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EXPERIMENTALLY STUDY ON THE USE OF FOUNDARY SAND IN THE RIGID PAVEMENT

Rouoof Ahmed Malik[1], Er. Mohit Bajaj[2]
M.tech Scholar in GEC, Panipat,
Assistant Professor in Architecture, Chandigarh University

Abstract: Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects, ports and harbors, to meet the requirements of globalization, in the construction of pavements and other structures concrete plays the key role and a large quantum of concrete is being utilized in every construction practices. The consumption of natural resources as an ingredient of concrete, costs high as well as it is on verge of extent. These problems force us to recover the natural resources or to find an alternative option to overcome this problem. Presently, the production of waste foundry sand as a by-product of metal casting industries causes various environmental problems. Foundry sand is basically high quality silica sand which is a by-product of both ferrous and non-ferrous metal casting industries. Foundry sand production is nearly 6 to 10 million tons annually. Like many waste products, foundry sand has beneficial applications to other industries. Metal industries use foundry sand which is uniform sized, high quality silica sand that is bound to form a mould for casting of ferrous and non-ferrous metal. In this research paper, As per IS: 10262-1982 mix design was prepared for M25 grade and same design was used in preparation of test samples. The Sand is replaced with foundary sand by 15 %, 30 % and 45 % replacement.

Keywords: Concrete mix, foundry sand, compressive strength, split tensile, workability

1.0 INTRODUCTION

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects, ports and harbors, to meet the requirements of globalization, in the construction of pavements and other structures concrete plays the key role and a large quantum of concrete is being utilized in every construction practices. In civil engineering, due to urbanization the demand for construction materials increases, with the increase in demand there is a strong need to utilize alternative materials for sustainable development however the responsible management of waste is an essential aspect of sustainable building. Fly ash is generated in huge quantities every day in major thermal power stations of India about 50 to 100 tons of fly ash is produced daily in a normal thermal power station depending on its capacity, quality of coal, load factor, *etc*. The huge quantities of fly ash are being accumulated day by day, occupying large area. Disposal of this huge quantity is therefore a problem. It is as fine as and sometimes even finer than cement. It contains silica, alumina, calcium oxide, and iron oxide. The fly ash can be used as an eco-friendly material for the construction of rigid pavement.

Another alternative for rigid pavement is foundry sand. The use of foundry sand in various construction engineering applications can solve the environmental problems. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of fine aggregates as supplementary replacement to achieve different properties of concrete. This foundry sand consumes a large area of local landfill space. Some industries burn their sludge in incinerators, contributing to our serious air pollution problems. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them. Keeping this in view, it is used to produce low cost concrete by blending various ratios of fine aggregate with used foundry sand. Use of foundry sand in various construction engineering applications can solve the environmental problems. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual and dust. Foundry sand can be used in concrete to improve its strength and other durability factors. Foundry Sand can be used as a partial replacement of fine aggregates as supplementary replacement to achieve different properties of concrete. This foundry sand consumes a large area of local landfill space. Some of the wastes are land spread on cropland, or running off into area lakes and streams. Some industries burn their sludge in incinerators, contributing to our serious air pollution problems. To reduce disposal and pollution problems emanating from these industrial wastes, it is most essential to develop profitable building materials from them. Keeping this in view, investigations were undertaken to produce low cost concrete by blending various ratios of fine aggregate with used foundry sand.

The study will lead to possible innovative utilization of foundry sand in construction of concrete roads apart from its present use in land fill application. The use of waste foundry sand, if could be feasible, will not only provide for its better utilization but also will help in conserving the precious natural resource of natural sand.

1.1 FOUNDARY SAND

It is a byproduct of the ferrous and nonferrous metal casting industry, where sand has been used for centuries as a molding material because of its unique engineering properties. In modern foundry practice, sand is typically recycled and reused through many production cycles. Industry estimates are that approximately 100 million tons of sand are used in production annually. Of that, four (4) to seven (7) million tons are discarded annually and are available to be recycled into other products and industries.

Sand used at foundries is of a high quality, much of it supplied by members of the Industrial Minerals Association of North America (IMA-NA). Stringent physical and chemical properties must be met as poor quality sand can result in casting defects. Foundries and sand producers invest significant resources in quality control of their sand systems, with extensive testing done to maintain consistency. As a result, FS from an individual facility will generally be very consistent in composition, which is an advantage for most end user applications.

Types of Foundry Sand

There are two basic types of foundry sand available, green sand (often referred to as molding sand) that uses clay as the binder material, and chemically bonded sand that uses polymers to bind the sand grains together.

1. **GREEN SAND**
   It consists of 85-95% silica, 0-12% clay, 2-10% carbonaceous additives, such as sea coal, and 2- 5% water. Green sand is the most commonly used molding media by foundries. The silica sand is the bulk medium that resists high temperatures while the coating of clay binds the sand together. The water adds plasticity. The carbonaceous additives prevent the "burn-on" or fusing of sand onto the casting surface. Green sands also contain trace chemicals such as MgO, K2O, and TiO2.

2. **CHEMICALLY BONDED SAND**
   It consists of 93-99% silica and 1-3% chemical binder. Silica sand is thoroughly mixed with the chemicals; a catalyst initiates the reaction that cures and hardens the mass. There are various chemical binder systems used in the foundry industry. The most common chemical binder systems used are phenolic-urethanes, epoxyresins, furfyl alcohol, and sodium silicates.

2.0 LITERATURE REVIEW

JOJU JOSE et al studied the Characteristics of Concrete Containing Waste Foundry Sand and Slag Sand. In this research, an attempt was made to evaluate the properties of concrete containing waste foundry sand as a partial replacement to slag sand. Concrete mixtures with 0%, 15%, 30% & 45% waste foundry sand replaced partially by weight of slag sand, with mix proportion of M25 grade were produced in laboratory. An additional mix with 30% waste foundry sand replaced for the sieve sizes 300μm, 150μm & 75μm was also proportioned. Both fresh and hardened properties were investigated. Water/cement ratio of 0.45 was kept constant for all the mixes. Hardened properties included compressive strength, split tensile strength, modulus of elasticity, drying shrinkage and flexural strength at different curing periods. The test results showed that strength properties show a decreasing trend with the increase in waste foundry sand content in cement concrete. For 28 days, maximum decrease in compressive strength was 39% for concrete mixtures containing 45% WFS, when compared to reference mixture. The mixtures containing waste foundry sand replaced more than 30% showed very high shrinkage. Among all the strength properties, flexural strength was found to be least affected by WFS. From this limited study it can be concluded that concrete containing waste foundry sand up to 15% can be effectively used for structural applications.

Akshay C. Sankh et al studied the Replacement of Natural Sand With Different Alternatives. The non-availability or shortage of river sand will affect the construction industry, hence there is a need to find the new alternative material to replace the river sand, such that excess river erosion and harm to environment is prevented. Many researchers are finding different materials to replace sand and one of the major materials is quarry stone dust. Using different proportion of these quarry dust along with sand the required concrete mix can be obtained. This paper presents a review of the different alternatives to natural sand in preparation of mortar and concrete. The paper emphasize on the physical and mechanical properties and strength aspect on mortar and concrete.

Suryawanshi et al. studied the use of ecofriendly waste material like fly ash in rigid pavement construction and done its cost benefit analysis. For experimental analysis, the fly ash was collected from Ekalahare, Nasik (Maharashtra) thermal power Plant. The various tests (Chemical Analysis, Lime Reactivity, Cement Reactivity, Sieve Analysis) were carried out in Maharashtra Engineers research Institute, Nasik as per IS: 1727-1967. For carrying out Economic analysis single lane width road section is considered and life cycle costs of construction per km per 3.5m width. For the economic analysis flexible, rigid and rigid pavement with fly ash and nominal reinforcement has been considered. The unit rates used to estimate construction costs of the pavement is derived from current CPWD, Delhi schedule of rates. It has been concluded that construction of rigid pavement with flyash save rupees one lakh per km and proves economical over rigid pavements. In concrete roads and runways, a part of cement and sand can be replaced by good quality fly ash to the extent of 10 – 30 % and 5 – 15 % respectively. This would result in lowering the cost of resultant concrete without any loss of strength and with increased durability.

Vojtech Vaclavik et al. describes the use of polyurethane foam after the end of its life cycle as an aggregate both for thermal insulating mortars for various wall surfaces and for lightweight concrete. Polyurethane foam is a macromolecular structural material (thermoset), prevailingly on an organic basis. It is produced by an exothermic reaction – polyaddition of diphenyl diisocyanate with mixes of polyhydric polyethers and polyester alcohols, activators, accelerators, stabilizers, flame retardants, water and auxiliary blowing agents. Due to the temperature of the chemical reaction and due to the carbon dioxide CO2 produced, the polyurethane substance being formed is foamed and creates a microscopic closed cell structure, due to which final polyurethane foam has excellent thermal and water insulating properties. He studied the use of polyurethane foam and concluded that polyurethane foam after the end of its life cycle is a full-value alternative to expanded volcanic glass and polystyrene crumb used at present as aggregates in thermal insulating renders and plasters.

Prajapati et al. describes the study of rigid pavement by using the used foundry sand. The experimental study has performed by preparing a concrete mix of M20 grade as per IS: 10262-1982. The evaluation of Used Foundry Sand for use as a replacement of fine aggregate material begins with the concrete testing. Concrete contains cement, water, fine aggregate, coarse aggregate and grit. With the control concrete, i.e. 10%, 30% and 50% of the fine aggregate is replaced with used foundry sand, the data from the used foundry sand is compared with data from a standard concrete without used foundry sand. Three cube samples were cast on the mould of size 150*150*150 mm and 100*100*500 mm for each 1:1.48:3.21 concrete mix with partial replacement of fine aggregate with w/c ratio as 0.50 were also cast. After about 24 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7,14 and 28 days for compressive strength and 28 days for flexural strength tests.

Pranita Bhandari et al studied the Use of Foundry Sand in Conventional Concrete. This research was carried out to produce a low-cost concrete. An experimental investigation was carried out on a concrete containing waste foundry sand in the range of 0%, 10%, 20%, 30%, 40%, 60%, 80% and 100% by weight for M-25 grade concrete. The concrete containing foundry sand was tested and compared with conventional concrete in terms of workability, compressive strength and acid attack. Cubes were casted and compression test was performed on 3rd, 7th and 28th day for mix of 1:1.01:2.5 at a w/c of 0.4. Through experimental result we conclude that after 20% partial replacement of foundry sand the compressive strength decreases with increase in partial replacement of waste foundry sand. The aim of this research is to know the mechanical properties of concrete after adding optimum quantity of waste Foundry sand in different proportion.

Vipul D. Prajapati et al studied the used foundry sand: opportunities for developing of low cost rigid pavement. It is most essential to develop profitable construction materials from used foundry sand. The innovative use of used foundry sand in concrete formulations as a fine aggregate replacement material was tested as an alternative to traditional concrete. The fine aggregate has been replaced by used foundry sand accordingly in the range of 0%, 10%, 30% & 50% by weight for M-20 grade concrete. Concrete mixtures were produced, tested and compared in terms of compressive and flexural strength with the conventional concrete. These tests were carried out to evaluate the mechanical properties for 7, 14 and 28 days. This research work is to investigate the behaviour of concrete while replacing used foundry sand in different proportion in concrete. This low cost concrete with good strength is used in rigid pavement for 3000 commercial vehicles per day (cvpd) and Dry Lean Concrete (DLC) 150mm thick for national highway to make it eco-friendly.

Pathariya Saraswati C et al studied the Application of Waste Foundry Sand for Evolution of Low-Cost Concrete. This research is carried out to produce a low-cost and eco-friendly concrete. This paper demonstrates the use of waste foundry sand as a partial replacement by fine aggregate in concrete. An experimental investigation is carried out on a concrete containing waste foundry sand in the range of 0%, 20%, 40%, and 60% by weight for M-25 grade concrete (PPC). Material was produced, tested and compared with conventional concrete in terms of workability and strength. These tests were carried out on standard cube of 150*150*150* mm for 7, 14 and 28 days to determine the mechanical properties of concrete. Through experimental result we conclude that the compressive strength increases with increase in partial replacement of waste foundry sand and split tensile strength decreases with increases in percentage of waste foundry sand. The aim of this research is to know the behaviour and mechanical properties of concrete after addition of industrial waste in different proportion by tests like compressive strength and split tensile.

3.0 EXPERIMENTAL METHDOLOGY

Concrete contains waste foundry sand as a partial replacement of fine aggregate is tested. Concrete is composed of cement, coarse aggregate, fine aggregate, waste foundry sand and water. Coarse aggregates of 20mm and 12mm are used in mix design. Plasticizers used for the better workability of concrete. Table No. 3.5 gives the quantity of ingredients of concrete which is taken for 0.041 m^3 i.e. 3 cube, 3 beam and 3 cylinder. All collected materials were thoroughly dry mixed and after that wet mixing was done. After properly mixing, the moulds were filled and tampered. It was also vibrated mechanically and placed for 24 hours. After demoulding cube, beam and cylinder were taken to a tank full of water for curing. The Sand is replaced with foundary sand by 15 %, 30 % and 45 % replacement. As per IS: 10262-1982 mix design was prepared for M25 grade and same design was used in preparation of test samples. After curing for 24hrs the samples were demoulded and subjected to compressive strength test and tensile split test for 7and 28 days.

Table 1: Mix Design of Samples

Designation	Mix	Water	Cement	Type	Weight of Foundary Sand	Fine Agg. (Sand) (kg/m³	Coarse Agg (kg/m³)
C-0	Control	181.97	443.84	-	-	567.75	1143.55
C-1	15 %	181.97	443.84	Foundary Sand	85.162	482.5875	1143.55
C-2	30 %	181.97	443.84	Foundary Sand	170.325	397.425	1143.55
C-3	45 %	181.97	443.84	Foundary Sand	255.4875	312.2625	1143.55

4.1 COMPRESSIVE STRENGTH TEST

Compressive strength tests were performed on compression testing machine of 2,000 KN capacity. Three cubes of 150*150*150 mm from each batch were subjected to this test. The comparative study was made on properties of concrete after percentage replacement of fine aggregate by waste foundry sand in the range of 0%, 15 %, 30 % and 45 %.The cubes were tested at the age of 7 and 28 days.

Table 2: Compressive strength Test

Mix Design	Compressive strength in N/mm²	
	7 Days	28 days
C-0	12.41	26.93
C-1	13.56	27.51
C-2	16.35	29.43
C-3	15.31	26.80

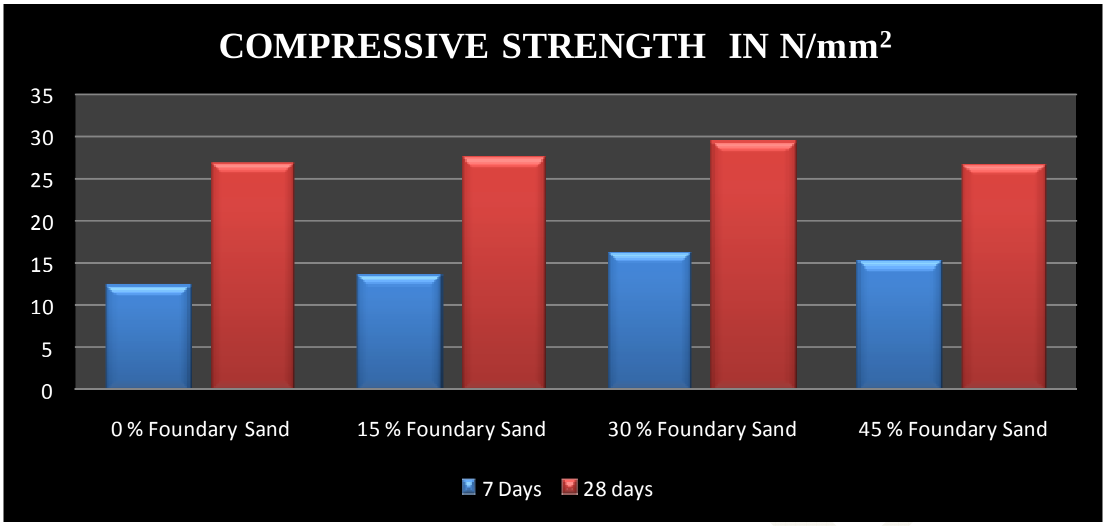

Figure 1: Compressive strength Test of different Mixes

4.2 SPLIT TENSILE STRENGTH TEST

The test was conducted according to IS Code 5816-19706. This test was carried out by placing a cylindrical specimen of size 150mm x 300mm dia. horizontally between the loading surfaces of a compression testing machine and the load was applied until failure of the cylinder, along vertical Diameter. The tensile strength of concrete is approximately 10% of its compressive strength.

Table 3: Split Tensile strength Test

Mix Design	Split Tensile strength in N/mm^2	
	7 Days	28 days
C-0	1.34	3.14
C-1	1.56	3.37
C-2	1.21	3.05
C-3	1.23	2.94

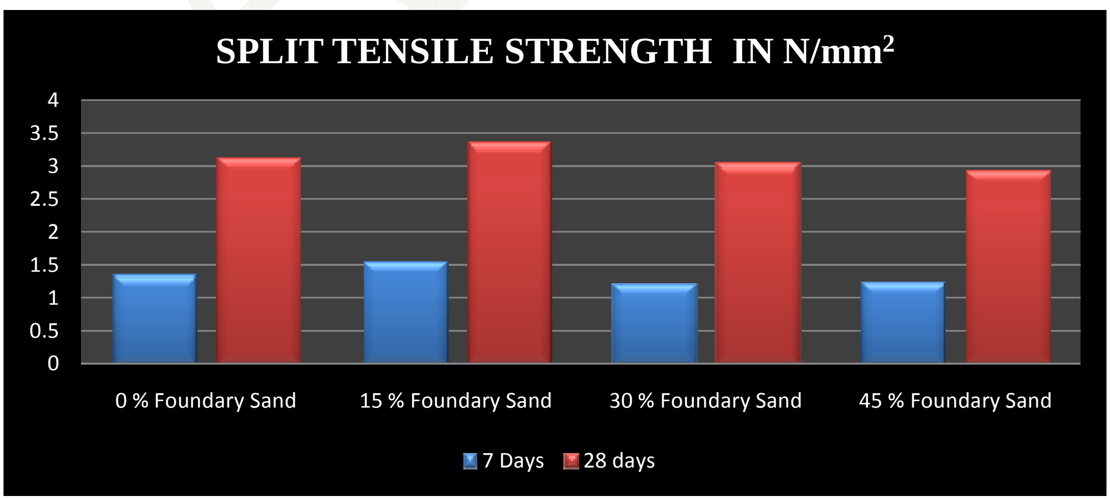

Figure 2: Split tensile strength Test of different Mixes

CONCLUSION

Based on above study the following observations are made regarding the properties and behaviour of concrete on partial replacement of fine aggregate by waste foundry sand:

1. Waste foundry sand can be efficacious used as fine aggregate in place of regularly river sand in concrete.
2. Use of foundry sand in concrete reduces the production and disposal of waste through metal industries.
3. Split Tensile Strength also increased with increase in age.
4. Substitution of foundry sand in concrete decreases Compaction factor of concrete.
5. In this study, maximum compressive strength is obtained at 30% replacement of fine aggregate by waste foundry sand.
6. In this study, maximum split tensile strength is obtained at 15% replacement of fine aggregate by waste foundry sand.
7. Split tensile strength decrease on increase in percentage of waste foundry sand after 15% replacement.
8. Excessive addition of waste foundry sand in concrete affects its workability due to the presence of very fine binders in waste foundry sand.
9. The problems of disposal and maintenance cost of land filling is reduced.
10. For particular mix of certain ingredient quantities volume of concrete reduces due to fine particles of foundry sand.
11. The used foundry sand can be innovative Construction Material but judicious decisions are to be taken by engineers.

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