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Application of Smart Materials in Civil Engineering for Better Tomorrows: A Review

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Abstract: ***The effective utilization of locally available waste material has certainly a great importance in civil engineering. In the recent years, the various materials such as flyash, silica sand, ceramic dust, steel scrap from lathe, polyurethane foam etc. were used as a smart material to decrease the various problems occur during and after the construction. The present study describes the use of such materials and their importance in the field of civil engineering for sustainable development. Due to urbanization, demand of construction materials increases and brings the need to use alternative materials. The use of eco-friendly materials solves the problems of waste disposing and their effect on environment. The properties of concrete may be enhanced by using these materials, resulting in the better alternative for use of recycled/waste materials.***

Keywords: *Waste materials, Sustainable development, Smart construction, concrete, cost, Recycled aggregate*

Introduction:

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 Maharashtra. 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.

The waste steel scraps obtained from lathe can be used in concrete pavement. In each lathe industries wastes are available in form of steel scraps are yield by the lathe machines in process of finishing of different machines parts and dumping of these wastes in the barren soil contaminating the soil and ground water that builds an unhealthy environment. Now a day's these steel scraps as a waste products used by innovative construction industry and also in transportation and highway industry. In addition to get sustainable progress and environmental remuneration, lathe scrap as worn-recycle fibers with concrete are likely to be used. When the steel scrap reinforced in concrete then it is called as steel fiber reinforced concrete (SFRC). The use of SFRC enhanced the workability and mechanical strength properties of concrete.

Expanded polystyrene (EPS) is a lightweight cellular plastics material consisting of fine spherical shaped particles which are comprised of about 98% air and 2% polystyrene. It has a closed cell structure and cannot absorb water. It has a good sound and thermal insulation characteristics as well as impact resistance. Polystyrene foam is a non-biodegradable material. It is a waste material from packaging industry. It creates disposal problem. Utilizing crushed polystyrene granules in concrete is a valuable waste disposal method and enhances the tensile and compressive strength of light weight concrete. There are many advantages to be gained from the use of lightweight concrete. These include lighter loads during construction, reduced self-weight in structures and increased thermal resistance. Lightweight concrete is generally accepted as concrete having a density of about 1800 kg/m3 or less.

The Indian ceramics industry, which is comprised of wall and floor tiles, sanitary ware, bricks and roof tiles, refractory materials and ceramic materials for domestic and others use is producing approximately 15 to 30 MT per annum waste. Out of total waste, 30% goes as waste in India and dumped the powder in open space. Ceramic waste is of generally two types, waste earthenware and also cracked during the manufacturing process. Ceramic waste is considered as non-hazardous solid waste and possesses pozzolanic properties. Therefore, after recycling can be reuse in different building construction application. The researchers used ceramic waste to make green concrete by using minimum 20% replacement natural aggregate. It was found that ceramic waste based concrete shows good workability and achieves characteristics strength. Use of non-hazardous industrial waste is also gaining popularity in India to use in building construction work for developing building material components. Even ceramic waste was also used to replace fine aggregate and found good compressive strength and abrasion resistance, together with less penetration by chlorides which could provide greater protection for the reinforcement used in reinforced concrete. However, such a use of ceramic waste powder should not compromise the quality and performance of the highway infrastructure nor create environmental problems. Hence, this paper presents the study on use of recycled waste material in concrete construction to curb the disposal problem via using an innovative way in concrete.

Literature Review:

The various researchers Suryawanshi *et al.* (2012), Vojtech Vaclavik *et al.* (2012), Prajapati *et al.* (2013), Electricwala Fatima *et al.* (2013) Joshi *et al.* (2014), Thomus Tamut *et al.* (2014), studied the use of various waste materials in civil engineering projects.

Suryawanshi[1] *et al.* (2012) studied the use of eco-friendly 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[2] *et al.* (2012) 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 CO_2 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[3] *et al.* (2013) 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.

The compressive strength and flexural strength of concrete increases with increase in foundry sand upto 50% and the maximum compressive strength, flexural strength is achieved at 50% replacement of natural fine aggregate with used foundry sand which comes to be 40.89 N/mm^2 and 8.45 N/mm^2 respectively as shown in Fig.1. The cost of rigid pavement also decreases with the use of foundry sand. Use of foundry sand in concrete can save the ferrous and non-ferrous metal industries disposal, cost and produce a ‘greener’ concrete for construction. Environmental effects from wastes and disposal problems of waste can be reduced through this research.

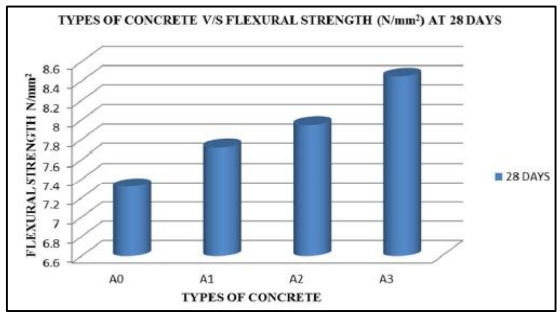

Figure 1: Variation of compressive strength and flexural strength for different types of concrete.

Electricwala Fatima[4] *et al.* (2013) describes the use of ceramic dust as construction material in rigid pavement. For this research, mainly three materials were used namely ceramic waste, aggregate and cement to prepare required samples. Cement, aggregate and sand was used as per IS 456-2000 codal provision for construction of cement concrete road. The ceramic waste was collected from Morbi Ceramic industrial area, Rajkot, Gujarat, India. The sample of the waste was collected manually and freshly at the beginning of the experimental work and stored as per standard specification. The mix design methodology was developed based upon absolute volume method by conducting several trail mix and proportion of these mixes were used to find an

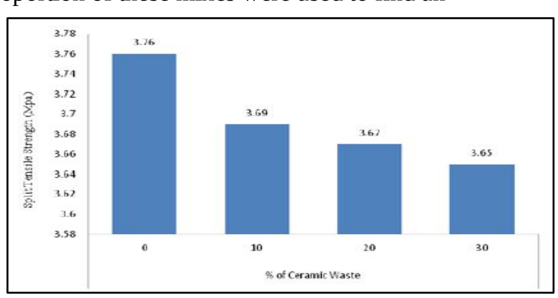

Figure 2: Variation of compressive strength

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optimum mix proportion. The experimental investigation was done to determine Compressive strength, Flexural

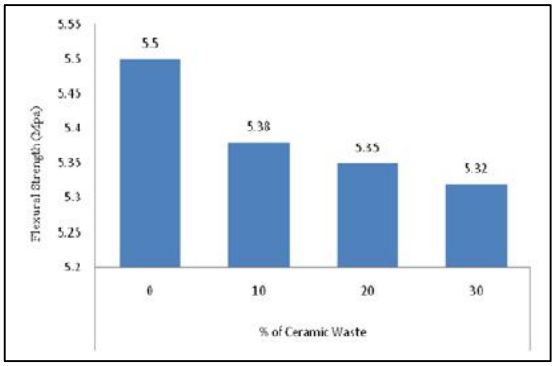

Figure 3: Variation of flexural strength.

strength, Split Tensile strength and Modulus of Elasticity of concrete mixed with different ratios of 10%, 20% and 30% ceramic dust for dry lean concrete (DLC) and pavement quality concrete (PQC). The compressive strength was obtained at 7-days and 28 days of different samples of concrete. The results show that ceramic waste proportion up to 20% is feable to use in DLC and PQC. The splitting tensile strength value varies from 0.89 Mpa to 1.28 Mpa at 7 days as shown in Fig. 4. It was observed that split tensile strength of the PQC decreases as the percentage of ceramic waste in concrete is increased up to 20%. It decreases by approximately 0.037 Mpa on every 10% addition of ceramic waste. The loose bond of the matrix might have led to the decreasing values of split tensile strength. However, results for splitting tensile strength have under limits and can be used in DLC and PQC. Hence, it was concluded that 20% replacement of ceramic waste may be for PQC and DLC may be used with proper quality control and assurance.

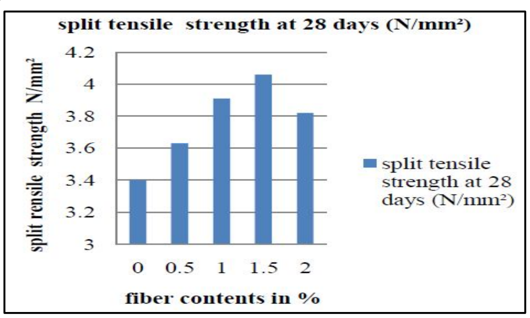

Figure 4: Variation of splitting tensile strength.

Joshi[5] *et al.* (2014) studied the reuse of lathe waste steel scrap in concrete pavements. The compressive strength, flexural strength and spilt tensile strength was studied for varying percentage of fiber contents (0.5 – 2.0) and found that compressive strength of steel fiber reinforced concrete (SFRC) slightly increases 3% as compared to plain concrete as shown in Fig. 5. Tensile strength of scraps steel fiber concrete increases up to 20% considerable increases as shown in Fig. 6. Flexural strength of SFRC effectively increases nearly 40 % as shown in Fig. 7. However, results were found that mechanical properties of SSFRC increases up to addition of 1.5% fiber contents and on further increasing fiber contents it will decrease the strength. Due to increase in flexural strength of SFRC, fatigue behavior of SFRC also need to analyzed, stress ratio for SFRC obtained i.e. 0.65 to 0.90.

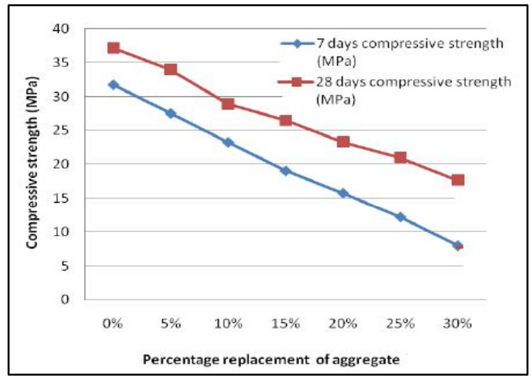

Figure 5: Variation of compressive strength.

Figure 6: Variation of splitting tensile strength.

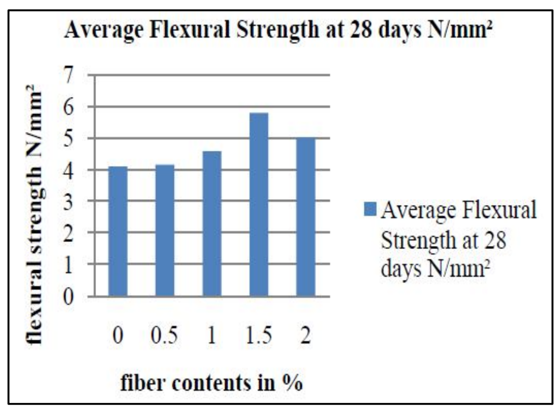

Figure 7: Variation of average flexural strength.

Thomus Tamut[6] *et al.* (2014) studied the partial replacement of coarse aggregates by expanded polystyrene beads in concrete. The objective of investigation was to study the properties, such as compressive strength and tensile strengths of lightweight concrete containing Expanded Polystyrene (EPS) beads. The properties are compared with those of the normal concrete *i.e.,* without EPS beads. EPS beads are used as partial replacement to coarse aggregates. The results showed that the amount of polystyrene beads incorporated in concrete influences the properties of hardened concrete. At 28 days, it was found that compressive strength of 5%, 10%, 15%, 20%, 25% and 30% EPS incorporated concrete strengths were 91%, 77 %, 71%, 63%, 57%, and 45%, respectively when compared to concrete with no EPS case. The variation of compressive strength and split tensile strength was as shown in Fig. 8 and 9 respectively. From results it was concluded that, increase in the EPS beads content in concrete mixes reduces the compressive and tensile strength of concrete. All the EPS concrete without any special bonding agent show good workability and could easily be compacted and finished. Workability increases with increase in EPS beads content.

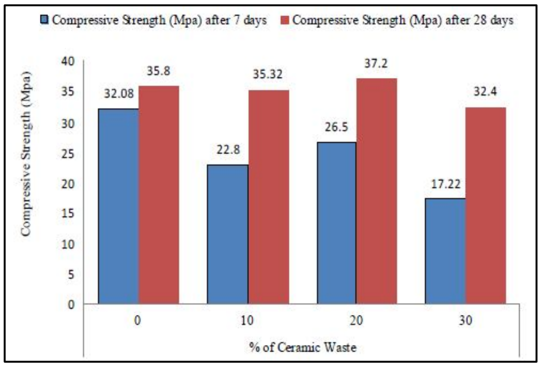

Figure 8: Variation of compressive strength

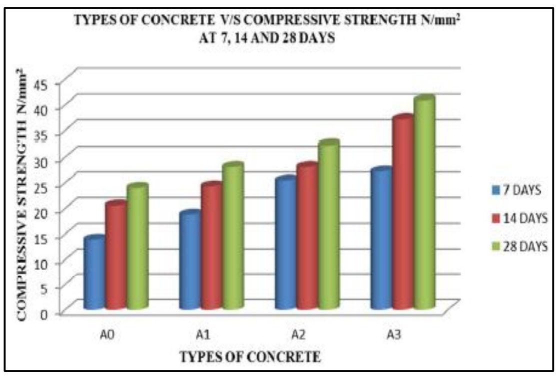

Figure 9: Variation of tensile strength

3. CONCLUSIONS:

The above literature review describes the use of different waste materials in the civil engineering construction for better tomorrow. The following conclusions will be drawn on the basis of above literature;

The waste materials can be efficiently used in the construction for sustainable development.

Cement and sand can be replaced by good quality fly ash to the extent of 10 – 30 % and 5 – 15 % respectively without any loss of strength.

Polyurethane foam can be used as an aggregate both for thermal insulating mortars for various wall surfaces and for lightweight concrete.

The compressive strength and flexural strength of concrete increases with increase in foundry sand upto 50% and the maximum compressive strength, flexural strength is achieved at 50% replacement of natural fine aggregate with used foundry sand.

The cost of rigid pavement also decreases with the use of foundry sand and produced greener concrete for construction.

The compressive strength for different proportions of concrete increases as ceramic waste quantity increases up to 20 % and can be used for DLC with proper quality control and assurance.

Compressive strength, tensile strength and flexural strength of steel fiber reinforced concrete (SFRC) increases upto 3%, 20% and 40 % respectively as compared to plain concrete.

Expanded Polystyrene (EPS) beads can be used as partial replacement of coarse aggregates.

An innovative (Smart) mix can be obtained by using above mentioned waste materials in concrete at respective optimum percentage, which would resolve the problems associated with concrete construction.

4. REFERENCES:

i. *Suryawanshi N., Bansode S. and Nemade P., "Use of Eco-Friendly Material Like Fly Ash in Rigid Pavement Construction & It's Cost Benefit Analysis", International Journal of Emerging Technology and Advanced Engineering, 2 (12), 2012, pp. 795 -800.*

ii. *Vaclavik V., Dvorsky T., Dirner V and Martin S., "Polyurethane Foam as Aggregate for Thermal Insulating Mortars and Lightweight Concrete", International Journal of Technology and Research, 19 (3), 2012, pp. 665-672.*

iii. *Prajapati V., Joshi N. and Pitroda D., "Techno-Economical Study of Rigid Pavement by using the used Foundry Sand", International Journal of Engineering Trends and Technology, 4 (5), 2013, pp. 1620-1628.*

iv. *Electricwala F., Jhamb A. and Kumar R., "Ceramic Dust as Construction Material in Rigid Pavement", American Journal of Civil Engineering and Architecture, 5, 2013, pp. 112-116.*

v. *Shrivastavaa P. and Joshi Y., "Reuse of Lathe Waste Steel Scrap in Concrete Pavements", Int. Journal of Engineering Research and Application, 4 (12), 2014, pp. 45-54.*

vi. *Thomas T. and Prabhu R., "Partial Replacement of Coarse Aggregates by Expanded Polystyrene Beads in Concrete", International Journal of Research in Engineering and Technology, 3 (2), 2014 pp. 238 – 241.*