EXPERIMENTAL STUDY ON THE BEHAVIOUR OF CONCRETE IN REPLACEMENT OF CEMENT WITH PULVERISED FUEL ASH (COAL ASH) AND LIMESTONE POWDER

Submitted as Partial fulfilment of the requirements for the award of the Degree of Master of Technology in Structural Engineering

PROJECT PHASE - II

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BONAFIDE CERTIFICATE

This is to certify that the project titled **"EXPERIMENTAL STUDY ON THE BEHAVIOUR OF CONCRETE IN REPLACEMENT OF CEMENT WITH PULVERISED FUEL ASH (COAL ASH)AND LIMESTONE POWDER"** is a bonafid record of work doneby **G.B.SANTHOSH KUMAR (1907SE2001)** in fulfillment of the requirements for the award of the degree of **Master of Technology** in **Structural Engineering** of PRIST University, Thanjavur.

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ABSTRACT

Large amount of coal ash and limestone powder are accumulating in countries all over the world most of these wastes are abandoned and causes certain serious environmental problems and healthhazards. These burned coal and coal combustion by product a quantity are increasing year to year the objectives of these experiment was to determine the possibilities of effective usage of construction materials. Pulverised fuel ashand limestone powder is an industrial waste material used as a partial replacement material in replace with ordinary portland cement in concrete. The pulverised fuel ashis used from 0% to 40% and limestone is used 10% replacement of cement in concrete in type 1 and in type 2 pulverised fuel ashand lime stone powder ash were replaced from 0 to 40% For M30 Grade of concrete. And these mixes are compared with normal concrete mix with OPC. Mechanical properties are studied compressive strength split tensile strength and carbonation test are carried out with different proportion of coal waste ash and constantly limestone powder as in 7 and 28 days .The test result shows that replacement upto 30% of coal waste ash with 10% LSP increases the performance of concrete as compared to conventional concrete. Carbonation test result was found to be good.

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cm	Centimeter
CWA	Coal Waste Ash
g	gram
G	Specific gravity
kN	Kilo Newton
kg	kilogram
LSP	Limestone Stone Powder
m	Meter
ml	millilitre
mm	Millimeter
MPa	Mega pascal
N	Newton
N/mm^2	Newton per square millimetre
µ	Microns
OPC	Ordinary Portland Cement
PPC	Portland Pozzolana Cement
V	Volume
w/c	Water Cement Ratio

x

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Most of the solid waste are produced by industries. The disposal these solid waste materials is an environmental hazard for the surrounding living beings. Various types of pollution are caused by these wastes like air pollution, water pollution, land pollution, etc. These pollution lead to various types of diseases to the life on earth and the waste production is increasing day by day so the disposal of these wastes is an serious issue and also the matter of concern, previous researches observed that because of increasing environmental concerns and sustainable issues, the utilization of solid waste materials is the best way to alleviate the problems associated with their disposal. This problem can be solved by the construction industry by using these solid wastes in the production of structural elements like concrete elements ,bricks, tiles, etc. Coal fired thermal power plants produce large volume of coal bottom ash. Till now it is treated as solid waste material and is disposed off on open land. This broad irrigation leads to both land and air pollution which in turn effect the life on earth.

The enormous quantity of coal bottom ash is getting accumulated near power plant sites. Use of by-products such limestone dust as filler materials in concrete may be beneficial for concrete properties such a strength and homogeneity, it may also help to conserve natural resources and at the same time be an economically viable portion.

Waste limestone powder is produced from processing plants sawing and polishing of marble blocks. India is very rich in marble industry as it export marble almost every part in the world.

As in exporting the marble it should be processed in the industry by cutting, shaping, and polishing. In this process the wastes are produced. This waste limestone powder is one of the materials which severalty affects. Though the usage of cement increases rapidly at the same time, cement material emits CO_2 which causes environment problem and greenhouse gas emission.

For every ton of production of OPC, it emits around 0.9 ton of CO_2. Man-made carbon emission is around 6% in the production of OPC. So, there is a necessity to find alternate cement replacement materials to reduce the usage of cement production. The industrial discarded products can be used as partial replacement materials in its place of cement. Many waste materials are available in replacement of cement materials. The pulverised fuel ash is one of the waste materials obtained in coal washing plants. Its is an industrial by-product material obtained during production of coal. In this study, pulverised fuel ash and limestone powder are used as cement replacement material. In effort to use pulverised fuel ash and limestone powder ,the present study is carried out to improve the strength properties of concrete on comparing it with the nominal mix.

1.2 PULVERISED FUEL ASH (COAL WASTE ASH)

Pulverised fuel ash is the waste that is left after coal is combusted (burned). It includes fly ash(fine powdery particles that are carried up the smoke stack and captured by pollution control devices) as well as coarser materials that fall to the bottom of the furnace. Most pulverised fuel ash comes from coal-fired electric power plants. The EPA estimates that 140 Million tons of pulverised fuel ash are generated annually.

That makes pulverised fuel ash the second largest industrial waste stream in the United States, second only to mine waste.

Pulverised fuel ash is obtained from Mettur thermal power plant , TAMILNADU was used for the study. This ash has spherical and irregular particles with varying particle sizes. Pulverised fuel ash was grinded in laboratory ball mill before using in concrete to get uniform particle size . The specific gravity of pulverised fuel ash found to be 1.98. Depending on where the coal was mined, pulverised fuel ash typically contains heavy metals including arsenic, lead, mercury, cadmium, chromium and selenium, as well as aluminium, antimony, barium, beryllium, boron, chlorine, cobalt, manganese, molybdenum, nickel thallium, vanadium, and zinc. If eaten, drunk or inhaled , these toxicants can cause cancer and nervous system impacts such as cognitive deficits, developmental delays and behavioural problems. They can also cause heart damage, lung disease, respiratory distress, kidney disease, reproductive problems, gastrointestinal illness, birth defects, and impaired bone growth in children. Without proper management, these contaminants can pollute waterways, ground water, drinking water, and the air. Pulverised fuel ash recycling poses health risks, especially where the ash is exposed to water. For an example when sprinkled as cinders on snowy roads, spread as agricultural fertilizer, or used as a landfill or to fill abandoned mines. These uses risk leaching into ground water or surfaces water. Pulverised fuel ash toxics also travel through the environment due to erosion and runoff, and through the air as fine particles or dust. Reusing pulverised fuel ash can create many environmental benefits such as reduced green house emissions, reduced need for disposing in landfills, and reduced use of other material, and economically its reduces the cost, and product benefits such as improved strength, durability, and workability of materials.

1.3 LIMESTONE POWDER

Lime stones are sedimentary rocks primarily of calcium carbonate. Lime stones are generally obtained from the calcareous remains of marine or fresh water organisms embedded in calcareous mud. The specific gravity of limestone powder is 2.5. They change from the soft chalks to hard crystalline rocks. The use of limestone as a concrete aggregate has sometimes been suspect on account of the unsuitability of the poorer graded rocks, and also because of a widespread fallacy that limestone concrete is less resistant to the action of fire than concrete made from other aggregates. He suggested that the use of lime stones might not be beneficial in concrete products, which are to be cured in high-pressure steam.

It is mainly composed of skeletal fragments of marine organisms such as coral, foarms, and molluscs. Its major materials are the minerals calcite and aragonite, which are different crystal forms of calcium carbonate ($CaCO_3$). Limestone has numerous uses as a building material, an essential component of concrete, as aggregate for the base of roads, as white pigment or filler in products such as toothpaste or paints, as a chemical feedstock for the production of lime, as a soil conditioner, or as a popular decorative addition to rock gardens.

The effect of substitution of limestone in cement concrete presented that the addition of limestone reduces the initial and final setting time, as well as total porosity, whereas the free lime and combined water increase with limestone content. Limestone fills the pores between cement particles due to formation of carboaluminate, which may accelerate the setting of cement pastes. The addition of limestone filler to neat cement pastes and mortars reduces the diffusion coefficient of chloride ions.

They also reported that the amount of limestone increases that heat of hydration, as well as the free lime and compressive strength while the total porosity decreases at early ages.

1.3.1 BUILDING LIME TERMINOLOGY

1.3.3.1 AIR LIMES

Lime mainly consisting of calcium of oxide or hydroxide which slowly harden in air by reacting with atmospheric carbon dioxide. Generally they do not harden under water as they have no hydraulic properties. They may be either quicklimes or hydrated limes.

1.3.3.2 QUICK LIMES

Air limes mainly consisting of calcium oxide and magnesium oxide produced by calcinations of limestone and dolomite rock. They have an exothermic reaction when in contact with water. They are offered in varying sizes ranging from lumps to ground powder materials. They include calcium limes and dolomitic limes.

1.3.3.3 DOLOMITIC LIMES

Limes mainly consisting of calcium oxide and magnesium oxide or calcium hydroxide and magnesium hydroxide without any additions of hydraulic or pozzolanic materials. They are produced in the form of a dry powder or putty or as a slurry. They have the property of setting and hardening under water. Atmospheric carbon dioxide contributes to the hardening process.

1.4 LIME CONCRETE

Lime concrete or limecrete is made by mixing controlled amounts of sand, aggregate, binder and water. Portland cement is normally used as the binder, although nowadays hydraulic lime or hydrated lime can also be used. This type of concrete is used all over the world, including almost every type of transport surface from roads, runways, bus and rail tracks to the construction of buildings and even large dams.

1.5 IMPORTANT CHARACTERISTICS

1.5.1 HIGH WORKABILITY

Water rentivity very high, This makes it perfectly suitable for use with some applications. The lime in the mortar improves adhesion and reduces rain penetration. In mortars containing lime, carbon dioxide dissolves in water and reacts with lime to produce insoluble calcium carbonate crystals. These dissolves in water and reacts with lime to produce insoluble calcium carbonate crystals. These crystals form in spaces such as cracks and grow, thereby sealing the cracks. This self sealing characteristic reduces water penetration and increases durability. Especially in areas where masonry work is prone to frost damage. The rate of carbonation is dependent upon several environmental conditions.

1.5.2 HIGH PLASTICITY

High plasticity, which allows the user to produce a flexible masonry structure, capable of contending with movement resulting from both, thermal and moisture content changes without cracking. Movement joints are not required since the lime mortar can absorb the expansion.

This reduction in the risk of cracking reduces problems related with water penetration. Lime mortar has a lower structural strength than Portland cement but it insures a lasting durability, as many old historical building and medieval castles prove.

1.6 CEMENT

Cement is the main component of concrete. It’s an economical, high quality construction material used in construction projects worldwide. Cement is a fine mineral powder manufactured with very precise process. Mixed with water, this powder transforms into a paste that binds and hardens when submerged in water. Because the composition and fineness of the powder may vary, cement has different properties depending upon its makeup. Cement is made by grinding together a mixture of limestone and clay, which is then heated at a temperature of 1450$^{\circ C}$. What results is a granular is a granular substance called clinker, a combination of calcium, silicate, alumina, and iron oxide.

1.6.1 ORDINARY PORTLAND CEMENT

OPC is manufactured by grinding together OPC clinker (95-97%) along with gypsum (3-5%). Ordinary portland cement is graded according to their compressive strength. The grade indicates the minimum compressive strength that the cement will attain after 28 days of setting. OPC 53 Grade cement attains a minimum compression strength of 43MPa in 28 days.

In case of 43 Grade cement, the initial setting of cement is slower as compared to 53 Grade cement. In other words, the hydration process and consequently, the release of heat is moderate and therefore, occurrence of micro cracking is much less and can be easily controlled by proper curing of the concrete or masonry work.

This cement is recommended for column, beam, and slabs, plastering, tiling, masonry works, Non-RCC structures, pathways etc. where initial days strength is the major structural requirement.

1.7 CONCRETE

Concrete is mostly used as a construction material in world wide. The basic ingredients are used in concrete mix is sand, gravel, cement and water. Freshly mixed concrete can be moulded into any shape and any size. Concrete is strong in compression but there are numerous drawbacks such as very less tensile strength, nature of brittle failure, low crack resistance, etc. For this reason it is usually reinforced with materials that are strong in tension. The combination of cement, water and aggregate to form concrete is a very important partnership. Concrete as a building material is extremely popular due to the fact that it is very reliable, durable and cheap when compared to alternatives. Concrete is used in almost every structure and plays a pivotal role in providing the structural righty of these structures. The production process can be broken up into steps such as obtaining raw materials, combining these raw materials and refining the product. Most concretes used are lime-based concretes such as Portland cement concrete or concretes made with other hydraulic cements, such as calcium aluminate cements.

When aggregate is mixed together with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and molded into shape. The elasticity of concrete is relatively constant at low stress levels as matrix cracking develops. Concrete has a very low coefficient of thermal expansion and shrinks as it matures. All concrete structures crack to some extent, due to shrinkage and tension. Concrete that is subjected to long-duration forces is prone to creep.

Concrete production is the process of mixing together the various ingredients water, aggregate, cement, and any additives to produce concrete. Concrete production is time-sensitive. Once the ingredients are mixed, workers must put the concrete in place before it hardens.

In modern usage, most concrete production takes place in a large type of industrial facility called a concrete plant, or often a batch plant. In general usage, concrete plants come in two main types, ready mix plants and central mix plants.

1.8 SUPERPLASTICIZER

CERAPLAST 300 is a high-grade super plasticizer based on Naphthalene, highly recommended for increased workability and high early and ultimate strengths of concrete. It is in brown colour. It has the specific gravity of 1.2.disperses cement particles more rapidly in the concrete mix by reducing the surface tension of water and solution. This makes the concrete highly workable and flow able even at lower water-cement ratios, resulting in increased strength. Ceraplast 300 is facilitates concrete placement especially where congestion of reinforcement occurs and vibration is not easy. It is recommended for producing pump able concrete and for ready mixed concrete.

It is highly useful for precast concrete constructions and for concrete sleepers, electric posts and for pre-stressed concrete constructions. It increases the durability of concrete structures by facilitating construction with the reduced water-cement ratio and hence it is ideal for marine or coastal structures, especially in tidal zones. The ceraplast 300 is directly added into the mix at the same time as the gauging water. Reduce water dosages for required consistency. It can be used with all types of Portland cement including blended cements and sulphate resistant cement.

0.3% to 1.5% ceraplast 300 by weight of cement. Maximum dosage may have to be increased to as high as 3% of cement weight where exceptional early strength is required. Suitable modifications in the mix design is required in such cases.

1.9 ENVIRONMENTAL ASPECTS

The world needs an environmentally friendly construction material because of the desire to reduce CO_2 emmisions, save non renewable energy resources, provide aesthetically pleasing and healthy surroundings and at the same time minimize waste. Fortunately we have just such a material-concrete, and most of the essential research has been done to enable concrete to fill this role.

CHAPTER 2

LITERATURE REVIEW

2.1 REVIEWS

S.Girishkumar, C.Sudha "An experimental study on the behavioroh HSC in replacement of cement with pulverised fuel ash and limestone powder" International journal of civil engineering(IJCIET), volume 8, 4 Apirl 2017,Chennai.

Many waste materials are available in replacement of cement materials and various studies results are revealed through literature studies. Pulverised fuel ash is one of the waste materials obtained in coal washing plants.It is an industrial by-product material obtained during production of coal. In this study, pulverised fuel ash is used as cement replacement material. In effort to use pulverised fuel ash, the present study is carried out to improve the strength properties of concrete on comparing it with normal mix. The experimental research work involves two phase. For the initial phase, mechanical properties which are like compressive strength, tensile strength and flexural strength of concrete are carried out with mix proportions of pulverised fuel ash varying as 0%,10%,20%,30% and 40% in cement content and limestone powder is kept as constantly as 10% in all mixes. And for the next phase, durability properties of concrete cubes and cylinder are made and tested for sorptivity, acid resistance attack and Sulphur resistance attack to find the chemical attacks against the concrete mix and the test results are compared with conventional concrete mix.

Tazeem-ul-haqzerdi , Md Imran, Safiullamohammed "Performance of limestone powder on strength properties as partial replacement of fine aggregate in concrete mix" Journal of civil engineering, Research paper, volume 6, Issue 5, May 2016, Karnataka.

A study is conducted to determine the engineering properties viz. compressive strength, and water absorption capacity by partial replacement of river sand in concrete. In recent days the demand for river sand is increasing due to its lesser availability. Hence the practice of partially replacing river sand with limestone powder is taking a tremendous growth. It is also inferred from the literature that partially replacement of normal river sand with limestone produces the appreciable increase in compressive strength by different variation of percentages of limestone powder replaced. The limestone powder obtained from limestone quarries. The concrete are made using varying contents of limestone powder as fine aggregate in OPC. The concrete cubes of M20 grade are made. It was found that at o.50 water/cement ratio higher compressive strength are obtained of concrete, and better workability for M20 mix, proportion.

These results compare favourably with those of conventional concrete. The concrete was found to be suitable for use as structural members for buildings and related structures. The main objective of the present work was to systematically study the effect of water cement ratio and percentage replacement of limestone powder by natural sand as 0%,10%,20%,30% respectively on the strength properties of concrete. The study was carried out on M20 grade concrete with 0.5 w/c ratio. Limestone powder can be used as fine aggregate, but it has to satisfy the technical requisites like workability and strength.

On this aspect research on concrete with limestone powder is scarce, so this paper investigates the concrete produced with limestone powder.

Kavitha.O.R, Nandhinipriyaa.K.C, "Effect of bottom ash as a mineral admixture in concrete".International journal of civil engineering October 2017, coimbator.

Solid waste management is important for the well-being of our society. Bottom ash, a by-product from coal has several issuses related with its disposal. This study investigates the effect of bottom ash as a supplementary cementitious material in concrete. Bottom ash is subsitituted in 0%,10%,20% and 30% by weight of cement. The test results indicate that the subsititution of bottom ash for cement improves the strength properties of concrete .Mechanical properties which are like compressive strength, split tensile strength and flexural strength shows superior performance in concrete while 30% of CWA and 10% of LSP is replaced in cement when comparing with conventional mix. The strength is increased up to 8.5%. The indicates that the mix M-4 possess good mechanical properties than all other mixes.

TarunR, FethullahCanpolat, and Yoon-moon chun, "Limestone powder use in cement and concrete"A CBU Report, Report No CBU-2003-31, July 2003, Milwaukee.

Limestone powder as a filler in cement. The use of Portland cement containing limestone filler is a commom practice in European countries, especially in france. This type of cement is formulated to achieve certain goals in the technical, economic, and ecological fields. Among the technical benefits are the increase of early strength, the control of bleeding in concrete with low cement content and the low sensitibility to the lack of curing "Although ENV 1971: 1992 limits the filler content to 5 percent it allows the use of limestone up to 35 percent provided the remaining cementitious material is Portland cement only. This cement is known as Portland L limestone cement (Class II/B-L). As limestone is in effect a type of filer, the limestone cement can be said to have a filler content of up to 35 percent. It can be expected that for some purpose, blended cements with a filler content of 15, or even 20, percent are likely to be popular in the future". In general limestone powder filler in cement and concrete effects acceleration of hydration, dilution of cement paste, increase of effective W/C ratio and increases the strength of early ages. The addition of limestone powder filler to fine cement pastes and mortars reduces the diffusion coefficient of chloride ion.

2.2 OBJECTIVE OF THE PROJECT

The aim of the present investigation is

a) To study different strength properties of coal waste ash and limestone powder concrete with age in comparison to control concrete.
b) To study the relative strength development with age of coal waste ash and limestone powder concrete with control concrete of same grade.

2.3 SCOPE OF THE PROJECT

The Experimental investigation is planned as under

a) To obtain mix proportion of control concrete by IS method.
b) To conduct compression Strength test and carbonation test on coal waste ash and limestone powder and control concrete on standard IS specimen size 150×150×150 mm.
c) To conduct split tensile test on coal waste ash and limestone powder and control concrete on standard IS specimen size 150×300 mm.

CHAPTER-3

METHODOLOGY

3.1 METHODOLOGY

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge.

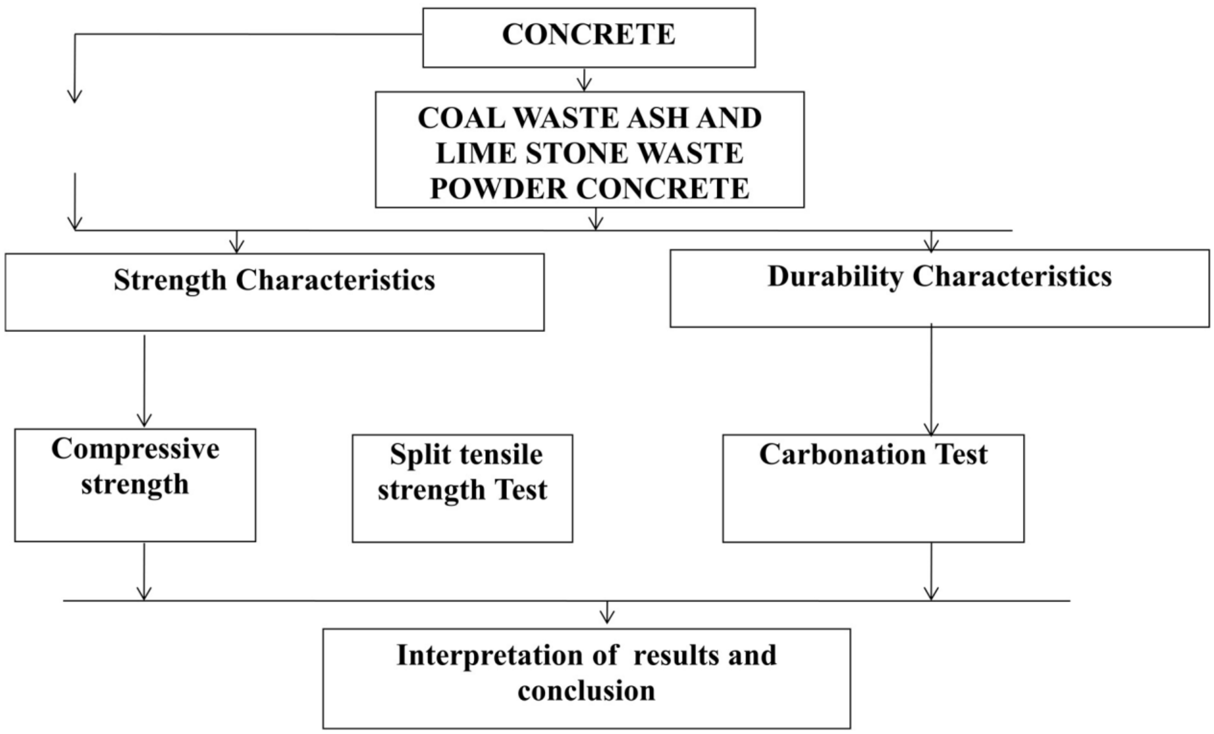

FIG 3.1 METHODOLOGY

3.2 COMPRESSIVE STRENGTH

Compressive strength test or compression test strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength which withstand loads tending to elongate in other words, compressive strength resists compression (being pushed together).

whereas tensile strength resists tension (being pulled apart) in the study of strength of material, tensile strength, compressive strength and shear strength can be analyzed independently.

Some materials fracture at their compressive strength limit others deform irreversibly so a given amount of deformation may be considered as the limit for compressive load, compressive strength is a key value for design of structures.

FIG 3.2 COMPRESSIVE TESTING MACHINE

3.3 SPLIT TENSILE STRENGTH TEST

The tensile strength of concrete is one of the basic and important properties, Splitting tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete.

The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack.

FIG 3.3 SPLIT TENSILE TESTING MACHINE

3.4 Carbonation Test

This test is carried out to determine the depth of concrete affected due to combined attack of atmospheric carbon dioxide and moisture causing a reduction in level of alkalinity of concrete. A spry of 0.01% solution of phenolphthalein is used as pH indicator of concrete after 14 and 28 days of ambient curing. It is noted that the colour of concrete is changed to pink.The change of colour of concrete to pink indicates that the concrete is in the good health.

CHAPTER 4
MATERIAL USED AND PRELIMINARY TEST

4.1 USES OF REPLACEMENT MATERIALS IN CONCRETE

In our world today, concrete has become ubiquitous. It is hard to imagine modern life without it. Approximately five billion tonnes of concrete are used around the world each year. The increasing popularity of concrete as a construction material is placing a huge burden on the natural sand reserves of all countries. In view of the environmental problems faced today considering the fast reduction of natural resources like sand and crushed granite aggregate, engineers have become aware to extend the practice of partially replacing fine aggregate with waste materials.

The aim of this research is to study the physical and mechanical properties of concrete, replacing fine aggregate with blast furnace slag and ground granulated blast furnace clag. We use different materials for replacement in concrete. Now we choose pulverised fuel ash, limestone and chemical admixture are also used. Chemical admixtures are the in concrete other than Portland cement, water, and aggregate that are added to the mix immediately before or during mixing. Then we explain about their properties of replacement material in concrete.

4.1.1 PULVERISED FUEL ASH (COAL ASH) USES

Beneficial use is the recycling or reuse of pulverised fuel ash in lieu of disposal. For example, pulverised fuel ash is an important ingredient in the manufacture of concrete and EPA supports the responsible use of pulverised fuel ash in this manner**.** Pulverised fuel ash are recycled in soil, raising questions about a build up of arsenic and other toxic substances in food crops.

Adding moderate amounts increases crop yields and stabilizes soils while reducing the need to throw huge quantities in landfills or holding ponds, said Yuncong Li, University of Florida Professor of soil and water. Pulverised fuel ash is commonly re-used in a number of ways.

For example it is used as structural fill or fill for abandoned mines as a top layer on unpaved roads as an ingredient in concrete, wallboard, and in school running tracks as an agricultural soil additive and as “cinders” to be spread on snowy roads.

48% of the pulverised fuel ash produced in 2014 was “recycled” in what the Environmental Protection Agency (EPA)And industry call “beneficial re-use.”. However, valid concerns exits around the safety of re-using unencapsulated pulverised fuel ash, as it poses another route for human and environmental exposure. When these uses of pulverised fuel ash are excluded, the percentage of pulverised fuel ash recycled drops to around 20%.

FIG 4.1 PULVERISED FUEL ASH

4.1.2 USES OF LIMESTONE

Limestone, quicklime and slaked lime are all used to neutralise excess acidity - which may be caused by acid rain- in lakes and in soils. Limestone is used as a building material and to purify iron blast furnaces, It's also used in the manufacture of glass and of cement(one of the components of concrete).

Pulverized limestone is used as a soil conditioner to neutralize acidic soils (agricultural lime). Limestone is very common in architecture, especially in Europe and North America. Many landmarks across the world, including the great pyramid and its associated complex in Giza, Egypt, were made of limestone.

FIG 4.2 LIMESTONE POWDER

THE MAIN USES OF LIMESTONE AND ITS PRODUCT

1. Limestone can be used as a building material and in the manufacturing of iron.
2. **Glass-**heated with sand and soda (sodium carbonate).
3. **Cement-**heated with clay in a kiln.
4. **Quicklime-**heated.
5. **Slaked lime-**mixed with water.
6. **Lime motar-**mixed with water.

4.1.3 USES OF SUPERPLASTICIZER

Super plasticizers also known as high ranger water reducers are admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation and to improve the flow characteristics of suspensions such as in concrete applications.

Their addition t-so concrete or mortar allows the reduction of the water to cement ratio, not affecting the workability of the mixture, and enables the production of self-consolidating concrete and high performance concrete. This effect drastically improves the performance of the hardening fresh paste. The strength of concrete increases when the water to cement ratio decreases. However, their working mechanisms lack a full understanding, revealing in certain cases cement-super plasticizer incompatibilities. We use ceraplast 300 super plasticizer. Ceraplast 300 is a high-grade super plasticizer based on Naphthalene, highly recommended for increased workability and high early and ultimate strengths of concrete.

FIG 4.3 CERAPLAST

4.2 APPARATUS USED FOR MAKING CONCRETE

1.Trowel

2.Bond

3.cube mould

4.cylinder mould

4.2.1 CUBE MOULD

The cube moulds for the specimen must be made of cast iron or cast steel. The inside faces must be machined plane. The cube mould is normally made in two halves to facilitate removal of the concrete cube without damage. Each mould has a base which is sepatate metal plate preferably fastened to the mould by clamps or springs. When assembled all the internal angles of the mould must be right angles. Cube of 100mm size are not suitable for concrete having a nominal maximum aggregate size exceeding 20mm. Cubes of 150mm size are not suitable for concrete having a nominal maximum aggregate size exceeding 40mm.

To comply with cs 1:1990 moulds are required to be within specified tolerances for dimensions, squareness and parallelism. These are covered in section 7 of cs 1.

FIG 4.4 CUBE MOULD

4.2.2 CYLINDRICAL MOULD

The concrete cylinder moulds have been manufactured from either hard plastic or steel and comply to the related standards. The moulds a two part and clamp attached base plate cast iron, and are extremely durable, corrosion resistant and simple to clean. We sell both Utest concrete cylinder moulds and PCTE branded concrete cylinder moulds. The mean internal diameter is within 0,2mm and height is within 1mm. The base plate and top plate are machined flat to 0.03mm. Mould, cylinder, cast iron, 15cm×30cm height. Cylindrical mould are available in different sizes and are according to Indian and british standards. The design is such that during dismantling are re-assembly these moulds attain accuracy of alignment. Humboidt provides a variety of metal and plastic concrete cylinder molds as part of a complete line of concrete testing equipment.

Concrete cylinder molds in a range of sizes meet ASTM C31 and othere ASTM/AASHTO test standards, and are made of cast-iron,steel, plastic or polystyrene.

FIG 4.5 CYLINDRICAL MOULD

4.3 PRELIMINARY TEST RESULTS OF USED MATERIALS

4.3.1 SPECIFIC GRAVITY

Specific gravity is the ratio of the density of a substance to the density of a reference substance equivalently. It is the ratio of the mass of a substance to the mass of a reference substance for the same given volume. Specific gravity can be measured in a number of value ways. The following illustration involving the use of the Pycnometer is instructive.

A Pycnometer is simply a bottle which can be precisely filled to a specific, but not necessarily accurately known volume,V. The Pycnometer is used for determination of specific gravity of soil particles of both fine grained and coarse grained soils. It is denoted by the symbol SG.

$$G = \frac{M2 - M1}{(M2 - M1\,) - (\,M3 - M4)}$$

Where, M1 = Mass of empty pycnometer,

M2 = Mass of pycnometer with dry soil,

M3 = Mass of the pycnometer and soil and water,

M4 = Mass of pycnometer filled with water only,

M5 = Specific gravity of soil.

The major advantages of the pycnometric method for the determination of density are high accuracy of measurement (10^{-5} g/cm^3), the possibility of using small quantities of material, the small area of free surface of the liquid in the pycnometer.

4.3.2 FINENESS MODULUS

The Fineness modulus is an empirical figure obtained by adding the total percentage of the sample of an aggregate retained on each of a specified series of sieves, and dividing the sum by 100. The sieve sizes are 150 µm, 300 µm, 60 0µm, 1.18 mm, 2.36 mm, 4.75 mm, 9.5 mm, 19.0 mm, 38.1 mm, and larger increasing in the ratio of 2:1. The same value of finess modulus may therefore be obtained from several different particle size distributions. In general, however, a smaller value indicates a finer aggregates. Fine aggregates range from a FM of 2.00 to 4.00, and coarse aggregates smaller than 38.1mm range from 6.50 to 8.00. Combinations of fine and coarse aggregates have intermediate values.

4.3.3 INITIAL & FINAL SETTING TIME

Division on setting time of cement is based on Initial setting time of cement and Final setting time of cement. The initial and final setting time of cement is determined by Vicat's apparatus using vicat's needle with annular collar of 5cm diameter. Generally initial is the time elapsed between the moment water is added to the cement to the time at which paste starts losing its plasticity. Initial setting time duration is required to delay the process of hydration or hardening. Final setting time is the time when the paste completely loses its plasticity. It is the time taken for the cement paste or cement concrete to harden sufficiently and attain the shape of the mould in which it is cast. The time taken by cement to gain its entire strength is a Final setting time of cement.

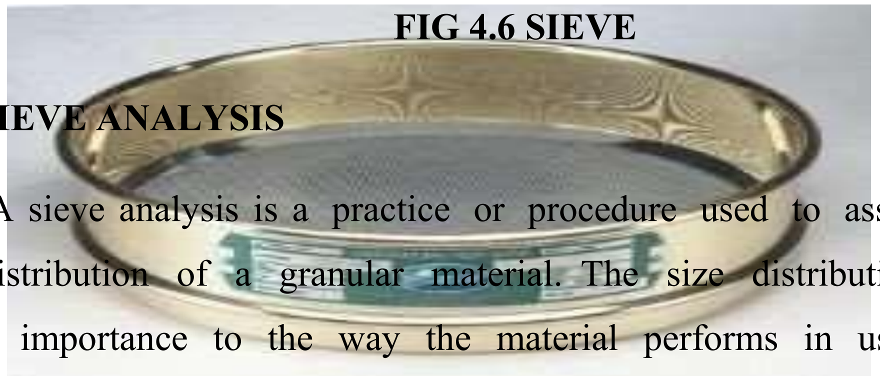

FIG 4.6 SIEVE

4.3.4 SIEVE ANALYSIS

A sieve analysis is a practice or procedure used to assess the particle size distribution of a granular material. The size distribution is often of critical importance to the way the material performs in use. Particle size determinations on large samples of aggregate are necessary to ensure that aggregate perform as intended for their specified use. The advantage of the sieve analysis include easy handling, low investment costs, precise and reproducible results in a comparably short time and the possibility to separate the particle size fractions. Sieve analysis is important for analysing materials because particle size distribution can affect a wide range of properties such as the strength of concrete, the solubility of a mixture, surface area properties.

4.4 TEST RESULTS

4.4.1 CEMENT

TABLE 4.1 Properties of cement

S.NO	DESCRIPTION	RESULT
1.	Type	OPC
2.	Grade	43
3.	Specific gravity	3.15
4.	Initial setting time	30 mins
5.	Final setting time	600 mins

4.4.2 FINE AGGREGATE

TABLE 4.2 Properties of Fine aggregate

S.NO	DESCRIPTION	RESULT
1.	Type	Natural River Sand
2.	Fineness modulus	3.38
3.	Specific gravity	2.6

4.4.3 COARSE AGGREGATE

TABLE 4.3 Properties of coarse aggregate

S.NO	DESCRIPTION	RESULT
1.	Size	20mm
2.	Fineness modulus	7.22
3.	Specific gravity	2.7

4.4.4 PULVERISED FUEL ASH

TABLE 4.4 Properties of pulverised fuel ash

S.NO	DESCRIPTION	RESULT
1.	Specific gravity	2.46
2.	Colour	Black

4.4.5 LIME STONE POWDER

TABLE 4.5 Properties of Lime stone powder

S.NO	DESCRIPTION	RESULT
1.	Specific gravity	2.29
2.	Colour	White

4.4.6 SUPER PLASTICIZER

TABLE 4.6 Properties of Super plasticizer

S.NO	DESCRIPTION	RESULT
1.	Type	CERAPLAST 300
2.	Specific gravity	1.15
3.	Colour	Dark brown

CHAPTER 5
EXPERIMENTAL WORKS AND RESULTS

5.1 MIX PREPARATION

5.1.1 TYPE -1

Mix preparation is to find the amount of ingredients of concrete required required to attain the suitable grade of concrete. The mix should possess proper ingredient content to achieve good workability, strength and durability properties. M30 Grade of concrete was made by the ratio 1:0.75:1.5 The experimental work involves two phases. For the first phase, mechanical properties which of compressive strength, tensile strength and carbonation of concrete are carried out with mix proportions of pulverised fuel ash varying as 0%, 10%, 20%, 30%, 40%, and 50% in cement content and limestone powder is kept as constantly as 10% in all mixes. CWA & LSP were included by replacing the equal mass of OPC in concrete. Mixes were named as M1 (0% CWA & 0%), M2 (10% CWA & 10%), M3 (20% CWA &10%), M4 (30% CWA & 10%), M3 (40% CWA & 10%), M4 (50% CWA & 10%) and super plasticizer are added to the mix to achieve HSC.

FIG 5.1 MIXING OF REPLACEMENT MATERAILS- 1

5.1.2 TYPE -2

In the second phase of experiment the percentage of limestone powder is varied by carrying out trials on workability test and for this percentage of limestone powder, the limestone powder is varied as 0%, 10%, 20%, 30%, and 40%. The limestone powder replaces the cement partially .In both the phases, the Mix design is adopted for designing M30 grade of mix. The concrete mixes were named as C1 (0% CWA & 0%), C2 (10% CWA & 10%), C3 (20% CWA & 20%), C4 (30% CWA & 30%), C3 (40% CWA & 40%), and superplasticizer are added to the mix to achieve HSC.

FIG 5.2 MIXING OF REPLACEMENT MATERAILS-2

5.2 EXPERIMENTAL RESULTS

5.2.1 MECHANICAL PROPERTIES

Mechanical properties are also used to help classify and identify material. The most common properties considered are strength, ductility, hardness, impact resistance, and fracture, toughness. Most structural materials are anisotropic, which means that their material properties vary with orientation.

5.2.2 COMPRESSIVE STRENGTH

Compressive strength test, mechanical test measuring the maximum amount of compressive load a material can bear before fracturing.

The test piece usually in the form of a cube, prism, or cylinder, is compressed between the platens of a compression testing machine by a gradually applied load. It is conducted on hardened concrete to determine the grade of concrete strength. Cube samples with dimension 150 × 150 × 150 mm are taken. For each mix type of samples were tested after 14 and 28 days of curing.

FIG 5.3 CUBE FOR COMPRESSIVE TEST

TABLE 5.1 Compressive strength test result for TYPE 1 Cube,

S.NO	MIX DESIGNATION	Avg compression strength after 14 days curing (N/mm^2)	Avg compression strength after 28 days curing (N/mm^2)
1.	M1	25.96	30.91
2.	M2	26.16	31.15
3.	M3	26.97	32.17
4.	M4	29.14	34.70
5.	M5	30.14	36.47
6.	M6	24.20	27.46

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FIG 5.4 COMPRESSIVE STRENGTH TEST

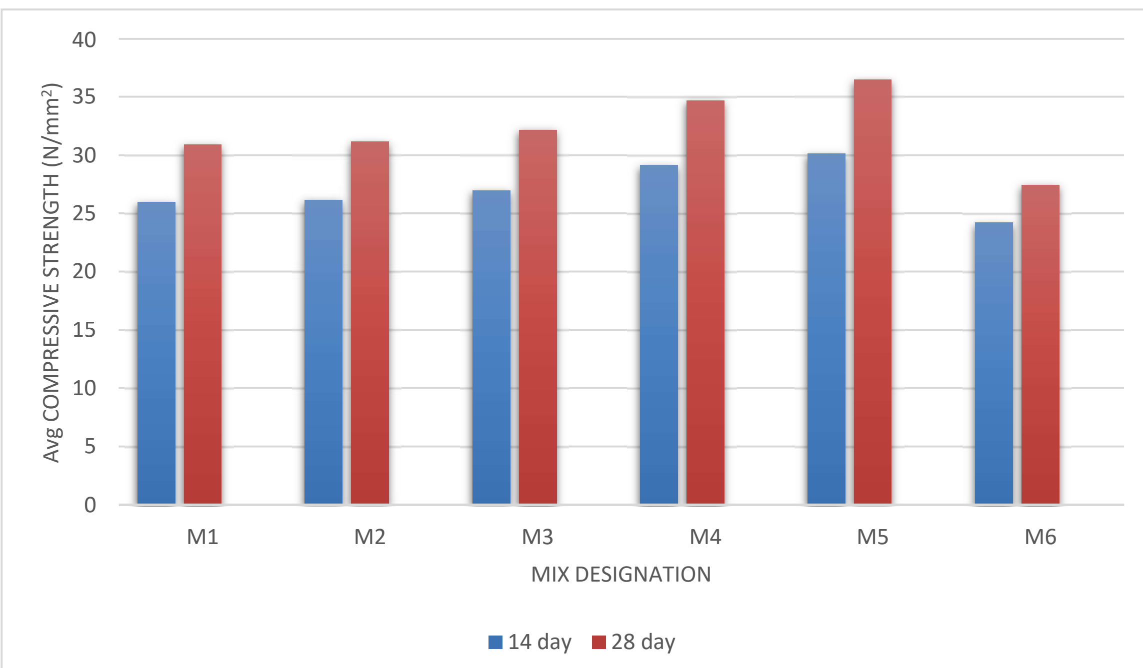

FIG 5.5 GRAPH FOR COMPRESSIVE TEST(TYPE-1)

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TABLE 5.2 Compressive strength test result for TYPE 2 Cube

S.NO	MIX DESIGNATION	Avg compression strength after 14th day curing (N/mm^2)	Avg compression strength after 28th day curing (N/mm^2)
1.	C1	34.1	33.58
2.	C2	34.35	36.62
3.	C3	33.43	35.61
4.	C4	31.21	33.17
5.	C5	32.15	31.32

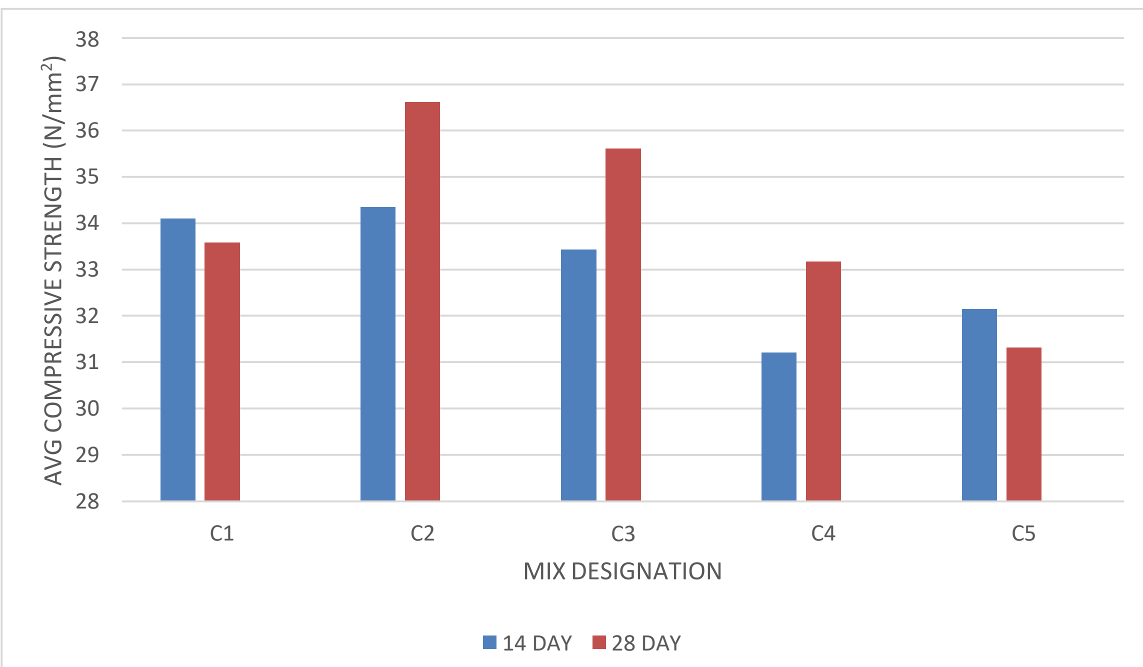

FIG 5.6 GRAPH FOR COMPRESSIVE STRENGTH TEST(TYPE-2)

5.2.3 SPLIT TENSILE STRENGTH

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The tensile strength is one the basic and main properties of the concrete. Cylinder samples with dimension 150 mm diameter, 300 mm height were made through casting and cured to measure the split tensile strength of concrete. For each mix type the samples were tested after 14th days and 28th days of curing.

The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. This test is employed to assess plastics under uniaxial tensile stressing. The advantage of the tensile test is that allows even ductile materials to be tested upto the point of complete fracture.Tensile properties indicate how the material will react to forces being applied in tension. A tensile test is a fundamental mechanical test where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of the specimen over some distance.

FIG 5.7 CURING FOR CONCRETE SPECIMEN

TABLE 5.3 Tensile strength test result for TYPE 1 Cylinder

S.NO	MIX DESIGNATION	Avg Tensile strength after 14th day curing (N/mm^2)	Avg Tensile strength 28th day curing (N/mm^2)
1.	M1	1.92	2.12
2.	M2	1.95	2.29
3.	M3	1.99	2.34
4.	M4	2.07	2.43
5.	M5	2.15	2.56
6.	M6	2.03	2.37

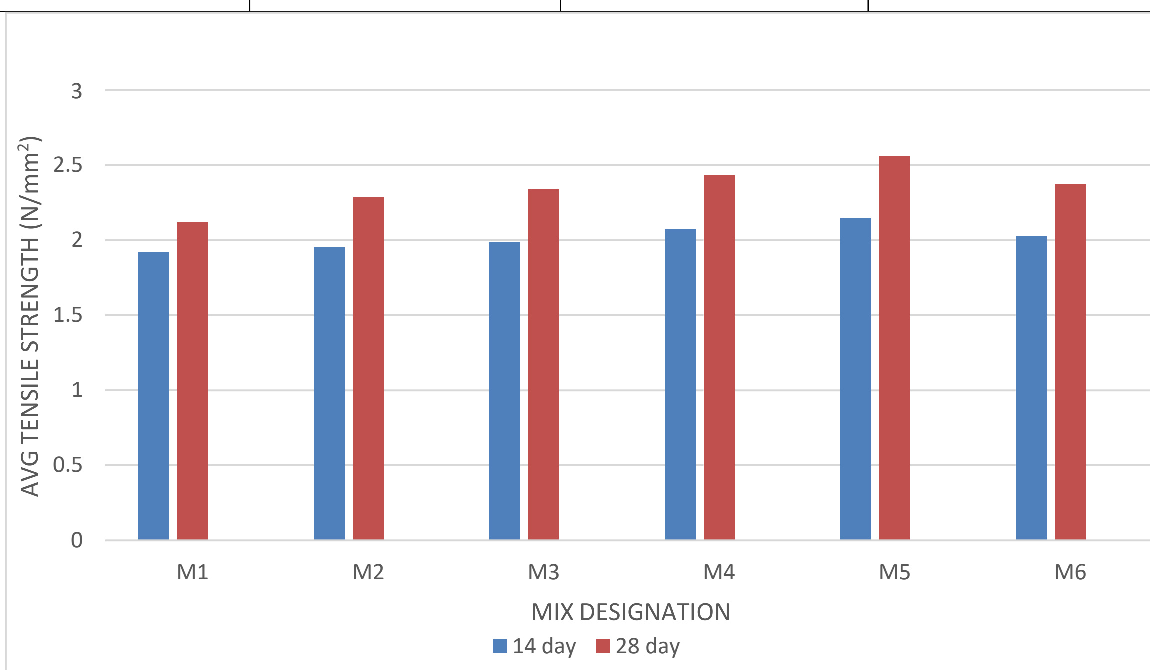

FIG 5.8 TENSILE STRENGTH TEST FOR TYPE-1

FIG 5.9 SPLIT TENSILE TESTING MACHINE

TABLE 5.4 Tensile strength test result for TYPE 2 Cylinder

S.NO	MIX DESIGNATION	Avg Tensile strength 14th day curing (N/mm^2)	Avg Tensile strength 28th day curing (N/mm^2)
1.	C1	1.56	2.08
2.	C2	1.68	2.14
3.	C3	1.76	2.25
4.	C4	1.43	2.17
5.	C5	1.34	1.09

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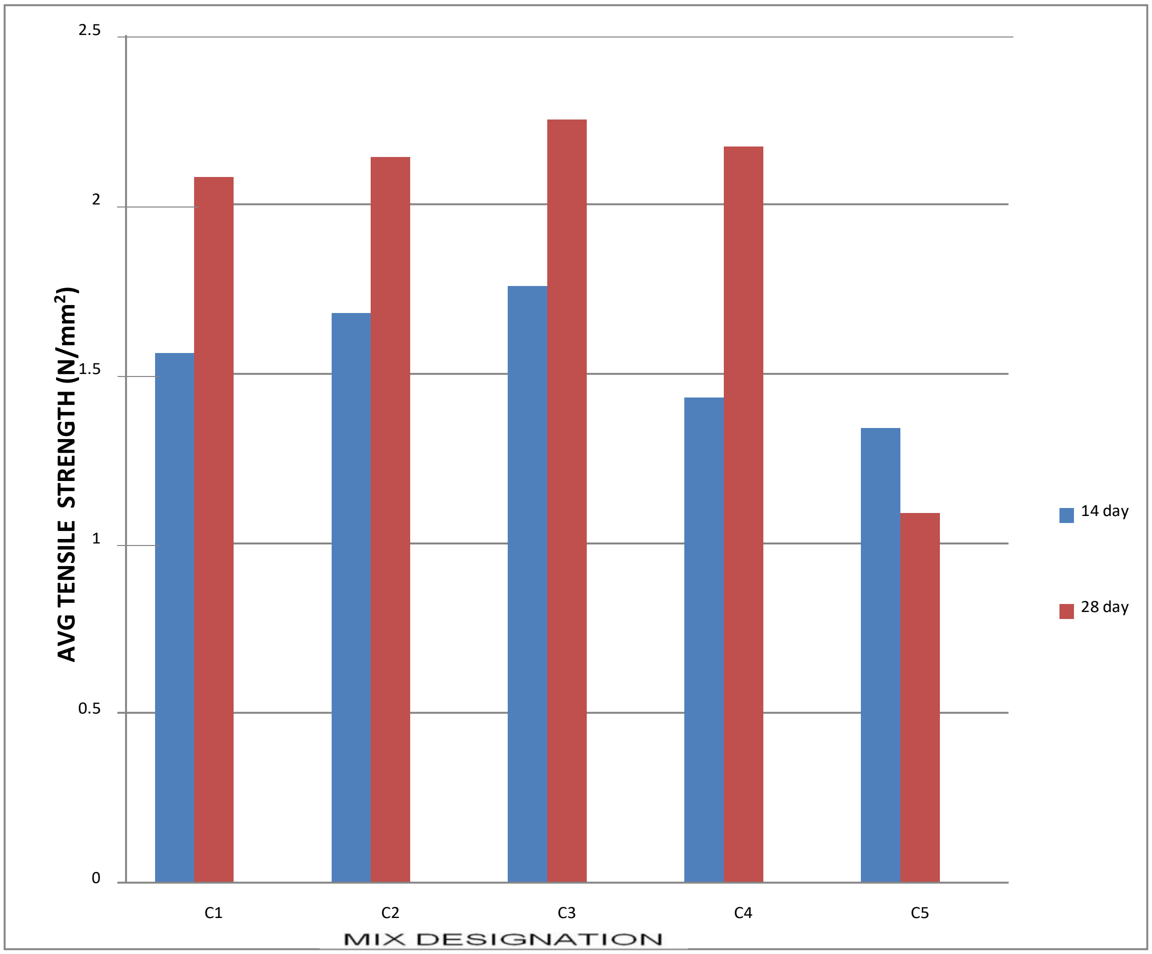

FIG 5.11 TENSILE STRENGTH TEST FOR TYPE-2

5.3 CARBONATION TEST

Carbonation of concrete is associated with the corrosion of steel reinforcement and with shrinkage. However, it also increases both the compressive and tensile strength of concrete, so not all of its effects on concrete are bad. Carbonation is the result of the dissolution of CO_2 in the concrete pore fluid and this reacts with calcium silicate hydrate to form calcite. Aragonite may form in hot conditions. Within a few hours, or a day or

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two at most, the surface of fresh concrete will have reacted with CO_2 from the air. Gradually, the process penetrates deeper into the concrete at a rate proportional to the square root of time. After a year or so it may typically have reached a depth of perhaps 1mm for dense concrete of low permeability made with a low water cement ratio, or upto 5mm or more for more porous and permeable concrete made using a high water cement ratio. All the specimens were not affected by carbonation

FIG 5.10 CARBONATION TEST

CHAPTER 5
CONCLUSION

From the experimental study, the following conclusions were made, mechanical properties which are like compressive strength and tensile strength shows superior performance in concrete while 40% of CWA and

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10% of LSP is replaced in cement when comparing with conventional mix. This indicates that the mix M5 possess good mechanical properties than all other mixes.

The carbonation are well resisted by mixes that contains CWA and LSP other than conventional mix. The mechanical properties is more in conventional mix than other mixes and starts reduce while contains CWA and LSP. The M5 mix possess less loss value indicates that it exhibits good strength properties against compression strength. Hence, overall replacement upto 50% (40% CWA & 10% LSP) is recommended through this first phase of the experiment. Carbonation test showed that all the specimens are free from carbonation attack

In this second phase of this experiment the different proportions of limestone powder replaces the conventional cement in the production of concrete for construction industry. The mechanical properties are determined. The compressive strength of concrete and split tensile strength test using limestone powder are tested in the laboratory. The 28 day compressive 0%, 10%, 20%, 30% and 40% concrete 33.58, 36.62, 35.61, 33.17 and 31.32 N/mm^2 for different mixes. Hence, overall replacement upto 40% (20% CWA & 20% LSP) is recommended through this experimental study.

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