TO STUDY THE DURABILITY CHARACTERISTICS OF HIGH STRENGTH CONCRETE BY REPLACING PART OF CEMENT WITH FLYASH ENRICHED WITH SELECTED MICRO ORGANISMS

CHAPTER 1
INTRODUCTION

1.1 GENERAL

Cement can be described as a material with adhesive and cohesive properties which make it capable of bonding mineral fragments into a compact mass. For constructional purposes cement is restricted to the bonding material which is used with stones, sand, bricks, blocks etc. It is the most important material in construction of structures because it is used at different stages of construction in the form of various forms viz mortar, concrete, cement slurry etc.

With nearly 420 million tonnes of cement production capacity, India is the second largest cement producer in the world and accounts for 6.9 per cent world's cement output. The cement production capacity is estimated to touch 550 million tonnes by financial year 2020. Of the total capacity, 98 per cent lies with the private sector and the rest with the public sector. The top 20 companies account for around 70 per cent of the total production.

A total of 188 large cement plants together account for 97 per cent of the total installed capacity in the country, while 365 small plants make up the rest. Of the total 188 large cement plants in India, 77 are located in the states of Andhra Pradesh, Rajasthan and Tamil Nadu. Cement production in India increased from 230 million tonnes in financial year 2012 to 280 million tonnes in financial year 2017.

Dalmia Cement Ltd has become the first cement company in India to commit itself to 100 per cent renewable power. The company plans to increase its capacity from existing 2.4 to 15-20 million tonnes by 2021 by investing US$ 1.27 billion.

The Government of India is strongly focused on infrastructure development to boost economic growth and is aiming for 100 smart cities. It plans to increase investment in infrastructure to US$ 1 trillion in the 12th Five Year Plan (2012–17). The government also intends to expand the capacity of the railways and the facilities for handling and storage to ease the transportation of cement and reduce transportation costs. These measures would lead to increased construction activity thereby boosting cement demand.

The production of cement releases greenhouse gas emissions both directly and indirectly: the heating of limestone releases CO_2 directly, while the burning of fossil fuels to heat the kiln indirectly results in CO_2 emissions.

The direct emissions of cement occur through a chemical process called calcination. Calcination occurs when limestone, which is made of calcium carbonate, is heated, breaking down into calcium oxide and CO_2.

In this project efforts are being made to reduce the cement content by usingflyash enriched with bacteria . Flyash enriched with bacteria is mixed in concrete that improves the durability, compressive strength, workabilty, mechanical properties.Durability of concrete may be defined as the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties.

The bacteria to be used as self-healing agent in concrete should be suitable for that purpose i.e. they should be able to perform long-term effective crack sealing , preferably during the total construction life time .the principle mechanism of bacterial crack healing is the bacteria themselves act largely as a catalyst, and transform a precursor compound to a suitable filler material. The newly produced compound such as calcium carbonate-based mineral precipitates should than act as a type of bio cement what effectively seals newly formed cracks. Thus for effective self-healing, both bacteria and a bio cement precursor compound should be integrated in the material matrix. However, the presence of the matrix embedded bacteria and precursor compound should not negatively affect other wanted concrete characteristics.

Bacteria that can resist concrete mixture incorporation exist in nature ,and these appear related to a specialized group of alkali-resistant spore-forming bacteria interesting feature of these bacteria is that they are able to form spores ,which are specialized spherical thick walled cells somewhat homogeneous to plant seeds .this spores are viable but dormant cells and can withstand mechanical and chemical stresses and remain in dry state visible for periods over 50 years however, when bacterial spores were directly added to the concrete mixture, their life time appeared to be limited to one-two months. The decrease in life time of the bacterial spores from several decades when in dry state to only a few month when embedded in the concrete mixture may be due to the continuing cement hydration resulting in matrix pore-diameter widths typically much smaller than the 1- m sized bacterial spores.

Another concern is whether direct addition of organic bio-mineral precursor compound to be concrete mixture will not result in unwanted loss to the other concrete properties .In the preceding study it was indeed found that various organic bio-cement precursor compound such as yeast extract, peptone and calcium acetate resulted in dramatic decrease of compressive strength. The only exception appeared to be calcium lactate what actually resulted in 10% increase in compressive strength compare to control specimens. In order to substantially increase the life time and associated functionality of concrete incorporated bacteria, the effect of bacterial spore and simultaneously needed organic bio mineral precursor compound immobilization in porous expanded clay particles was tested in this study.

It was found of the bacterial spores by immobilization inside porous expanded clay particles before addition to the concrete mixture in deed substantially prolonged their life time. Currently running viability experiments show that still after six months concrete incorporation no loss of viability is observed, suggesting that their long term viability as observed in dried state when not embedded in concrete in maintained. In subsequent experiments the expanded clay particles loaded with two component biochemical healing agent were applied as additive to the concrete mixture to test selfhealing potential of bacterial concrete.

1.2OBJECTIVE OF THE STUDY

- To replace cement in concrete with fly without compromising in strength and durability.
- To enrich flyash with bacteria so as to achieve higher percentage of replacement to cement in concrete.
- To ensure the partial replacement of cement with flyash enriched with bacteria is having required strength and durability characteristics.
- To reduce the emission of CO_2 in atmosphere by reducing the requirement of cement.
- To ensure major quantity of fly ash is produce is utilized in a better way.

1.3 SCOPE OF THE PROJECT

- To make mix design for M40 concrete.
- Casting the specimens for durability characteristics and testing the concrete specimens for a period of 180 days.
- Comparing the bacterial concrete with control concrete.
- Tests to be conducted are RCPT, Acid Resistance, Air and Water Permeability, SEM and XRD
- Comparing the cost raw materials, electricity, water,release of carbon dioxde in atomosphere with normal concrete and concrete made with flyash enriched with bacteria.

CHAPTER 2
LITERATURE REVIEW

2.1 GENERAL

The use of bacterially induced calcite precipitation has been in focus from last decade the literature review in briefly presented in the following sections.

2.2 REIVEW OF LITERATURE

Murthy, (2013)studied Bacillus sp.CT-5,isolated from cement ,was used to study compressive strength and water absorption test . The highest compressive strength was obtained with mortar cubes prepared with Bacillus sp. CT-5 that were incubated for 28 days(31MPa) as compared to those with water(23 Mpa) and NBU medium(24 Mpa).There was about 36.15% increase in the compressive strength of mortar specimens at 28 days, prepared with bacterial cells compared to control . The deposition of a layer of calcium carbonate crystal on the surface resulted in a decrease of the permeation properties. As a consequence the ingress of harmful substances may be limited.

Willem De Muynck., et al(2008)studied Bacterial carbonate precipitation improves the durability of cementitious materials,observed the absorption of bacteria and precipitation of carbonate crystals resulted in a weight increase of mortar specimens and lowest weight gain was observed for the treatment with bacteria in absence of calcium source.Mortar cubes treated with bacteria and a calcium source showed significantly less water absorption compared to treated specimens.Decrease in gas permeability due to the biodecomposition treatments resulted in an increased resistance towards carbonation increase causes effects

Tittelboom, et al (2010),studied theUse of bacteria to repair cracks in concrete, ,examined the objective of this present investigation is to study the potential application of bacterial species that is B.sphericus to improve the strength of cement concrete. The compressive strength and split tensile test were carried both on conventional and concrete specimen. It was observed that there was a considerable gain in the yield strength of cement paste. The application of bacteria will improve the strength and durability of cement concrete therefore it appears a promising field in the near future.

NavneetChahal, et al (2011),influence of bacteria on the compressive strength, water absorption and rapid chloride permeability of flyash concrete,concluded *SporoscarcinaPasteurii*in flyash concrete enhanced the compressive strength, reduced the porosity and permeability of flyash concrete.Inclusion of bacteria, chloride ingress capacity of flyash concretes decreased with increase in bacteria concentration.

J.Y.Wang,et al (2009), studiedApplication of hydrogel encapsulated carbonate precipitating bacteria for approaching a realistic self-healing in concrete2014 studied maximum healed crack was about 0.5mm width.Water permeability was decreased by 68% in average. Nonbacterial specimens has maximum healed crack width of (0-0.3mm). Water permeability of nonbacterial specimens was decreased by 15-55% only.

Chung Ho Huang, et al (2013) Mix proportions and mechanical properties of concrete containing very high volume of class F flyash, studied the Compressive and felxural strength of HVFA concrete mixtures demonstrated continuous and significant improvement at late ages of 95 and 365 days.Mixture containing low –LOI flyash exhibited superior mechanical properties as compared to high-LOI flyash.

F. Pacheco-Torgal, et al (2013)evaluated that the deterioration of reinforced concrete structures is a very common problem due to the fact that this material has a high permeability which allows water and other aggressive media to enter, thus leading to corrosion problems. The use of sealers is a common way of contributing to concrete durability. However, the most common ones are based on organic polymers which have some degree of toxicity. The Regulation (EU) 305/2011 related to the Construction Products Regulation emphasizes the need to reduce hazardous substances. Therefore, new low toxicity forms to increase concrete durability are needed. Recent investigations in the field of biotechnology show the potential of bioinspired materials in the development of low toxic solutions. This paper reviews current knowledge on the use of bacteria for concrete with enhanced durability. It covers the use of bacteria in concrete mix and also bio mineralization in concrete surface treatments. Investigation gaps are described. Results from practical applications in which there is exposure to environmental conditions are still needed in order to confirm the importance of this new approach.

RuotingPei, Jun Liu, et al (2013) examined,this research presents the role of bacterial cell walls of Bacillus subtilis as a concrete admixture to improve the mechanical performance of concrete. The bacterial cell walls are known to mediate microbial induced carbonate precipitation, a process in which CaCO3 is formed from Ca2+ ions and dissolved CO2. Consistent with such knowledge, incorporation of bacterial cell walls increased carbonation of Ca(OH)2 and formation of CaCO3 in concrete. Furthermore, the bacterial cell walls significantly increased compressive strengths of concrete by 15% while also decreased porosity at 28 days of curing. Assay for CaCO3 precipitation in vitro indicated that bacterial cell walls, but not dead cells, accelerated carbonation of Ca2+ ions in Ca(OH)2 solution. Since CaCO3formed can fill up the void, decrease the porosity and increase the compressive strength in concrete, bacterial cell walls could act as a promising concrete admixture with benefits in enhancing mechanical performance and improving other carbonation-related properties.

Navneet Chahal., Rafat Siddiqui, et al (2013) Permeation properties of concrete made withflyash and silica fume observed *SporoscarcinaPasteurii*in flyash concrete enhanced the compressive strength,reduced the porosity and permeability of flyash concrete.

Kim Van Tittleboom, et al (2009) studied the use of bacteria to repair cracks in concrete, studied Pure bacteria culture were not able to fill the cracks. Bacteria when protected with silica gel was able to fill the cracks completely.

VarenyamAchal,et al.(2010) In the present study Bacillus sp.CT-5,isolated from cement ,was used to study compressive strength and water absorption test . The highest compressive strength was obtained with mortar cubes prepared with Bacillus sp. CT-5 that were incubated for 28 days(31MPa) as compared to those with water(23 Mpa) and NBU medium(24 Mpa).There was about 36.15% increase in the compressive strength of mortar specimens at 28 days, prepared with bacterial cells compared to control . The deposition of a layer of calcium carbonate crystal on the surface resulted in a decrease of the permeation properties. As a consequence the ingress of harmful substances may be limited.

CHAPTER 3
MATERIALS AND METHODOLOGY

3.1 GENERAL

Fly ashis a coal combustion product composed of fine particles that are driven out of the boiler with the flue gases. Ash that falls in the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash.

Bacteria are used for the reduction of cracks in concrete. As bacterial concrete is called as self-healing concrete, thus the cement is replaced by the flyash enriched with bacteria.

3.2 MATERIALS USED

In this project, following materials are used for study and experiment

- Ordinary Portland Cement (Grade 53)
- Fine aggregate
- Coarse aggregate
- Water
- Flyash
- Bacteria*Bacillus Sphaericus*

3.2.1 Ordinary Portland Cement (Grade 53)

ASTM C150 defines Portland cement as 'hydraulic cement (cement that not only hardens by reacting with water but also forms a water-resistant product) produced by pulverizing clinkers which consist essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulphate as an inter ground addition. The European Standard EN 197-1 uses the following definition.

Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates, (3 $CaO{\cdot}SiO_2$, and 2 $CaO{\cdot}SiO_2$), the remainder consisting of aluminium- and iron-containing clinker phases and other compounds. The ratio of CaO to SiO_2 shall not be less than 2.0. The magnesium oxide content (MgO) shall not exceed 5.0% by mass.

Ordinary Portland cement of 53 grade was used in this study which is shown below in the Fig. 3.1. The cement was tested according to IS: 12269-1987.Different test were carried out on the cement to ensure that it confirms to the requirements of the IS: 12269-1987specifications.

Fig. 3.1 Ordinary Portland Cement

This OPC has various characteristics i.e shown in Table 3.1, which is the specific gravity and the fineness modulus of the cement,that are considered in the physical propertites of cement.

Table 3.1 Physical Properties of Cement

Serial No.	Characteristics	Value
1	Specific gravity	3.14
2	Fineness Modulus	7%

3.2.2 Fine Aggregate

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. As with coarse aggregates these can be from Primary, Secondary or Recycled sources.River sand shown in Fig.3.2 is used as the fine aggregate,whose properties are described below in the Table 3.2 along with the values.

Fig. 3.2 River Sand

Table 3.2 Physical Properties of Fine Aggregate

Serial No.	Characteristics	Value
1	Specific gravity	2.5
2	Water Absorption	1.6%

3.2.3 Coarse Aggregate

Construction aggregate, or simply "aggregate", as shown in the Fig 3.3 below is a broad category of coarse to medium grained particulate material used in construction, The coarse aggregate used in this investigation is 20 mm size is used for this experiment. Specifications for coarse aggregate are as per IS 383:1970. The physical properties have been determined as per IS 2386:1963.Some of the physical properties are described in the Table 3.2.

Fig. 3.3 Coarse Aggregates

Table 3.3 Physical Properties of Coarse Aggregate

Serial No.	Characteristics	Value
1	Specific gravity	2.79
2	Water Absorption	0.5%

3.2.4 Water

The water used in the mix design was potable drinking water, locally available and it's free from organic material sand suspended solids, which might have affected the properties of the fresh and hardened concrete.

The water–cement ratio is the ratio of the weight ofwater to the weight of cement used in a concrete mix. A lower ratio leads to higher strength and durability, but may make the mix difficult to work with and form. Workability can be resolved with the use of plasticizers or super-plasticizers.

3.2.5 Flyash

Class F fly ash is designated in ASTM C 618 and originates from anthracite and bituminous coals. It consists mainly of alumina and silica and has a higher loss on ignition (LOI) than Class C fly ash. Class F fly ash also has a lower calcium content than Class C fly ash.

Class F fly ash can be used to replace cement in concrete upto 20% of the mass of cementitious material.

When used as a portland cement replacement, Class F fly ash offers the following advantages when compared to unmodified portland cement,

- Increased late compressive strengths (after 28 days)
- Increased resistance to alkali silica reaction (ASR)
- Increased resistance to sulfate attack
- Less heat generation during hydration
- Increased pore refinement
- Decreased permeability
- Decreased water demand
- Increased workability
- Decreased cost ($80/ton for portland cement vs. $30/ton for fly ash).

When using Class F fly ash as a portland cement replacement, it is important to know several precautions. The time of set may be slightly delayed, and the early compressive strengths (before 28 days) may be decreased slightly. Also, the fine aggregate fraction of the concrete will need to be modified because fly ash has a lower bulk specific gravity than does portland cement, and therefore occupies a greater volume for an equal mass. If using any organic admixtures such as air entrainment, the amount added must be modified since the carbon (LOI) in the fly ash adsorbs organic compounds. Finally, if the fly ash has a high calcium content, it should not be used in hydraulic applications. When using this or any other alternative cementing material with portland cement, it is necessary to create trial mixtures to ensure proper proportioning for the desired properties.

The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content present as of the coal burned (i.e., anthracite, bituminous, and lignite)

3.2.6 Bacteria

Concrete is very weak in tension and hence all concrete elements are subject to cracks. When crack width is less than 0.2mm strength is not affected but it affects the durability of concrete as moisture and gases to ingress through the cracks. Enhancing the durability of concrete is main concern throughout the world, because retrofitting of cracked concrete structure involves very huge amount A environment friendly solution is preferred i.e biological concrete over other alternatives like epoxy resins which is non-degradable. In previous works Bacillus pasteurii was the only well-known species used to precipitate the calcium carbonate. Bacillus sphaericus was yet another partially characterized species with similar entity, having the capability of precipitating calcium carbonate. Earlier researchers have shown very less implementation of the organism in remediation aspect. B.sphaericus was used for this study. Selection of this strain was based upon earlier work by our research group. This strain showed a high urease activity, a very negative ζ-potential and a continuous formation.

Types Of Bacteria

- Pseudofirmus
- Cohnii
- Filla
- Pasteuri
- Sphaericus

Classification Of Bacteria

- **Classification on the basis of shapes**
  Bacteria are usually classified on the basis of their shapes. Broadly, they can be divided into Rod shaped bacteria, sphere shaped bacteria and spiral shaped bacteria**.**
- **Classification on the basis of Gram stain**
  This classification is based on the results of Gram staining method, in which an agent is used to bind to the cell wall of the bacteria, they are Gram positive and Gram negative.
- **Classification on the basis of Oxygen requirement**
  This classification is based on the requirement of Oxygen for the survival of the bacterium. They are Aerobic and Anaerobic.

IntrumenstUsedTo Culture Bacteria

Autoclave

An autoclave is a pressure chamber used to sterilize equipment and supplies by subjecting them to high pressure saturated steam at 121 °C (249°F) for around 15–20 minutes depending on the size of the load and the contents. It was invented by Charles Chamber land in 1879, although a precursor known as the steam digester was created by Denis Papin in 1679. The name comes from Greek auto-, ultimately meaning self, and Latin clavis meaning key a self-locking device.Other types of autoclave are used in the chemical industry to cure coatings, vulcanize rubber and for hydrothermal synthesis, growing crystals under high temperatures and pressures. Synthetic quartz crystals used in the electronic industry are grown in autoclave.

Laminar air flow cabinets

For many years microbiologists have attempted to devise more efficient techniques for controlling microbial contamination. These efforts have ranged from the use of cotton-plugged tubes to large germ-free isolators used by gnotobiologists. Experience has shown that considerable care, time, and money are required to prevent contamination of animals, culture media, antigens, antisera, and other materials which must be maintained or handled in a sterile condition. Laminar or minimal-turbulence airflow systems have been used by the aerospace industry to control particulate contamination such as dust or lint which could affect the reliability of precision parts. In general, the units consist of a bank of ultrahigh-efficiency (HEPA) filters enclosed in a cabinet or hood. Laminar flow cabinets have been used extensively in our laboratory to provide an environment free from microorganisms, with excellent and consistent results.

Orbital shaker

A shaker is a device used in chemistry and biology laboratories to stir liquids. A typical shaker has a table board that oscillates horizontally, powered by an electric motor. The liquids to be stirred are held in beakers, jars, or Erlenmeyer flasks that are placed over the table or, sometimes, in test tubes or vials that are nested into holes in the plate. Orbital shakers also exist, that shake the vessel in a circular fashion.

Shakers have largely been replaced by magnetic stirrers for many purposes, but are still favoured for some situations, such as those involving large volumes

Incubator

In biology, an incubator is a device used to grow and maintain microbiological cultures or cell cultures. The incubator maintains optimal temperature, humidity and other conditions such as the carbon dioxide (CO2) and oxygen content of the atmosphere inside. Incubators are essential for a lot of experimental work in cell biology, microbiology and molecular biology and are used to culture both bacterial as well as eukaryotic cells. This often results in higher hatch rates due to the ability to control both temperature and humidity. Various brands of incubators are commercially available to breeders.

The simplest incubators are insulated boxes with an adjustable heater, typically going up to 60 to 65 °C (140 to 150 °F), though some can go slightly higher (generally to no more than 100 °C). The most commonly used temperature both for bacteria such as the frequently used E. coli as well as for mammalian cells is approximately 37 °C,as these organisms grow well under such conditions. For other organisms used in biological experiments, such as the budding yeast Saccharomyces cerevisiae, a growth temperature of 30 °C is optimal.

Petri plates

A Petri dish (sometimes spelled "Petrie dish" and alternatively known as a Petri plate or cell-culture dish), named after the German bacteriologist Julius Richard Petri, is a shallow cylindrical glass or plastic lidded dish that biologists use to culture cells – such as bacteria or small mosses.

Modern Petri dishes usually feature rings and/or slots on their lids and bases so that when stacked, they are less prone to sliding off one another. Multiple dishes can also be incorporated into one plastic container to create a "multi-well plate". While glass Petri dishes may be reused after sterilization (via an autoclave or one hour's dry-heating in a hot-air oven at 160 °C, for example), plastic Petri dishes are often disposed of after experiments where cultures might contaminate each other.

3.3 METHODOLOGY FOR PROJECT

Fig. 3.4 Flow chart of methodology

3.4 WORKABILITYTEST

3.4.1 Slump Cone Test

The test is done for the determination of the consistency and workability of fresh concrete. The apparatus consists of a slump cone and a base made of galvanized steel.

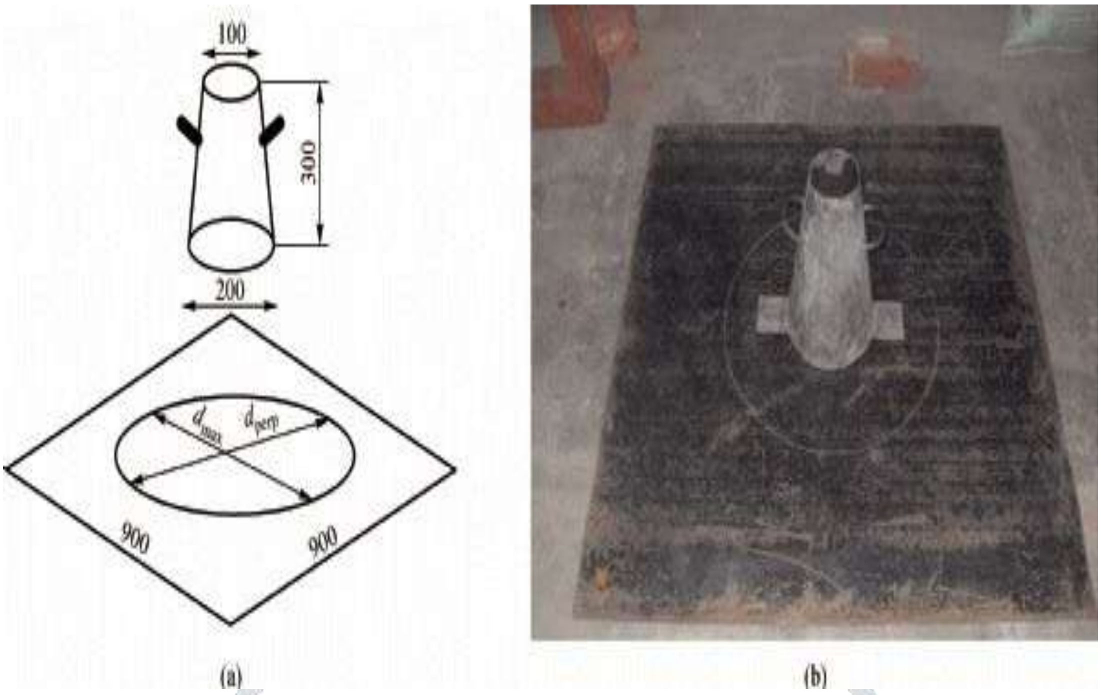

Fig. 3.5 Slump Cone Test

The above Fig. 3.5 shows the slump cone used for the test. The fresh mortar after mixing is poured in 3 stages after 25 blows with tamping rod for each stage. The surface is levelled with a steel towel. The slump cone is removed off vertically and the mortar is found collapsed and the slump is recorded.

3.4.2. Compaction Factor Test

The test depends on IS 1199 – 1959. The contraption utilized is Compaction Factor Apparatus which is shown in Fig. 3.6. The specimen of cement is set in the upper container up to the overflow. The trap-entryway is opened so that the solid falls into the lower container. The trap-entryway of the lower container is opened and the solid is permitted to fall into the chamber. The abundance concrete staying over the top level of the chamber is then cut off with the assistance of plane edges. The solid in the chamber is weighed. This is known as weight of somewhat compacted concrete. The chamber is loaded with a new specimen of cement and vibrated to acquire full compaction. The solid in the chamber is weighed once more. This weight is known as the heaviness of completely compacted concrete.

Compacting factor = (Weight of partially compacted concrete)/ (Weight of fully compacted concrete)

Fig.3.6Compaction Factor Apparatus

3.4 MIX DESIGN

Concrete mix design is economically proportioning of concrete ingredients for better strength and durability based on construction site. While the nominal concrete mix may have higher amount of cement, when it is designed mix, the cement requirement may be low for the same grade of concrete for a given site. The proportions resulting from concrete mix design are tested for their strength with the help of compressive strength test on concrete cubes and cylinders.The concrete mix design proves to provide better quality economically.

3.4.1 Advantages Of Concrete Mix Designs

1. Good Quality Concrete

As per requirements, this means the concrete will have required strength, workability, impermeability, durability, density and homogeneity.

2. Nominal Mix Concrete

It may suggest more cement than other materials, and concrete mix designs gives the accurate quantity of cement consumption. Thus it is an economical solution for large projects.It is possible to save up to 15% of cement for M20 grade of concrete with the help of concrete mix design. In fact higher the grade of concrete more are the savings. Lower cement content also results in lower heat of hydration and hence reduces shrinkage cracks.

3. Best Use Of Available Materials

The nominal mix of concrete does not consider the quality of local construction materials. The concrete mix design is based on the quality of available materials locally. Thus it is also an economical solution to reduce the transportation cost of materials from long distance.

4. Desired Concrete Properties

The designed mix concrete will have desired concrete properties based on project or construction requirements. Requirements such as durability, strength, setting times, workability etc. can be controlled with the type of construction with concrete mix design.Other requirements such as early de-shuttering, pumpability, flexural strength, lightweight concrete can also be controlled.

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Parameters for mix design M40

Grade of concrete = M40
Type of cement = O.P.C-53 grade
Brand of cement = Chettinad Ordinary Portland Cement (53 grade)
Maximum size of aggregate = 20mm
Sand grading zone II of IS 383-1970
Specific gravity of cement = 3.14
Specific gravity of coarse aggregate = 2.79
Specific gravity of fine aggregate = 2.5
Quality control is good

Target Mean Strength

= fck+1.65 X S
= 40 + (5 X 1.65)
= 48.25 Mpa

Selection of water cement ratio

From the table 5 of IS 456, max water content ratio = 0.45
Based on experience, adopt water cement ratio as = 0.40
0.40 < 0.45

Calculation of water

From table 2, max water content for 20mm aggregate = 186 litre
Estimated water content for 75mm slump = 186 + (3/100)186
= 191.6 litres

Calculation of cement content

Water cement ratio = 0.40
Cement content = 191.6/0.40 = 479kg/m^3
From table 5 IS 456 Minimum cement content = 320kg/m^3
479kg/m^3> 320kg/m^3

Proportions of volume of coarse aggregate and fine aggregates

For water cement ratio 0.50 = 0.62
0.40 = 0.02
Total = 0.64
Volumeof coarse aggregate = 0.64
Volume of fine aggregate = 1- 0.64 = 0.36

Mix calculations

Volume of concrete = 1m^3
Volume of cement = (Mass of cement/Sp. Gravity of cement)X (1/1000)
= (479/3.14)X(1/1000)
= 0.152m^3
Volume of water = (Mass of water/Sp. Gravity of water)X(1/1000)
= (191.6/1)X(1/1000)
= 0.191m^3

Volume of all in aggregates = [1-(1.152+0.191)]
= 0.657m^3
Mass of coarse aggregates = Vol. of all in aggregates X Vol. of C.A X Sp. Gravity of C.A X 1000
= 0.657 X 0.64 X 2.7 X 1000
= 1135.2 kg
Mass of fine aggregates = Vol. of all in aggregates X Vol. of F.A X Sp. Gravity of F.A X 1000
= 0.657 X 0.36 X 2.5 X 1000
= 591.3 kg

Material required for 1m^3

Cement = 479 kg
Water = 191.60 kg
Fine aggregates = 591.3 kg
Coarse aggregates = 1135.2 kg

Mix ratio of concrete

Cement: Fine Aggregate: Coarse Aggregate: Water
1 : 1.23 : 2.36 : 0.4

CHAPTER 4
RESULTS AND OBSERVATIONS

4.1 GENERAL

In this chapter we discuss about the results of conventional concrete and bacterial concrete .testing procedure are explained and result are tabulated. Compressive strength, RCPT ,Impact test , Split Test , Permeability Test , Acid Resistance Test were conducted to find the durability characteristics of concrete made with fly ash enriched with bacteria .

4.2 COMPRESSIVE STRENGTH TEST

4.2.1 Test procedure for compressive strength

After curing the specimen, the specimens are taken out removed of surface dust and tested .Apply a compressive axial load to a cube specimen by macine shown if Fig. 4.1 in at a prescribed rate until failure occur .Calculate and report the compressive strength.
Compressive strength = Maximum load / cross section area of specimen

Fig. 4.1 Compression Testing Machine

4.2.2 Testing on specimen and result

The methods adopted to finding the compressive strength of concrete are as per IS 456:2000. The results of compressive strength of concrete cube of M40 design of specimens with different percentages of flyash and the value is tabulated in Table 4.1 and 4.2 for 28 days.

Table 4.1 Compressive Strength Of Cubes

SPECIMEN	COMPRESSIVE STRENGTH N/mm^2
CF25	33.76
CF30	39.46
CF35	35.66
CF40	38.83

The graph below in Fig. 4.2 shows the compressive strength of cubes with different percentage of flyash used in concrete.

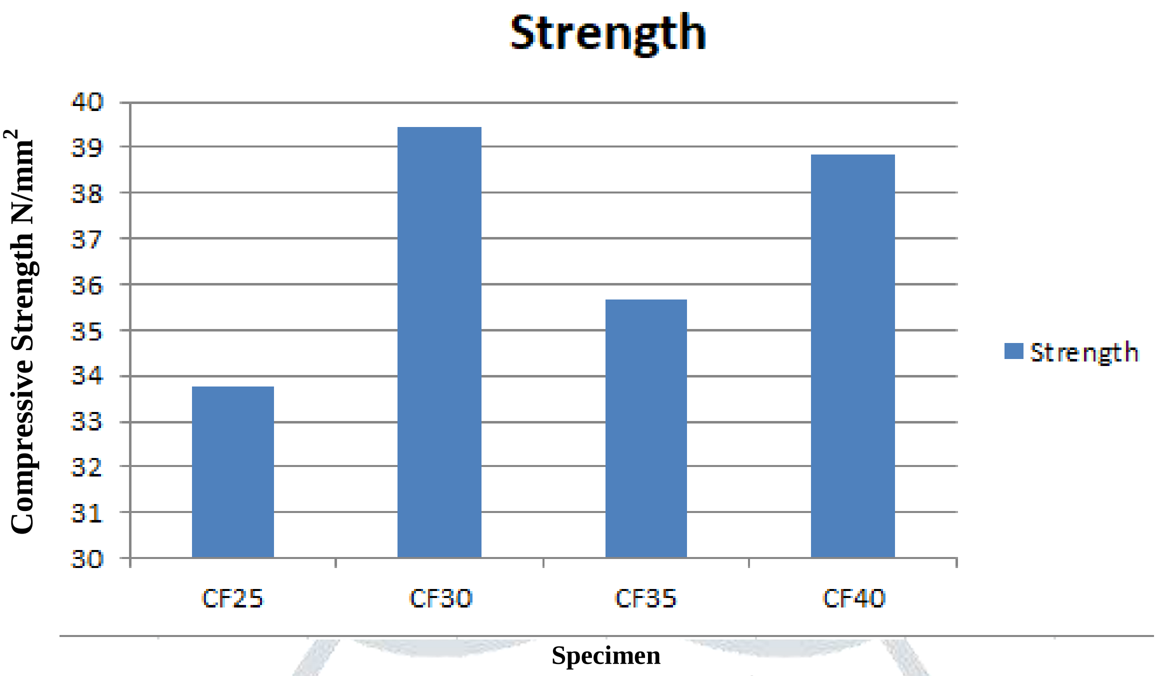

Fig .4.2 Compressive Strength of Cubes

These different % of flyash added is just to determine which of the composition has the maximum compressive strength, sofrom the above graph we can predict that the CF30 has the maximum compressive strength.

Table 4.2Flexural Strength Of Beams

SPECIMEN	FLEXURAL STRENGTH N/mm^2
CF25	3.2
CF30	4
CF35	4.8
CF40	4.4

The graph below shows the flexural strength of beams with different percentage of flyash used in concrete.Flexural strength is expressed as Modulus of Rupture in MPa and was determined by standard methods ASTM C 78 (third point loading). The experimental setup is as shown in the Fig 4.3. The load, P from the Universal Testing Machine (UTM) is applies to a uniform I section made of cast iron having 2 loading points underneath.

Fig. 4.3 Flexural Test On Beam

Flexural strength of beams as shown in Fig.. 4.4got increased in CF35 and then it is getting reduced as the amount of flyash is added more. As the aim of this research is to replace higher percentage of cement from concrete, the specimen with more % of flyash with bacterial concrete will be added and then all the test will be done and compared to get the best composition with better results.

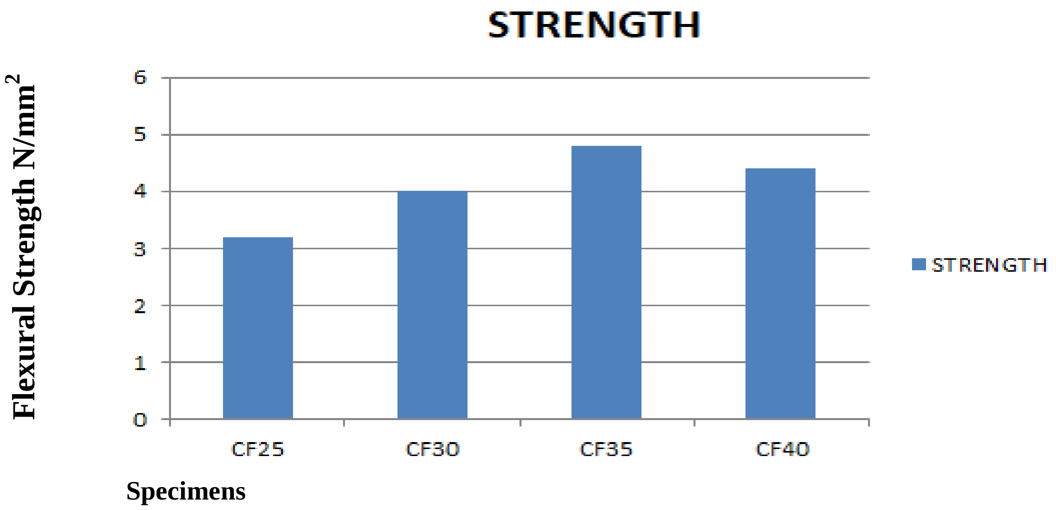

Fig 4.4 Flexural Strength of Beams

Unlike a compression test or tensile test, a flexure test does not measure fundamental material properties. When a specimen is placed under flexural loading all three fundamental stresses are present: tensile, compressive and shear and so the flexural properties of a specimen are the result of the combined effect of all three stresses as well as (though to a lesser extent) the geometry of the specimen and the rate the load is applied.

The most common purpose of a flexure test is to measure flexural strength and flexural modulus. Flexural strength is defined as the maximum stress at the outermost fiber on either the compression or tension side of the specimen. Flexural modulus is calculated from the slope of the stress vs. strain deflection curve. These two values can be used to evaluate the sample materials ability to withstand flexure or bending forces.

CHAPTER 5
PRELIMINARY CONCLUSIONS

- Culture of Bacillus Sphaericus .
- Enhancing the fly ash with Bacillus Sphaericus .
- Casting of specimenCubes, cylinders, beams with controlled concrete, concrete with cement and fly ash, Bacterial Concrete.
- Testing of specimen for RCPT, Air and Water Permeability, Acid Resistance, XRD and SEM
- Result analysis
- Graphs will be plotted using test results and conclusions are to be made based on test results.

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