into a fine powder. In a process called calcining, the powder is heating to approximately 350°F, driving off three fourths of the chemically combined water. The calcined gypsum, or hemihydrate, becomes the base for gypsum plaster, gypsum board and other gypsum products. Gypsum uses include: manufacture of wallboard, cement, plaster of Paris, soil conditioning, and a hardening retarder in Portland cement. Varieties of gypsum known as "satin spar" and "alabaster" are used for a variety of ornamental purposes; however, their hardness limits their durability.

4. Lime:

Lime is a calcium-containing inorganic material in which carbonates, oxides, and hydroxides slaking" is when quicklime is slaked with just enough water to hydrate the quicklime, but remain as a powder and is referred to as hydrated lime. Lime is a soil amendment made by grinding limestone, a naturally occurring type of rock that is very high in calcium. Two types of lime are commonly used in lawns and gardens, agricultural lime and dolomitic lime.

Agricultural lime, also sold as garden lime, is made from calcium carbonate. These materials are still used in large quantities as building and engineering materials, as chemical feed stokes, among other uses. Lime is extensively for wastewater treatment with ferrous sulfate which is extracted from quarries. Part of extracted stone, selected according to its chemical composition.

5. Steel Slag:

Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling. Virtually all steel is now made in integrated steel plants using a version of the basic oxygen process or in specialty steel plants (mini-mills) are using an electric arc furnace process.

The open hearth furnace process is no longer used. In the basic oxygen process, hot liquid blast furnace metal, scrap, and fluxes, which consist of lime (CaO) and dolomitic lime (CaO, MgO or "dolime"), are charged to a converter (furnace). A lance is lowered into the converter and high- pressure oxygen is injected. The oxygen combines with and removes the impurities in the charge. These impurities consist of carbon as gaseous carbon monoxide, and silicon, manganese, phosphorus and some iron as liquid oxides, which combine with lime and dolime to form the steel slag.

At the end of the refining operation, the liquid steel is tapped (poured) into a ladle while the steel slag is retained in the vessel and subsequently tapped into a separate slag pot. There are many grades of steel that can be produced, and the properties of the steel slag can change significantly with each grade. Grades of steel can be classified as high, medium, and low, depending on the carbon content of the steel. High-grade steels have high carbon content. To reduce the amount of carbon in the steel, greater oxygen levels are required in the steel-making process.

6. Tapioca Powder:

Tapioca powder, also known as tapioca starch, is starchy white flour that has a slight sweet flavor to it. Tapioca flour is an alternative to traditional wheat flours and has a variety of uses in baking. The flour is made from the starch extracted from the South American cassava plant. When it comes to recipes it really varies by the author or cookbook on what it is called, but if a recipe calls for tapioca starch, you can easily use tapioca flour, since they are the same thing. Tapioca flour comes from the root of the

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cassava plant. Tapioca flour/starch adds structure to gluten free baking. It contains only minor amounts of protein, fat and fiber. Tapioca is almost pure starch and contains only negligible amounts of protein and nutrients. Health Benefits of Tapioca. Tapioca doesn't have many health benefits, but it is grain and gluten-free.

7. Mixing Proportion:

Generally we are planned to make three different mix proportion are used to manufacture the fly ash bricks they are;

- Fly Ash 55 -60%
- Sand/Stone dust 20-25%
- Sludge Lime 15-20%
- Gypsum 5%

III. EXPERIMENTAL WORKS

1. Tests on Bricks:

1.1 Shape and Size: Shape and size of bricks are very important consideration. All bricks used for construction should be of same size. The shape of bricks should be purely rectangular with sharp edges. Standard brick size consists length x breadth x height as 23cm x 11cm x 7cm. to perform this test, select 20 bricks randomly from brick group and stack them along its length , breadth and height and compare. So, if all bricks similar size then they are qualified for construction work.

1.2 Compressive Strength: Compression testing machine ,the compression plate of which shall have ball seating in the form of portion of a sphere center of which coincides with the Centre of the plate. Remove unevenness observed the bed faces to provide two smooth parallel faces by grinding. Immerse in water at room temperature for 24 hours. Remove the specimen and drain out any surplus moisture at room temperature.

Fill the frog and all voids in the bed faces flush with cement mortar (1portion of cement, 1clean coarse sand of grade 3mm and down). Store it under the damp jute bags for 24 hours filled by immersion in clean water for 3 days. Remove and Wipe out any traces of moisture. Place the specimen with flat face s horizontal and mortar filled face facing upwards between plates of the testing machine. Apply load axially at a uniform rate of 140kg\cm2per minute till failure occurs and note maximum load at failure. The load at failure is maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine. The minimum compressive strength of clay brick is 3.5 N/mm^2 and the fly ash brick has compressive strength of 10-12N/mm^2

1.3 Water Absorption Test: The specimen is dried in a ventilated oven at a temperature of 105 to 1150°C; till it attains substantially constant mass. The specimen is cooled to room temperature and its weight is recorded (M1) the dried specimen is immersed completely in clean water at a room temperature of 27±20c for 24 hours.

The specimen is then removed and any traces of water are wiped out with a damp cloth and the specimen is weighed. The weighing is completed 3min after the specimen has removed from water (M2).

1.4 Effflorescence Test: Efflorescence is a crystalline deposit on surfaces of masonry, stucco or concrete. It is whitish in appearance, and is sometimes referred to as "whiskers". Efflorescence has been a problem for many years, and is a topic of much controversy. The formation of these salt deposits is not mysteries. They are, for the most part, water-soluble salts that come from many possible sources to mar and detract from an otherwise beautiful and serviceable structure.

First of all, there must be water present to dissolve and transport the salts. Groundwater is often a source of efflorescence. For water to carry or move the salts to the surface there must be channels through which to move and migrate. The more dense the material, whether it be brick, stone, stucco or concrete, the more difficult for the water to transport salts to the surface Conversely, the more porous the material, the greater the ease with which salts are transported and deposited.

Salt-bearing water, on reaching the surface of a structure, air evaporates to deposit the salt. When humidity is low, the water may evaporate before reaching the surface of the structure, leaving the salt deposit beneath the surface, and unseen. When the humidity is high, water evaporation is slower allowing more opportunity for whisker growth. Growths which project 1/4 to 1/2 inch below the surface have been reported in some areas of the country.

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1.5 Structure Test: To know the structure of brick, pick one brick randomly from the group and break it. Observe the inner portion of brick clearly. It should be free from lumps and homogeneous. A brick is broken and its structure is examined. It should be compact and free from any defects such as holes, etc.

IV. CONCLUSION

Based on the experimental study, following conclusions can be drawn regarding the strength behavior of fly-ash brick. The tapioca powder and the steel slag increase the Compressive strength of fly ash bricks and also water absorption of fly ash bricks is decreased. While adding the mix of tapioca powder and steel slag to the brick at 7.5% to the weight of bricks it increases the compressive strength of the bricks and also resulted in lower water absorption on comparing with the normal clay and fly ash bricks.

As per IS 12894:2002, bricks with 7.5% mix of tapioca powder and steel slag comes under class II. As per IS 12894 minimum average compressive strength of fly ash-lime bricks when tested for compressive strength will not be less than the one specified for each class which weighed 9.72% lighter than the conventional fly ash bricks. Also its water absorption is 8.23% which is lesser than20%.

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