

STUDY ON PERFORMANCE OF CONCRETE FOR PARTIAL REPLACEMENT OF COARSE AGGREGATE USING E WASTE

Submitted in partial fulfillment of the requirements for the award
of Bachelors of Engineering degree in
Civil Engineering

by

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(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **BADUGU SHASHIDHAR (37200012) AND YADARI.CHARAN RAM (37200077)** who is carried out the Project entitled **"STUDY ON PERFORMANCE OF CONCRETE FOR PARTIAL REPLACEMENT OF COARSE AGGREGATE USING E WASTE"** under my supervision from October 2020 to April 2021.

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DECLARATION

I **BADUGU SHASHIDHAR (37200012) AND YADARI.CHARAN RAM (37200077)** hereby declare that the Project Report entitled **“STUDY ON PERFORMANCE OF CONCRETE FOR PARTIAL REPLACEMENT OF COARSE AGGREGATE USING E WASTE”** done by me under the guidance of **Dr. R. PADMAPRIYA** at Sathyabama Institute Of Science And Technology is submitted in partial fulfilment of the requirements for the award of Bachelor Of Engineering degree in Civil Engineering.

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ABSTRACT

Concrete is the most important engineering material and the addition or replacement of some of the materials that may be more feasible to change the philosophy of the concrete. This paper reports the study of concrete using partial replacement of Coarse aggregate by E waste. In this project work, M30 grade of concrete was taken for concrete mix design. The properties and characteristics of materials for cement, fine aggregate, coarse aggregate and other supplementary materials was studied for concrete mix design with reference to Indian standard codes as per specification. The compressive strength, split tensile strength and flexural test of concrete was studied for various replacements of Coarse aggregate that are 0%, 10%, 15% and 20%. At 15% partial replacement of Coarse aggregate with E waste, the concrete gains higher compressive strength at 7 and 28 days. As the Integral part of this project, the maximum optimum content of the E-Waste substituted concrete is occurred at 15% partial replacement of Coarse aggregate respectively.

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CHAPTER - 1

INTRODUCTION

1.1 GENERAL:

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time. When aggregate is mixed with dry Portland cement and water, the mixture forms a fluid slurry that is easily poured and moulded into shape. Standard ready-mix concrete is the most common form of concrete. It is prepared for delivery at a concrete plant instead of mixed on the construction site, which guarantees the quality of the concrete.

1.1.1 Waste in Concrete:

In the last decades, due to the modern lifestyle, the progresses in industry and technology had led to an important increase in the amount and type of wastes. The problem of waste accumulation every year is all over the world. These industrial and agricultural wastes are by-products, slag, rice husk ash, fly ash, cement dust, brick dust, sludge, glass, tires, etc. The wastes represent a major problem for the environment because the air pollution (the dust and very fine particles which spread in the atmosphere) and leaching toxic chemicals (arsenic, beryllium, boron, cadmium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, hydrocarbon compounds, etc.) when are dumped in landfills, quarries, rivers or oceans. The capitalization of waste is difficult because of their variety, as well as their unknown properties over time. Lately, the environmental sustainability became an important problem from the point of view of natural resources and that of wastes. The construction and the building materials sectors are involved in both processes: building industry is the largest user of natural materials and in addition a large amount of wastes results from the demolition of constructions.

The building material industry is a domain of interest for using the wastes and researchers have tried to produce new construction materials incorporating wastes.

The new generation of building materials is developing on other theories in concordance with the sustainability of environment.

Concrete is obtained from natural aggregates, cement and water, compounds which make it a cheap material and easy to produce anywhere. Usually, ordinary concrete contains about 12% cement, 8% water and 80% aggregates by mass. Aggregates and water are from natural resources, only cement must be produced in fabrics, processes which are polluted the environment (for producing 1 m³ of concrete a quantity of 480 kg of CO₂ is liberated in the atmosphere). For reducing the aggregate and cement consumption, the replacing materials obtained from wastes were studied.

Because the cement industry is responsible for 5-7% of worldwide emission of CO₂, (which means 1.6 billion tons of carbon dioxide into the atmosphere), in preparing concrete, the cement dosage can be reduced by using mineral additions, strategy that also can contribute to environment protection by preserving the energy and consume the huge quantities of wastes.

Near cement concrete other building materials are obtained by using wastes, such as: high strength concrete, which has in the mix different additions (silica fume, fly ash, etc.), asphalt concrete, bricks, pavements, roof tiles, prefabricated units, claddings, etc. Some building materials are totally obtained from wastes, such as "green" materials. The new concept of green buildings offers more energy-and resource efficiency. This concept means the greening of building industry by using only green materials. The technologies of obtaining green materials are available, but their use in construction industry is limited.

The building material and construction industry is one of the principal users of wastes in the processes for obtaining materials or products, for constructing bridges or highways, in soil stabilization, in hydraulic construction, etc. From environmental considerations an extensive waste utilization in construction is recommended, although particular wastes may be too risky to use.

Using waste material in concrete production is an appropriate method for achieving two goals: eliminating waste and adding positive properties in concrete. Since the green concrete industry is expanding, it is necessary to evaluate concrete that contains waste from all aspects in order to determine its capability.

1.1.2. Different types of Waste used in Concrete:

The **5 R's**: Refuse, Reduce, Reuse, Repurpose, Recycle.

1. Liquid or Solid Household Waste. This can be called 'municipal waste' or 'black bag waste' and is the type of general household rubbish we all have. ...
2. Hazardous Waste. ...
3. Medical/Clinical Waste. ...
4. Electrical Waste (E-Waste) ...
5. Recyclable Waste. ...
6. Construction & Demolition Debris. ...
7. Green Waste.

1.2 E-WASTE IN CONCRETE:

Concrete is the first choice for the construction many countries today. This has increased the fast vanishing of natural resources. On the other hand, new electrical and electronic products have become an integral part of daily lives providing us with more comfort, security, easy, and faster acquisition. Due to technological growth, there is a high rate of obsolescence in the electronic equipment which leads to one of the fastest growing waste streams in the world. Although principally Favourable from a life cycle environment impact perspective, recycling of plastic from waste electrical and electronic equipment (WEEE) is not uncontested because of the potential dissipation of hazardous substance into new products. This study attempts to give a contribution to the effective use of domestic wastes (plastic in electronic waste) in concrete in order to prevent the environmental strains caused by them, also to limit the consumption of high number of natural resources.

E- waste seems to have a more pronounced effect on the flexural strength than the split tensile strength. The use of E-waste in concrete is possible to improve its mechanical properties and can be one of the economical ways for their disposal in environment friendly manner.

1.3 UTILIZATION OF E WASTE IN INDIA :

Almost all e-wastes contain some form of recyclable material, including plastic, glass, and metals; however, due to improper disposal methods and techniques these materials cannot be retrieved for other purposes. If e-waste is dismantled and processed in a crude manner, its toxic constituents can wreak havoc on the human body. Processes such as dismantling components, wet chemical processing, and incineration are used to dispose the waste and result in direct exposure and inhalation of harmful chemicals. Safety equipment such as gloves and face masks are not widely used, and workers often lack the knowledge and experience required to carry out their jobs properly. In addition to this, manual extraction of toxic metals leads to entering of dangerous material in the

Blood stream of the individual doing so. The health hazards range from kidney and liver damage to neurological disorders. Recycling of e-waste scrap is polluting the water, soil, and the air. Burning to retrieve metal from wires and cables has led to the emission of brominated and chlorinated dioxins as well as carcinogens which pollute the air and, thereby, cause cancer in humans and animals. Toxic chemicals that have no economic value are simply dumped during the recycling process. These toxic chemicals leach into underground aquifer thereby degrading the local groundwater quality and rendering the water unfit for human consumption as well as agricultural purposes. When e-waste is dumped in landfills, the lead, mercury, cadmium, arsenic, and

PCBs make the soil toxic and unfit for agricultural purposes. Very recent studies on recycling of e-waste has pointed towards increasing concentrations of PCBs, dioxins and furans, plasticizers, bisphenol-A (BPA), polycyclic aromatic hydrocarbons (PAH), and heavy metals in the surface soil of the four metro cities of India, that is, New Delhi, Kolkata, Mumbai, and Chennai where e-waste is being processed by the informal sectors.

1.4 Composition of E waste:

TABLE:1.4.1. Average Composition of E Waste

ELEMENT	PERCENTAGE (%)
PLASTICS	30.23%
REFRACTORY OXDIES	30.23%
COPPER(Cu)	20.12%
IRON(Fe)	8.11%
TIN(Sn)	4%
NICKEL(Ni)	2%
LEAD(Pb)	2%
ALUMINUM(Al)	2%
ZINC(Zn)	1%
SILVER(Ag)	0.2%
GOLD(Au)	0.1%
PALLADIUM(Pd)	0.01%

1.5. Hazardousness of E waste:

Research concerning the use of Electronic waste to augment the properties of concrete has been going on for recent years. Waste Electronic and Electrical Equipment (WEEE) is diverse and complex in terms of materials and components as well as the manufacturing process. Non recycling Waste materials are posing serious pollution problems to the human and the environment. So, new effective waste management options need to be considered. Efforts have been made in the concrete industry to use non-biodegradable components of E-waste as a partial replacement of the coarse or fine aggregates. In the recent decades, the efforts have been made to use electronic waste from various sources in concrete for the replacement of cement, fine and coarse aggregate. The use of these materials in concrete comes from the environmental constraints in the safe disposal of these products. Use of E-waste materials not only helps in getting them utilized in cement, concrete and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects.

1.6. Benefits of E waste in concrete:

The use of E-waste in concrete industry is measured as the most viable application for soothing the disposal of large amount of E-waste materials. E-waste is one of the fastest growing waste streams in the world. The production rate of E-waste in developed countries rises from 1% to 2%. Total municipal solid waste in developing countries ranges from 0.01% to 1%. Suchlike, the increasing of E-waste is an emerging issue as well as it carries serious pollution problems to the human life. So, considering the environment options it needs to be measured especially on recycling concepts. E-Waste describes loosely rejected surplus, outdated, broken, electrical or electronic devices. The major cause of fast growing surplus of electronic waste around the globe is that Rapid technology change and low initial cost. For that reasons, several tones of E-waste need to be disposed per year. E-

waste can create serious human health problem due to presence of numerous types of substances and environment problems if not handled properly. Owing to the shortage of coarse aggregate for the groundwork of concrete, partial replacement of E-waste with coarse was struggled in many research. This study reviewed the potential use of electronic waste in concrete as well as its environmental impact.

CHAPTER – 2

LITERATURE REVIEWS

2.1. GENERAL:

A literature review is a scholarly paper, which includes the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. In such a case, the review usually precedes the methodology and results sections of the work. The literature collected from various sources collected for the successful completion of the project is given below.

2.2 REVIEW OF JOURNAL PAPERS:

Prasanna et al (2014) Examined on replacing the coarse aggregate with e-waste by 5%, 10%, 15% and 20% in one batch and they also made another batch with using same percentage of E-waste and also adding 10% of fly ash. The concrete strength is found out to be optimum when 15% of coarse aggregate is replaced with e-waste.

Amiya Akram et al (2015) Examined shredded e-plastic and fly ash and partially replace the coarse aggregate with it they make two batches one with e-plastic alone and one with e-plastic and fly ash. In one batch they replace coarse aggregate with e-plastic by 5%,10% and 15%. They check the compressive strength and the flexure strength of the concrete. They found out that the compressive strength will increase at 10% but decrease after that and same for flexure strength the concrete became more ductile when E-plastic is added to it as in flexure strength test the specimen fails without any sound as it became less brittle.

Balasubramanian et al (2016) investigated to evaluate the compressive strength, flexure strength and split tensile strength when coarse aggregate is partially replaced with e-waste. Concrete mixtures were made by replacing the coarse aggregate with e-waste by 5%, 10%, 15%, 20%, 25% and 30% and then comparing the results with standard concrete mixture in their research they have found out that the compressive strength, flexure strength and split tensile strength have increased when coarse

aggregate is replaced with e-waste by 15% and after that the strength starts reducing. They have found out that the concrete became more light weight and it can bear the seismic loads more effectively as compared to conventional concrete. This research work is conducted in the M25 grade concrete and the percentage of replacement of aggregate varies from 0%, 5%, 7.5% and 12%. We have casted concrete cubes and check the compressive strength of concrete. We also compared the results with the strength of conventional concrete cubes. In our research we have found increment in the compressive strength and workability, both the characteristics of concrete after adding e-waste till the 7.5%, thereafter it starts decreasing. This research shows that if we replace the coarse aggregate with 7.5% of e waste, the compressive strength is increased by 35% So by using e-waste as raw material it will solve the problem of e-waste disposal, less amount of conventional aggregate is required and it will also increase the strength of concrete.

Shini Shanmugam et al.(2010) Researched on Wastelands printed circuit boards (pcbs) consists of almost 30% metals and 70% nonmetals. It comprises huge amount of silica in its polished form. Hereafter it forms the perfect auxiliary material of fine aggregate in concrete, it can also reduce the dead weight of the structure. The pcbs are sluggish in nature which makes it as a compulsory component in all the electronic devices. It gives intent to its inert nature, this are not participate to any further reaction with the concrete matrix. These are gives less deviation in strength parameters.

Yanhong Zheng et al.(2009) Examined the Flexural strength and flexural modulus of the composites can be successfully amended by filling non-metals second hand from waste printed circuit boards (PCBs) into polypropylene (PP). By using scanning electron microscopy (SEM), the influence of non-metals on fracture behaviour of PP composites is evaluated by in situ flexural test

M. Iqbal Malik et al. (2013) Investigated on the Application of E-Waste glass by Partial Replacement of sand in Concrete. They also tried to find on the problems of environmental concern and economic concern. They used the percentage of waste powder as 10%, 20%, 30% and 40% by weight for M 25 mix as the replacement of fine aggregates. Compressive strength, durability (water absorption), splitting tensile strength, and density at 28 days of age have been tested over concrete specimen

and obtained results associated with those of normal concrete. Concluded that e-waste glass can be used as the replacement of fine aggregate up to 30% by weight for particle size of range 0-1.18mm.

Chen et al.(2005) Inspected with the utilize of E-glass waste in concrete as fine aggregate replacement. The result are significantly decreases weight and strength loss, mostly for the specimens with lower water/cement ratio when increase in E-glass content. The surface faults of tested specimens are also show a qualitative sign of sulphate attack. The confident outcome of E-glass on sulphate resistance of concrete is very bulbous.

R. lakshmi,.(2010). Examined that waste electronic or E-waste and electrical equipment is an emerging issue posturing serious pollution problems to the human as well as the environment. New active waste management options need to be considered especially on recycling concepts. It has been found that almost 70% of the heavy metals (mercury and cadmium) come from electronic waste and most of the part of it come from landfill of e-waste. An effort has been made to detail a systematic study of compressive strength of concrete with various proportions of E-waste as coarse aggregate in concrete. From the compressive strength tests, this research confirmed that no main changes in compressive strength of concrete which was found in test with the presence of E- plastic as percentage replacement to coarse aggregate. However when 20% of the coarse aggregate is replaced by electronic-plastic, the compressive strength was reduced by 23.6% compared the compressive strength was reduced by 23.6% compared to control mix. In general strength gain of E-plastic concrete is satisfactory and it has been concluded that 12% E-plastic particles can be incorporated as aggregate replacement without any long term detrimental effects .

S.P. Kale,.(2013). Investigated that Concrete is the greatest widely used construction materials all over the world in view of its compressive strength, High mould ability, structural stability and economic considerations. It decreases the cost, effort of transportation and production as well as demand of new resources. The main object of this project is to determine the compressive strength, tensile strength, flexural strength and bond strength by using fresh concrete material, waste concrete material and E-waste material various mixes were prepared for carrying out the research by

varying the preparations of cement, sand and aggregate designed for characteristic strength of M25. The compressive strength was tested in laboratory after 7 and 28 days. The main aim of this study recommended the recycling of waste concrete and sand material in the production of new concrete.

Lakshmi and Nagan (2011) studied the utilization of E-waste particles as coarse aggregates in concrete with a percentage replacement ranging from 0 % to 30% on the strength criteria of M20 concrete. The compressive strength, tensile strength and flexural strength of concrete with and without E-waste as aggregates was observed which exhibits a good strength gain. Arora and Dave (2013) used E-waste and plastic waste in concrete. The grinded E-waste and plastic waste were replaced by 0%, 2%, and 4% of the fine aggregates. The compressive strength and flexural strength were tested and compared with control concrete. They found that compressive strength of concrete has increased by 5% and reduce the cost of concrete production by 7% at optimum percentage of grinded waste.

Manjunath (2015) studied the utilization of E-waste particle as a fine and coarse aggregate in concrete. An experimental study was made on the use of E-waste particles as fine and coarse aggregates in concrete with a percentage replacement ranging from 0% to 30% (in an interval of 10%) for M20 grade of concrete. The compressive strength, tensile strength and flexural strength of concrete with E- waste gives better strength as compared to concrete without E-waste.

Siddhique et al. (2015) Studied on the use of E-waste as a substitute/replacement of aggregate in concrete. The effect of E-waste on the properties of concrete such as compressive strength, split tensile strength and durability were presented.

Dawande et al. (2016) studied the use of recycled E-waste material as a replacement of coarse aggregates in concrete. It was found that the use of E-waste aggregates results in the formation of light weight concrete. In this study coarse aggregate was partially replaced by E-waste material up-to 25% along with fly ash partially replacing cement in M40 grade of concrete and properties like workability, compressive strength and flexural strength were evaluated.

Donadkar et al. (2016) presented an overview on possible use of E-waste like printed circuit board in concrete. It showed that E-waste can be a substitute for fine aggregate. More use of this tends to decrease the use of natural aggregates in concrete and it is of prime importance that substitute of fine aggregates can be explored.

Suchithra et al. (2015) studied the use of E-waste product as an alternative material for coarse aggregate for M20 grade mix. The coarse aggregate replaced in the range of 0%, 5%, 10%, 15%, and 20%. The mechanical and durability of the concrete mix was compared with control concrete mix. The test results showed that a satisfactory rise in compressive strength of E-waste concrete compared to conventional concrete and can be used in concrete effectively.

Devi et al. (2017) carried out the utilization of E-waste materials from discarded old computers, TVs, refrigerators, radios. The E-waste were used as a partial replacement of the coarse aggregates, ranging from 0 % to 20%, for M20 concrete. They found that E-waste used as coarse aggregates exhibits strength gain.

Raut et al. (2018) studied the mechanical property of concrete like workability, compressive strength and flexural strength for M20 grade mix with 0.5 w/c ratio. They replaced coarse aggregate by 0 to 15% with regular interval of 5% with E- plastic aggregate.

Vivek S. Damal et al.(2015) have investigated about the use of fine aggregate in concrete with a percentage replacement of E Waste Particles ranging from 0% to 21.5%. i.e.(7.5%, 15%, 21.5%) on the strength criteria of M30 concrete. Their main objective is to reduce the accumulation of used and discarded electronic and electrical equipments and transfer waste into socially and industrially beneficial raw materials using simple, low cost and environmental friendly technology. The E-Waste used for their investigation was collected from Computers, TV Cabinets, Refrigerator, Mobile Phones and Washing Machine etc. They have also casted cubes and tested for Compressive Strength. The Compressive Strength of concrete is found to be optimum when fine aggregate is replaced by 7.5% with Electronic Waste. Beyond it the Compressive Strength of concrete goes on decreasing. The Compressive Strength of concrete get decreased gradually when fine aggregate are replaced beyond 15% with Electronic Waste.

Pravin A.Manatkar et al.(2018) have analysed compressive strength of M20 and M25 grade of concrete by replacing coarse aggregate by adding non-metallic E-Waste in 0% to 20% (0%, 5%, 10%, 15%, 20%). They have observed that compressive strength decreases with increasing E-Waste percentage for both grades. Upto 5%, it is nearly same to normal concrete but after 15%, it reduces maximally. Upto 56% replacement of E-Waste is suitable to use up to (G+2) building construction, road construction. Up to 10% is not considerably useful for construction field because of strength decrease. E-Waste concrete block having flexibility it directly not fails during test. Firstly it compresses up to 1cm then break. It is very important at the time of earthquake it provides some time for clearance in structure. Thus, they have concluded that the E-Waste can dispose in concrete as a coarse aggregate.

Pejman Hadi et al.(2015) have reviewed the recent trends and developments in PCB waste recycling techniques, including both physical and chemical recycling. The 70% by weight non-metallic fraction has been traditionally discarded to landfill or used as very low cost fillers in the construction industry. The present review indicates that while substantial research needs to be done to pave the way forward for successful, environmentally friendly and economic waste PCB recycling, significant progress has been made both in the methods for separating PCB waste into its metallic and non-metallic fractions but also in identifying more economically attractive uses for the 70% by weight non-metallic component of E-Waste. They have concluded that the physical recycling techniques effectively separate the metallic and non-metallic fractions of waste PCBs, offer the most promising gateways for the environmentally-benign recycling of this waste.

Manikandan et.al (2020) Examined on the improper disposal of e-waste. In our Country (India), primary source of Electronic waste generated was from public & private sector which are 70% from the total waste being generated. The annually estimated generation of E-waste was around 4,00,000 tons. It is found that most of the e-waste generated is from cities like Bombay, Delhi, Bangalore, and Madras was estimated approx. 10,000 , 9,000, 8,000 ,and 6,000 Tonnes Respectively. only 4% of total waste generated is recycled per annum, it's a disappointment. So, they made efforts for usage of E-waste components as for partially replacing the coarse (10-12) mm Aggregate. The major conclusions drawn by them are: Density of Electronic Waste as Replacement of Coarse or Fine Aggregate in concrete is less when

compared to Existing Normal or Conventional concrete as resulting in the lightweight blocks emerge which also reduced the cost of concrete blocks. Up to 15% replacement is allowable as it increased compressive strength and durability compared to conventional concrete.

Sagar R. Raut et.al (2020) focused on the replacing the coarse aggregate by electronic waste & also tried to replace fine aggregates by e-waste. They have mainly focused on the replacement of aggregates but not included fly-ash for partially replacing the cement. The major conclusions that were drawn by them were: 15% of partial replacing of aggregates gave the best results for Testing of Compression. Electronic Waste can be used as a possible partial replacement for the Coarse Aggregates. Tensile Strength (Split) was max. at 15 percent partially replacing the coarse aggregate by electronic waste. This Study show the Optimum percentage of replacement.

Hamsavathi Et.al Investigated on E Waste as fillers in order to improve the mechanical Properties of Concrete Structural Members. Therefore both traditional method & New methods were used in development of the newer concrete cubic samples. Electronic wastes were downsized to around 12 mm taking help of a electronic shredder. These are the particles which were used for partially replacing the coarse aggregate materials with 0–20 wt.% ranged gravel to Concrete Grade M25. Study between the conventional concrete and Experimental concrete revealed that the usage of electronic waste as the coarse aggregate or partial replacement was displaying more flexural and compressive strength compared to that conventional regular concrete cubes. When Beam comparison was done, it was seen that the capacity for load carrying was also increased from 426 kilo Newton to 480 kilo Newton, & the compressive strength of was also improved between 18 N/mm² - 30 N/mm². The Final results further gave them an idea that partially replacing the coarse aggregate with Electronic waste, displays more performance when up to 15 wt.% is added; when further added it decremented the strength in terms of compressive.

CHAPTER-3

SCOPE AND OBJECTIVES

3.1 AIM and Objectives:

1. To determine the properties of basic concrete making materials such as cement, fine aggregate, coarse aggregate, E waste and water.
2. To compare the properties with E waste with coarse aggregate and to check the suitability of adopting in concrete.
3. To determine the mechanical properties of e waste concrete and to compare with controlled concrete.
4. To determine the composition and formation of crystals in E-Waste concrete and compare with the controlled concrete using SEM Analysis.

3.2 Scope:

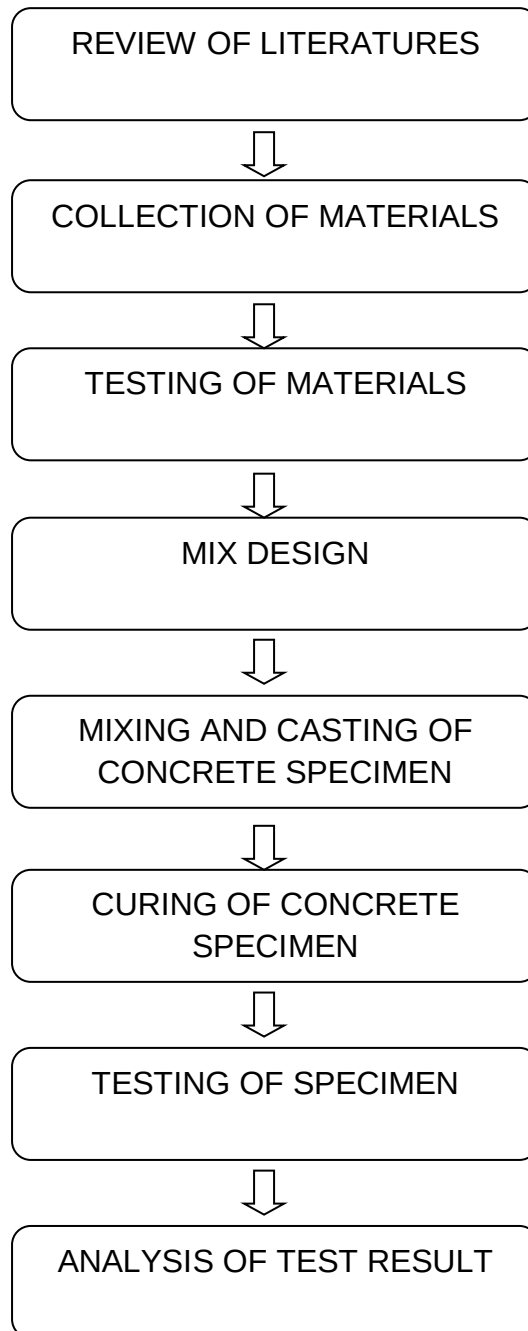
1. Effectively reduce the demand upon the natural resources.
2. Reduce the cost and production of coarse aggregate.
3. Reduce the environmental pollution by landfills and deposits of e waste.
4. Waste utilization and recycling can prove to be beneficial to society by reducing the green house gases to atmosphere.

CHAPTER – 4

MATERIALS AND METHODOLOGY

4.1. GENERAL : In this chapter, the methodology and materials collection have been discussed briefly.

4.2. METHODOLOGY :



4.3. MATERIALS COLLECTION

The materials used for concrete are cement, Fine aggregates, Coarse aggregates, supplementary materials (Fly ash, Ground Granulated Blast Furnace Slag, Copper slag), Chemical admixture and Water. The above mentioned materials were tested at accredited laboratory about their physical and chemical properties to decide their suitability, for their utilization in concrete

4.3.1. CEMENT :

Ordinary Portland Cement (OPC) is the most preferred binder in the manufacturing of concrete which are locally acquired as Penna OPC of 43 grade cement conforming to IS 269-2015 is used as shown in fig 1 .The cost of production is not expensive making it the sought after cement in the building industry. They are widely used for the construction of high-rise buildings, roads, dams, bridges, flyovers. Also, Ordinary Portland cement is used for making grouts and mortars. OPC is ideal for the construction of residential and industrial complexes. The physical and chemical test properties were conducted as per IS 4031 - 1988 and IS 4032 — 1985.



Fig 4.1 Cement

4.3.2. Fine Aggregates

Crushed stone sand conforming to IS 383 - 2016 from SS crusher, Cheyyur are used as fine aggregates as shown in fig 4.2. Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand is less than 4.75mm. They are used in construction industry mainly for concrete production and mortar mix.

This is mainly crushed fine aggregate produced from a source material with suitable strength, durability, and shape characteristics.



Fig 4.2 M Sand

4.3.3. Coarse Aggregates

Crushed aggregates from SS crusher, Cheyyur conforming to IS 383 -2016 is used as coarse aggregates as shown in fig 4.3. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder. Coarse aggregates have several uses in construction. The most obvious is as part of the mix in concrete. They are also used in the preparation of the moisture break under the slab and vapor barrier. They are part of the base preparation for driveways and roadways. Coarse aggregate is the portion of the concrete which is made up of the larger stones embedded in the mix.



12.5 mm



20 mm

Fig 4.3 Coarse aggregate

4.3.4. Water

FRFCF (Fast Reactor Fuel Cycle Facility) Under Ground Sump water is used as source of water for the design mix as shown in fig 4.7. Water has been tested as per IS: 3025-1964 and confirms the requirement of IS: 456 - 2000. Potable water is suitable as mixing water for cement concrete, plain cement concrete for road construction and other applications, since its chemical composition is known and well regulated.



Fig 4.4 Water

4.3.5. E-Waste

E-Waste may also be used for partial or full replacement of coarse aggregates in concrete. E-Waste concrete aggregate processing consists of crushing the e- waste to maximum size of 20mm.



Fig 4.5 E-Waste

4.4. TESTS ON MATERIALS PROPERTY:

4.4.1. CEMENT :

The physical properties of cement used in this study were evaluated by standard tests such as setting time, standard consistency, compressive strength and specific gravity and the results were tabulated in Table 4.4.1.1.



Fig: 4.6 Standard Consistency



Fig: 4.7 Initial Setting

Table 4.4.1.1. Physical Properties of Cement

PHYSICAL PROPERTIES OF CEMENT			
S.No	Description of Test	Results	Limit as per IS 269 / IS 456
1	Standard consistency (%)	29	-
2	Initial setting time(minutes)	180	30 (Min)
3	Final setting time(minutes)	290	600 (Max)
4	Specific gravity	3.14	3.15
5	Compressive strength (N/mm ²)	51.43	43 (Min) 58 (Max)
6	Fineness of cement in 90mic sieve Retained (%)	1.88	10 (Max)

Table 4.4.1.1 Chemical Properties of Cement

CHEMICAL PROPERTIES OF CEMENT			
S.No	Description of Test	Results	Limit as per IS 269 / IS 456
1	Lime saturation factor	0.82	0.66 Min 1.02 Max
2	Al ₂ O ₃ / Fe ₂ O ₃	1.04	0.66 Min
3	Insoluble residue (% by mass)	1.80	3.00 Max
4	Magnesia (% by mass)	0.20	6.00 Max
5	Sulphuric Anhydride (% by mass)	2.90	3.00 Max
6	Total Loss on ignition (% by mass)	1.30	5.00 Max
7	Total chlorides (% by mass)	0.0014	0.10 Max

4.4.2 Fine aggregate

Crushed stone sand conforming to IS 383 - 2016 from SS crusher, Cheyyur are used as fine aggregates were tabulated in Table 4.4.2.1.

Table: 4.4.2.1 Physical Properties of Fine Aggregate

PHYSICAL PROPERTIES OF FINE AGGREGATE			
S.No	Description of Test	Results	Limit as per IS 383 : 2386
1	Material passing 75 micron by mass (%)	3.80	10.0 Max
2	Specific gravity	2.652	-
3	Water Absorption (%)	1.62	-

Table: 4.4.2.1. Chemical Properties of Fine Aggregate

CHEMICAL PROPERTIES OF FINE AGGREGATE			
S.No	Description of Test	Results	Limit as per IS 383 : 2386
1	Chloride (%)	0.0006	0.02 Max
2	Sulphates (%)	0.028	0.4 Max
3	Petrography for strained quartz (%)	4-5%	20 Max
4	Alkali aggregate reactivity by mortar bar method (%)	0.016	0.1 Max
5	Alkali aggregate reactivity by chemical method (%)	Innocuous Zone	Innocuous Zone
6	Soundness Loss with sodium Sulphate 5 cycles	1.60%	10 Max
7	Soundness Loss with Magnesium Sulphate 5 cycles	1.2%	15 Max

4.4.2.1.Sieve Analysis for Fine Aggregate

The sieve analysis test for fine aggregate is described as follows. Take one kg of sand from the laboratory sample. Arrange the sieves in order of IS sieves nos. 480, 240, 120, 60, 30 and 15, keeping sieve no. 480 at the top and 15 at the bottom and cover the top. Keep the sample in the top sieve no. 480. Carry out the sieving in the set of sieves for not less than 10 minutes. Find the weight of the sample retained in each sieve. Tabulate the values in a given table 4.4.2.2.

Table:4.4.2.2. Sieve Analysis for Fine Aggregates

Sieve Analysis for Fine Aggregates					
S. No	Sieve size in (mm)	Weight Retained in(gms)	Percentage of weight Retained in(gms)	Cumulative Percentage of weight Retained	Percentage of Passing
1	10	0	0	0	100
2	4.75	0	0	0	100
3	2.36	18	1.80	1.80	98.2 0
4	1.18	358	35.80	37.60	62.4 0
5	0.60	204	20.40	58.00	42.0 0
6	0.30	194	19.40	77.40	22.6 0
7	0.15	114	11.40	88.80	11.2 0
	Pan	112	11.20	100	0
	Total	1000		364	

Fineness modulus of heavy weight fine aggregate = Sum of Cumulative % of retained / 100

Grading Zone : II F.M : 364 / 100 = 3.6

4.4.3. Coarse aggregate:

Crushed aggregates from SS crusher, Cheyyur conforming to IS 383 -2016 is used as coarse aggregates were tabulated in Table 4.4.3.1

Table: 4.4.3.1 Physical and Chemical Properties of Coarse Aggregate

PHYSICAL PROPERTIES OF COARSE AGGREGATES				
S.No	Description of Test	Results		Limit as per IS 383 : 2386
		12.5mm	20mm	
1	Specific gravity	2.780	2.750	-
2	Water Absorption (%)	0.42	0.61	-
3	Flakiness (%)	3.21	5.8	25 (Max)
4	Elongation (%)	6.08	8.15	25 (Max)
5	Crushing Value (%)	14.97	14.97	30 (Max)
6	Impact Value (%)	13.43	13.43	30 (Max)
7	Abrasion Value (%)	13.2	13.2	30 (Max)

CHEMICAL PROPERTIES OF COARSE AGGREGATES			
S.No	Description of Test	Results	Limit as per IS 383 : 2386
1	Chloride (%)	0.82	0.66 Min 1.02 Max
2	Sulphates (%)	1.04	0.66 Min
3	Petrography for strained quartz (%)	1.80	3.00 Max
4	Alkali aggregate reactivity by mortar bar method (%)	0.20	6.00 Max
5	Alkali aggregate reactivity by chemical method (%)	2.90	3.00 Max
6	Soundness Loss with sodium Sulphate 5 cycles	1.30	5.00 Max
7	Soundness Loss with Magnesium Sulphate 5 cycles	0.0014	0.10 Max

4.4.3.1 Sieve Analysis for Coarse Aggregate:

The sieve analysis test for fine aggregate is described as follows. Take one kg of coarse aggregates. Arrange the sieves one over the other in relation to their size of opening. (25mm, 20mm, 12.5mm, 10mm, 4.75mm). Carry out the sieving for the specified time. Find the weight of aggregate retained on each sieve taken in order and tabulated in table Plot the graph.

Draw a graph with sieve opening to log scale on the X- axis and % finer on Y- axis. The curve is called a grading curve.



Fig: 4.11 Sieve Analysis

Table: 4.4.3.2 Sieve Analysis for 12.5 mm Coarse Aggregates

SIEVE ANALYSIS FOR 12.5mm COARSE AGGREGATES					
Sl.no	Sieve size in (mm)	Weight Retained in(gms)	Cumulative weight Retained in (gms)	Cumulative Percentage of weight Retained	Cumulative Percentag eof Passing
1	16	0	0	0	100
2	12.5	494	4.94	4.94	95.06
3	10	2718	27.18	32.12	67.88
4	4.75	6726	67.26	99.38	0.62
5	PAN	62	0.62	100	0.00
	TOTAL	1000	-	-	-

Table: 4.4.3.3 Sieve Analysis for 20mm Coarse Aggregates

SIEVE ANALYSIS FOR 20mm COARSE AGGREGATES					
Sl no	Sieve size in (mm)	Weight Retained in(gms)	Cumulative weight Retained in(gms)	Cumulative Percentage ofweight Retained	Cumulative Percentage of Passing
1	40	0	0	0	100
2	20	562	5.62	5.62	94.38
3	10	9390	93.90	99.52	0.48
4	4.75	26	0.26	99.78	0.22
5	Pan	22	0.22	100	0.00
	Total	10000	-	-	-

Table: 4.4.3.4 Combined Gradation of Coarse Aggregates

COMBINED GRADATION OF COARSE AGGREGATES							
Sieve Size (mm)	Weight Retained in gms		% Retained		% Passing	LL	UL
	20 mm	12.5 Mm	20 mm	12.5 Mm			
40	100	100	24.75	30.25	100	100	100
20	94.38	100	23.36	30.35	98.61	95	100
4.75	0.22	0.62	0.05	0.19	45.24	30	50
0.60	0.00	0.00	0.00	0.00	18.90	10	35
0.150	0.00	0.00	0.00	0.00	5.04	0	6

Specific Gravity

Specific gravity test of aggregates is done to measure the strength or quality of the material. Specific Gravity is the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. It is the measure of strength or quality of the specified material. Aggregates having low specific gravity are generally weaker than those with higher specific gravity values.

A clean, dry pycnometer is taken and its empty weight is determined. About 1000g of clean sample is taken into the pycnometer, and it is weighed. Water at 27°C is filled up in the pycnometer with aggregate sample, to just immerse sample. Immediately after immersion the entrapped air is removed from the sample by shaking pycnometer, placing a finger on the hole at the top of the sealed pycnometer. Now the pycnometer is completely filled up with water till the hole at the top, and after confirming that there is no more entrapped air in it, it is weighed. The contents of the pycnometer are discharged, and it is cleaned. Water is filled up to the top of the pycnometer, without any entrapped air. It is then weighed. Specific gravity of aggregates is considered as an indication of strength. Material having higher specific gravity is generally considered as having higher strength.

The specific gravity (G) is calculated by using the following formula in given table.

$$G = (W_3 - W_1) / (W_3 - W_1) - (W_4 - W_2)$$



Fig: 4.10 Pycnometer

Table: 4.4.3.5 Specific Gravity of Coarse Aggregates

Description	Notations	20mm in gms	12.5mm in gms
Weight of empty Pycnometer	W_1	180	170
Weight of pycnometer + Water	W_2	466	458
Weight of pycnometer + Aggregate	W_3	260	250
Wt.of pycnometer + water + aggregate	W_4	516	506
$G = (W_3 - W_1) / (W_3 - W_1) - (W_4 - W_2)$		2.66	2.58

4.4.4. Water

Water has been tested as per IS: 3025-1964 and confirms the requirement of IS:456 – 2000 weretabulated in Table 4.4.7.1.

Table: 4.4.4.1 Physical and Chemical Properties of Water

S.No	Description of Test	Results	Limit as per IS 456
1	Ph Value	8.68	6.0 (Min)
2	Organic solids (mg/l)	46	200 (Max)
3	Inorganic Solids (mg/l)	284	3000 (Max)
4	Suspended Matter (mg/l)	1.0	2000 (Max)
5	Chloride Content (mg/l)	193	2000 (Max) for PCC
			500 (Max) for RCC
6	Sulphate Content (mg/l)	1.0	400 ax)

4.4.5. E-WASTE :

Electronic waste or e-waste describes discarded electrical or electronic devices. Used electronics which are destined for reuse, resale, salvage, recycling or disposal are also considered as e-waste.

Informal processing of electronic waste in developing countries may cause serious health and pollution problems, as these countries have limited regulatory oversight of e-waste processing.

E-wastes were crushed to the size of coarse aggregates shown in figure 4.6 and used in concrete. The result obtained after testing of e waste is as follows;



Fig .4.5. Crushed E-Waste

4.4.5.1 SPECIFIC GRAVITY OF E WASTE:

Weight of pycnometer (w_1) = 680gms

Weight of pycnometer + e waste (w_2) = 1005gms

Weight of pycnometer + e waste + water (w_3) = 1516gms

Weight of pycnometer + water (w_4) = 1510 gm

CALCULATION:

Specific gravity of e waste $G = [(w_2 - w_1) / \{(w_2 - w_1) - (w_3 - w_4)\}]$

$$G = [(1005 - 680) / \{(1005 - 680) - (1516 -)\}]$$

$$G = 1.01$$

RESULT:

Specific gravity of e waste, $G = 1.01$

4.5 MIX DESIGN

The mix design is done as per IS code 10262 — 2002 and the design is done for grade concrete.

CONCRETE MIX PROPORTIONING (AS PER IS-10262:2002)

i) STIPULATIONS FOR PROPORTIONS

1. Grade designation : M-30
2. Type of cement : Coromandel OPC-53 Grade
3. Maximum nominal size of aggregate : 20 mm
4. Minimum cement content : 320 kg/m³
5. Maximum water-cement ratio : 0.45
6. Workability : 75-100mm(slump)
7. Degree of supervision : Good
8. Type of aggregate : Crushed granular Aggregate
9. Maximum cement content : 420 kg/m³
10. Chemical admixture : Nil

ii) TEST DATA FOR MATERIALS

1. Cement used : Coromandel OPC-53 Grade confirming to IS-12269

2. Specific gravity of cement : 3.15.

3. Specific gravity of

a) Coarse aggregate (Fresh) = 2.70.

b) Fine aggregate = 2.65.

4. Water absorption

a) Coarse aggregate (Fresh) = 1.0%

b) Fine aggregate = 1.0%

5. Free surface Moisture:

a) Coarse aggregate (Fresh) = Nil

b) Fine aggregate = Nil

6. Sieve Analysis:

Table 4.5.0. Grading of Coarse Aggregate

IS Sieve Size(mm)	Analysis of C.A. Fraction			Percentage of Different fractions		
	I	II	Combined	I	II	combined
40	100	100	100	60	40	100
20	100	100	100	60	40	100
12.5	2	100	40	1.2	40	41.2
10	0	3	0	0	1.2	1.2
4.75	0	0	0	0	0	0

Thus, we adopt coarse aggregate grading as 60:40(i.e., 20 mm: 12.5 mm)

b) Fine Aggregate: Conforming to zone-II of table 4 of IS-383.

STEP 1: TARGET MEAN COMPRESSIVE STRENGTH OF CONCRETE:

1.As per IS code 10262-2002; (Clause no.2.2) $F_{ck} = f_{ck} + (t \times s)$

Where 't' is tolerance factor (1.65)

2.As per IS code 10262-2002; (Table no. 1) Standard deviation for M30 grade and quality control good = $5F_{ck} = f_{ck} + 1.65s$

$$F_{ck} = 30 \text{ N/mm}^2 \quad S = 5$$

$$F_{ck} = 30 + (1.65 \times 5)$$

$$F_{ck} = 38.25 \text{ N/mm}^2$$

STEP 2 : SELECTION OF WATER CEMENT RATIO

As per IS code 10262-2002 ; (Clause no. 3.1) Water cement ratio = 0.45
Water cement ratio (W/C) = 0.45 for 38.25 N/mm²

STEP 3: SELECTION OF WATER

CONTENT: From Table 2, maximum water content for 20mm aggregate = 186 liter (for 25 to 50 mm slump value)

STEP 4: DETERMINATION OF CEMENT CONTENT:

As per 10262-2002; (Clause no. 6) Water –cement ratio (w/c) = 0.45 $186/C = 0.45$

$$C = 186/0.45$$

$$C = 413 \text{ Kg/m}^3$$

STEP 5: DETERMINATION OF COARSE AND FINE AGGREGATE CONTENT:

For pump able concrete these values should be reduced by 10% Therefore,

Volume of coarse aggregate = 0.66 Zone 4 (Table 4) Volume of fine aggregate = $1 - 0.66 = 0.3$.

STEP 6: MIX CALCULATIONS:

The mix calculations per unit volume of concrete shall be as follows :

- a) Volume of concrete $= 1\text{m}^3$
- b) Volume of cement $= \text{Mass of cement} / \text{Specific gravity of cement}$
 $\quad \quad \quad * 1/1000 = 413/3.15*1/1000$
 $= 0.13 \text{ m}^3$
- c) Volume of water $= \text{Mass of water} / \text{Specific gravity Of water}$
 $\quad \quad \quad \quad \quad \quad * 1/1000$
 $= 186/1*1/1000 = 0.186 \text{ m}$
- d) Volume of all in aggregate $= [a - (b + c)]$
 $= [1 - (0.13 + 0.186)]$
 $= 0.684 \text{ m}^3$
- e) Mass of coarse aggregate $= e * \text{Volume of coarse aggregate} * \text{Specific gravity of coarse aggregate} * 1000$
 $= 0.684 * 0.66 * 2.7 * 1000$
 $= 1237 \text{ kg}$
- f) Mass of fine aggregate $= e * \text{volume of fine aggregate} * \text{Specific gravity of fine aggregate} * 1000$
 $= 0.684 * 0.3 * 2.7 * 1000$
 $= 567\text{kg}$

STEP 7: MIX PROPORTIONS:

Table 4.5.1 Mix Design Ratio

WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
186	413 kg	567 kg	1237 kg
0.45	1	1.37	3

Table 4.5.2. Quantity of materials required for Compression Test (per cube)

SL NO	REPLACEMENT OF COARSE AGGREGATE	WEIGHT OF CEMENT	WEIGHT OF SAND	WEIGHT OF FRESH COARSE AGGREGATE	WEIGHT OF RECYCLED COARSE AGGREGATE	QUANTITY OF WATER
	%	kg	Kg	kg	kg	liters
1	0	1.66	2.27	4.98	-	0.82
2	10	1.66	2.27	4.48	0.49	0.82
3	15	1.66	2.27	4.23	0.74	0.82
4	20	1.66	2.27	3.98	0.99	0.82
	TOTAL	6.64	9.08	17.67	2.22	3.28

Table 4.5.3. Quantity of materials required for Compression Test (6 cubes)

SLNO	REPLACEMENT OF COARSE AGGREGATE	WEIGHT OF CEMENT	WEIGHT OF SAND	WEIGHT OF FRESH COARSE AGGREGATE	WEIGHT OF RECYCLED COARSE AGGREGATE	QUANTITY OF WATER
	%	kg	Kg	kg	kg	liters
1	0	9.96	13.62	29.88	-	4.92
2	10	9.96	13.62	26.88	2.94	4.92
3	15	9.96	13.62	25.38	4.44	4.92
4	20	9.96	13.62	23.88	5.94	4.92
	TOTAL	39.84	64.48	106.02	13.32	19.68

Table 4.5.4. Quantity of materials required for Flexural Test (per beam)

S. NO	% OF COARSE AGGREGATE REPLACED	WEIGHT OF CEMENT	WEIGHT OF SAND	WEIGHT OF FRESH COARSE AGGREGATE	WEIGHT OF RECYCLED COARSE AGGREGATE	QUANTITY OF WATER
	%	kg	kg	Kg	kg	liters
1.	0	2.44	3.34	7.32	-	1.2
2.	10	2.44	3.34	6.58	0.73	1.2
3.	15	2.44	3.34	6.22	1.08	1.2
4.	20	2.44	3.34	5.85	1.46	1.2
	TOTAL	9.76	13.36	22.97	3.27	4.8

Table 4.5.5. Quantity of materials required for Flexural Test (3 beam)

S. NO	% OF COARSE AGGREGATE REPLACED	WEIGHT OF CEMENT	WEIGHT OF SAND	WEIGHT OF FRESH COARSE AGGREGATE	WEIGHT OF RECYCLED COARSE AGGREGATE	QUANTITY OF WATER
	%	kg	kg	Kg	kg	liters
1.	0	7.32	10.02	21.96	-	3.6
2.	10	7.32	10.02	19.74	2.19	3.6
3.	15	7.32	10.02	18.66	3.24	3.6
4.	20	7.32	10.02	17.55	4.38	3.6
	TOTAL	29.28	40.08	77.91	9.81	14.4

Table 4.5.6. Quantity of materials required for Split Tensile Test (per cylinder)

S. NO	% OF COARSE AGGREGATE REPLACED	WEIGHT OF CEMENT	WEIGHT OF SAND	WEIGHT OF FRESH COARSE AGGREGATE	WEIGHT OF RECYCLED COARSE AGGREGATE	QUANTITY OF WATER
	%	kg	kg	Kg	kg	liters
1.	0	2.3	3.2	6.9	--	1.15
2.	10	2.3	3.2	6.2	0.6	1.15
3.	15	2.3	3.2	5.9	1.03	1.15
4.	20	2.3	3.2	5.5	1.22	1.15
	TOTAL	9.2	12.8	24.5	2.85	4.6

Table 4.5.7. Quantity of materials required for Split Tensile Test (3 cylinder)

S. NO	% OF COARSE AGGREGATE REPLACED	WEIGHT OF CEMENT	WEIGHT OF SAND	WEIGHT OF FRESH COARSE AGGREGATE	WEIGHT OF RECYCLED COARSE AGGREGATE	QUANTITY OF WATER
	%	kg	kg	Kg	kg	liters
1.	0	6.9	9.6	20.7	--	3.45
2.	10	6.9	9.6	18.6	1.8	3.45
3.	15	6.9	9.6	17.7	3.09	3.45
4.	20	6.9	9.6	16.5	3.66	3.45
	TOTAL	27.6	38.4	73.5	8.55	13.8

4.6 CASTING AND CURING

4.6.1.GENERAL

Testing plays an important role in controlling the quality of concrete work. Systematic testing of raw material, the fresh and hardened inseparable part of any quality control program for concrete which helps to achieve higher efficiency and Test Method should be simple, direct and convenient to apply.

In considering, all the above, the preparation test specimen is the major role. It involves, Batching and Weighing, Mixing, Casting, Demoulding and Curing. These all activities should be carried out as per code recommendation and design mix requirement. The different kind of concrete test specimen is involved in preparation for evaluating the strength and durability parameters.

The additional care should be taken while preparing test specimen and nothing shall be neglected. The preparation test specimen should be with good workmanship as well as strict supervision. The preparation of concrete test specimen of each activity is directly connected with strength parameters.

4.6.2 CASTING

The casting of various concrete specimens such as cubes, cylinders and reinforced beams are described as follows.

4.6.2.1. Casting of Cubes

The concrete cube specimens are casted by the consideration of following steps

Cube Mould

The cube moulds of required size 150 x 150 x 150 mm for nominal size of aggregate not exceeding 38 mm. Cube moulds shall be provided with a base plate and they shall be as per IS:10086-1982.

Tamping Rod

As per IS:10086-1982, the tamping rod shall be 16 ± 0.5 mm dia and 600 ± 2 mm long with rounded working end and shall be made of mild steel.

Casting Process

The cube mould plates should be removed, properly cleaned assembled and all the bolts should be fully tight. A thin layer of oil then shall be applied on all the faces of the mould. It is important that cube side faces must be parallel. After taking concrete samples and mixing them, the cubes shall be cast as soon as possible. The concrete sample shall be filled into the cube moulds in layers approximately 5 cm deep.

In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete within the mould. Each layer shall be compacted either by hand or by the vibration as described below.

Compaction by Hand

Each layer of the concrete filled in the mould shall be compacted by not less than 35 strokes by tamping bar. The strokes shall be penetrating into the underlying layer and the bottom layer shall be rodded through its depth. Where voids are left by the tamping bar the sides of the mould shall be tapped to close the voids.

4.6.2.2. Casting of Cylinders

The material properties of concrete can only be properly evaluated if test specimens are made and cured according to standards. Concrete cylinders are typically made to evaluate the compressive strength of the concrete as well as split tensile strength.

Cylinder Mould

Metal 100 x 200 mm or 150 x 300 mm cylinder moulds are used for casting concrete test specimens in the field. Before filling, they should be placed on a smooth, firm, level surface.

Tamping Rod

If 100 mm diameter moulds are used then it should be filled in 3 equal layers and each layer rodded uniformly 20 times with a 10 mm diameter x 450 - 600 mm long hemisphericallytipped steel rod. If 150 mm diameter moulds are used then it should be filled in 3 equal layers and each layerrodded uniformly 25 times with a 16 mm diameter x 450 - 600 mm long hemi sphericallytipped steel rod.

Casting Process

The strokes shall be distributed uniformly over the cross-section of the mould. The bottom layer shall be rodded throughout its depth. For each upper layer, the rod shall penetrate about 25 mm into the underlying layer. If voids are left by the rod, the sides of the mould should be tapped to close voids before adding the extra layer of material.

4.6.2.3. Casting of Beams

According to standards Concrete beam are casted to evaluate the flexural strength of the concrete. The casting and testing procedure to be followed as Indian standard code IS 516:1959.

Mould

The mould standard size will be 150 x 150 x 700 made out of metal. The tamping bar shall be a steel bar weighing 2kg, 40 cm long and shall have a ramming face 25 mm square.

The test specimen shall be made as soon as practicable after Mixing and in such way as to produce full compaction of concrete while neither segregation nor excessive laitance.

Casting Process

The compaction shall be distributed uniformly over the section of the mould. The bottom layer shall be rodded throughout its depth. For each upper layer, the rod shall penetrate about 25 mm into the underlying layer. If voids are left by the rod, the sides of the mould should be tapped to close voids before adding the next layer of material.



Fig: 4.11 casting of cubes and cylinders



Fig: 4.12 casting of prisms

4.6.3: DEMOULDING

Test concrete test specimens should be demoulded between 16 and 24 hours after they have been made. If after this period of time the concrete has not achieved sufficient strength to enable demoulding without damaging the specimens then the demoulding should be delayed for a further 24 hours. When removing the concrete specimens from the mould, take the mould apart completely. Take care not to damage the specimens because, if any cracking is caused, the all strength parameters may be reduced.

After demoulding, each test concrete specimens should be marked with a legible identification on the top or bottom using a waterproof crayon or ink. The mould must be thoroughly cleaned after demoulding. Ensure that grease or dirt does not collect between the faces of the flanges, otherwise the two halves will not fit together properly and there will be leakage through the joint and an irregularly shaped may result.

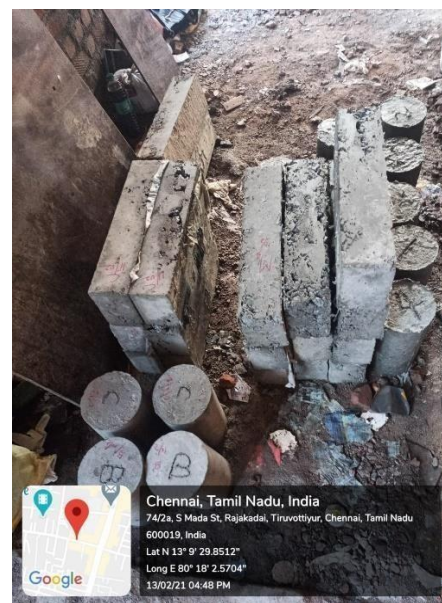


Fig: 4.13 Demoulded specimens

4.6.4: CURING

Curing plays a vital role concerning concrete strength development and Durability. Curing of Concrete is a method by which the concrete is protected against loss of moisture required for hydration and kept within the recommended temperature range. Curing will increase the strength and decrease the permeability of hardened concrete. Curing is also helps in mitigating thermal and plastic cracks, which can severely impact durability of structures.

Curing practice involves keeping the concrete damp or moist until the hydration of concrete is complete and strength is attained. Curing of concrete should begin soon after initial setting time of concrete.

As per IS 456 — 2000 concrete should not be cured less than 7 days for ordinary Portland cement, and it must be at least 10 days for concrete with mineral admixtures or blended cement are used. In case of hot weather and very dry temperature conditions, the curing should not be less than 10 Days for OPC and 14 days for concrete with blended cement & mineral admixtures.



Fig: 4.14 Curing

4.7. TESTS ON FRESH CONCRETE

The fresh concrete test is defined as Green properties of concrete which is carried out by the method of workability (slump), air content test, bleeding tests which are described as follows.

4.7.1. Slump

This procedure covers the tests method of determining the workability of plastic concrete by using slump cone apparatus in laboratory. The internal surface of the mould shall be thoroughly cleaned and free from moisture before commencing the test. The mould shall be placed on a smooth, horizontal and carefully levelled non absorbent metal surface. The mould shall be filled in four equal layers with concrete sample and each layer shall be tamped with twenty five strokes of the rounded end tamping rod of 16mm diameter and 600mm long as shown in fig 4.13. The strokes shall be distributed uniformly over the cross-section of the mould and for the second and subsequent layer shall penetrate into the under lying layer. The bottom layer shall be tamped throughout its depth. After the top layer had been rodded, the excess quantity of concrete shall be struck off and level with a trowel or the tamping rod, so that the mould is exactly filled. Any mortar which may have leaked out between the mould and the base plate shall be cleaned away. The mould shall be removed from the concrete immediately by raising it slowly and carefully in vertical direction. The slump shall be measured immediately by determining the difference between the height of mould and that of the highest point of the specimen being tested. The slump measured shall be recorded in terms of millimeters of subsidence of the specimen during the test.

Slump

The height of the slump cone	= 300mm
The height of concrete after subsidence	= 110mm
Hence, the slump measured	= 180mm



Fig: 4.15 Slump Test

4.7.2. Air Content Test

This test method covers the determination of the air content of freshly mixed concrete. The test determines the air content of freshly mixed concrete exclusive of any air that may exist inside voids within aggregate particles. For this reason, it is applicable to concrete made with relatively dense aggregate particles and requires determination of the aggregate correction factor. This test method (IS 1199 : 1959) specifies the procedure for determining the Air content for freshly mixed concrete. The measure shall be filled with concrete as soon as after mixing in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. The concrete shall be filled into the measure in layers approximately 5cm deep and each layers shall be compacted either by hand or mechanical vibration. After the top layer has compacted the surface of the concrete shall be struck off level with the top of the measure.

The Air content shall be calculated as follows

$$A = (T - W/T) \times 100$$

Where

A = Air content (% age of voids in the concrete)

T = Theoretical weight in the concrete in Kg/m³ – computed on free air basis

W = Weight of concrete in Kg/m³.

4.7.3. Bleeding Test

For determination of relative quantity of mixing water that will bleed from a sample of freshly mixed concrete. The test is carried out as per IS 9103 : 1999 — Method of sampling and analysis of concrete. The container is filled with concrete up to height of 250mm. it is filled approximately 50mm deep and each layer is compacted by hand. The minimum numbers of strokes are 60 strokes per layer. The top surface of the concrete is levelled. The mass is recorded. The container is kept on a level surface free from vibration and covered with a lid.

Water accumulated at the top is drawn off by means of a pipette, at 10 min intervals during the first 40 min and at 30 min interval subsequently till bleeding water as shown in fig 4.14. The water is transferred to graduated jar and accumulated quantity of water is recorded after each transfer. The result is expressed in percentage. Accumulated bleeding water expressed as a percentage of the net mixing water is calculated as follows.

$$\text{Bleeding water (\%)} = V_w / (W_s/W) \times 100$$

Where,

V_w = Total mass of the bleeding water, kg
 W_s = Net mass of water in the batch, kg

W = Total mass of the batch, kg
= The mass of sample, kg



Fig 4.16: Bleeding Test

4.7.4. Setting Time of Concrete

The setting time of concrete is found by plunger needle test. This method of test is covered by IS 8142:1976. The apparatus consists of a container which should have minimum lateral dimension of 150 mm and minimum depth of 150 mm. Remove bleeding water from the surface of the mortar specimens just prior to making a penetration test by means of a pipette or a suitable instrument. To facilitate collection of bleeding water, tilt the specimen carefully to an angle of about 12° from the horizontal by placing a block under one side 2 minutes prior to removal of the bleeding water.

Insert a needle of appropriate size, depending upon the state of hardening of the mortar, in the penetration resistance apparatus and bring the bearing surface of the needle into contact with the mortar surface. Gradually and uniformly apply a vertical force downward on the apparatus until the needle penetrates the mortar to a depth of 25 mm as indicated by the scribe mark. The time required to penetrate to the 25 mm depth shall be approximately 10 seconds. Record the force required and the time of application, measured as elapsed time after initial contact of cement and water. In subsequent penetration tests take care to avoid areas where the mortar has been disturbed by previous tests. The clear distance between two needle impressions shall be at least two diameters of the needle being used, but not less than 13 mm. The clear distance between any needle impression and the side of the container shall be not less than 25 mm.

Make penetration tests at hourly intervals for normal mixtures and normal temperatures, the initial test being made after an elapsed time of 3 to 4hr. For accelerated mixtures or high temperatures, it may be advisable to make the initial test after an elapsed time of 1 or 2 h and subsequent tests at + h intervals. For low-temperature conditions or retarded concrete mixtures, the initial penetration test may be deferred for an elapsed time of 4 to 6 h, and perhaps longer. Subsequent tests may be made at intervals of 1h, unless the rate of increase in penetration resistance indicates that shorter intervals are desirable.

Not less than six penetration resistance determinations shall be made in each rate of hardening test and the time intervals between penetration resistance determinations shall be such as to give a satisfactory rate of hardening curve, as indicated by equally spaced points. Continue the tests until one penetration resistance of at least 26.97 N/mm² (275kgf/cm²) is reached.

4.8. TESTS ON HARDENED CONCRETE

The hardened concrete test consists of both the strength and durability properties of the concrete. The strength properties of concrete are carried out by compressive strength test, split tensile strength test, flexural strength test, cylindrical compression test, and young's modulus test and the durability properties of the concrete is carried out by Rapid chloride penetration test and sulphate attack test as follows.

4.8.1. Compressive Strength Test

Compressive strength of Concrete cubes was determined based on IS Code 516: 1959. Cube moulds of size 150 mm × 150 mm × 150 mm were cast. Concrete mixes were prepared using E-waste as partial replacement and bacteria as an admixture. The mixture is then placed in mould with and compressed using the rod of size 16 mm diameter. After 24 h the specimens were unmoulded and subjected to water curing. The cube Specimens were finally tested for compressive diameter. After 24 h the specimens were unmoulded and subjected to water curing. The cube Specimens were finally tested for compressive strength at the end of 7, 14 and 28 days. The Ultimate load was determined after failure and the compressive strength is calculated by dividing the maximum load by the area of Specimen This procedure is applicable for establishing testing method for the compressive strength of concrete specimens. Specimens stored in

water shall be tested immediately on removal from the water and while they are still in the wet condition. Wet condition is also maintained by covering the specimens with wet burlap.

The bearing surfaces of the testing machine shall be wiped clean and dry loose sand or other material removed from the surfaces of the specimen which are to be in contact with the compression platens. In case of the cubes, the specimen is placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast that is, not to the top and bottom. The axis of the specimen shall be carefully aligned with the center of thrust of the spherically seated platen. No packing shall be use between the faces of the test specimen and the steel platen of the testing machine. The loading rate shall be set to 5.2 KN/sec for 15 cm cube, to uniformly load the specimen as shown in fig 4.20.

The load shall be applied without shock, and increased continuously until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

Compressive strength (N/mm²) =

Ultimate load in N

Area of cross section (mm²)



Fig 4.17 Compressive Strength Test

4.8.2. Split Tensile Test

Splitting tensile strength on concrete cylindrical specimens was conducted based on IS 5816:1999 to determine the tensile strength of concrete. The cylindrical mould used for the research was 300 mm height and 150 mm diameter. Tensile strength test was adopted by placing the cylinders in the compressive testing machine as shown in [Fig.](#) The load was gradually applied till failure and the split tensile strength of the sample is computed using the suitable formula recommended by IS 5816:1999. This procedure is applicable for establishing testing method for the split tensile strength of concrete specimens.

Specimen when received dry shall be kept in water for 24 hours before they are taken for testing. Unless other conditions are required for specific laboratory investigation specimen shall be tested immediately on removal from the water whilst they are still wet. Surface water and grit shall be wiped off the specimens and any projecting fins removed from the surfaces which are to be in contact with the packing strips. Marking - Diametral lines shall be drawn on the two ends of the specimen using any suitable procedure and device that will ensure that they are in the same axial plane. Placing of the specimen in the Testing Machine- The bearing surfaces of the testing machine and of the packing strips shall be wiped clean as shown in fig

Positioning — One of the plywood strips shall be cantered along the center of the lower platen. The specimen shall be placed on the plywood strip and aligned so that the lines marked on the ends of the specimen are vertical and centered over the plywood strip. The second plywood strip shall be placed lengthwise on the cylinder, centered on the lines marked on the ends of the cylinder.

The assembly shall be portioned to ensure the following conditions:

- The lines marked on the ends of the specimen are vertical and that the projection of the plane of the two lines marked on the ends of the specimen intersects the centre of the plate.
- The supplementary bearing bar or plate, when used, and the centre of the specimen are directly beneath the centre of thrust of the spherical bearing block.

Rate of Loading — The load shall be applied without shock and increased continuously at a rate to produce approximately a splitting tensile stress of approximately 14 to 21 kg/cm²/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. This rate of loading for 15 cm diameter and 30 cm length cylinder works out 1.62 KN/sec to 2.43 KN/sec. The maximum load applied to the specimen shall then be recorded. The appearance of concrete and any unusual features in the type of failure shall also be noted.

The measured splitting tensile strength (T_{sp}) of the specimen shall be calculated to the nearest 0.01 N/mm² using the following formula

$$\text{Split tensile strength (N/mm}^2\text{)} = \frac{2P}{\pi L D}$$

Where,

P= maximum load in N applied to the specimen,

d= measured diameter in mm of the specimen, and

l = measured length in mm of the specimen.



FIG: 4.18 Split Tensile Strength Test

4.8.3. Flexural Strength test

Flexural strength of concrete prisms was determined based on recommendations IS Code 516: 1959 . A beam mould of size 500 mm × 100 mm × 100 mm was used in the test. With and without E-Waste concrete was filled in the beam moulds and then compacted using the tamping rod. After 24 h the specimens were unmoulded and subjected to water curing. The cube specimens were loaded to UTM and ultimate load at failure at the period of 7, 14 and 28 days. Two-point loading method were adopted to fail the specimen at the constant rate. Flexural strength of the concrete beam specimens was determined using the formula recommended by IS 516:1959.

This procedure is applicable for establishing testing method for the flexural strength of test specimens. Specimens stored in water at a temperature of 24o to 30o C for 48 hours before testing shall be tested immediately on removal from the water whilst they are still in a wet condition. No preparation of the surfaces is required.

The bearing surfaces of the supporting and loading rollers shall be wiped clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers. The specimen shall then be placed in the machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould, along two lines spaced 200 mm apart. The axis of the specimen shall be carefully aligned with the axis of the loading device. The bed of testing machine should be provided with two steel rollers 38mm in diameter on which the specimen is to be supported, and these rollers should be placed at distance 600mm c/c. No packing shall be used between the bearing surfaces of the specimen and the rollers as shown in fig.

The load shall be applied without shock and increasing continuously at a rate such that the extreme fibre stress increases at approximately 0. 7 kg/sq cm/min, that is, at a rate of loading of 400kg/min for the 150 mm specimens. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded. The appearance of the fractured faces of concrete and any unusual features in the type of failure shall be noted. The flexural strength of the specimen shall be expressed as the modulus of rupture shall becalculated to the nearest 0.05 N/mm² as follows:

$$\text{Flexural strength (N/mm}^2\text{)} = \frac{P L}{B D^2}$$

Where,

b= measured width in mm of the specimen,

h= measure depth in mm of the specimen at the point of failure,

l= length in mm of the span on which the specimen was supported, and

P= maximum load in N applied to the specimen.



FIG 4.19 Flexural Strength

4.9. Compression strength test

Table 4.9.1 Compressive Strength of M-30 Grade Concrete on 7 days test

S. NO	% OF COARSE AGGREGATE REPLACED	DATE OF CASTING	DATE OF TESTING	ULTIMATE LOAD "P"	COMPRESSIVE STRENGTH "fc= P/A"
	%			KN	MPa
1.	0	17-02-21	24-03-21	460	20.5
2.	10	17-02-21	24-03-21	480	21.3
3.	15	17-02-21	24-03-21	490	21.7
4.	20	17-02-21	24-03-21	440	19.5

Table 4.9.2 Compressive Strength of M-30 Grade Concrete on 14days test

S. NO	% OF COARSE AGGREGATE REPLACED	DATE OF CASTING	DATE OF TESTING	ULTIMATE LOAD "P"	COMPRESSIVE STRENGTH "f _c = P/A"
	%			KN	MPa
1.	0	18-02-21	04-03-21	670	29.9
2.	10	18-02-21	04-03-21	690	30.8
3.	15	18-02-21	04-03-21	720	32
4.	20	18-02-21	04-03-21	635	28.2

Table 4.9.3 Compressive Strength of M-30 Grade Concrete on 28 days test

S. NO	% OF COARSE AGGREGATE REPLACED	DATE OF CASTING	DATE OF TESTING	ULTIMATE LOAD "P"	COMPRESSIVE STRENGTH "f _c = P/A"
	%			KN	MPa
1.	0	14-02-21	13-03-21	710	31.5
2.	10	14-02-21	13-03-21	730	32.4
3.	15	14-02-21	13-03-21	760	33.7
4.	20	14-02-21	13-03-21	755	33.5

4.10. Split Tensile strength test

Table: 4.10.1. Split Tensile Strength of M-30 Grade Concrete on 7 days test

S. NO	% OF COARSE AGGREGATE REPLACED	DATE OF CASTING	DATE OF TESTING	SPLIT TENSILE STRENGTH $F=2P/\pi DL$
	%			MPa
1.	0	17-02-21	24-03-21	4.1
2.	10	17-02-21	24-03-21	4.2
3.	15	17-02-21	24-03-21	4.1
4.	20	17-02-21	24-03-21	3.7

Table: 4.10.2. Split Tensile Strength of M-30 Grade Concrete on 14days test

S. NO	% OF COARSE AGGREGATE REPLACED	DATE OF CASTING	DATE OF TESTING	SPLIT TENSILE STRENGTH $F=2P/\pi DL$
	%			MPa
1.	0	18-02-21	04-03-21	4.3
2.	10	18-02-21	04-03-21	4.7
3.	15	18-02-21	04-03-21	4.7
4.	20	18-02-21	04-03-21	4.1

Table: 4.10.3. Split Tensile Strength of M-30 Grade Concrete on 28 days test

S. NO	% OF COARSE AGGREGATE REPLACED	DATE OF CASTING	DATE OF TESTING	SPLIT TENSILE STRENGTH $F=2P/\pi DL$
	%			MPa
1.	0	14-02-21	13-03-21	4.6
2.	10	14-02-21	13-03-21	4.9
3.	15	14-02-21	13-03-21	5.1
4.	20	14-02-21	13-03-21	4.7

4.11. FLEXURAL STRENGTH OF CONCRETE BEAM:

Table: 4.11.1. Flexural Strength of M-30 Grade Concrete on 7 days test

S. NO	% OF COARSE AGGREGATE REPLACED	DATE OF CASTING	DATE OF TESTING	FLEXURAL STRENGTH " $f_c = PL/BD^2$ "
	%			MPa
1.	0	17-02-21	24-03-21	5.1
2.	10	17-02-21	24-03-21	5.5
3.	15	17-02-21	24-03-21	5.4
4.	20	17-02-21	24-03-21	5

Table: 4.11.2. Flexural Strength of M-30 Grade Concrete on 14 days test

S. NO	% OF COARSE AGGREGATE REPLACED	DATE OF CASTING	DATE OF TESTING	FLEXURAL STRENGTH " $f_c = PL/BD^2$ "
	%			MPa
1.	0	18-02-21	04-03-21	6.2
2.	10	18-02-21	04-03-21	6.4
3.	15	18-02-21	04-03-21	6.7
4.	20	18-02-21	04-03-21	6.1

Table: 4.11.3. Flexural Strength of M-30 Grade Concrete on 28 days test

S. NO	% OF COARSE AGGREGATE REPLACED	DATE OF CASTING	DATE OF TESTING	FLEXURAL STRENGTH " $f_c = PL/BD^2$ "
	%			MPa
1.	0	14-02-21	13-03-21	7
2.	10	14-02-21	13-03-21	7.2
3.	15	14-02-21	13-03-21	7.4
4.	20	14-02-21	13-03-21	6.9

CHAPTER – 5

RESULTS AND DISCUSSIONS

In this chapter the results for test on materials, compressive strength of concrete cube, Flexural strength of concrete beam with fresh coarse aggregate and partially & fully replaced recycled coarse aggregate with bacterial solution were separately studied and compared.

5.1 RESULTS ON TEST OF MATERIALS

5.1.1. Tests on cement

i. Fineness of Cement:

The fineness of cement is 3%.

ii. Specific gravity of Cement:

Specific gravity of a sample of cement = 3.15.

5.1.2. Tests on fine aggregate

Sieve Analysis:

The fineness modulus of fine aggregate is 3.86, on comparing the above result with Table IS-383, we confirm that the sand belongs to Zone-II

i. Specific Gravity of Fine Aggregate:

The Specific gravity of Fine Aggregate sample is 2.65.

ii. Water absorption Test:

Water absorption of given fine aggregate is 1.0%

5.1.3. Tests on coarse aggregate

Sieve Analysis:

The fineness modulus of coarse aggregate is 2.60, on comparing the above result with Table IS-383, we confirm that the coarse aggregate belongs to Zone-II.

i. Specific Gravity of Coarse Aggregate:

Specific gravity of a sample of Fresh C.A. = 2.70

Specific gravity of a sample of Recycled C.A. = 1.01

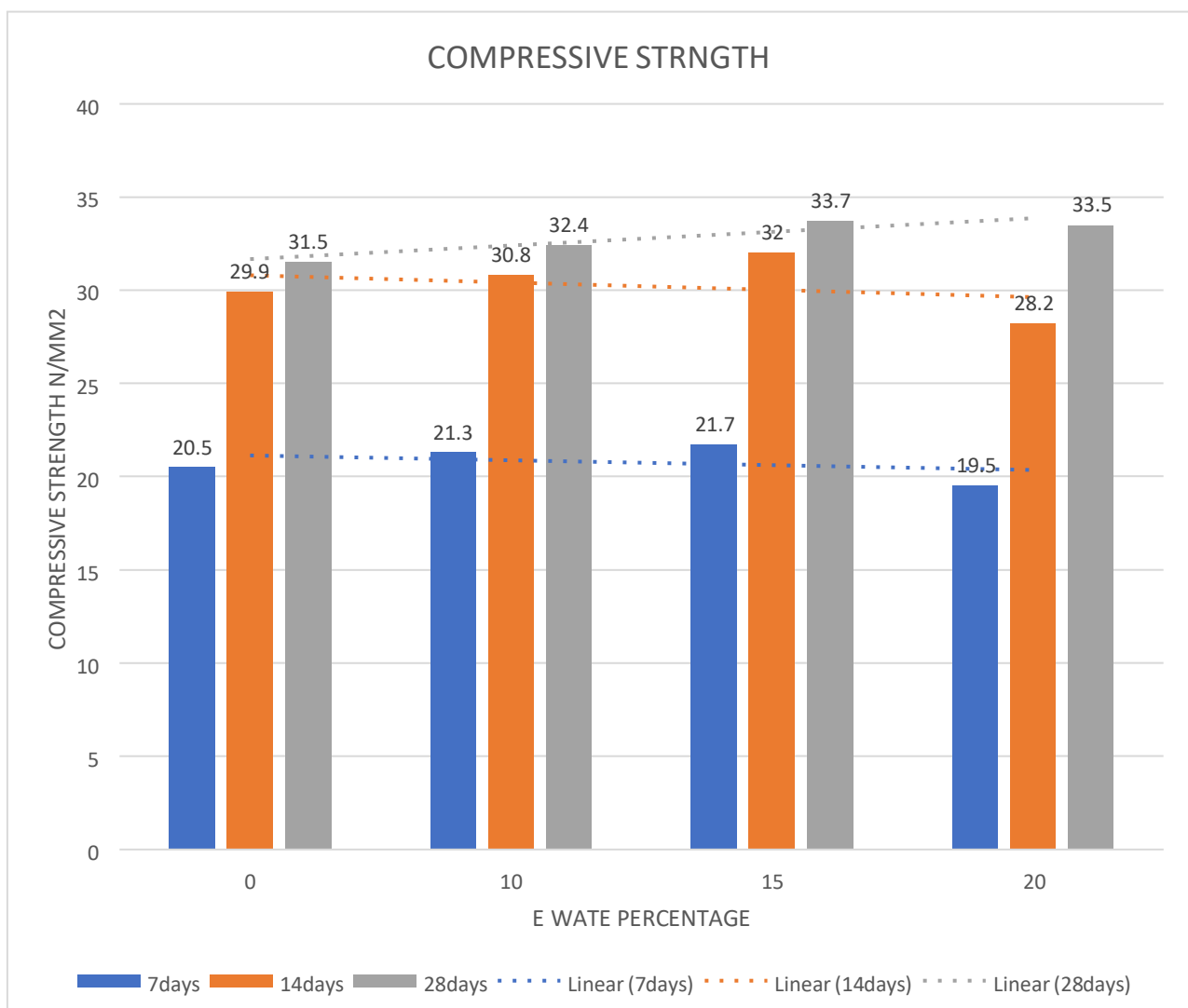
ii. Water absorption Test:

Fresh Coarse Aggregate (F.C.A.) is 1.00%

Recycled Coarse Aggregate (R.C.A.) is 2.02%

5.2. COMPRESSION TEST:

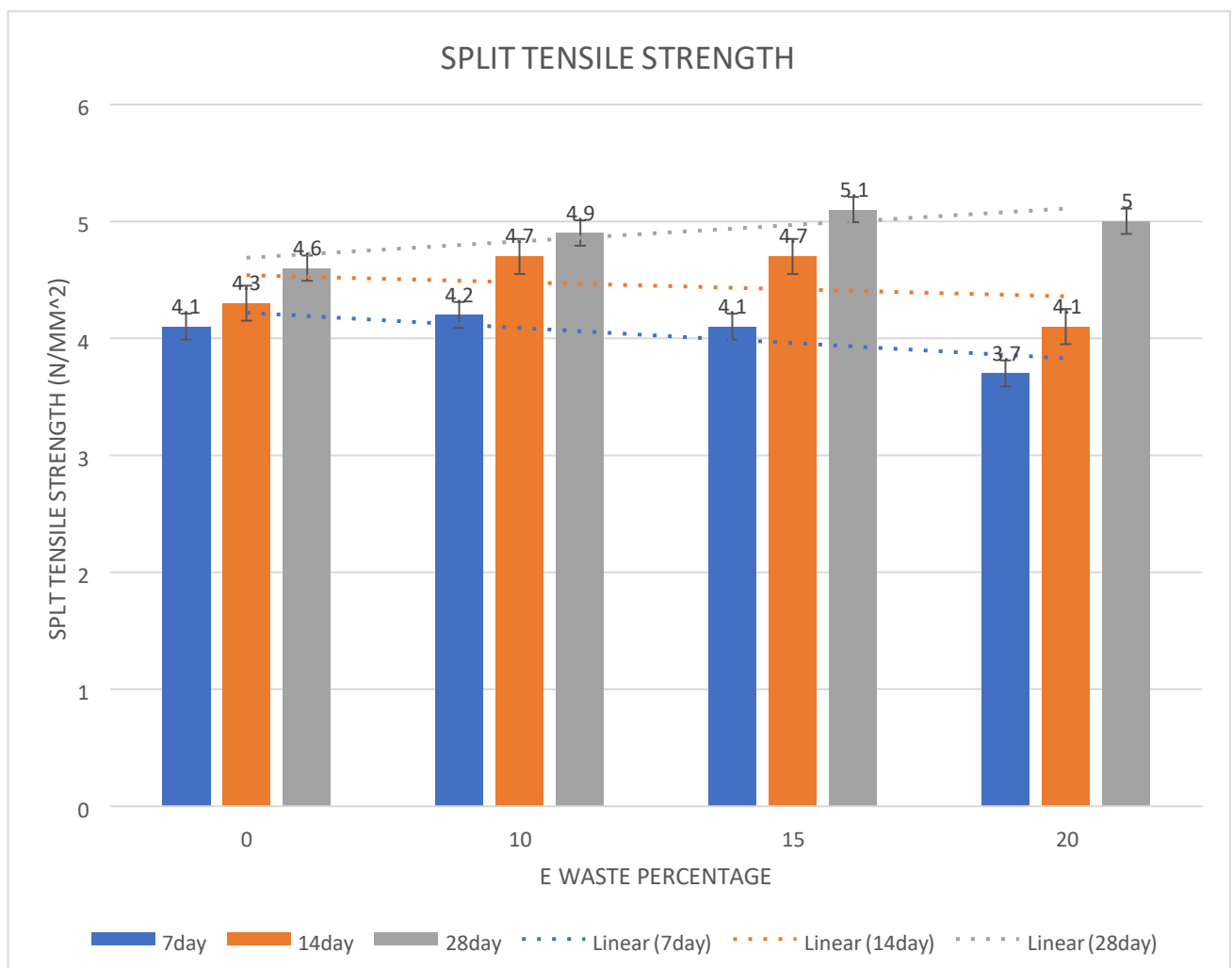
Compression test done on cubes by partial replacement of coarse aggregate with Ewaste in the ratios of 0%, 10%, 15%, 20% on 7th day, 14th day and 28th day.



Graph: 1 Compression test on cubes

5.3. SPLIT TENSILE STRENGTH:

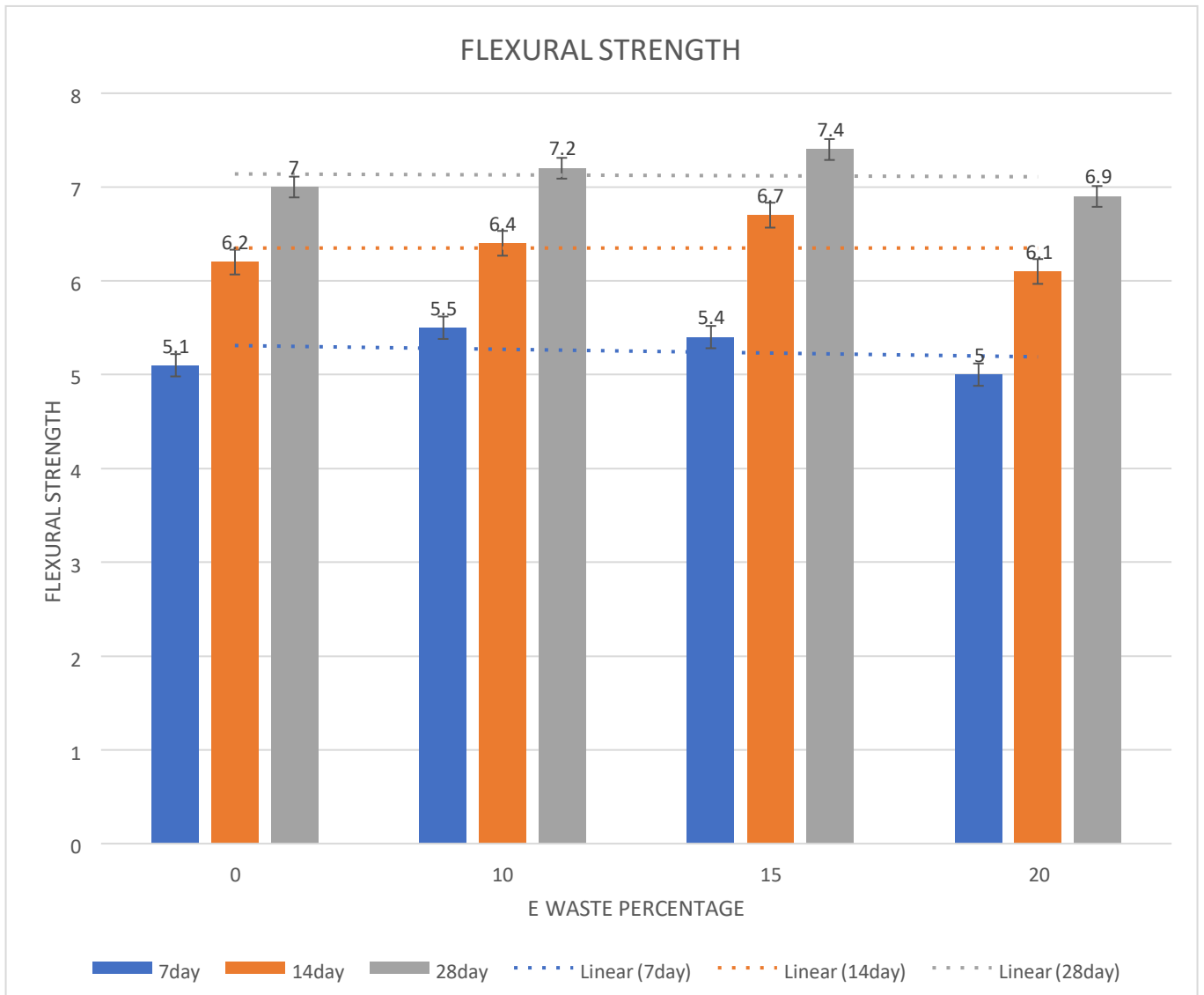
Split tensile strength done on cylinder by partial replacement of coarse aggregate with E waste in the ratios of 0%, 10%, 15%, 20% on 7th day, 14th day and 28th day.



Graph: 2 Split Tensile test on cylinders

5.4. FLEXURAL STRENGTH TEST:

Flexural test done on prisms by partial replacement of coarse aggregate with E waste in the ratios of 0%, 10%, 15%, 20% on 7th day, 14th day and 28th day.



Graph:3 Flexural test on prisms

5.5. SEM Images

The E Waste mixed in the concrete was analyzed using Scanning Electron Microscope. The broken pieces were collected after crushing the cube specimen. The specimens were desiccated in the oven at 100⁰C for three days and subjected for SEM analysis. The SEM images were retrieved for identification of formation of calcium carbonate crystals. Also, the SEM analysis proves to be the evidence test for the E Waste action on concrete. The presence of individual crystals can be observed in SEM images which indicate the presence of calcite formation. Various rectangular and polygonal crystals indicate the formation of calcium carbonate. where as for the controlled concrete no such formations exist which is depicted in Fig.5.1(a) and fig.5.1(b).

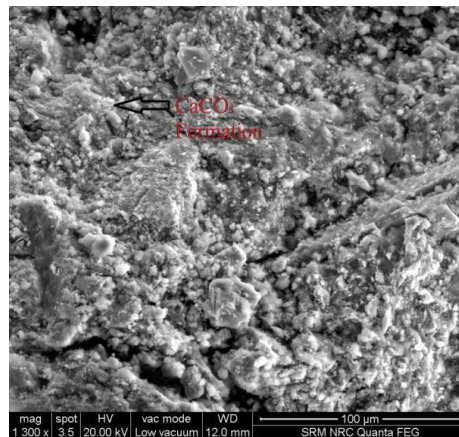


Fig.5.1(a).SEM image for E Waste concrete with substitution of coarse aggregate

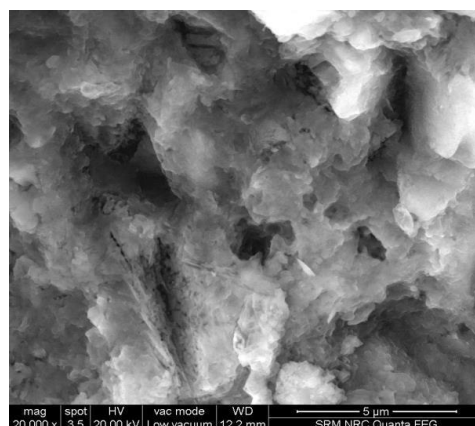


Fig.5.1(b).SEM image for Controlled concrete

CHAPTER 6

CONCLUSION

6.1 GENERAL

The Following Conclusions Are Given Below:

- E Waste as a partial replacement of Coarse aggregate in concrete gives good result in both fresh and hardens state. In low volume of replacement gives good strength and workability than high volume of replacement.
- Every year millions of ton E-waste produce whole over the world. The use of e-waste will also help in shielding the environment surroundings by using the low quantity of E waste as a replacement of coarse aggregate can improve the strength up to a 15% replacement.
- E Waste as a Partial substitute for coarse aggregate possesses a great potential to be utilized as coarse aggregate in concrete. Partial substitution of coarse aggregate by E Waste effectively improves compressive strength of concrete up to substation level.
- Experimental investigations were conducted to determine the Characteristics and Strength of concrete by replacing of coarse aggregate with e-waste.
- Concrete specimens were casted and tested to determine the Compressive Strength, split tensile strength and flexural strength by error standard deviation method.
- Based on the test results it was inferred, which percentage gave better results than the conventional concrete with respect to 7,14- and 28-days Compressive strength, split tensile and flexural strength when replaced with e-wastes.
- Research works reported that the addition of E-waste shows increase in compressive strength up to 15% replacement.
- Increase in split tensile strength has occurred even up to 15 % replacements. E-waste seems to have a more pronounced effect on the split tensile strength.
- Research works reported that the addition of E-waste shows increase in flexural strength up to 15% replacement.

- Disposal and land filling problems can be sorted out thereby proves beneficial to the society.
- The Maximum deflection of RCC beams with E waste was less than the theoretically predicted value and the experimental results have little convergence with the numerical results obtained from finite element software Abacus.
- Based on the Scanning Electron Microscope Analysis it can be concluded that improvement in the overall performance of E Waste concrete and formation of calcite which is identified by the polygonal crystals.

CHAPTER 7

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