An Experimental Investigation On High Performance Concrete By Partial Replacement Of Saw Dust Ash With Cement , M-Sand With Fine Aggregate And Study On Environmental Effects Of Concrete With CO_2 Emission

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Abstract— **Concrete technology has made tremendous strides in the past decade, it is one of the largest consumers of natural resources in which it is used to make long-lasting and energy-efficient buildings. In this technocratic era, there is a massive ascend in diligence and metropolis which shows the continuous exploitation in emerging materials. Due to the continuous utilization of construction materials leads to the scarcity of natural concrete and also there is a raise in dumping of wastage. To overcome dumping of concrete waste many researchers made an alternate/substantial material, which is a high performance concrete (HPC) provides high workability and durability over conventional concrete with lower water-cement ratio..To overcome the above mentioned issues, Firstly the use of partial replacement of materials is considered. HPC will be cast for M35 grade and the partial replacement of concrete material is used to reuse industrial waste such as saw dust ash (SDA) as a cement replacement in the range of 10%, 15%, 20% by weight for M35, the M-Sand as a fine aggregate replacement in the range of 20%, 30%, 40% by weight of sand and class 1 quarry stone as coarse aggregate by weight of aggregate. Water reducing admixture added to lower water-cement ratio of concrete. In this concrete, strength and durability properties such as compressive, split tensile and flexural strength are evaluated for mixes of concrete. Secondly, to be eco-friendly (i.e.) reduction of greenhouse gases from the cement , where cement production emits 5% of global carbon dioxide in which half of it from combustion and calcination process. A wide range of options exists to reduce the emission of CO2 in the concrete and will be discussing their systematic investigation in that field.**

Index Terms— **Compressive strength, Durability, split tensile strength, Saw Dust Ash (SDA), Manufactured Sand (M-sand), Workability, High performance concrete (HPC), CO_2**

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I. INTRODUCTION

Concrete is a homogeneous and composite material consisting of coarser particles contained in a matrix of materials. The cement is the main constituent material that fills the voids among the aggregate particles and adheres them together. The use of concrete in the world is lot more than as steel, wood, plastics, and aluminium. The economy, efficiency, durability, rigidity and strength of reinforced concrete make it an optimum material for a large range of structural usages. High Performance Concrete is a special type of concrete which is made by using suitable materials to exhibit particular propertieson hardening. In this paper the HPC using SDA and M-sand with Liquid water reducer compound (Superplasticiser) as admixture is demonstrated. For the past many years India is using wood items and the waste which come out from wood is useless, generally this wood wastes are useless and it is not used anywhere. These wastes obtained from wood is called saw dust and when this saw dust is burnt, its ash shows pozzolonic properties along with this it is very fine. Due to these peculiar properties use of saw dust ash can be partially replaced by cement. The role of the fine aggregate is to help in the workability and homogenity in the mixture. The river sand is the most common source of fine aggregate. Concrete is used to build large and rigid structures such as building frames, bridges and other related civil engineering structures.

Now-a-days the natural river sand has become scarce and very costly. Hence we are forced to think of substitute materials. Saw Dust Ash (SDA) can be used in place of Cement partly & the Manufactured sand (M-Sand) may be used in the place of river sand fully or partly. Superplasticizers, also called as high range water reducers are chemical admixtures that are used in places where well-flowing is required.

Plasticizers (water reducers), and superplasticizer (high range water reducers), are chemical compounds that can be added to concrete mixtures to increase workability of concrete. The strength of concrete is inversely proportional to the amount of water added or water-cement (w/c) ratio. Chemical admixtures are the key materials in concrete other than Portland cement, water, and aggregate that are added to the mix before or during mixing. Producers use admixtures initially to reduce the cost of construction; to alter the properties of hardened concrete; to confirm the quality of concrete during mixing, transporting, placing, and curing; and to overcome some difficulties during concreting. Most admixtures are provided in ready-to-use liquefied form and they are added to the concrete at the plant or at the worksite.

Some admixtures, such as colorings and pumping aids are used only in extremely small amounts and are usually batched by hand from measured containers. This study on the experiment consists of liquid water proofing water reducer which helped in reducing water content and made concrete impermeable to water and increases durability of HPC.

CARBON DIOXIDE EMISSION FROM CALCINATION (PROCESS EMISSIONS)

CO_2 (Carbon-di-oxide) is formed by calcination process which can be expressed by the following equation:

$CaCO_3 \rightarrow CaO + CO_2$

1 kg 0.56 kg + 0.44 kg

The part of CaO in clinker amounts to 64-67%. The remaining part contains iron oxides and aluminium oxides. CO_2 emissions from clinker production results at about 0.5 kg/kg clinker. The process of CO_2 emission for cement production depends on the ratio clinker/cement. This ratio varies normally from 0.5 to 0.95.

II. LITERATURE REVIEW

The below are the literatures collected on each material and the findings of the authors are quoted and shown below for reference, study and understanding of literature purposes only:

C.Marthong found in his paper that the possibility of using Sawdust Ash (SDA) as a construction material was experimentally investigated. Saw dust was burnt and the ash was sieved using a 90 micron sieve. Three grades of ordinary Portland cements 33, 43 and 53 as categorized by Bureau of Indian Standard (BIS) are used in construction industry. A relative study was done on the effects of concrete properties with OPC of changeable grades was partly replaced by SDA is discussed in this paper. Percentage replacement of OPC with SDA was 0, 10, 20, 30 and 40% respectively.

A. A. Raheem B. S. Olasunkanmi C. S. Folorunso, this research consist of the use of saw dust ash as a pozzolanic material in the production of concrete. The study showed the physical properties and chemical composition of saw dust ash (SDA) and also the workability, and compressive strength properties of the concrete produced by altering 5%, 10%, 15%, 20% and 25% by weight of ordinary Portland cement with SDA. Slump and compacting factor tests were done out on the fresh concrete and compressive strength test on hardened concrete. The concrete cube was tested at the days of 3, 7, 28, 56 and 90 days. The results indicated that SDA is a good pozzolan with combined SiO2, Al2O3 and Fe2O3 of 73.07%. An optimum value of 23.26N/mm2 at 90 days was obtained for concrete with 5% SDA replacement.

T.Shanmugapriya, R. N. Uma, This paper present the optimization of partial replacement of manufactured sand by river sand with silica fume in High Performance Concrete (HPC). Concrete mixes were tested for compressive strength and flexural strength. The cement was partially replaced with silica fume by 1.5%, 2.5 %, and 5% and natural sand was replaced with manufactured sand by four proportions (i.e., 10%, 30%, 50%, 70%). The results showed that there is an increase in the compressive and flexural strength of HPC nearly 20% and 15% respectively with the increase of manufactured sand percentage.

Priyanka , Jadhava and Dilip K. Kulkarni, The response of water cement ratio on fresh and hardened properties of concrete with partial replacement of natural river sand by manufactured sand was explored. Concrete mix design of M20 grade was done with compliance to Indian Standard code (IS: 10262). Concrete cube, beam and cylindrical specimens was tested for evaluation of compressive, flexural and split tensile strength. Workability was measured in terms of slump test and compacting factor test. The concrete gave excellent strength with 60% replacement of natural sand, so it can be used in concrete as an alternative to natural sand. The compressive, split tensile and flexural strength of concrete with 60% replacement of natural sand by manufactured sand exhibit higher strength as compared to reference mix.

Manguriu, G.N., Karugu, C.K., Oyawa , W.O., Abuodha, S.O. And Mulu, The use of crushed rock sand as a partial replacement of river sand in concrete production was investigated. Water cement ratio changed between 0.55 and 0.59 for 0 % to 100 % natural sand replacement. The slump oscillated between 49 and 60 mm for 0 % to 100 % natural sand replacement. The average compressive strength of the control concrete was 22.5 N/mm^2. The actual natural sand replacement ranged between 0 and 60 % with the best results attained at 20 % replacement. The highest compressive strength and indirect tensile strength values of 23.2 N/mm2 and 1.42 N/mm^2 respectively were gained. Modulus of elasticity of concrete amplified from 22 KN/mm^2 to 23 KN/mm2 with 20 % replacement of natural sand. Also, the indirect tensile strength improved from 1.28 N/mm^2 to 1.42 N/mm2 with 20 % river sand replacement.

Concrete International 2001, Reducing environmental impact of concrete , kumar metha ,The world's yearly cement manufacture of 1.6 billion tons accounts for about 7% of the global loading of carbon dioxide into the atmosphere. Portland cement, in use today, is not only one of the most energy-intensive materials of construction but also is responsible for a large amount of greenhouse gases. Ordinary concrete typically contains about 12% cement and 80% aggregate by mass. Cement , aggregate and water reuse and conservation are stated in this paper.

Energy Efficiency and CO_2 Emissions from the Global Cement Industry Michael Taylor, Cecilia Tam and Dolf Gielen Energy Technology Policy Division International Energy Agency 2006. This Paper shows that the production of cement clinker from limestone is the main energy consuming process in this industry. The most widely used cement is Portland cement, which contains 95% cement clinker. Clinker is produced by heating limestone to temperature above 950°C. Most of the energy used is in the form of fuel for the production of cement clinker and electricity for crushing & grinding the raw materials and finished cement. CO_2 is produced at two stages during cement production : the first is as a by-product of burning of fossil fuels, primarily coal, to generate the heat necessary to conduct the cement-making process. the second from the thermal decomposition of calcium carbonate in the process of producing cement clinker.

$CaCO_3$ (limestone) + heat → CaO (lime) + CO_2.

M. K. Maroliya, Tests conducted on concrete addition of chemical admixtures to observe the change in ingredients contents of concrete like sand and cement under the influence of plasticizers and superplasticizers at various prescription levels. The result of the preserved mix was related with the control mix. Remarks were made on soft stages of concrete, to note the variation in workability at constant and decrease water cement ratio. From the understanding and information gained from this course of study both, plasticizers and super-plasticizers not only improved workability at constant water-cement ratio but considerably improved the compressive strength at lesser water-cement ratio. However rise in sand content is required to overcome bleeding and segregation for the same strength it became likely to reduce the cement content is noted

Mr. M K Maroliya, The efforts were made to understand the possible differences between plasticizers and super plasticizers. The result of tests conducted on concrete in the presence of plasticizers and superplasticizers. The objective was to note the change in mechanical properties under the encouragement of plasticizers and superplasticizers at various dosages level. The result of the treated mix was compared with the control mix. Observations were made on solid phases of concrete, to note the difference in properties at constant and varying reduce water/cement ratio. From the experience and knowledge gained from this course of study both, plasticizers and super- plasticizers not only improved workability at constant water cement ratio but also enhanced the compressive strength at reduce water-cement ratio with slump value remaining unchanged , at every stage superplasticizers were known to perform better than plasticizers.

III. METHODOLOGY

The methodology performed involves of preparing, testing of specimens in the laboratory and studying the environmental effects of co_2 emission in concrete industry. As per IS 10262: 2009 M35 mix is prepared with water cement ratio 0.40, 0.45 and 0.50 are also mixed with Superplasticiser chemical compound (for e.g.:10%, 20% etc;).. Mix is prepared with 10%, 15% and 20% Saw dust ash as a partial replacement of cement. Another Mix is prepared with 20%, 30% and 40% M-sand as a partial replacement of River sand. Cubes of 150mm * 150 mm * 150mm 150*300 cylinders are casted which is tested for compressive strength & Split tensile strength for 7, 14 and 28 days. Curing is done in curing tank at room temperature with clean water. All the materials of the concrete is mixed thoroughly and this fresh concrete checked for its workability by slump cone test, then this concrete is casted in 150 mm cubes & 150*300 mm cylinders. These cubes & cylinders are tested in compression testing machine for compressive and split tensile strength after 7, 14 and 28 days of curing. The study on environmental effects of concrete and co_2 emissions are studied and possible solutions discussed in this paper

IV. MATERIALS SELECTIONS & DESCRIPTIONS:

In this project material which is used is given below :

A. Cement: ordinary Portland cement is used in this experiment of grade 53 with specific gravity 3.15.

B. Saw Dust Ash: Saw Dust is collected from local timber cutting industry and then this saw dust is burn approximately 5-6 hours then it is left for cooling. Specific gravity of saw dust ash is 2.10.

C. Aggregate: Natural River sand of zone II, specific gravity 2.65 and crushed stone with specific gravity 2.72 is employed in this project of HPC.

D. Superplasticisers: Chemical waterproofing and water reducing agent (off) have been used in mixing the concrete of HPC.

V. HIGH PERFORMANCE CONCRETE

High performance concrete is a mixture, which has high durability and high strength when compared to normal conventional concrete. This concrete contains one or more of cemetatious materials and usually a super plasticizer. The term 'High Performance' is differential because the essential feature of this concrete is that it's constituents and mix proportions are specifically designed so as to have particularly special properties for the expected use of the structure such as high durability, strength and low permeability.

CEMENT:

	PROPERTY	VALUE
1	Specific Gravity	3.1
3	Initial Setting Time	45 min
4	Final Setting Time	385 min
5	Fineness Modulus	6 %
6	Bulk density(Dense)	1.56g/ cm^3
7	Bulk density(Loose)	1.16g/ cm^3

Table 1. Physical Properties of OPC

Ordinary Portland cement is nowadays the common type of cement that is being used in general around the world. It is used as a basic part of concrete, mortar and grouts. For HPC cement must have high amount of C_3A and C_3S which are called as bogue compounds formed from its chemical composition.
SiO2 (silicon dioxide) - cap rock
CaO (calcium oxide) - limestone
Al2O3 (aluminum oxide) – clay
Fe2O3 (ferric oxide).

The above materials are responsible to react and form the bogue compounds it is responsible for the initial setting time and rapid hardening of the cement.

Chemicals	%
CaO	60-67
SiO_2	17-25
Al_2O_3	3-8
Fe_2O_3	0.5-6.0
MgO	0.5-4.0
Alkalis	0.3-1.2
SO_3	2.0-3.5

Table 2. Chemical composition of OPC

The bogue compound which usually form in process of mixing:

- 1-triclcium silicate (3CaO.SiO2)

- 2-Dicalcium silicate (2CaO.SiO2)
- 3-tricalcium aluminates (3CaO.Al2O3)
- 4-tetracalcium aluminoferrite (4CaO.Al2O3.Fe2O3)

Fine Aggregate:
Fine aggregates are basically obtained from natural sand in the land or marine areas. In india it is often taken from river beds. Fine aggregates generally consist of natural sand or crushed rocks with most particles passing inside a 9.5mm sieve.

Purpose And Use:

- Increases the volume of concrete
- Provide dimensional stability
- Adds hardness, resistance properties to the concrete making it durable and stronger.

Materials	**Fine Aggregate**
Specific Gravity	2.56
Finess Modulus (%)	3.91
Bulk Density (Kg/m^3)	1736
Water Absorption (%)	1.69

Table 3 . Physical Properties of Sand

Coarse Aggregate:

Coarse aggregate is rock type material which passes through 80mm sieve and retained on a 4.75mm sieve. The portion of aggregates used in the investigational work passed in 20mm sieve and recollected on 10mm IS sieve comes under Zone II aggregates conforming to IS: 383-1970. In the project we have used 1st Class Quary stone as coarse aggregate.

Materials	Coarse Aggregate
Specific Gravity	2.71
Finess Modulus (%)	3.18
Bulk Density (Kg/m^3)	1612.67
Water Absorption (%)	0.33

Table 4 . Physical Properties of Coarse Aggregetes

Admixtures:
A material other than water, aggregates, or cement that is used in concrete or mortar to control setting and early hardening, workability, or to provide additional cementing properties. **Chemical admixtures** are Accelerators, Retarders, Water-reducing agents, Super plasticizers, Air entraining agents etc.

Actions Involved:

1. ***Dispersion:*** Surface active agents change the chemical forces at the interface. They are adsorbed on surface of the cement particles and give them a negative charge (ionic) which leads to repulsion of the particles. Electrostatic forces are established causing fragmentation and the free water become accessible for workability.
2. ***Lubrication:*** As these agents are organic by nature, they lubricate the mix decreasing the friction and increasing the workability.
3. ***Retardation:*** A tinny layer is formed over the cement particles shielding them from hydration and growing the setting time.
4. ***Increased fluidity:***

- Flowing
- Self-leveling
- Self-compacting concrete
- Penetration and compaction

5. ***Reduced W/C ratio:***

- Very high early strength, >200% at 24 hours or earlier
- Very high later age strengths, >100 MPa or 15000 psi.
- Reduced shrinkage, especially if combined with reduced cement content.
- Improved durability by removing water to reduce permeability and diffusion.

VI. STUDY ON ENVIRONMENTAL IMPACT OF CONCRETE & CO2 EMISSIONS

The environmental impact of concrete, its creation and solicitations is complex. Some effects are dangerous. Many depend on situations. The Government of india has set many rules and regulations via its environmental ministry to all the toxic emmiting industries to control their process of harmfull emissions that cause illness to humans. A major module of concrete is cement, which has its own environmental and social impacts and donates largely to those of concrete. The cement industry is one of the main makers of carbon dioxide, a major greenhouse gas. Concrete causes impairrment to the most fertile layer of the topsoil. Concrete is used to create rigid surfaces which add to surface run-off that may root to soil erosion, water pollution and flooding.
The environmental impacts of concrete are :

- Climate change
- Global warming
- Transportation fuel emission
- Dust production
- Heat generation
- Waste disposal problems

- Safety issues and health related problems
- Emission of greenhouse gases c02.

Prevention Of Co2 Emissions :

Co2 Emissions are the worst nightmare to the cement and concrete industries because most of the emissions takes place at the process of cement manufacture where the clinkers are formed while heating lime. The ways to decrease emissions are given below after proper research of the topic.

- Alternate clinker substitutes in cement
- Lowering carbon materials usage
- Using wet process for cement manufacture
- Proper storage facility
- Recycle and Reuse of materials
- Proper Handling of Materials

VII. RESULT & DISCUSSIONS:

1)Compressive Strength Test
2)Split Tensile Strength Test

Due to the use of superrplasticiserand lower Water Cement ratio, the values of the strength tests are obtained at a greater level and so that High Preformance Concrete Proves to be Economical.

On Collecting the Literatures and observing the above and From the experimented & analysed results, the test results are being plotted under the graph and analysed. The graph 1 below indicates the compressive strengths of concrete with M-sand Replacements in 20%(m1), 30%(m2), 40%(m3). It is seen that the average compressive strengths rises in optimum level with alternate replacement of materials in relevant percentages and M-sand works fine with the fine aggregate replacements in HP concrete. The optimum result was obtained at 20 %.

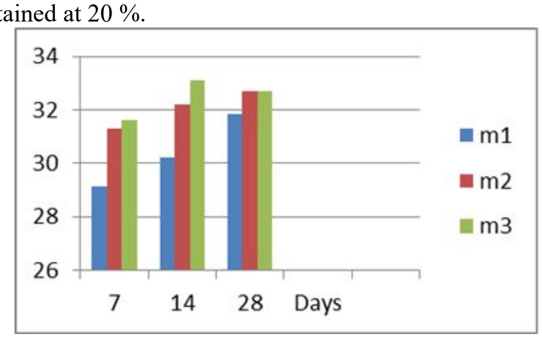

Fig 1: Compressive Test results on M-sand

The test results are being plotted under the graph and analysed. The graph 2 below indicates the compressive strengths of concrete with SDA Replacements in 10%(m1), 15%(m2), 20%(m3). It is seen that the average compressive strengths rises in optimum level with alternate replacement of materials in relevant percentages and SDA works fine with the cement replacements in HP concrete. The best esult optimum is obtained at 15%.

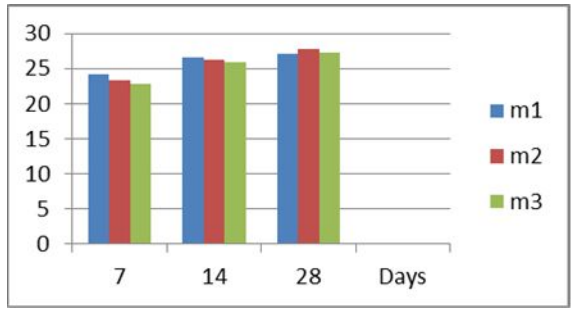

Fig 2: Compressive Test results on SDA

The Split tensile test results are being plotted under the graph and analysed. The graph 3 below indicates the indirect tensile strengths of concrete with SDA Replacements in 20%(m1), 30%(m2), 40%(m3). It is seen that the average compressive strengths rises in optimum level with alternate replacement of materials in relevant percentages and SDA works fine with the cement replacements in HP concrete. The best esult optimum is obtained at 30%.

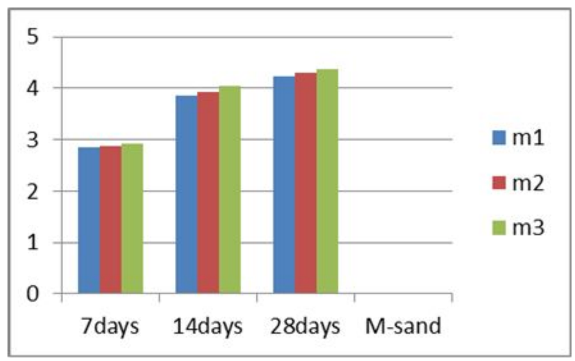

Fig 3: Split Tensile Test on M-sand

The Split Tensile test results are being plotted under the graph and analysed. The graph 2 below indicates the compressive strengths of concrete with SDA Replacements in 10%(m1), 15%(m2), 20%(m3). It is seen that the average compressive strengths rises in optimum level with alternate replacement of materials in relevant percentages and SDA works fine with the cement replacements in HP concrete. The best esult optimum is obtained at 15%.

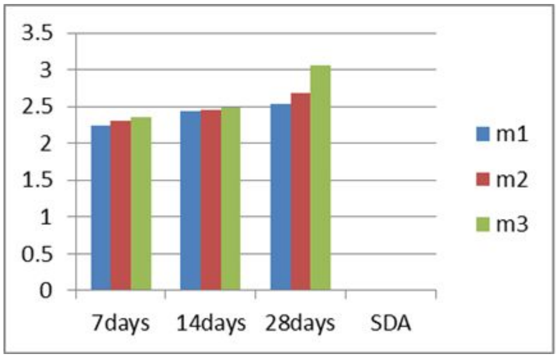

Fig 4: Split Tensile Test on SDA

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