A VISION TOWARDS GREEN AND SUSTAINABLE CONCRETE-STRENGTH CHARACTERISTICS OF M20 AND M25 GRADES OF CONCRETE

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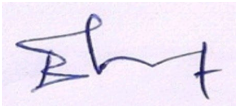

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ABSTRACT

Concrete is the most versatile product used as building material and it generates CO2 to the atmosphere.A research study shows that six billion tons of cement produced every year which produces an immense measure of CO2 and other greenhouse gases which leads to global warming and climate change.Cement industries consumed three percentage of the global primary energy consumption or almost five percentage of the global industrial energy consumption.Research are going to develop green and sustainable concrete incorporating different waste materials.This paper presents the usage of different types of wastages in M20 and M25 grades of concrete to form a green innovative sustainable concrete.This concept make the system more sustainable,it is also cheap to produce.

TABLE OF CONTENTS

CHAPTER ONE:INTRODUCTION

1.1.GENERAL

The buildings and other structures wherein we live and work tremendously affect our global environment.CO_2 produced for the manufacture of structural concrete is estimated as 410 kg/m^3.The CO_2 emission from the concrete production is directly proportional to the cement used in concrete.

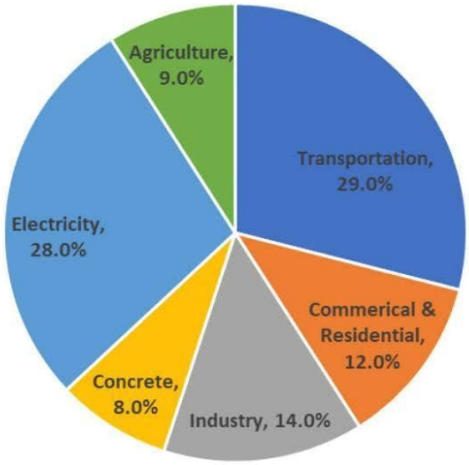


Fig 1.1 Global waste report

According to reports taken on 2019 by various organizations,concrete had a significant impact on global warming.This paper presents the ideology about using the different types of waste materials as green concrete.In this paper,Green concrete is a concrete which uses waste materials as at least one of its components.In this paper,we are using different types of wastes such as industrial wastages,agricultural wastages,construction wastages and nanoparticles as components in concrete.The strength characteristics such as split tensile strength,flexural strength and compressive strength were calculated for M20 and M25 grades of concrete incorporating those wastages.

1.2.PROBLEM STATEMENT

The Intergovernmental panel on climate carrying out global warming research have recently predicted that average global temperature could increase between 1.4 to

5.8 degree celsius by the year 2100.concrete is responsible for 5 to 8 percent of CO_2 worldwide.This leads to global warming and climate change.

The construction industry is going with major believe on infrastructure.The demand for sand has increased by 360 percentage in last 30 years and it continues to do so.Sand is essential for the development of country.But at the same time,damages posed due to sand mining cannot be disregarded.Uncontrolled river sand mining creates a level of dangers to rivers that are ecologically irreversible.So,an urgent and sustainable solution is needed.

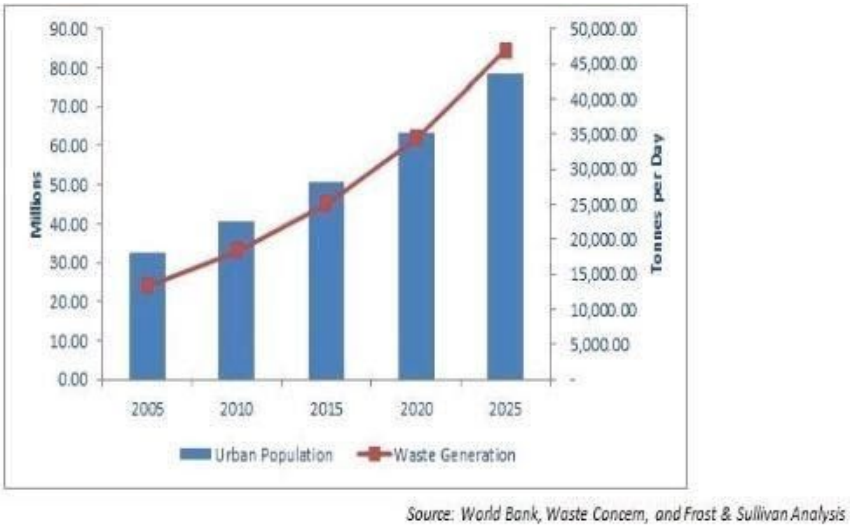


Fig 1.2 World bank report

According to World bank report,each individual person produces an average of 1.25 kg of solid waste per day.Urban centres generate 9 billion tons of solid waste daily and it is set to grow to 9.9 billion tons by 2025.On producing the waste at this rate,we are turning our beautiful world into huge garbage dump.So,there is a solution needed to utilize these wastages.

1.3.RESEARCH SIGNIFICANCE

This research was undertaken to address the need of green concrete,a revolutionary topic in the history of concrete industry.And also,it gives an awareness for people and industries about sustainable development and waste management.Experimental assessment and parametric study were fully implemented.These results will help to choose the appropriate alternatives.

1.4.RESEARCH GOALS

- To reduce the CO_2 emissions by 21 percentage.This is in accordance with the Kyoto protocol of 1997.
- To make the recycling capacity of green concrete not be less compared to existing concrete types.
- To make the production and the use of green concrete will not deteriorate the working environment.
- To make the structure do not impose harm to the environment during their service life.
- To reduce the amount of solid wastes and create awareness about green concrete and sustainable development.

CHAPTER TWO:GREEN CONCRETE

2.1.GREEN CONCRETE-INTRODUCTION:

Green concrete is a revolutionary topic in the history of concrete industry.This was first invented in Denmark in the year 1998.Green concrete is a concrete consisting of recycled materials as possible and leaving the smallest carbon footprint as possible.

Fig 2.1 Sustainable Concrete

Construction activities have a negative impact on the environment by consuming natural resourses.It is important that every stage of production carries ecological characteristics in order to have sustainably sensitive structures.

2.2.DESIRABLE PROPERTIES

1. MECHANICAL PROPERTIES
    - Strength
    - Shrinkage
    - Creep
    - Static Behaviour
2. WORKMANSHIP
    - Workability
    - Strength Development
    - Curing
3. DURABILITY
    - Corrosion Protection

- Frost
- New Deterioration Mechanisms

4. FIRE RESISTANCE
5. ENVIRONMENTAL IMPACT

2.3.MATERIALS SELECTION CRITERIA

1. RESEARCH EFFICIENCY

   Research efficiency essentially includes properties like recycled content,natural resource efficient manufacturing process,locally available,recyclable and durability.

2. INDOOR AIR QUALITY

   Indoor air quality is enhanced by using materials that meet non-toxic, minimal chemical emission,moisture resistant and healthfully maintained.

3. ENERGY EFFICIENCY

   Materials are preferred that require the minimal amount of energy.

4. WATER CONSERVATION

   Materials that conserve water are preferred to be used.

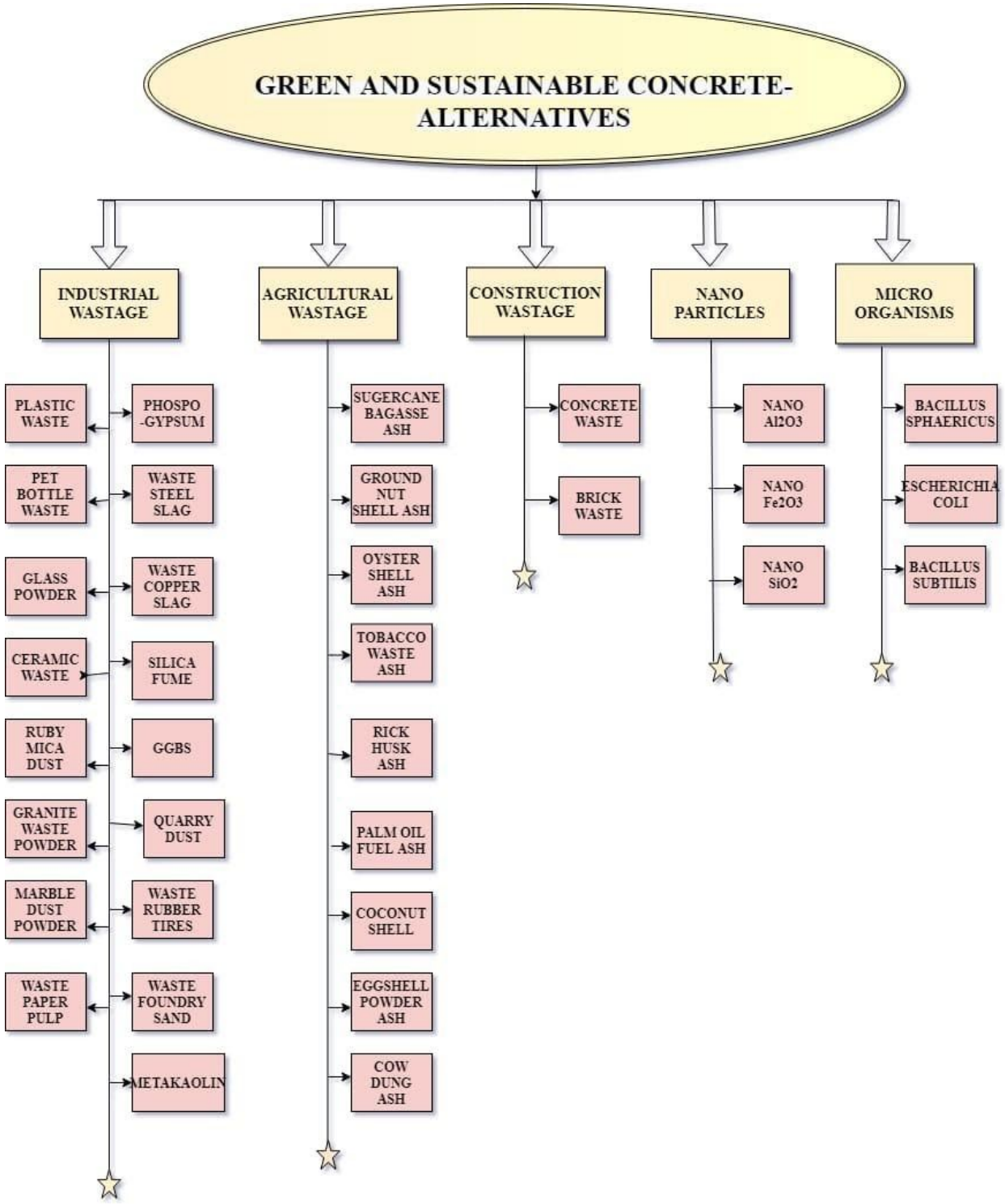
5. AFFORDABILITY

   Building product lifecycle costs are comparable to conventional materials.

2.4.SUITABILITY OF GREEN CONCRETE

- Good thermal and fire resistance
- Improve damping resistance of building
- Reduction of CO_2 emission
- Increased use of waste products
- No environmental pollution
- Green concrete requires less maintenance
- Better workability

2.5.TYPES OF WASTAGE USED



2.5.1.INDUSTRIAL WASTAGE

Industrial waste is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process.It may be solid,liquid or gaseous.

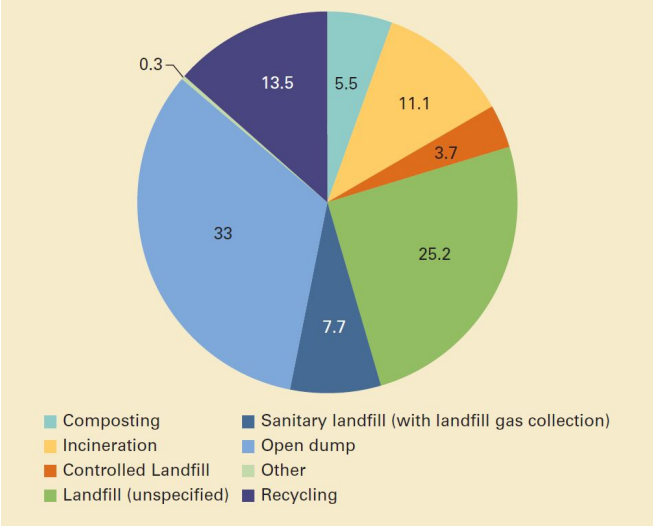


Fig 2.2 Solid waste report

The world generates 2.01 billion tonnes of municipal solid waste annually.Global industrial waste is expected to grow 3.40 billion tonnes by 2050.It is important to dispose the industrial waste properly or it can lead to disastrous consequences.Utilizing that wastage is one of the solutions for this problem.

In our study we used industrial waste such as waste steel slag,waste copper slag,silica fume,waste foundry sand,waste paper pulp,waste rubber tires,glass powder etc.

2.5.2.AGRICULTURAL WASTAGE

Agricultural waste is the waste produced from agricultural operations including wastes from farms.Storing agricultural waste can multiply the hazards associated with it since stored waste can release harmful gases.

Fig 2.3 Agricultural waste

In our study,we used agricultural waste such as sugarcane bagasse,cow dung,coconut shell etc.

2.5.3.CONSTRUCTION WASTAGE

Fig 2.4 Construction Waste

Construction waste is the waste produced directly or indirectly by the construction activities and industries.This includes bricks,concrete,wood etc.The reuse of waste material is one of the important form of pollution prevention.It is because these changes reduce the amount of waste generated year to year.

2.5.4.NANO PARTICLES

Nanoparticles generally improve mechanical,durability properties of concrete. Using of nanoparticles leads to sustainable development in construction industries.Concrete containing nano particles has proven to be very effective.

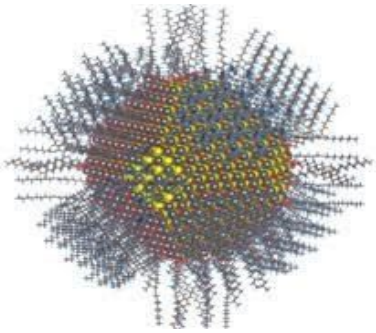


Fig 2.5 Nano particles

The addition of nanoparticles into concrete as thin films on aggregate surfaces has a high potential for improving the overall performance of concrete.

2.5.5.MICRO ORGANISMS

Fig 2.6 Bacterial concrete

Microbial metabolic activity taking place in concrete leads to increasing overall performance of concrete.The Bacillus sphaericus showed a reduction in water absorption.The use of bacteria reduces porosity and permeability.It ensures the best crack healing and reduces water permeability.

CHAPTER THREE:STRENGTH OF CONCRETE CONTAINING INDUSTRIAL WASTAGE

3.1.PHOSPHOGYPSUM

3.1.1.INTRODUCTION

Fig 3.1 Phosphogypsum

Phosphogypsum is a by-product of phosphate fertilizer plants for manufacture of phosphoric acid by the action of sulphuric acid on the rock phosphate.The disposal of phosphogypsum is a serious environmental problem.It can be used as cement in concrete because of its pazzolonic properties.In India,6 MT of waste gypsum including phosphogypsum,fluorogypsum are being generated annually.

3.1.2.PHYSICAL AND CHEMICAL PROPERTIES OF PHOSPHOGYPSUM

- Color : gray
- Particle size : 0.5 mm (No. 40 sieve) and 1.0 mm (No. 20 sieve) and majority of the particles (50-75%) are finer than 0.075 mm (No. 200 sieve).
- Specific gravity : 2.3 - 2.6
- Dry bulk density : 1470 -1670 kg/m^3
- Moisture content : 25 -30 %

Chemical constituents	Percentages (%)
CaO	31.2
SiO_2	3.92
SO_2	43.3
Fe_2O_3	1.82
MgO	0.49
Na_2O	0.36
P_2O_5	0.5
Organic matter	0.26

3.1.3.PREPARATION OF CONCRETE

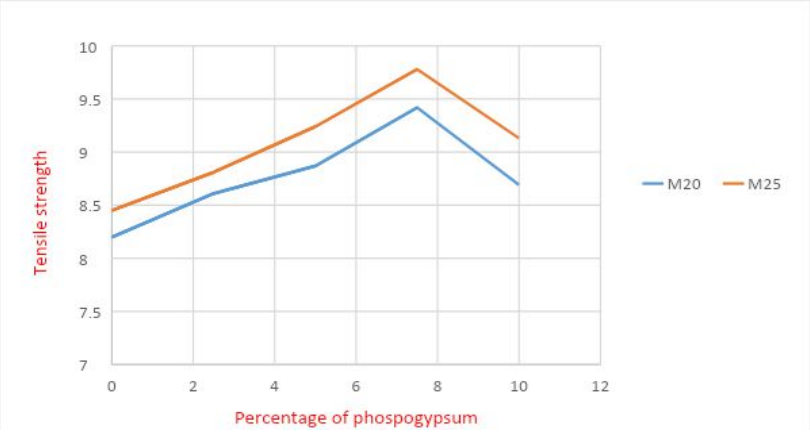
Phospogypsum was obtained from mahalakshmi chemical and fertilizers,Chennai in Tamilnadu.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used according to IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.65.Water-cement ratio kept constant in all mixes.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm) for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test and standard metal moulds(150 mm x 150 mm x 700 mm) for flexural strength test.After casting,concrete cubes are cured for 28 days.Finally,cubes are removed from water and dried for one day.

3.1.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out according to IS:5186-1999.

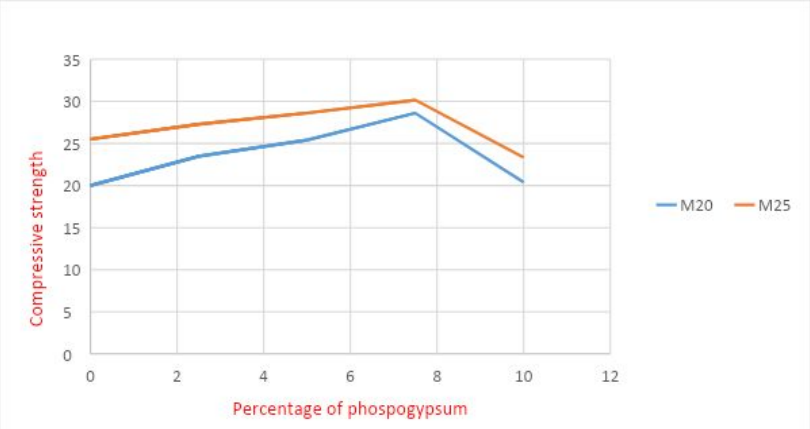
Percentage of phosphogypsum used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	**8.2**	**8.45**
2.5	**8.61**	**8.81**
5	**8.87**	**9.24**
7.5	**9.42**	**9.78**
10	**8.69**	**9.13**



3.1.5.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out according to IS:516-1959

Percentage of phosphogypsum used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	20.01	25.51
2.5	23.49	27.29
5	25.41	28.62
7.5	28.61	30.16
10	20.39	23.33



3.1.6.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 7.5 percent of phosphogypsum and decreases further replacement for both M20 and M25 grades of concrete.
- The compressive strength increases upto replacement of 7.5 percent of phosphogypsum and decreases further replacement for both M20 and M25 grades of concrete.
- Phospogypsum resolving the environmental problems created by fertilizer industries.

3.2.WASTE STEEL SLAG

3.2.1.INTRODUCTION

Fig 3.2 Waste steel slag

Steel slag is a by-product of steel.It is produced during the separation of the molten steel from impurities.It is estimated that 7 to 7.5 million metric tons of steel slag

used each year in the United States.We are going to use steel slag as fine aggregate in M20 and M25 grades of concrete.

3.2.2.PHYSICAL AND CHEMICAL PROPERTIES OF WASTE STEEL SLAG

Property	Value
CaO	40 – 52%
SiO_2	10 – 19%
FeO	10 - 40 (70 - 80% FeO, 20 - 30% Fe2O3)%
MnO	5 – 8%
MgO	5 – 10%
Al_2O_3	1 – 3%
P_2O_5	0.5 – 1%
S	< 0.1%
Metallic Fe	0.5 – 10%
Specific Gravity >	3.2 - 3.6
Unit Weight, kg/m^3 (lb/ft^3)	1600 - 1920 (100 - 120)
Absorption	up to 3%

3.2.3.PREPARATION OF CONCRETE

Waste steel slag was obtained from steel plant at Tirunelveli.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12669.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.63.Water cement ratio kept constant in all mixes.

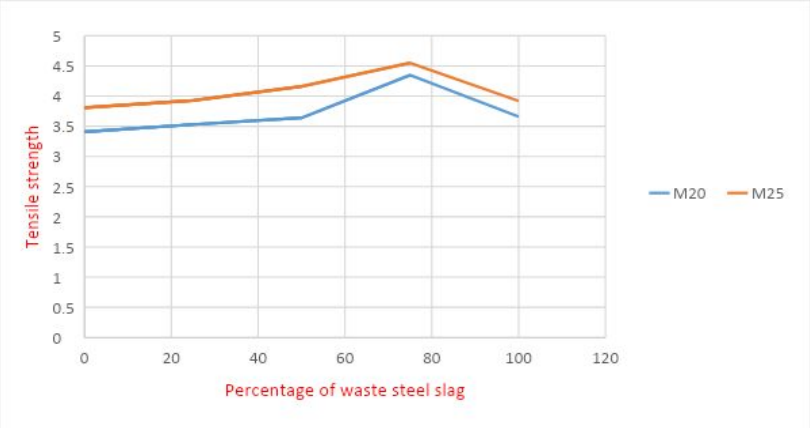
The main purpose of this experiment is to estimate the optimum amount of waste steel slag that can be replaced with fine aggregate.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test and standard metal moulds(150 mm x 150 mm x 700 mm) for flexural strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.2.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out according to IS 5816-1999.

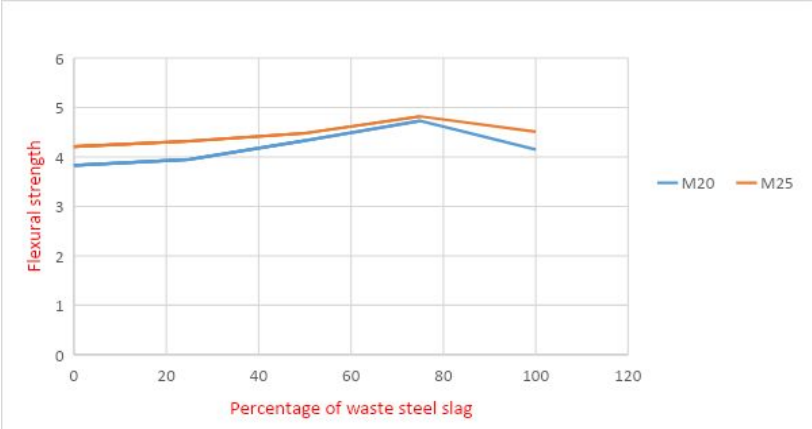
Percentage of waste steel slag used as replacement with fine aggregate	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	3.41	3.81
25	3.53	3.93
50	3.64	4.16
75	4.35	4.55
100	3.66	3.92



3.2.5.FLEXURAL STRENGTH TEST

Experimental investigation for flexural strength has been carried out according to IS:516-2002.

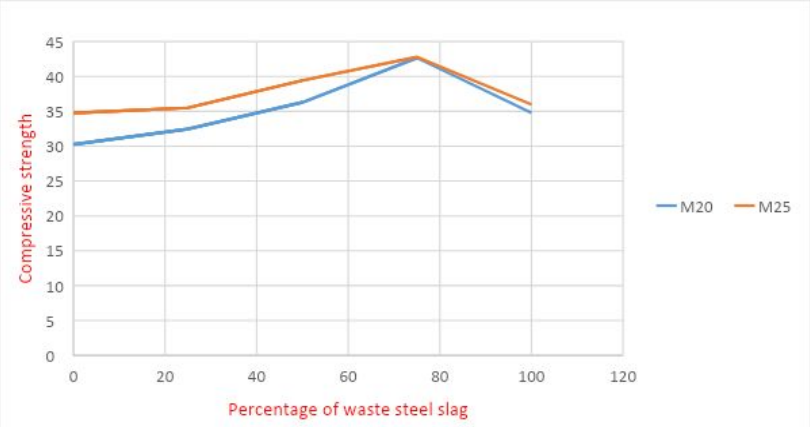
Percentage of waste steel slag used as replacement with fine aggregate	Flexural strength of M20 grade of concrete(N/mm^2)	Flexural strength of M25 grade of concrete(N/mm^2)
0	3.83	4.21
25	3.95	4.32
50	4.33	4.48
75	4.73	4.82
100	4.15	4.51



3.2.6.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out according to IS:516-1959.

Percentage of waste steel slag used as replacement with fine aggregate	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	30.24	34.74
25	32.45	35.49
50	36.28	39.42
75	42.65	42.77
100	34.76	35.98



3.2.7.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 75 percent of waste steel slag and decreases further replacement for both M20 and M25 grades of concrete.
- The flexural strength increases upto replacement of 75 percent of waste steel slag and decreases further replacement for both M20 and M25 grades of concrete.
- The compressive strength increases upto replacement of 75 percent of waste steel slag and decreases further replacement for both M20 and M25 grades of concrete.
- The cost of slag is half that of the natural aggregates.So,it is economical to use.

3.3.COPPER SLAG AND SILICA FUME

3.3.1.INTRODUCTION

Copper slag is a by-product of copper extraction by smelting.It is estimated that 2.2 tons of copper slag is generated for every ton of metallic copper production.In the world 24.6 million tons of slag is produced annually.

Fig 3.3 Copper slag

Silica fume is a by-product of the silicon and ferrosilicon alloy production.Because of its chemical and physical properties,it is used in concrete.

3.3.2.PHYSICAL AND CHEMICAL PROPERTIES OF COPPER SLAG AND SILICA FUME

Composition	% By mass
Fe_2O_3	55–60
Fe_3O_4	<10
SiO_2	27–33
CaO	1–3.5
S	0.2–1.5
Cu	<1
Al_2O_3	<3

Specific gravity (SSD): 4.12, Bulk density (SSD): 2.31 g/cc Fineness modulus: 3.4, Deleterious Materials: Not present

3.3.3.PREPARATION OF CONCRETE

Copper slag and silica fume was obtained.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269 is used.Zone of fine aggregate

was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.63.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.

The main purpose of this experiment is to estimate the optimum amount of copper slag and silica fume that can be replaced with fine aggregate.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test and standard metal moulds(150 mm x 150 mm x 700 mm) for flexural strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.3.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS 5816-1999.

Percentage of copper slag(cs) and silica fume(sf) used as replacement with fine aggregate	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0cs+0sf	**2.71**	**2.88**
20cs+5sf	**2.78**	**2.96**
40 cs+5sf	**2.75**	**2.85**
30cs+15sf	**3.07**	**3.15**
40cs+15sf	**2.86**	**2.99**

3.3.5.FLEXURAL STRENGTH TEST

Experimental investigation for flexural strength has been carried out as per IS:516-2002.

Percentage of copper slag(cs) and silica fume(sf) used as replacement with fine aggregate	Flexural strength of M20 grade of concrete(N/mm^2)	Flexural strength of M25 grade of concrete(N/mm^2)
0cs+0sf	2.55	2.75
20cs+5sf	2.64	2.86
40 cs+5sf	2.61	2.82
30cs+15sf	2.82	3.02
40cs+15sf	2.73	2.90

3.3.6.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of copper slag(cs) and silica fume(sf) used as replacement with fine aggregate	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0cs+0sf	21.53	25.25
20cs+5sf	22.30	27.24
40 cs+5sf	21.82	26.10
30cs+15sf	24.97	29.15
40cs+15sf	23.62	27.51

3.3.7.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 30 percent of copper slag and 15 percent of silica fume for both M20 and M25 grades of concrete.
- The flexural strength increases upto replacement of 30 percent of copper slag and 15 percent of silica fume for both M20 and M25 grades of concrete.
- The compressive strength increases upto replacement of 30 percentage of copper slag and 15 percentage of silica fume for both M20 and M25 grades of concrete
- It is economical to use.
- Copper slag increases workability because of its water absorption characteristics.
- Copper slag behaves like river sand as it contains silica fume.

3.4.GROUND GRANULATED BLAST-FURNACE SLAG(GGBS)

3.4.1.INTRODUCTION

Fig 3.4 GGBS

GGBS is obtained by quenching molten iron slag from a blast furnace in water or stream,to produce a glassy,granular product that is then dried and ground into a fine powder.GGBS is very useful in the design and development of high quality concrete.

We are going to use GGBS to increase the strength characteristics of M20 and M25 grades of concrete.

3.4.2.PHYSICAL AND CHEMICAL PROPERTIES OF GGBS

Characteristics	Values
Physical form	Off white powder
Specific gravity	2.88
Surface area(m^2/kg)	400
SiO_2(%)	32.50
CaO(%)	37.05
MgO(%)	7.81
SO_3(%)	0.54
MnO(%)	0.11

3.4.3.PREPARATION OF CONCRETE

GGBS was obtained.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269 is used.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.71.Aggregates were tested as per IS:383-1970.Water content ratio kept constant in all mixes.

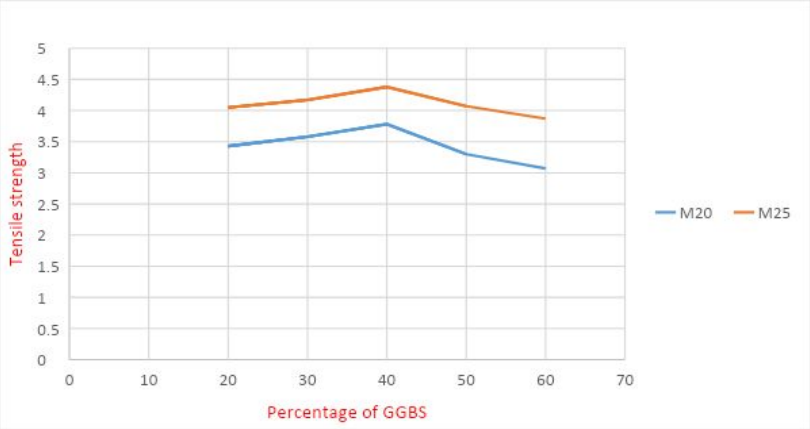
The main purpose of this experiment is to estimate the optimum amount of GGBS that can be used.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test and standard metal moulds(150 mm x 150 mm x 700 mm) for flexural strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.4.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

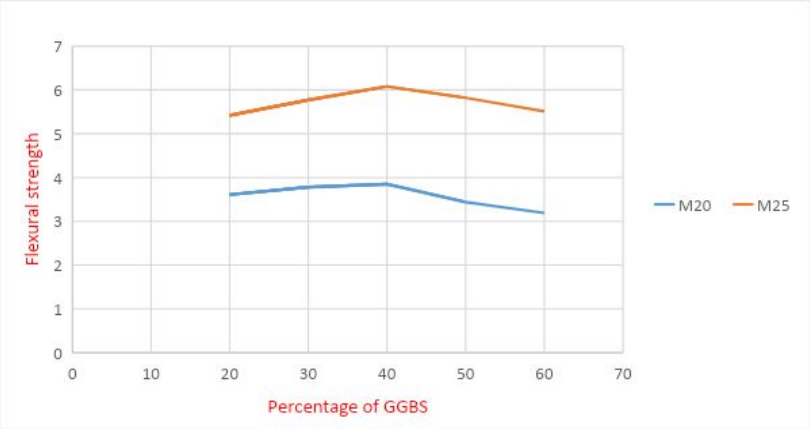
Percentage of GGBS used	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
20	3.43	4.05
30	3.58	4.17
40	3.78	4.38
50	3.30	4.07
60	3.07	3.87



3.4.5.FLEXURAL STRENGTH TEST

Experimental investigation has been carried out as per IS:516-2002.

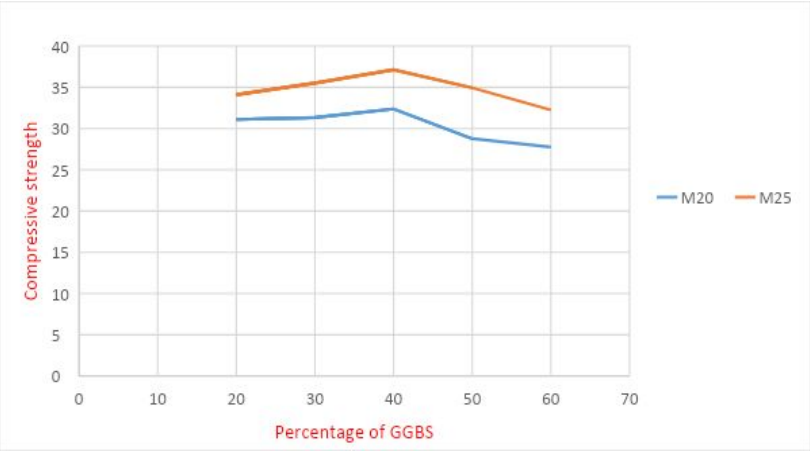
Percentage of GGBS used	Flexural strength of M20 grade of concrete(N/mm^2)	Flexural strength of M25 grade of concrete(N/mm^2)
20	3.61	5.42
30	3.78	5.77
40	3.85	6.08
50	3.44	5.82
60	3.19	5.51



3.4.6.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of GGBS used	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
20	31.10	34.12
30	31.34	35.52
40	32.38	37.13
50	28.77	34.95
60	27.75	32.25



3.4.7.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 40 percent of GGBS for both M20 and M25 grades of concrete.
- The flexural strength increases upto replacement of 40 percent of GGBS for both M20 and M25 grades of concrete.
- The compressive strength increases upto replacement of 40 percent of GGBS for both M20 and M25 grades of concrete.
- The degree of workability of concrete increases with the increase in GGBS.

3.5.QUARRY DUST

3.5.1.INTRODUCTION

Fig 3.5 Quarry dust

Quarry dust is a by-product of the crushing process which is a concentrated material to use as aggregates for concrete.In quarrying,the rock has been crushed.During the process,the dust generated is known as quarry dust and it formed as waste.So becomes useless material and also results in pollution.It has been used as building materials,road development materials,aggregates and bricks.

3.5.2.PHYSICAL AND CHEMICAL PROPERTIES OF QUARRY DUST

Property	Quarry rock dust
Specific gravity	2.54-2.60
Bulk relative density (kg/m3)	1720-1810
Absorption (%)	1.20-1.50
Moisture content (%)	Nil
Fine particles less than 0.075mm (%)	12-15
Sieve analysis	Zone II

Constituents	Quarry Dust (%)
SiO_2	65.73
Al_2O_3	19.31
Fe_2O_3	5.27
CaO	3.64
MgO	2.16
Na_2O	Nil
K_2O	2.26
TiO_2	1.28
Loss of ignition	0.35

3.5.3.PREPARATION OF CONCRETE

Quarry dust was obtained from nearby quarry in madurai,Tamilnadu.In our experiment,IS method has been used to get proportions M25 grade of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.68.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.

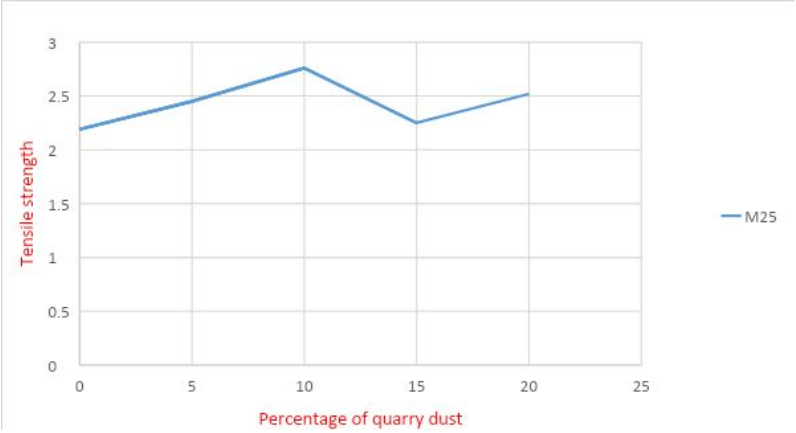
The main purpose of this experiment is to estimate the optimum amount of quarry dust that can be replaced with cement.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test and standard metal moulds(150 mm x 150 mm x 700 mm) for flexural strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.5.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

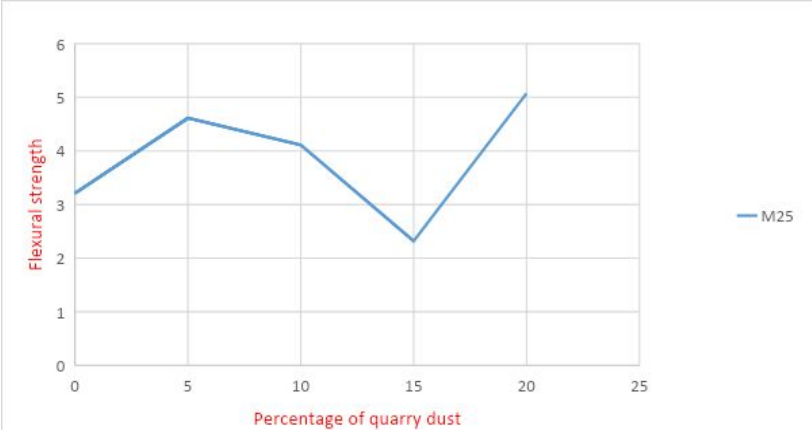
Percentage of quarry dust used as replacement with cement	Tensile strength of M25 grade of concrete(N/mm^2)
0	**2.19**
5	**2.45**
10	**2.76**
15	**2.25**
20	**2.52**



3.5.5.FLEXURAL STRENGTH TEST

Experimental investigation for split tensile strength has been carried as per IS:516-2002.

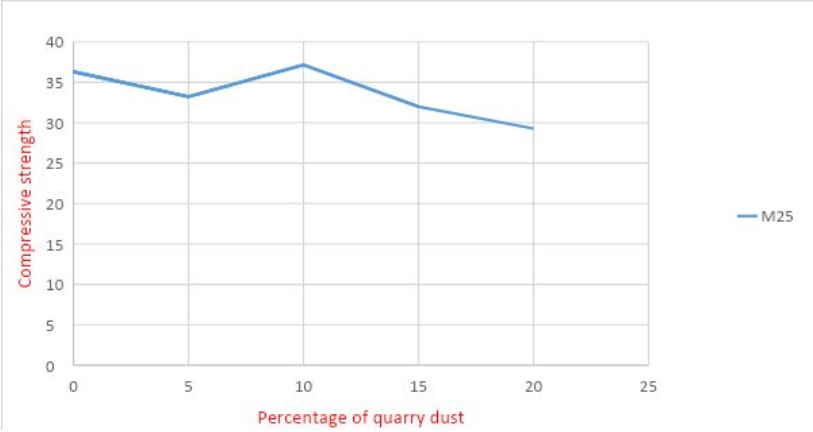
Percentage of quarry dust used as replacement with cement	Flexural strength of M25 grade of concrete(N/mm^2)
0	3.21
5	4.61
10	4.11
15	2.32
20	5.07



3.5.6.COMPRESSIVE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out for the concrete cubes.

Percentage of quarry dust used as replacement with cement	Compressive strength of M25 grade of concrete(N/mm^2)
0	36.30
5	33.22
10	37.14
15	31.98
20	29.26



3.5.7.RESULTS AND DISCUSSION

- The tensile strength is increasing as the percentage of quarry dust increases.
- The flexural strength increases upto replacement of 20 percent of quarry dust.
- The compressive strength is greater when 10 percent of quarry dust is used as replacement.
- The degree of workability of concrete increases with the increase in quarry dust.

3.6.WASTE FOUNDRY SAND

3.6.1.INTRODUCTION

Fig 3.6 Waste foundry sand

Waste foundry sand is a byproduct from the production of both ferrous and nonferrous metal castings.It is a high quality silica content.Currently

approximately 500.000 to 700,000 tons of foundry sand are used annually in engineering applications.The largest volume of foundry sand is used in geotechnical applications.According to American Foundry Society,less than 30 percentage of the 10 million tons of foundry sands generated annually are recycled.

In our experiment,we used waste foundry sand as a replacement with fine aggregate.

3.6.2.PHYSICAL AND CHEMICAL PROPERTIES OF WASTE FOUNDRY SAND

Sl. No	Properties	Burnt Black Sand	Used and weathered sand	Currently used sand	Local Fine Aggregate
1.	Specific gravity	2.42	2.52	2.50	2.74
2.	Fineness modulus	4.09	4.25	4.24	3.60
3.	Water absorption	8.1%	11.02%	11.08%	0.61%
4.	Silt Content	Nil	Nil	Nil	Nil
4.	Bulk density a)Loose b)Compacted	1.47g/cc 1.64g/cc	1.38g/cc 1.56g/cc	1.4g/cc 1.5g/cc	1.51g/cc 1.69g/cc

3.6.3.PREPARATION OF CONCRETE

Waste foundry sand was obtained from locally.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.78.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.

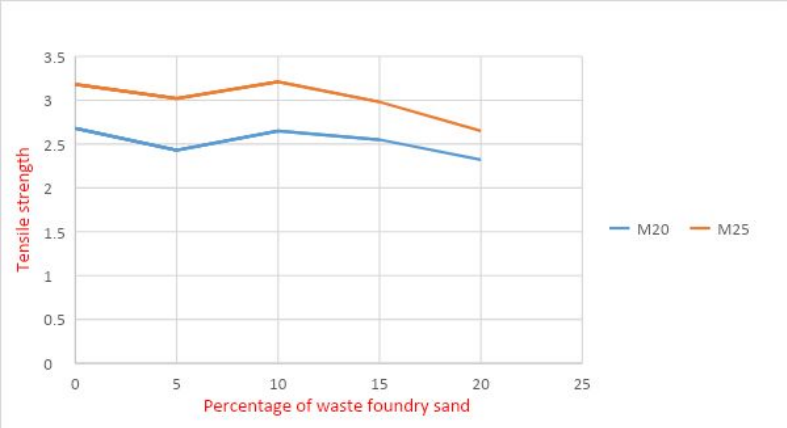
The main purpose of this experiment is to estimate the optimum amount of waste foundry sand that can be replaced with coarse aggregate.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 700 mm)for flexural strength test and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.6.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

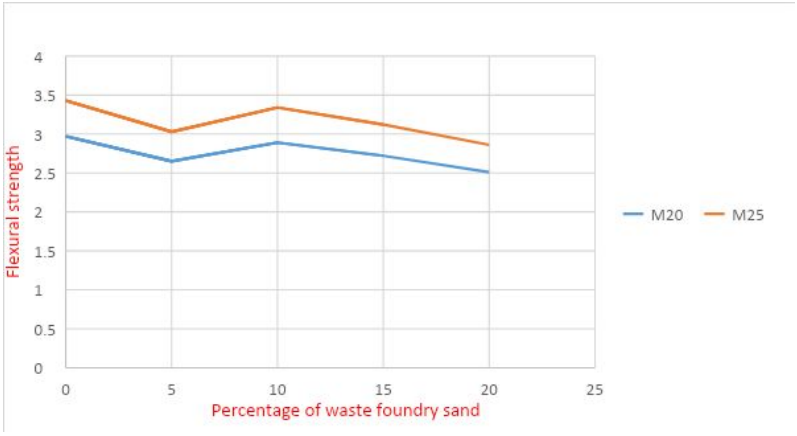
Percentage of waste foundry sand used as replacement with fine aggregate	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	2.68	3.18
5	2.43	3.02
10	2.65	3.21
15	2.55	2.98
20	2.32	2.65



3.6.5.FLEXURAL STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-2002.

Percentage of waste foundry sand used as replacement with fine aggregate	Flexural strength of M20 grade of concrete(N/mm^2)	Flexural strength of M25 grade of concrete(N/mm^2)
0	2.97	3.43
5	2.65	3.03
10	2.89	3.34
15	2.72	3.12
20	2.51	2.86



3.6.6.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 10 percent of waste foundry sand and decreases further replacement for both M20 and M25 grades of concrete.
- The flexural strength increases upto replacement of 10 percent of metakaolin and decreases further replacement for both M20 and M25 grades of concrete.
- It is resistant to sulphate attack.
- Fineness of waste foundry sand is the same as that of the local sand.

3.7.METAKAOLIN

3.7.1.INTRODUCTION

Fig 3.7 Metakaolin

Metakaolin is highly reactive super pozzolan with high purity amorphous reactive silica.It is produced from calcining kaolin clay at a specific temperature range to make it reactive.Metakaolin concrete is a more sustainable concrete compared to other types.It required low energy to produce.

In our experiments,we used metakaolin as replacement with cement.

3.7.2.PHYSICAL AND CHEMICAL PROPERTIES OF METAKAOLIN

	Item	Portland Cement	Metakaolin
Chemical properties	CaO (%)	61.60	0.5
	SiO_2 (%)	19.43	53
	Al_2O_3 (%)	5.64	43
	Fe_2O_3 (%)	4.00	1.2
	MgO (%)	2.41	0.4
	SO_3 (%)	2.94	–
	K_2O	0.78	–
	Na_2O	0.11	–
	LOI (%)	1.85	0.4
Physical properties	Specific gravity	3.19	2.60
	Fineness (m^2/kg)	328[a]	18,000[b]

[a] Blaine specific surface area.
[b] BET specific surface area.

3.7.3.PREPARATION OF CONCRETE

Metakaolin was obtained from Ashwin ceramics,Tamilnadu.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific

gravity was 2.74.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.

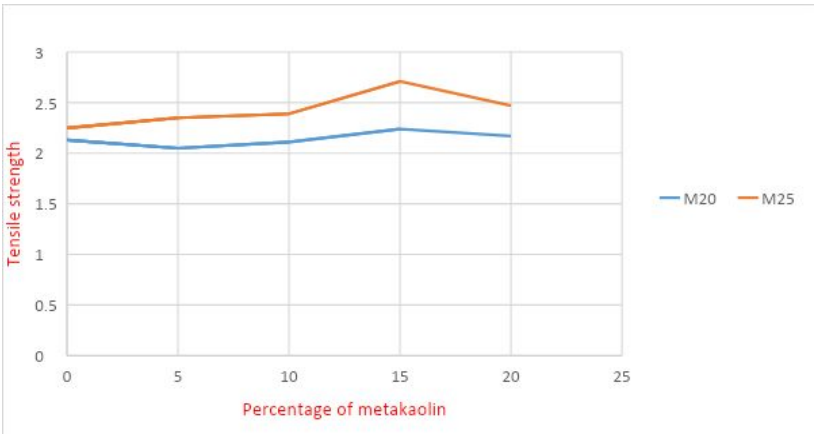
The main purpose of this experiment is to estimate the optimum amount of metakaolin that can be replaced with cement.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.7.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

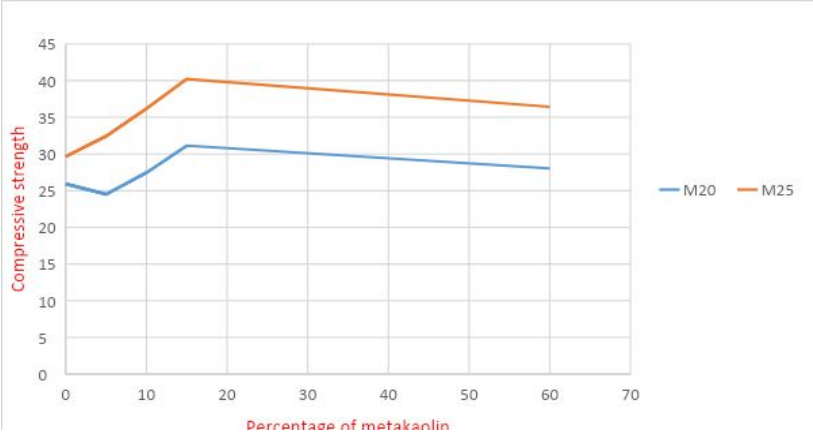
Percentage of metakaolin used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	2.13	2.25
5	2.05	2.35
10	2.11	2.39
15	2.24	2.71
20	2.17	2.47



3.7.5.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of metakaolin used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	25.92	29.66
5	24.50	32.42
10	27.45	36.17
15	31.14	40.21
60	28.04	36.42



3.7.6.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 15 percent of metakaolin and decreases further replacement for both M20 and M25 grades of concrete.
- The compressive strength increases upto replacement of 15 percent of metakaolin and decreases further replacement for both M20 and M25 grades of concrete.
- Adding metakaolin in concrete significantly enhances many performance characteristics of concrete.

3.8.WASTE PAPER PULP

3.8.1.INTRODUCTION

Fig 3.8 Waste paper pulp

The waste paper pulp production process includes pulping,screening,deslagging, flotation,washing,dispersion,bleaching and etc.

According to the Environmental Protection Agency(EPA), 27 percent of municipal solid waste is comprised of paper waste.

By using the right proportion of mixes,concrete mixtures containing waste paper pulp can be produced.we used waste paper pulp as replacement with cement.

3.8.2.PREPARATION OF CONCRETE

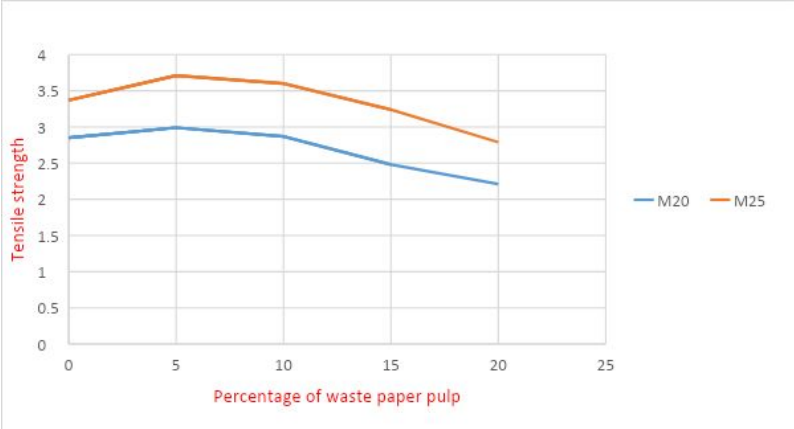
The paper pulp used in our experiment was obtained from Lakshmi paper mill,Tamilnadu.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.78.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.8.3.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

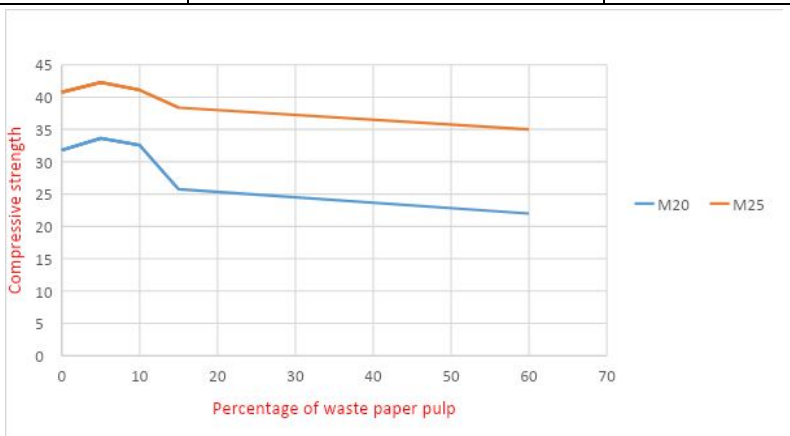
Percentage of waste paper pulp used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	**2.85**	**3.37**
5	**2.99**	**3.71**
10	**2.87**	**3.60**
15	**2.48**	**3.24**
20	**2.21**	**2.79**



3.8.4.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of waste paper pulp used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm2)	Compressive strength of M25 grade of concrete(N/mm2)
0	31.78	40.76
5	33.63	42.27
10	32.57	41.11
15	25.76	38.37
60	21.99	34.99



3.8.5.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 10 percent of waste paper pulp and decreases further replacement for both M20 and M25 grades of concrete.
- The compressive strength increases upto replacement of 10 percent of waste paper pulp and decreases further replacement for both M20 and M25 grades of concrete.
- It will help to solve the problem of disposal of waste paper pulp for the paper industry.
- It is economical to use.

3.9.WASTE RUBBER TIRES

3.9.1.INTRODUCTION

Fig 3.9 Waste rubber tires

The growing amount of waste rubber produced from used tires has resulted in an environmental problem.The disposal of waste tires into expensive and continuously decreasing numbers of landfills generates significant pressure to the local bodies identifying the potential application for these waste products.One feasible solution to overcome this issue of tire disposal waste is the use of waste rubber tire to replace aggregate in concrete.

3.9.2.PREPARATION OF CONCRETE

The waste rubber tire was obtained.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone

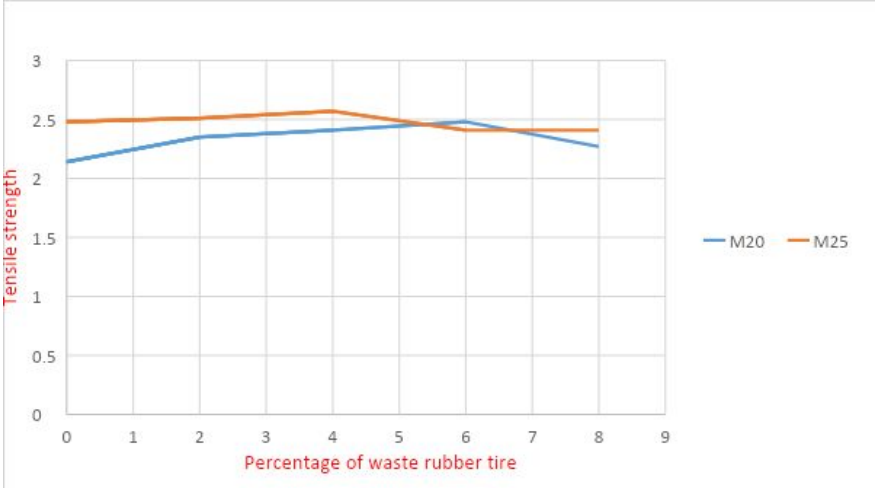
2.Size of coarse aggregate was 20 mm and specific gravity was 2.78.Aggregates were tested as per IS:383-1970.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(150 mm x 150 mm x 700 mm)for flexural strength and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.9.3.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

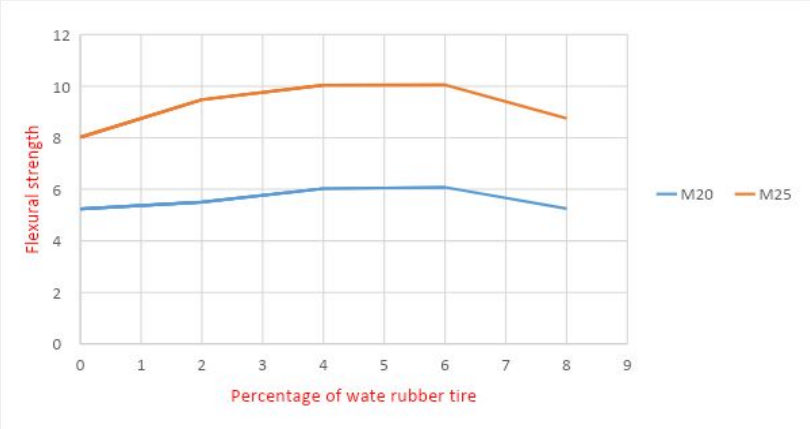
Percentage of waste rubber tire used as replacement with coarse aggregate	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	**2.14**	**2.48**
2	**2.35**	**2.51**
4	**2.41**	**2.57**
6	**2.48**	**2.41**
8	**2.27**	**2.41**



3.9.4.FLEXURAL STRENGTH TEST

Experimental investigation for flexural strength has been carried out as per IS:516-2002.

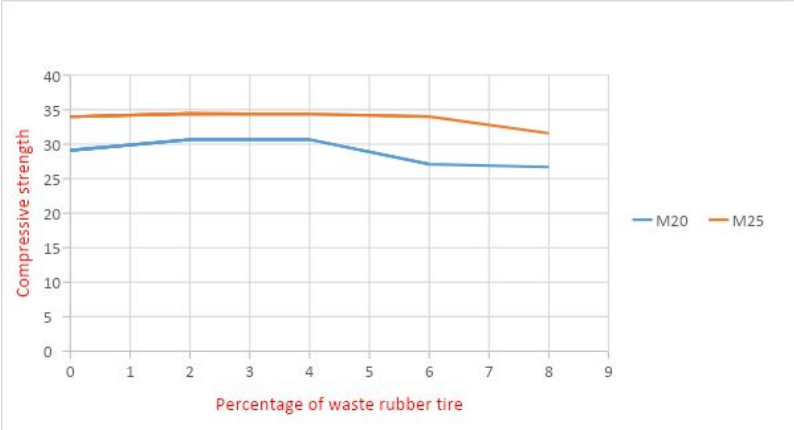
Percentage of waste rubber tire used as replacement with coarse aggregate	Flexural strength of M20 grade of concrete(N/mm^2)	Flexural strength of M25 grade of concrete(N/mm^2)
0	5.24	8.02
2	5.50	9.48
4	6.03	10.04
6	6.08	10.05
8	5.25	8.75



3.9.5.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of waste rubber tire used as replacement with coarse aggregate	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	29.11	33.97
2	30.66	34.44
4	30.66	34.36
6	27.11	33.99
8	26.69	31.58



3.9.6.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 6 percent of waste rubber tires and decreases further replacement for both M20 and M25 grades of concrete.
- The flexural strength increases upto replacement of 6 percent of waste rubber tires and decreases further replacement for both M20 and M25 grades of concrete.
- The compressive strength increases upto replacement of 4 percent of waste paper pulp and decreases further replacement for both M20 and M25 grades of concrete.
- It will help to solve the problem of disposal of waste rubber tires.

- All the replacements of coarse aggregate with waste rubber tires show gradual and strong improvement in both the grades of concrete in all the requisite strengths.

3.10.MARBLE DUST POWDER

3.10.1.INTRODUCTION

Fig 3.10 Marble dust powder

Marble dust powder is a by-product obtained during the quarrying process from the parent marble rock which contains high calcium oxide content.It has been used as a building material.It has been estimated that several million tons of marble dust powder are produced during quarrying worldwide.The industry's disposal of the marble dust powder is one of the environmental problems around the world.Therefore,maximum utilization of marble dust powder in various industrial sectors,especially the construction,agriculture and paper industries would help to protect the environment.

In our experiment,we used marble dust powder as replacement with cement.

3.10.2.PHYSICAL AND CHEMICAL PROPERTIES OF MARBLE DUST POWDER

Properties	Marble Powder
Specific gravity (g/cm^3)	2.71
Surface by blaine (cm^2/g)	4372
SiO_2 (%)	0.94
Fe_2O_3 (%)	0.46
$CaCO_3$ (%)	97.35

3.10.3.PREPARATION OF CONCRETE

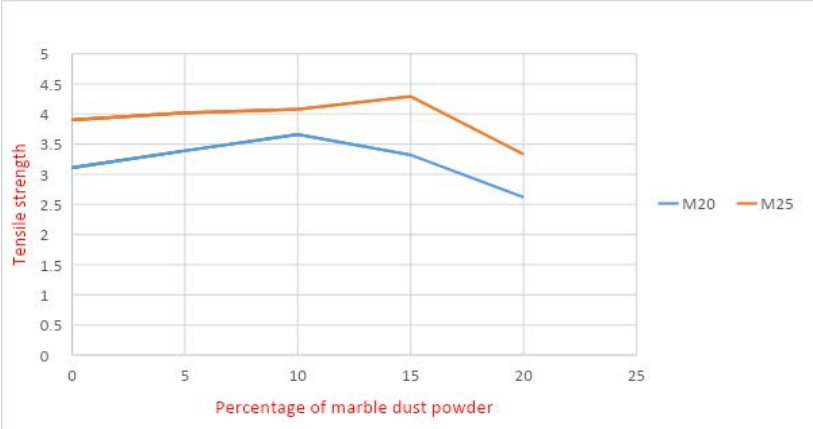
Marble dust powder was obtained.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.76.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.10.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation has been carried as per IS:5816-1999.

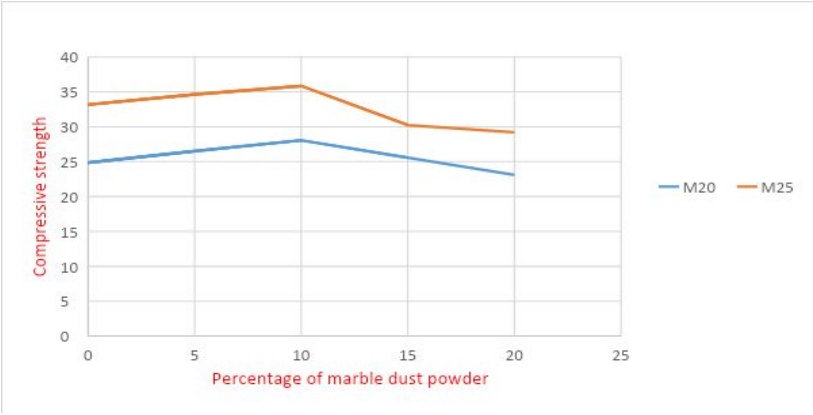
Percentage of marble dust powder used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	**3.11**	**3.90**
5	**3.39**	**4.02**
10	**3.66**	**4.08**
15	**3.32**	**4.29**
20	**2.62**	**3.33**



3.10.5.COMPRESSIVE STRENGTH TEST

Experimental investigation has been carried out as per IS:516-1959.

Percentage of marble dust powder used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	24.84	33.18
5	26.51	34.63
10	28.05	35.85
15	25.57	30.24
20	23.09	29.19



3.10.6.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 10 percent of marble dust powder for M20 and 15 percent of marble dust powder for M25 grade of concrete.
- The compressive strength increases upto replacement of 10 percent of marble dust powder and decreases further replacement for both M20 and M25 grades of concrete.
- Use of these materials leads to sustainable development in construction industries.

3.11.GRANITE WASTE POWDER

3.11.1.INTRODUCTION

Fig 3.11 Granite waste powder

Granite waste powder is a by-product obtained during the process of sawing of granite industries.Granite is generally coarse to medium grained,holocrystalline and equigranular rock.The granite waste generated by the industry has accumulated over years.

In Brazil,granite waste powder has been effectively studied and proved compatible for making ceramic bricks and tiles,the results have been acknowledged by Brazil standardization for ceramic bricks and tiles.

3.11.2.PHYSICAL AND CHEMICAL PROPERTIES OF GRANITE WASTE POWDER

Sl No	Properties	Values
1	Porosity	Very low
2	Absorption	0.5 to 1.5%
3	Specific Gravity	2.6 to 2.8
4	Density	2500-2650Kg/m^3
5	Crushing strength	1000-2500Kg/m^2
6	Frost resistance	Good
7	Fire resistance	Low
8	Color	Mostly light colored

3.11.3.PREPARATION OF CONCRETE

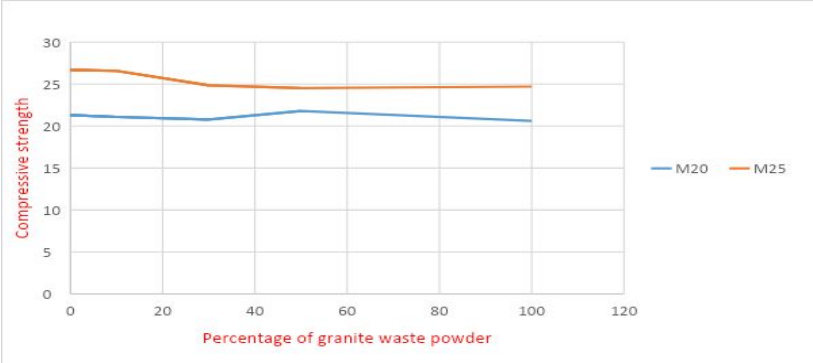
Marble dust powder was obtained.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.76.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.11.4.COMPRESSIVE STRENGTH TEST

Experimental investigation has been carried as per IS:516-1959.

Percentage of granite waste powder used as replacement with fine aggregate	**Compressive strength of M20 grade of concrete(N/mm^2)**	**Compressive strength of M25 grade of concrete(N/mm^2)**
0	**21.31**	**26.68**
10	**21.09**	**26.58**
30	**20.77**	**24.85**
50	**21.80**	**24.53**
100	**20.61**	**24.70**



3.11.5.RESULTS AND DISCUSSION

- The compressive strength increases upto replacement of 50 percent of granite waste powder for M20 and 30 percent of granite waste powder for M25 grade of concrete.
- Use of these materials leads to sustainable development in construction industries.
- The physical and chemical properties of granite waste powder are suitable for its proposed use.It has a positive effect on density, shrinkage and plasticity.

3.12.RUBY MICA DUST

3.12.1.INTRODUCTION

Ruby mica is a stable element when exposed to electricity, temperature and moisture.So,it is used as a dielectric in capacitors.In india, ruby mica is widely distributed in Jharkhand.

Generally we are using ruby mica dust as an alternative for natural sand.

3.12.2.PHYSICAL AND CHEMICAL PROPERTIES OF RUBY MICA DUST

S.N	Physical Properties	Result Value
1.	Physical State	Non toxic
2.	Appearance	Fine
3.	Particle Size	<45 micron
4.	Colour	Grey
5.	Odour	Odourless
6.	Hardness	2.5

3.12.3.PREPARATION OF CONCRETE

The large amount of ruby mica dust was obtained.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.67.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.

The main purpose of this experiment is to estimate the optimum amount of ruby mica dust that can be replaced with fine aggregate.

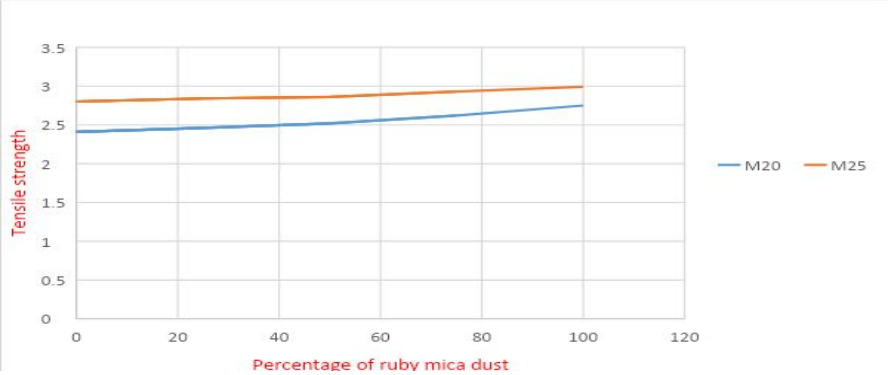
Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(150 mm x 150 mm x 700 mm)for flexural strength and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.

After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.12.4.SPLIT TENSILE STRENGTH TEST

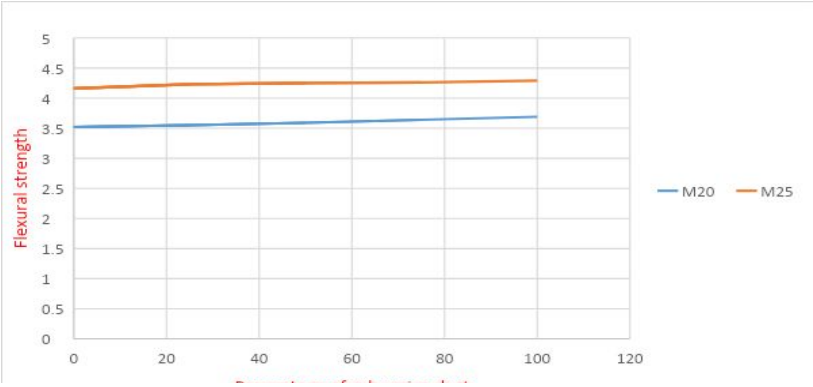
Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

Percentage of ruby mica dust used as replacement with fine aggregate	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	2.41	2.80
25	2.46	2.84
50	2.52	2.86
75	2.62	2.93
100	2.75	2.99



3.12.5.FLEXURAL STRENGTH TEST

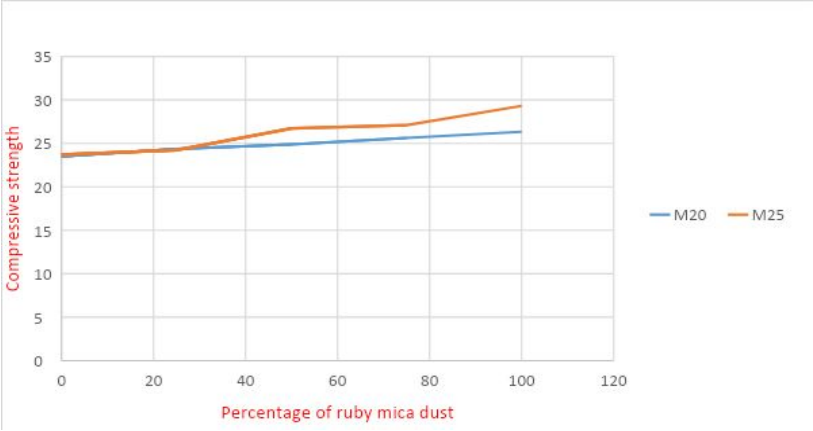
Percentage of ruby mica dust used as replacement with fine aggregate	Flexural strength of M20 grade of concrete(N/mm^2)	Flexural strength of M25 grade of concrete(N/mm^2)
0	3.52	4.16
25	3.55	4.23
50	3.59	4.25
75	3.64	4.26
100	3.69	4.29



3.12.6.COMPRESSIVE STRENGTH TEST

Experimental investigation has been carried out as per IS:516-1959.

Percentage of ruby mica dust used as replacement with fine aggregate	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	23.50	23.71
25	24.36	24.23
50	24.88	26.72
75	25.63	27.10
100	26.33	29.32



3.12.7.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 75 percent of ruby mica dust and further replacement helps to fully strength to both M20 and M25 in tensile strength.
- The flexural strength increases upto replacement of 75 percent of ruby mica dust and further replacement helps to fully strength to both M20 and M25 in flexural strength.
- The compressive strength increases upto replacement of 50 percent of ruby mica dust and further replacement helps to fully strength to both M20 and M25 in compressive strength.
- The utilization of ruby mica dust in concrete will prevent natural resources.
- Use of industrial waste materials leads to sustainable development in construction industries.

3.13.CERAMIC WASTE

3.13.1.INTRODUCTION

Fig 3.12 Ceramic waste

Ceramic waste are generated as a waste during the process of dressing and polishing.It is a non-metallic solid which is inorganic produced by the action of heat and subsequent cooling.The global production of ceramic tiles in the world is about 8500 million square meters.Recently,in the ceramic industry the production goes as waste,which is not undergoing the recycle process yet.It has been estimated that about 30 percentage of the daily production in the ceramic industry goes as waste.

In our experiment,we used ceramic waste as replacement with fine aggregate.

3.13.2.PREPARATION OF CONCRETE

Ceramic waste was obtained from Avathar ceramics,Tamilnadu.In our experiment,IS method has been used to get proportions M25 grade of concrete.Ordinary portland cement(OPC) grade-53 was used according to IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.80.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.

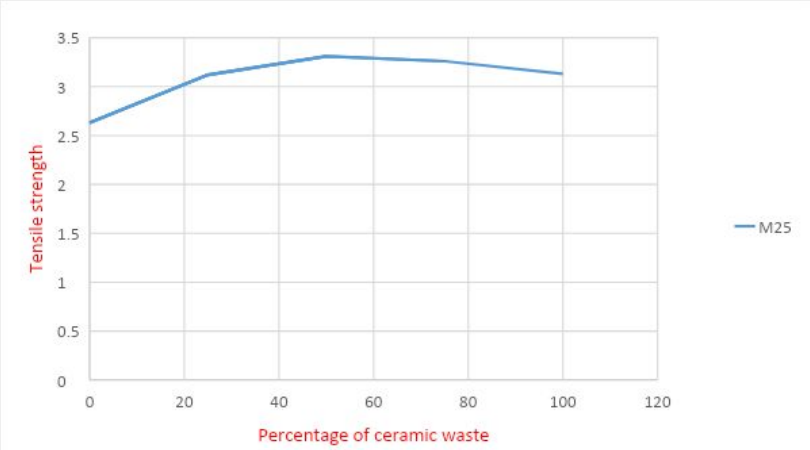
The main purpose of this experiment is to estimate the optimum of granite ceramic waste that can be replaced with fine aggregate.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(150 mm x 150 mm x 700 mm)for flexural strength and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.13.3.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

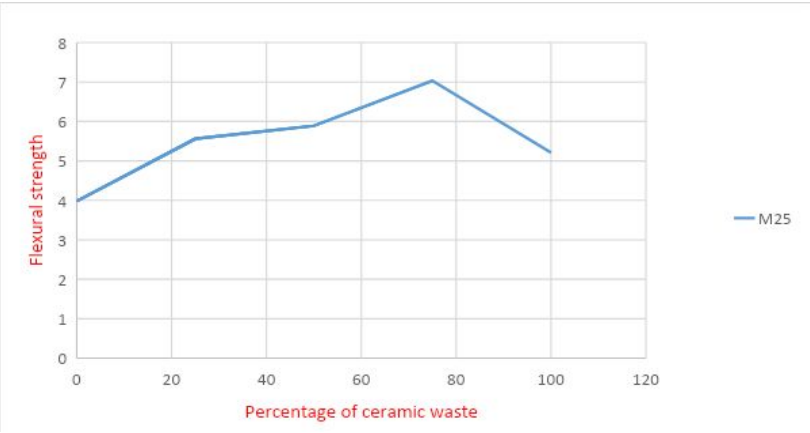
Percentage of ceramic waste used as replacement with fine aggregate	Tensile strength of M25 grade of concrete(N/mm^2)
0	**2.63**
25	**3.12**
50	**3.31**
75	**3.26**
100	**3.13**



3.13.4.FLEXURAL STRENGTH TEST

Experimental investigation has been carried out as per IS:516-2002.

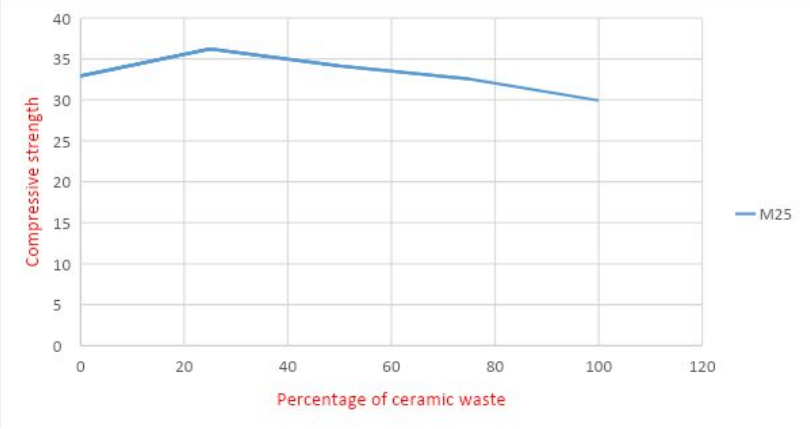
Percentage of ceramic waste used as replacement with fine aggregate	Flexural strength of M25 grade of concrete(N/mm^2)
0	**3.98**
25	**5.56**
50	**5.89**
75	**7.03**
100	**5.21**



3.13.5.COMPRESSIVE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:516-1959.

Percentage of ceramic waste used as replacement with fine aggregate	Compressive strength of M25 grade of concrete(N/mm^2)
0	**32.92**
25	**36.23**
50	**34.15**
75	**32.56**
100	**29.92**



3.13.6.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 75 percent of ceramic waste and decreases further replacement for M25 grade of concrete.
- The flexural strength increases upto replacement of 75 percent of ceramic waste and decreases further replacement for M25 grade of concrete.
- The compressive strength increases upto replacement of 25 percent of ceramic waste and decreases further replacement for M25 grade of concrete.
- It is the alternative solution of safe disposal of ceramic waste.

3.14.GLASS POWDER

3.14.1.INTRODUCTION

Fig 3.13 Glass powder

Glass is a product of the supercooling of a melted liquid mixture consisting of silicon dioxide and soda ash to a rigid condition,in which the supercooled materials does not crystallize and retains the organization and internal structure of the melted liquid(From Federal Highway Administration Research and Technology)

Approximately,10.4 million metric tons of postconsumer glass was discarded in the municipal solid waste stream in the United States.It is disposed as landfills but as a matter of fact the waste of glass does not decompose in the environment.That has created a threat to the environment.

In our experiment,we used waste glass powder as replacement with cement.

3.14.2.PHYSICAL AND CHEMICAL PROPERTIES OF WASTE GLASS POWDER

Composition	Value
SiO_2	64.32%
Al_2O_3	2.90%
CaO	18.18%
Fe_2O_3	-
SO_3	-
MgO	-
Na_2O	13.03%
K_2O	1.56%
Density	2555 kg/m^3
ıine surface area	3230 m^2/kg

3.14.3.PREPARATION OF CONCRETE

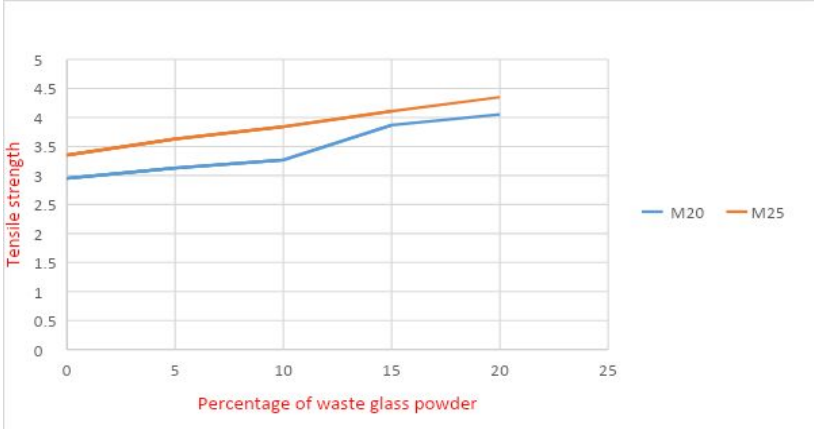
Waste glass powder was collected from IIT Madras campus.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used according to IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.85.Aggregates were tested as per IS:383-1970.Water-cement ratio kept as constant in all mixes.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 700 mm)for flexural strength and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.14.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

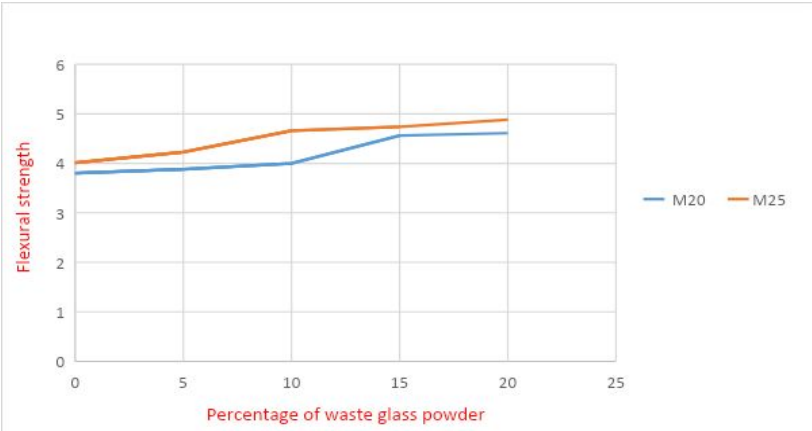
Percentage of waste glass powder used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	2.95	3.35
5	3.13	3.63
10	3.27	3.84
15	3.87	4.11
20	4.05	4.35



3.14.5.FLEXURAL STRENGTH TEST

Experimental investigation for flexural strength has been carried out as per IS:516-2002.

Percentage of waste glass powder used as replacement with cement	Flexural strength of M20 grade of concrete(N/mm^2)	Flexural strength of M25 grade of concrete(N/mm^2)
0	3.80	4.01
5	3.88	4.23
10	4.00	4.66
15	4.56	4.74
20	4.61	4.88



3.14.6.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 20 percent of waste glass powder.
- The flexural strength increases upto replacement of 20 percent of waste glass powder.
- Use of industrial waste materials leads to sustainable development in construction industries.

3.15.POLYTHENE TEREPHTHALATE(PET) BOTTLE FIBER

3.15.1.INTRODUCTION

Fig 3.14 PET bottle waste

Bottles made of PET can be used to make lower grade products.It is used as a raw material for making packaging such as bottles and containers.A million plastic bottles are bought around the world every minute and the number will jump another 20 percentage by the year 2021,creating an environmental crisis.

According to International's global packaging trends report,480 billion plastic water bottles were sold,by 2021 this will increase to 583.3 billion.There is a solution needed to overcome this problem.In our experiment,we used PET waste as replacement with fine aggregate.

3.15.2.PHYSICAL AND CHEMICAL PROPERTIES OF PET BOTTLE

Properties	Plastic powder	Plastic fibers
Diameter (mm)	1.5	0.5
Length (mm)	/	4
Apparent density(kg/m^3)	350	950
Bulk density (kg/m3)	450	1230
Fineness modulus	2.8	/
Young's modulus (MPa)	1900	2400
Tensile strength (MPa)	45	60
Melting point(°C)	135	260

3.15.3.PREPARATION OF CONCRETE

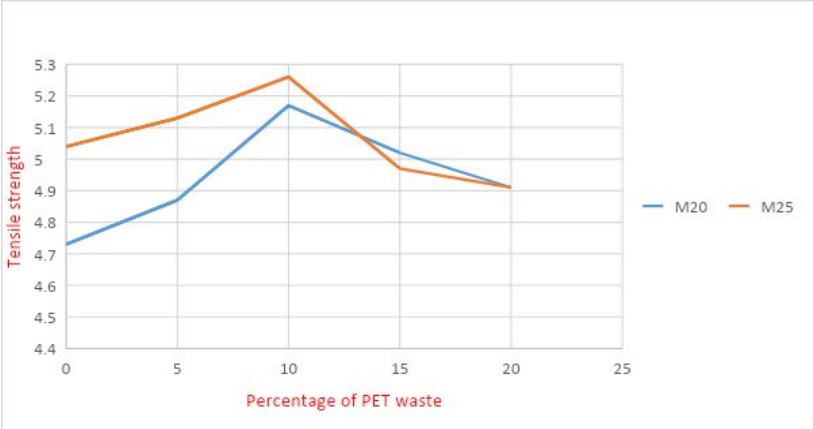
36 numbers of PET bottles were obtained.It can be shredded and grinded into granules. In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used according to IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.65.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(150 mm x 150 mm x 700 mm)for flexural strength and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.15.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

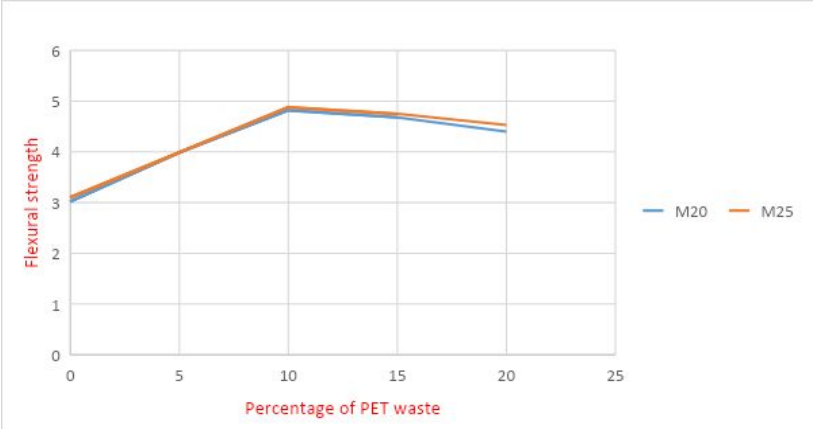
Percentage of PET waste used as replacement with fine aggregate	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	**4.73**	**5.04**
5	**4.87**	**5.13**
10	**5.17**	**5.26**
15	**5.02**	**4.97**
20	**4.91**	**4.91**



3.15.5.FLEXURAL STRENGTH TEST

Experimental investigation for flexural strength has been carried out as per IS:516-2002.

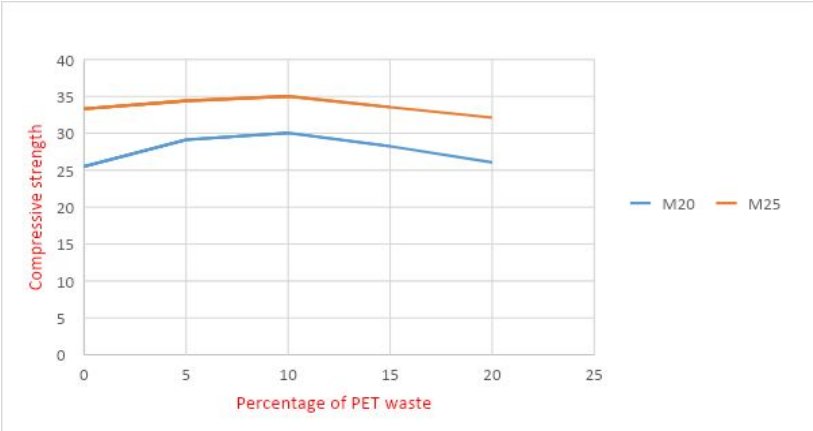
Percentage of PET waste used as replacement with fine aggregate	Flexural strength of M20 grade of concrete(N/mm^2)	Flexural strength of M25 grade of concrete(N/mm^2)
0	3.02	3.10
5	3.99	3.99
10	4.82	4.88
15	4.68	4.75
20	4.40	4.53



3.15.6.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of PET waste used as replacement with fine aggregate	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	25.50	33.32
5	29.12	34.41
10	30.05	35.02
15	28.25	33.54
20	26.05	32.13



3.15.7.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 10 percent of waste PET fiber and decreases further replacement for both M20 and M25 grades of concrete.
- The flexural strength increases upto replacement of 10 percent of waste PET fiber and decreases further replacement for both M20 and M25 grades of concrete.

- The compressive strength increases upto replacement of 10 percent of waste PET fiber and decreases further replacement for both M20 and M25 grades of concrete.
- It is economically very less compared to fine aggregate.

3.16.PLASTIC WASTE

3.16.1.INTRODUCTION

Fig 3.15 Plastic waste

Plastic is the general common term for a wide range of synthetic or semi synthetic organic amorphous solid materials derived from oil and natural gas.Since the late 19th century,we have depended on plastic as an affordable and durable material.

The important problem is the volume of plastic that is exported to developing nations from Europe,the US and Japan.Recycling standards in developing countries do not compare to standards deployed in the developed world and, as such, releasing plastics into the environment is causing significant environmental damage.

Each year approximately eight million tonnes of plastic ends up in our oceans.Some researchers predict that this figure could double by 2025.There is a solution needed to these problems.Utilization of wastage is one of the solutions.

3.16.2.PREPARATION OF CONCRETE

Plastic waste was collected and cleaned.It was then sundried for few hours and then melted in container.The melted plastic was drawn into sheets by pouring it on

flat surface ,and then allowed to cool down and get hard.Cooled and hard plastic sheets were then broken into smaller particles by hammering the sheets.

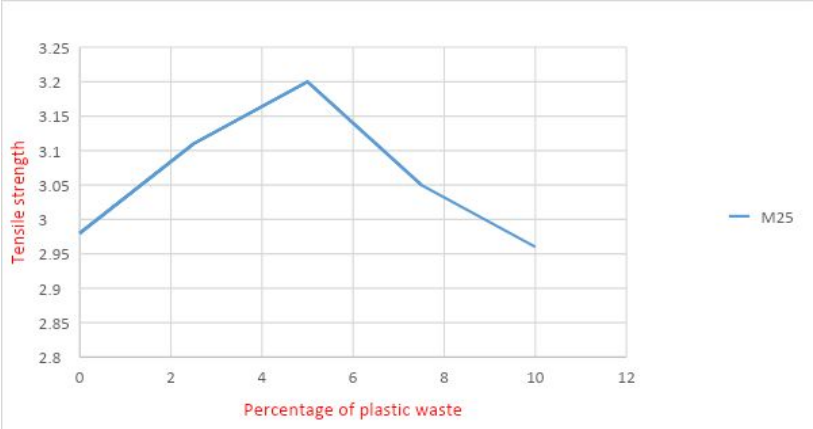
In our experiment,IS method has been used to get proportions M25 grade of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.62.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.The main purpose of this experiment is to estimate the optimum amount of plastic waste that can be replaced with coarse aggregate.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test and standard metal moulds(150 mm x 150 mm x 700 mm) for flexural strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

3.16.3.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

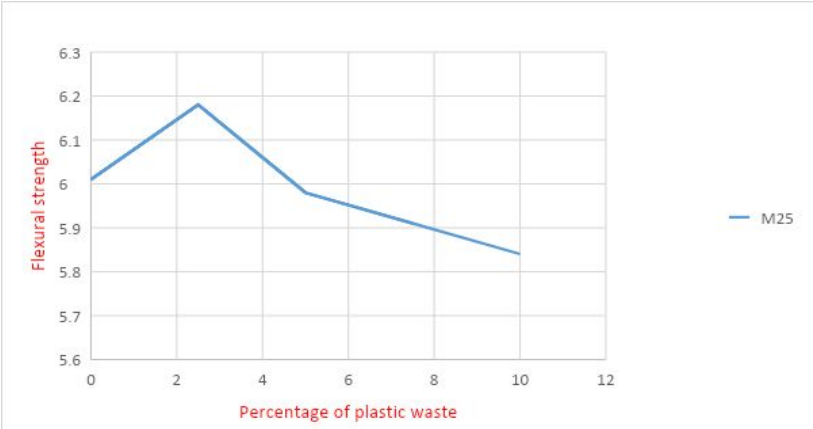
Percentage of plastic waste used as replacement with coarse aggregate	Tensile strength of M25 grade of concrete(N/mm^2)
0	**2.98**
2.5	**3.11**
5	**3.20**
7.5	**3.05**
10	**2.96**



3.16.4.FLEXURAL STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:516-2002.

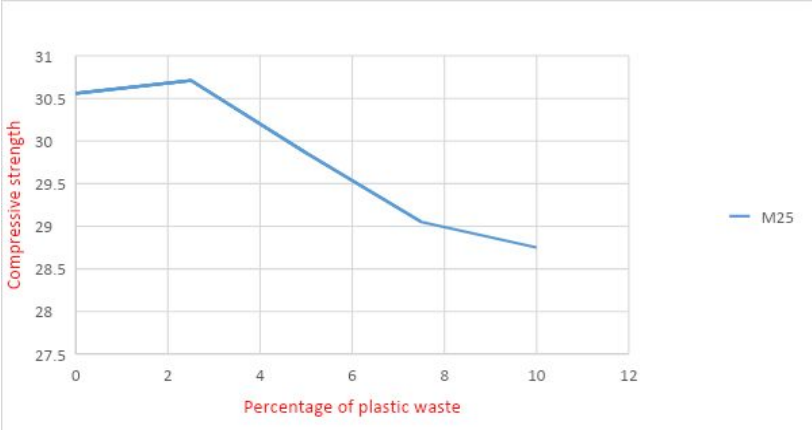
Percentage of plastic waste used as replacement with coarse aggregate	Flexural strength of M25 grade of concrete(N/mm^2)
0	6.01
2.5	6.18
5	5.98
7.5	5.91
10	5.84



3.16.5.COMPRESSIVE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:516-1959.

Percentage of plastic waste used as replacement with coarse aggregate	Compressive strength of M25 grade of concrete(N/mm^2)
0	**30.56**
2.5	**30.71**
5	**29.86**
7.5	**29.05**
10	**28.75**



3.16.6.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 5 percent of plastic waste and decreases further replacement.
- The flexural strength increases upto replacement of 2.5 percent of plastic waste and decreases further replacement.
- The compressive strength increases upto replacement of 2.5 percent of plastic waste and decreases further replacement.
- Use of plastic waste leads to sustainable development in construction industries.

CHAPTER FOUR:STRENGTH OF CONCRETE CONTAINING AGRICULTURAL WASTAGE

4.1.SUGARCANE BAGASSE ASH

4.1.1.INTRODUCTION

Fig 4.1 Sugarcane bagasse ash

Sugarcane bagasse ash is a by-product of sugar factories found after burning sugarcane bagasse which itself is found after the extraction of all economical sugar from sugarcane.Use of bagasse ash as a mineral admixture needs to be established, especially in India, where sugarcane cultivation is widespread, to reduce land required for its disposal and cement consumption in construction industry.

The major quantities of waste generated from agricultural sources include sugarcane bagasse, rice husk and coconut husk.Reusing such waste as a sustainable construction seems to be a suitable solution for the problem of landfilling and the high cost of construction materials.

4.1.2.PHYSICAL AND CHEMICAL PROPERTIES OF SUGARCANE BAGASSE ASH

Bagasse Ash Properties	Bagasse Ashes			
	A	B	C	D
Silica (SiO_2), (%)	8.2	24.1	37.0	40.6
Alumina (Al_2O_3), (%)	7.1	15.3	18.6	16.7
Ferrit (Fe_2O_3), (%)	2.9	10.7	3.7	7.8
Quick lime (CaO), (%)	*9.4*	*26.1* *)	*5.9*	*9.6* **)
Magnesium (MgO), (%)	1.5	5.5	1.3	4.5
CaO / SiO_2	*0.182*	*1.08*	*0.159*	*0.236*
$CaO/(SiO_2 + Al_2O_3)$	*0.15*	*0.66*	*0.11*	*0.17*
Loss of ignition (LOI), (%)	45.5	21.8	9.5	8.7
(SiO_2)+ (Al_2O_3) +(Fe_2O_3), (%)	*18.2*	*51.1* *)	*60.1*	*75.1* **)
Degree of acidity (pH)	10.2	11.3	11.9	12.2
Specific Gravity (G)	2.3	2.35	2.41	2.45

Note: *) equivalent to C class Fly Ash: CaO > 20%, (SiO_2)+ (Al_2O_3) +(Fe_2O_3), (50 - 60%). **) equivalent to F class Fly Ash:

4.1.3.PREPARATION OF CONCRETE

Sugarcane bagasse consists of 50 percentage of cellulose,25 percentage of hemicellulose and 25 percentage of lignin.Each ton of sugarcane generates approximately 26 percentage of bagasse.For our experiment sugarcane bagasse ash was from the Government sugarcane mill,Tamilnadu.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used according to IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.73.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

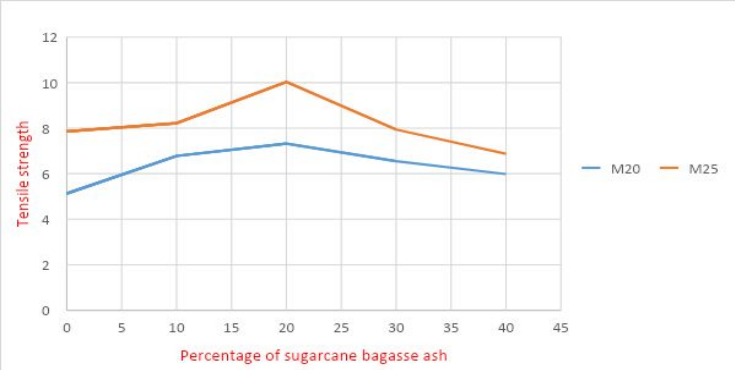
The main purpose of this experiment is to estimate the optimum amount of sugarcane bagasse that can be replaced with cement.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(150 mm x 150 mm x 700 mm)for flexural strength and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

4.1.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

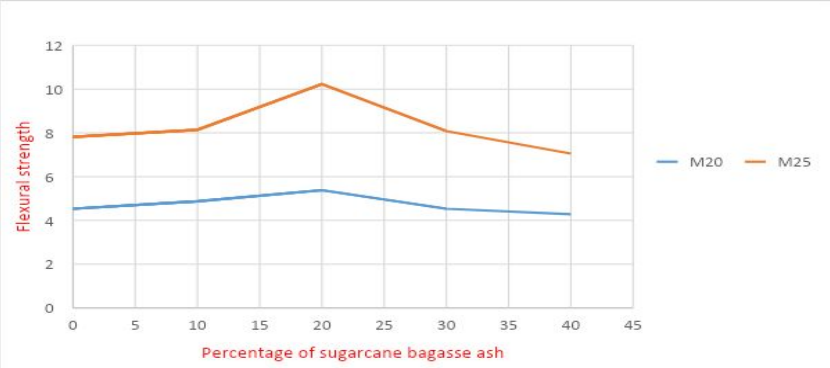
Percentage of sugarcane bagasse used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	**5.13**	**7.86**
10	**6.78**	**8.22**
20	**7.32**	**10.03**
30	**6.55**	**7.94**
40	**5.98**	**6.87**



4.1.5.FLEXURAL STRENGTH TEST

Experimental investigation has been carried out as per IS:516-2002.

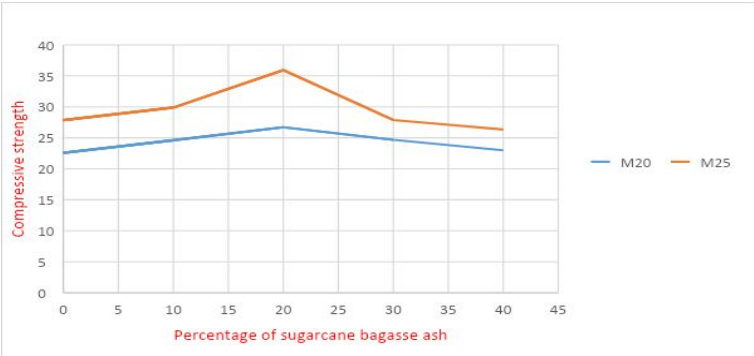
Percentage of sugarcane bagasse used as replacement with cement	Flexural strength of M20 grade of concrete(N/mm^2)	Flexural strength of M25 grade of concrete(N/mm^2)
0	4.53	7.82
10	4.87	8.14
20	5.38	10.23
30	4.53	8.08
40	4.28	7.05



4.1.6.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried as per IS:516-1959.

Percentage of sugarcane bagasse used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	22.58	27.85
10	24.62	29.88
20	26.70	35.93
30	24.67	27.87
40	22.98	26.34



4.1.7.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 20 percent of sugarcane bagasse ash and decreases further replacement for both M20 and M25 grades of concrete.
- The flexural strength increases upto replacement of 20 percent of sugarcane bagasse ash and decreases further replacement for both M20 and M25 grades of concrete.

- The compressive strength increases upto replacement of 20 percent of sugarcane bagasse ash and decreases further replacement for both M20 and M25 grades of concrete.
- It contributes to useful disposal of waste materials and reduces consumption of cement.

4.2.GROUNDNUT SHELL ASH

4.2.1.INTRODUCTION

Fig 4.2 Groundnut shell ash

Groundnut shells are composed of cellulose, hemicellulose and lignin.Increased groundnut production leads to the accumulation of these groundnut shells which is not utilized,thus either burnt or buried.Groundnut shell can be utilized in many ways.It can be used as cement in concrete.Thus,the possible use of agriculture waste will considerably reduce and eliminate the environmental hazards caused by such waste.

4.2.2.PHYSICAL AND CHEMICAL PROPERTIES OF GROUNDNUT SHELL ASH

Sl.No	Physical properties of cement	Results
1	Specific gravity	3.2
2	Standard consistency (%)	34%
3	Initial setting time (min)	135
4	Final setting time (min)	330

4.2.3.PREPARATION OF CONCRETE

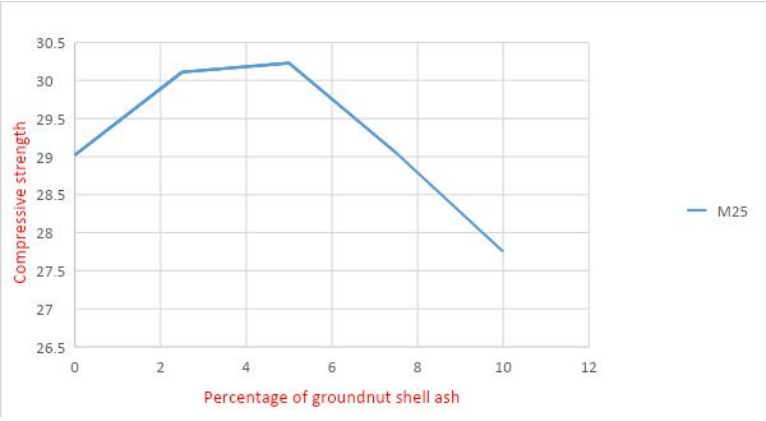
Groundnut shell was collected from farmers and broken into small pieces.In our experiment,IS method has been used to get proportions for M20 grade of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.95.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

4.2.4.COMPRESSIVE STRENGTH TEST

Experimental investigation has been carried out as per IS:516-1959.

Percentage of groundnut shell ash used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)
0	**29.02**
2.5	**30.11**
5	**30.23**
7.5	**29.05**
10	**27.75**



4.2.5.RESULTS AND DISCUSSION

- The compressive strength increases upto replacement of 5 percent of groundnut shell ash and decreases further replacement.
- Use of groundnut shell ash leads to sustainable development in construction industries.

4.3.OYSTER SHELL ASH

4.3.1.INTRODUCTION

Fig 4.3 Oyster shell

Oyster shell is composed of protein polysaccharides and minerals including calcium, magnesium, sodium, copper, iron and some microelements.More than 7 million tons of "nuisance waste" discarded every year by the seafood industry.Researcher James morries calls the practice "A colossal waste of potentially useful biomaterials."

According to scientist morris,"Reusing shell waste is a perfect example of a circular economy,particularly as shells are a valuable biomaterial.Not only does it improve the sustainability of the aquaculture industry moving forwards,but it can also provide secondary economic benefits to shellfish growers and protectors as well".

4.3.2.PHYSICAL AND CHEMICAL PROPERTIES OF OYSTER SHELL ASH

OXIDE	PERCENTAGE
Sio2	1.60
Al2o3	0.92
Cao	51.56
Mgo	1.43
Na2o	0.08
K20	0.06
H2o	0.31
Loi	41.84

4.3.3.PREPARATION OF CONCRETE

Oyster shell was collected from nearby the seashore area and broken into small pieces.In our experiment,IS method has been used to get proportions for M25 grade of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.69.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

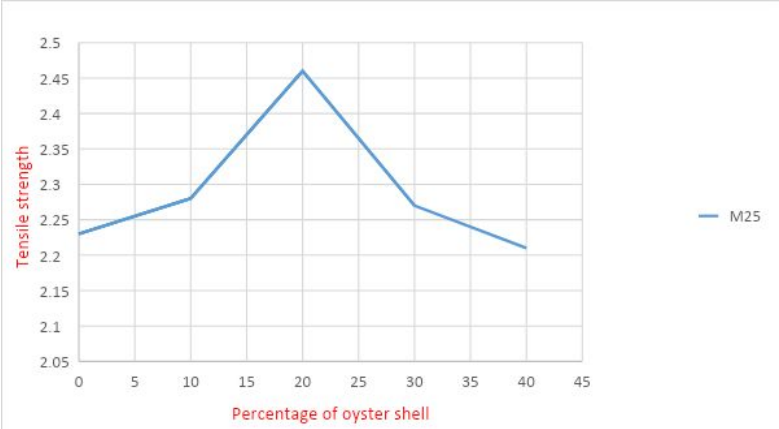
The main purpose of this experiment is to estimate the optimum amount of oyster shell that can be replaced with coarse aggregate.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

4.3.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

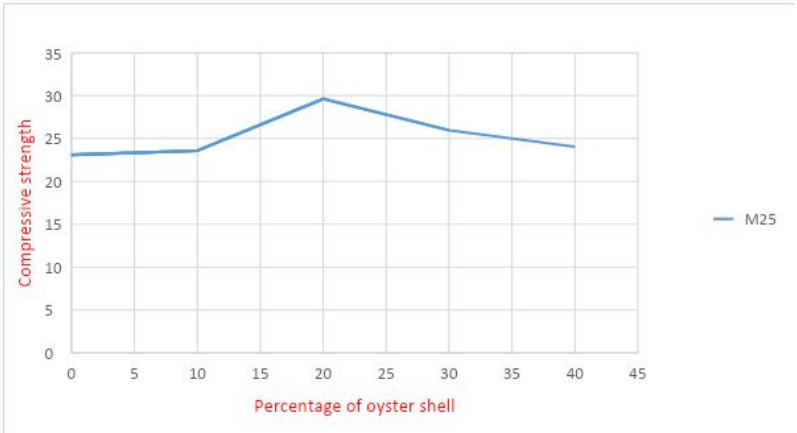
Percentage of oyster shell used as replacement with coarse aggregate	Tensile strength of M25 grade of concrete(N/mm^2)
0	**2.23**
10	**2.28**
20	**2.46**
30	**2.27**
40	**2.21**



4.3.5.COMPRESSIVE STRENGTH TEST

Experimental investigation for split compressive strength has been carried out as per IS:516-1959.

Percentage of oyster shell used as replacement with coarse aggregate	Compressive strength of M25 grade of concrete(N/mm^2)
0	23.11
10	23.58
20	29.63
30	25.97
40	24.05



4.3.6.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 20 percent of the oyster shell and decreases further replacement.
- The compressive strength increases upto replacement of 20 percent of the oyster shell and decreases further replacement.
- It reduces the construction cost by reducing the cost of coarse aggregate.
- It reduces the environmental pollution due to oyster shells.

4.4.TOBACCO WASTE ASH

4.4.1.INTRODUCTION

Tobacco product waste is the most common items picked up in urban and beach cleanups worldwide.It consists all the toxins,nicotine and carcinogens.According to Ocean conservancy data,this material comprises the largest percentage of waste collected globally during the coastal clean up each year.In our experiment,we used tobacco waste ash as replacement with cement.

4.4.2.PHYSICAL AND CHEMICAL PROPERTIES OF TOBACCO WASTE ASH

Chemical composition		Physical properties	
Component	(%)		
SiO_2	68,50	Specific gravity (kg dm^{-3})	1,60
Al_2O_3	14,90	Bulk density (kg dm^{-3})	0,45
Fe_2O_3	3,10	Water absorption (%)	39
CaO	2,90		
Na_2O	4,10		
K_2O	2,75		
MgO	0,95		

4.4.3.PREPARATION OF CONCRETE

The tobacco waste composed of tobacco stems was collected from a local factories and burned.The resulting ashes were sieved to eliminate undesirable particles.In our experiment,IS method has been used to get proportions for M20 grade of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific

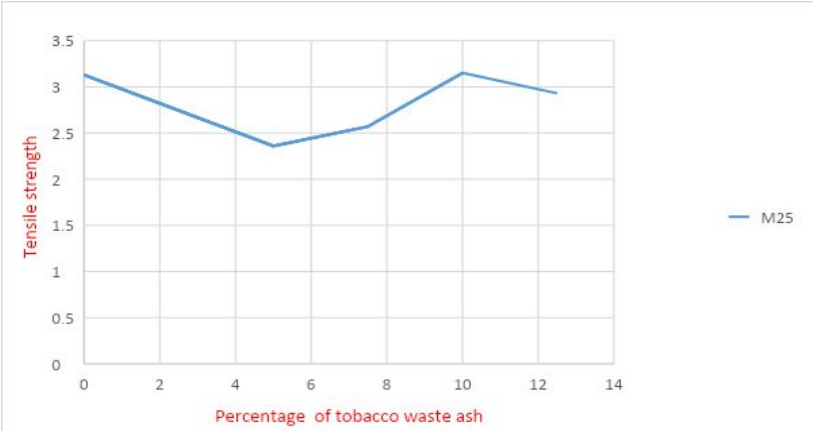
gravity was 2.66.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test and standard metal moulds(150 mm x 150 mm x 700mm).After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

4.4.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

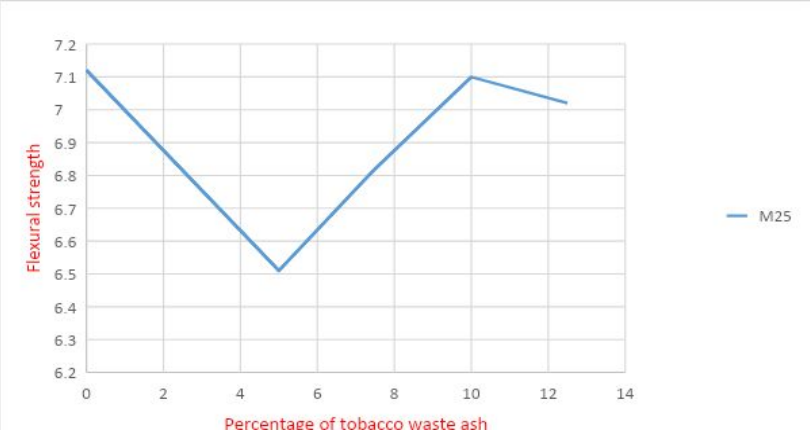
Percentage of tobacco waste ash used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)
0	**3.13**
5	**2.36**
7.5	**2.57**
10	**3.15**
12.5	**2.93**



4.4.5.FLEXURAL STRENGTH

Experimental investigation has been carried out as per IS:516-2002.

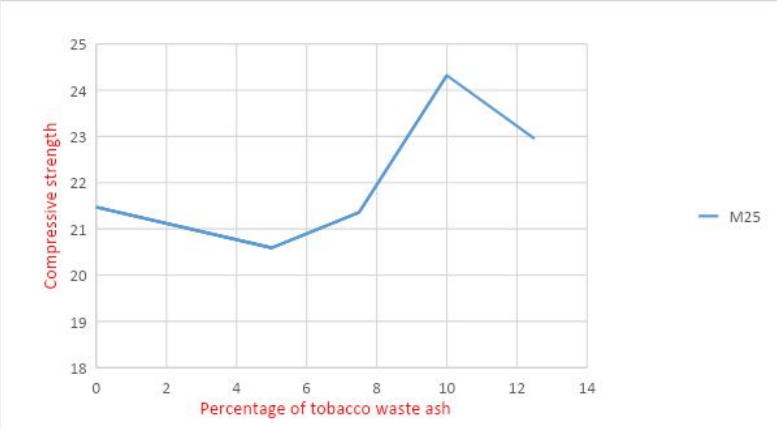
Percentage of tobacco waste ash used as replacement with cement	Flexural strength of M20 grade of concrete(N/mm^2)
0	7.12
5	6.51
7.5	6.82
10	7.10
12.5	7.02



4.4.6.COMPRESSIVE STRENGTH TEST

Experimental investigation has been carried out as per IS:516-1959.

Percentage of tobacco waste ash used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)
0	21.47
5	20.59
7.5	21.36
10	24.32
12.5	22.95



4.4.7.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 10 percent of tobacco waste ash and decreases further replacement.
- The flexural strength increases upto replacement of 10 percent of tobacco waste ash and decreases further replacement.
- The compressive strength increases upto replacement of 10 percent of tobacco waste ash and decreases further replacement.
- It reduces the construction cost by reducing the cost of cement.

4.5.RICE HUSK ASH

4.5.1.INTRODUCTION

Fig 4.4 Rice husk ash

Rice husk is an agro-waste material abundantly available in all rice producing countries.It constitutes 20 percentage of the 500 million tons of paddy produced in the world.It is a environment threat causing damage to land and surrounding where

it is dumped.Therefore the commercial usage of rice husk and its ash is the alternative solution to disposal problem.

Rice husk ash is a highly reactive pozzolan obtained when rice husks are calcinated below the crystallization temperature at 780 degree celsius.It is found to be good material which fulfills the physical characteristics and chemical composition of mineral admixtures.

4.5.2.PHYSICAL AND CHEMICAL PROPERTIES OF RICE HUSK ASK

Sl. No	Parameters	Values
1	Fineness passing 45 micron	96%
2	Specific gravity	2.06
3	Specific surface (nitrogen absorption) m^2/ kg	27400
4	Silicon dioxide (SiO_2)	87.20%
5	Aluminium oxide (Al_2O_3)	0.15%
6	Ferric oxide (Fe_2O_3)	0.16%
7	Calcium oxide (CaO)	0.55%
8	Magnesium oxide (MgO)	0.35%
9	Sulphur trioxide (SO_3)	0.24%
10	Carbon (C)	5.91%
11	Loss on ignition	5.44%
12	Pozzolanic activity	84%
13	Particle size (μm)	7

4.5.3.PREPARATION OF CONCRETE

The rise husk was collected from a locally and deliberated until fine ash is being produced.The resulting ashes were sieved to eliminate undesirable particles.In our experiment,IS method has been used to get proportions for M20 grade of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.71.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

The main purpose of this experiment is to estimate the optimum amount of rice husk ash that can be replaced with cement.

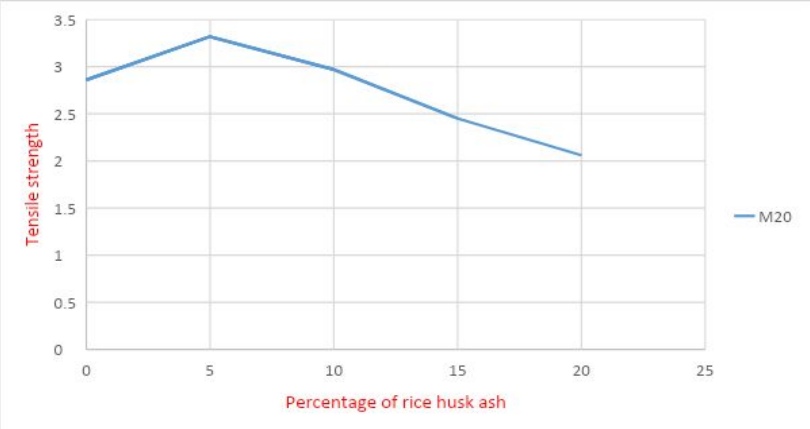
Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test and standard metal moulds(150 mm x 150 mm x

700mm).After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

4.5.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

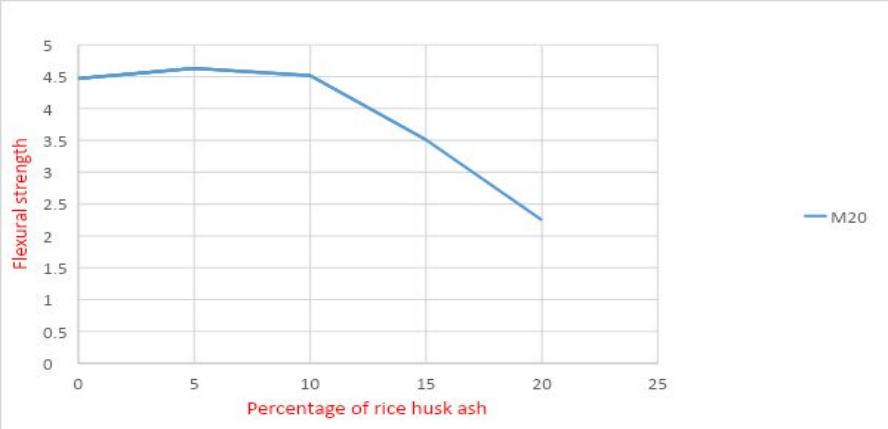
Percentage of rice husk ash used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)
0	**2.86**
5	**3.32**
10	**2.97**
15	**2.45**
20	**2.06**



4.5.5.FLEXURAL STRENGTH

Experimental investigation has been carried out as per IS:516-2002.

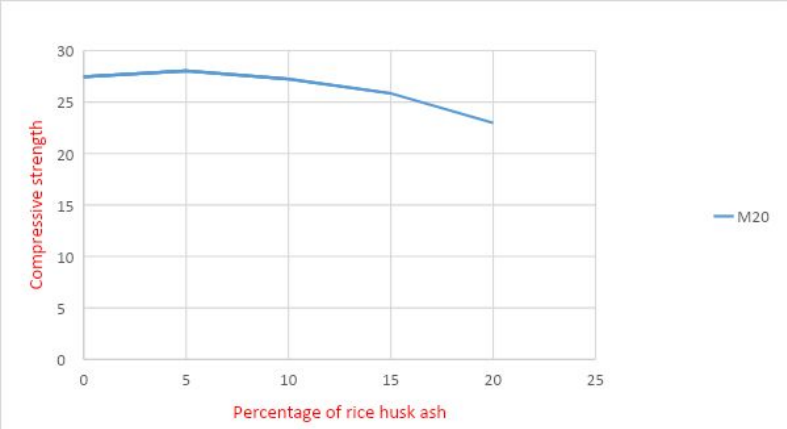
Percentage of rice husk ash used as replacement with cement	Flexural strength of M20 grade of concrete(N/mm^2)
0	4.47
5	4.63
10	4.52
15	3.51
20	2.25



4.5.6.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of rice husk ash used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)
0	27.47
5	28.04
10	27.23
15	25.85
20	22.98



4.5.7.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 5 percent of rice husk ash and decreases further replacement.
- The flexural strength increases upto replacement of 5 percent of rice husk ash and decreases further replacement.
- The compressive strength increases upto replacement of 5 percent of rice husk ash and decreases further replacement.
- It is environment polluting material and best supplementary material for cement replacement.

4.6.PALM OIL FUEL ASH

4.6.1.INTRODUCTION

Fig 4.5 Palm oil fuel ash

Palm oil fuel ash is a by-product obtained during the burning of waste materials such as palm kernel shell,palm oil fiber and palm oil husk.The growing increase in amount of palm oil fuel ash is major concern for environment.There is a solution needed for the efficient disposal of palm oil fuel ash.The use of palm oil fuel ash in concrete contributes in effective disposal of fuel ash and also contributes to the strength and other structural properties of concrete.

In our experiment,we used palm oil fuel ash as replacement with cement.

4.6.2.PHYSICAL AND CHEMICAL PROPERTIES OF PALM OIL FUEL ASH

Physical Properties	**OPC**	**POFA**
Specific surface area (m^2/kg)	475	1440
Retained on sieve No.325 (%)	5%	1.5%
Chemical Analysis		
Silicon Dioxide (SiO_2)	28.2	53.82
Aluminium Oxide (AL_2O_3)	4.9	5.66
Ferric Oxide (Fe_2O_3)	2.5	4.54
Calcium Oxide (CaO)	50.4	4.24
Magnesium Oxide (MgO)	3.1	3.19
Sodium Oxide (Na_2O)	0.2	0.1
Potassium Oxide (K_2O)	0.4	4.47
Sulphur Oxide (SO_3)	2.3	2.25
Phosporus Oxide (P_2O_2)	<0.9	3.01
Loss On Ignition (LOI)	2.4	10.49

4.6.3.PREPARATION OF CONCRETE

Palm oil fuel ash was obtained from burning palm oil husk and fine particles are settled using water.The ash is then pulverized before using in concrete.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.73.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(150 mm x 150 mm x 700 mm)for flexural strength.

After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

4.6.4.FLEXURAL STRENGTH TEST

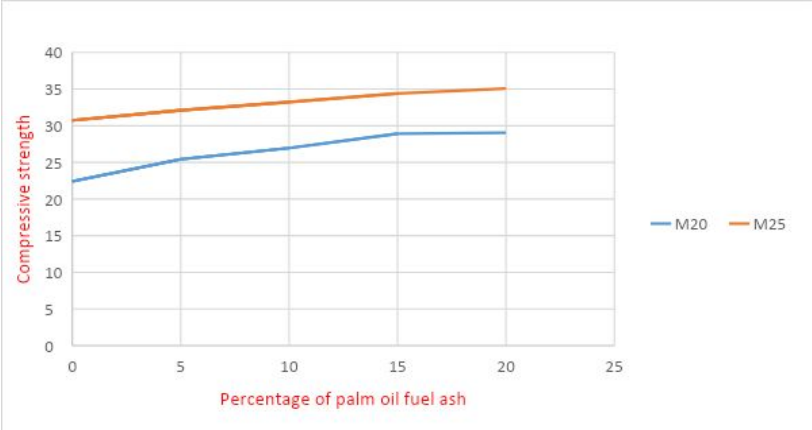
Experimental investigation for flexural strength has been carried out as per IS:516-2002.

Percentage of palm oil fuel ash used as replacement with cement	Flexural strength of M20 grade of concrete(N/mm^2)	Flexural strength of M25 grade of concrete(N/mm^2)
0	2.24	2.34
5	2.26	2.66
10	3.15	3.23
15	3.33	4.14
20	4.07	4.91

4.6.5.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of palm oil fuel ash used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	22.42	30.73
5	25.43	32.10
10	26.95	33.23
15	28.90	34.41
20	29.05	35.08



4.6.6.RESULTS AND DISCUSSION

- The flexural strength increases upto replacement of 20 percent of palm oil fuel ash for both M20 and M25 grades of concrete.
- The compressive strength increases upto replacement of 20 percent of palm oil fuel ash for both M20 and M25 grades of concrete.
- It contributes to useful disposal of waste materials and reduces consumption of cement.

4.7.COCONUT SHELL

4.7.1.INTRODUCTION

Fig 4.6 Coconut shell

Coconut shell is a hard material between the husk and coconut fruit.It is an agricultural waste and is available in plentiful quantities throughout tropical countries worldwide.It is subjected to open burning which contributes significantly to CO2 and emissions.

In our experiment, we used coconut shells as a replacement with coarse aggregate.

4.7.2.PREPARATION OF CONCRETE

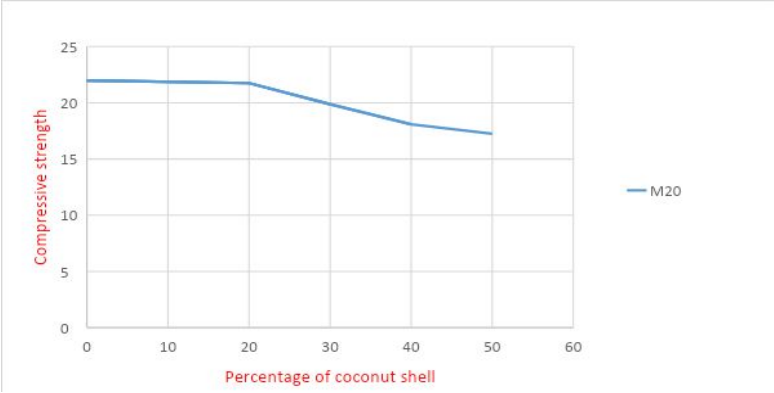
Coconut shell was obtained from farmers and broken into small pieces.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.95.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

The main purpose of this experiment is to estimate the optimum amount of coconut shell that can be replaced with coarse aggregate.Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

4.7.3.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of coconut shell used as replacement with coarse aggregate	Compressive strength of M20 grade of concrete(N/mm^2)
0	21.98
20	21.75
30	19.87
40	18.08
50	17.24



4.7.4.RESULTS AND DISCUSSION

- The compressive strength increases upto replacement of 20 percent of coconut shell and decreases further replacement.
- Using the coconut as aggregate in concrete can reduce the material cost in construction.

4.8.EGG SHELL POWDER ASH

4.8.1.INTRODUCTION

Fig 4.7 Eggshell powder ash

Eggshells are one of the solid wastes in the world and are considered as hazardous waste according to European Commission Regulations(ECR).According to studies, eggshell waste generation is 150,000 tons annually in the United States.In United States,waste eggshells disposed in landfills at a cost of 100,000 dollars annually.Eggshells are one of the sources of calcium carbonate which can replace limestone.

In our experiment,we used eggshell powder ash as replacement with cement.

4.8.2.PHYSICAL AND CHEMICAL PROPERTIES OF EGG SHELL POWDER ASH

	White eggshell powder	Brown eggshell powder
Moisture (%)	0.46	0.20
Protein (%)	3.92	5.04
Ash (%)	94.61	94.28
Fat (%)	0.35	0.08
Calcium (%)	34.12	33.13
Magnesium (%)	0.29	0.36
Phosphorous (%)	0.04	0.07
Potassium (%)	0.03	0.04
Sodium (%)	0.05	0.04
Copper (ppm)	<1ppm	<1ppm
Iron (ppm)	22ppm	<1ppm
Manganese (ppm)	<1ppm	<1ppm
Zinc (ppm)	<1 ppm	<1ppm

4.8.3.PREPARATION OF CONCRETE

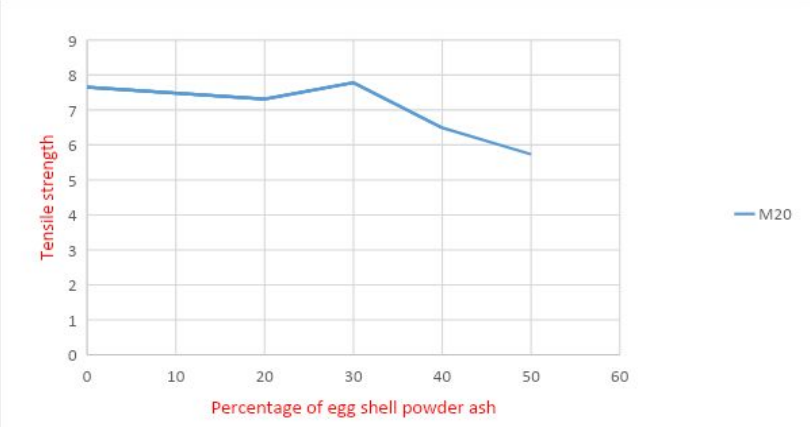
Eggshell was obtained and broken into small pieces.In our experiment,IS method has been used to get proportions for M20 grade of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.79.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

The main purpose of this experiment is to estimate the optimum amount of egg shell powder ash that can be replaced with cement.Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.After casting,concrete cubes are cured for 28 days.Finally,samples are removed from water and dried for one day.

4.8.4.SPLIT TENSILE STRENGTH TEST

Experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

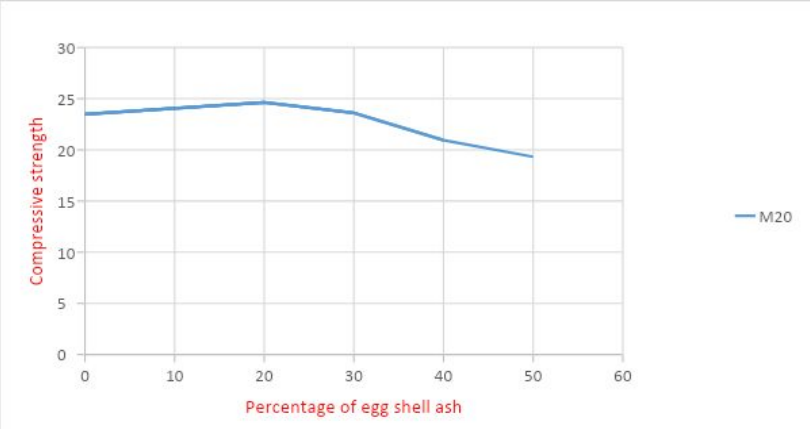
Percentage of eggshell used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)
0	**7.65**
20	**7.31**
30	**7.78**
40	**6.49**
50	**5.73**



4.8.5COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of eggshell used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)
0	23.49
20	24.63
30	23.61
40	20.94
50	19.32



4.8.6.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 30 percent of eggshell powder ash and decreases further replacement.
- The compressive strength increases upto replacement of 20 percent of eggshell powder ash and decreases further replacement.
- It is economical to use.
- It leads to sustainable development.
- The degree of workability of concrete increases with the increase of eggshell powder ash.

4.9.COW DUNG ASH

4.9.1.INTRODUCTION

Fig 4.8 Cow dung ash

Cow dung is the waste product of bovine animal species.Cow dung as a binder instead of using cement is taken under study.It is one of the solutions to solve the problems related to the environment caused by cement.

In our experiment,we used cow dung ash as replacement with cement.

4.9.2.PHYSICAL AND CHEMICAL PROPERTIES OF COW DUNG ASH

	Cowdung ash
SiO_2	69.65
Al_2O_3	4.27
Fe_2O_3	2.99
CaO	12.55
MgO	2.22
SO_3	1.36
K_2O	2.94
Na_2O	0.57
P_2O_5	1.48
Mn_2O_5	0.63
TiO_2	0.33

4.9.3.PREPARATION OF CONCRETE

Cow dung ash was obtained from Tamilnadu agricultural university,Coimbatore.In our experiment,IS method has been used to get proportions for M20 grade of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific

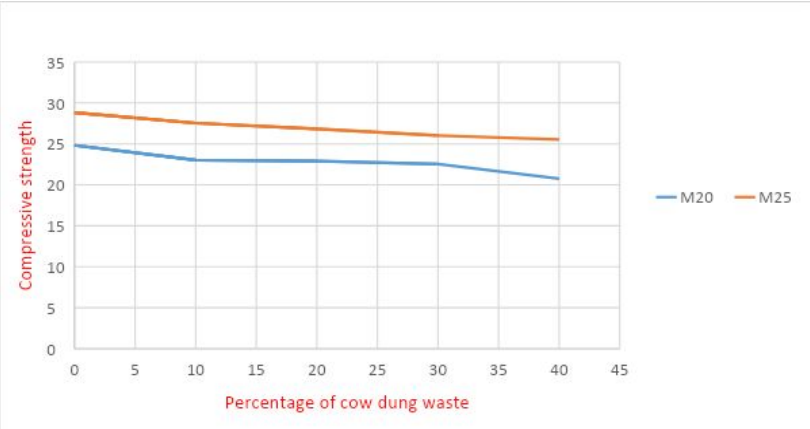
gravity was 2.86.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

The main purpose of this experiment is to estimate the optimum amount of cow dung ash that can be replaced with cement.Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test.Finally,samples are removed from water and dried for one day.

4.9.4.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of cow dung ash used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	**24.83**	**28.83**
10	**23.03**	**27.54**
20	**22.90**	**26.83**
30	**22.54**	**26.03**
40	**20.76**	**25.54**



4.9.5.RESULTS AND DISCUSSION

- The compressive strength increases upto replacement of 10 percent of palm oil fuel ash for both M20 and M25 grades of concrete.
- It will be an innovative approach towards sustainable development.

CHAPTER FIVE:STRENGTH OF CONCRETE CONTAINING CONSTRUCTION WASTAGE

5.1.BRICK AND CONCRETE WASTE

5.1.1.INTRODUCTION

Fig 5.1 Brick and concrete waste

The construction industry is growing rapidly and now we are seeing relatively huge construction.With this,a concern of its waste management also growing with the same speed everyday.Concrete and bricks are the most common materials in construction industry.In every batch of brick manufacturing,a large number of over burnt bricks are produced which acts as a waste.Concrete has created industrial waste and debris accumulation.

In our experiment,we used brick and concrete waste as coarse aggregate.

5.1.2.PREPARATION OF CONCRETE

Brick and concrete waste was obtained locally and broken into small pieces.In our experiment,IS method has been used to get proportions for M25 grade of concrete.Ordinary portland cement(OPC) was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.97.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

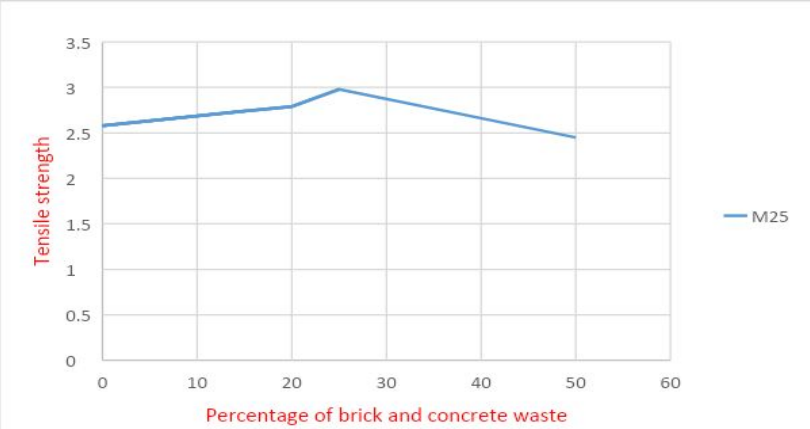
The main purpose of this experiment is to estimate the optimum amount of cow dung ash that can be replaced with cement.Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile and standard

metal moulds(150 mm x 150 mm x 700 mm) for flexural strength.Finally,samples are removed from water and dried for one day.

5.1.3.SPLIT TENSILE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:5816-1999.

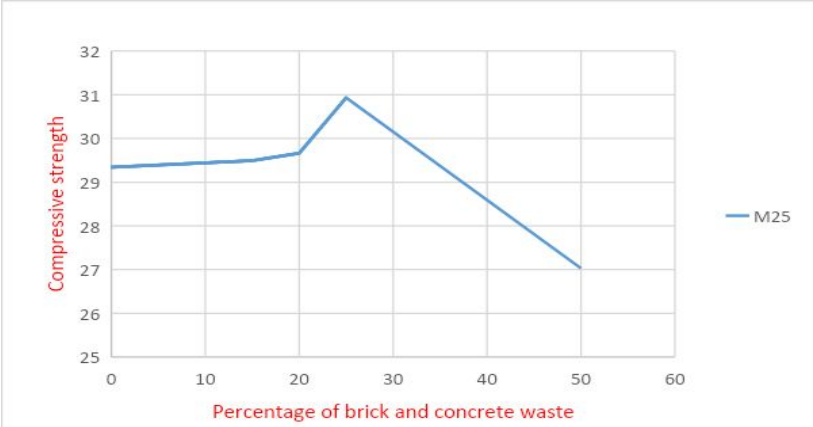
Percentage of brick and concrete waste used as replacement with cement	Tensile strength of M25 grade of concrete(N/mm^2)
0	**2.58**
15	**2.74**
20	**2.79**
25	**2.98**
50	**2.45**



5.1.4.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of brick and concrete waste used as replacement with cement	Compressive strength of M25 grade of concrete(N/mm^2)
0	29.34
15	29.49
20	29.66
25	30.93
50	27.03



5.1.5.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 25 percent of eggshell powder ash and decreases further replacement.
- The compressive strength increases upto replacement of 25 percent of eggshell powder ash and decreases further replacement.
- Use of these waste materials leads to sustainable development in construction industries.

CHAPTER SIX:STRENGTH OF CONCRETE CONTAINING NANO PARTICLES

6.1.NANO Al_2O_3 AND NANO Fe_2O_3

6.1.1.INTRODUCTION

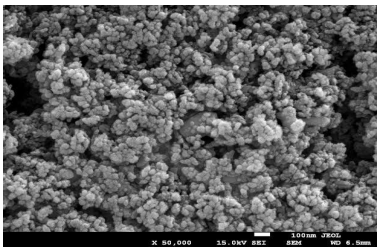


Fig 6.1 Nano Al_2O_3

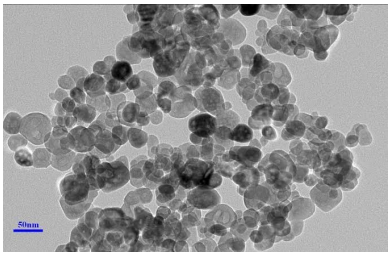


Fig 6.2 Nano Fe_2O_3

Al_2O_3 is most significantly used in the production of aluminium metal and used as an abrasive because of its hardness.

Fe_2O_3 occurs naturally as the mineral magnite.It is the main source of the iron for steel industry.

6.1.2.PREPARATION OF CONCRETE

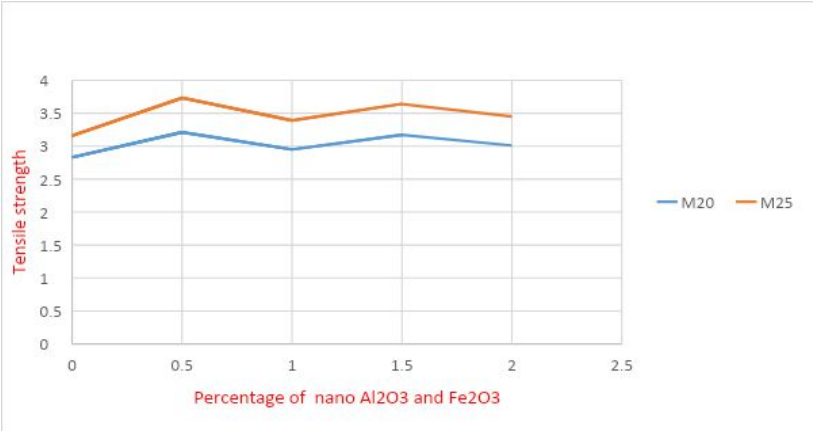
Nano Al_2O_3 and Nano Fe_2O_3 was obtained from KK chemicals,Chennai.In our experiment,IS method has been used to get proportions for M20 and M25 grades of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.72.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

The main purpose of this experiment is to estimate the optimum amount of nano Al_2O_3 and Fe_2O_3 that can be added.Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test and standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test.Finally,samples are removed from water and dried for one day.

6.1.3.SPLIT TENSILE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:5816-1999.

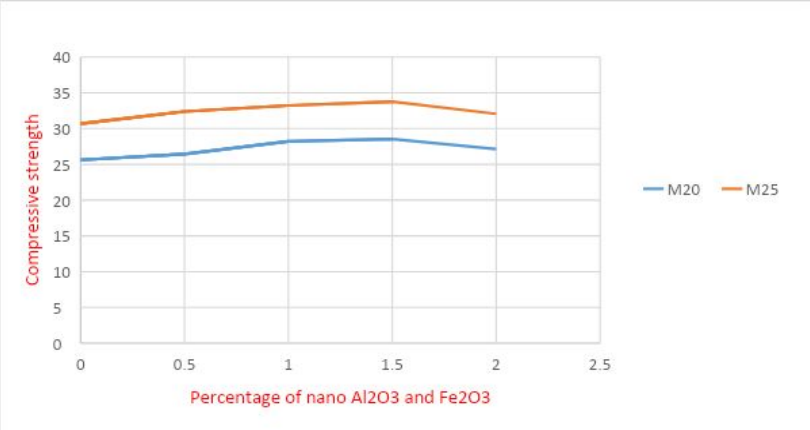
Percentage of nano Al_2O_3 and Fe_2O_3	Tensile strength of M20 grade of concrete(N/mm^2)	Tensile strength of M25 grade of concrete(N/mm^2)
0	2.83	3.16
0.5	3.21	3.73
1	2.95	3.39
1.5	3.17	3.64
2	3.01	3.45



6.1.4.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of nano Al_2O_3 and Fe_2O_3	Compressive strength of M20 grade of concrete(N/mm^2)	Compressive strength of M25 grade of concrete(N/mm^2)
0	25.63	30.68
0.5	26.45	32.39
1	28.20	33.23
1.5	28.55	33.78
2	27.14	32.07



6.1.5.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 0.5 percent of nano Al_2O_3 and Fe_2O_3 for both M20 and M25 grades of concrete.
- The compressive strength increases upto replacement of 1.5 percent of Al_2O_3 and Fe_2O_3 for both M20 and M25 grades of concrete.
- Nano particles are lighter and stronger structural composites.
- Nano particles act as a porous filler will results high durability.

6.2.NANO SiO_2

6.2.1.INTRODUCTION

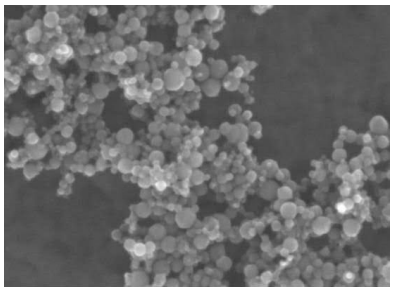


Figure 6.3

Nano SiO_2 are single particles of silicon dioxide,an inorganic metal oxide.The use of nano SiO_2 by replacement of adding a proportion of cement can lead to an increase in the compressive strength.

In our experiment,we used nano SiO_2 with silica fume as replacement with cement.

6.2.2.PHYSICAL AND CHEMICAL PROPERTIES OF NANO SiO_2

Surface area (m2/g)	200±30
SiO_2 content (percent)	>99.8
Tamped bulk density (g/l)	Approx. 40
Moisture (percent)	<1.5
Loss on ignition (percent)	<1.5
PH value (4% dispersion in water)	3.8 – 4.3
Al2O3 content (percent)	<0.05
Fe2O3 content (percent)	<0.005
TiO2 content (percent)	<0.003

6.2.3.PREPARATION OF CONCRETE

Nano SiO_2 was obtained from KK chemicals,Chennai.In our experiment,IS method has been used to get proportions for M25 grade of concrete.Ordinary portland cement(OPC) grade-53 was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.75.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

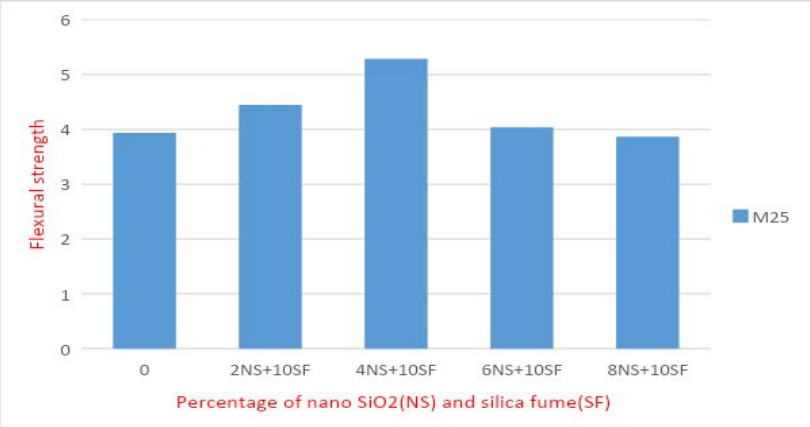
The main purpose of this experiment is to estimate the optimum amount of nano SiO_2 that can be added.Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test and standard

metal moulds(150 mm x 150 mm x 700 mm) for flexural strength test. Finally,samples are removed from water and dried for one day.

6.2.4.FLEXURAL STRENGTH TEST

The experimental investigation for flexural strength has been carried out as per IS:516-2002.

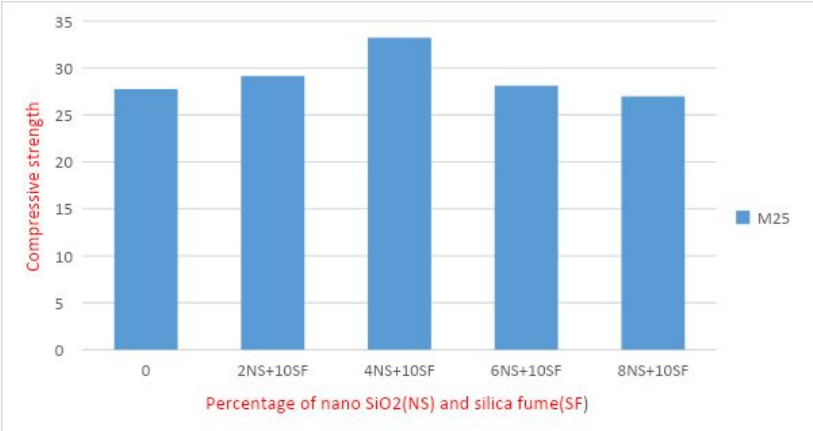
Percentage of nano SiO_2(NS) and silica fume(SF) used as replacement with cement	Flexural strength of M25 grade of concrete(N/mm^2)
0	**3.94**
2NS+10SF	**4.45**
4NS+10SF	**5.29**
6NS+10SF	**4.04**
8NS+10SF	**3.87**



6.2.5.COMPRESSIVE STRENGTH TEST

Experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of nano SiO_2(NS) and silica fume(SF) used as replacement with cement	Compressive strength of M25 grade of concrete(N/mm^2)
0	**27.75**
2NS+10SF	**29.13**
4NS+10SF	**33.21**
6NS+10SF	**28.09**
8NS+10SF	**26.98**



6.2.6.RESULTS AND DISCUSSION

- The flexural strength increases upto replacement of 4 percent of nano SiO_2 and 10 percent of silica fume and decreases further replacement.
- The compressive strength increases upto replacement of 4 percent of nano SiO_2 and 10 percent of silica fume and decreases further replacement.
- Nano particles act as a porous filler will results high durability.

CHAPTER SEVEN:STRENGTH OF CONCRETE CONTAINING MICROORGANISMS

7.1.1.BACILUS SPHAERICUS

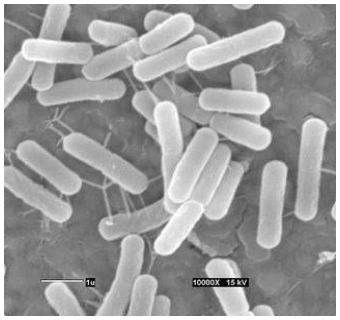


Fig 7.1 Bacillus sphaericus

Bacillus sphaericus is a gram-positive,mesophilic and rod shaped bacterium commonly found in soil.It can form resistant endospores that are tolerant to high temperature and ultraviolet light.It is a spore forming bacteria which means that can dormant for many years.

In our experiment,we used bacillus sphaericus in bacterial concrete.

7.1.2.PREPARATION OF CONCRETE

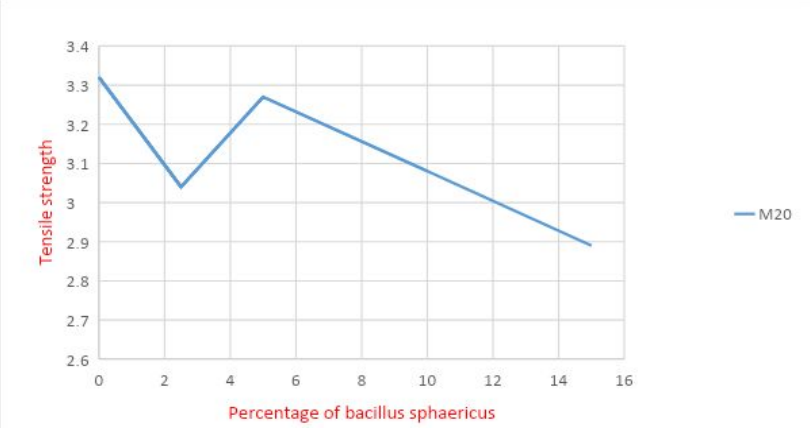
The bacteria used in our experiment was already cultivated one.It is mixed and placed in agar plate.Then,the media was heat sterilized by autoclave.Finally,the colony isolated from other colonies in air flow incubator were taken.In our experiment,IS method has been used to get proportions for M20 grade of concrete.Portland pozzolana cement(PPC) was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.79.Aggregates were tested as per IS:383-1970.Water-cement ratio kept constant in all mixes.

The main purpose of this experiment is to estimate the optimum amount of nano SiO_2 that can be added.Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test and standard metal moulds(150 mm x 150 mm x 700 mm) for flexural strength test.Finally,samples are removed from water and dried for one day.

7.1.3.SPLIT TENSILE STRENGTH TEST

The experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

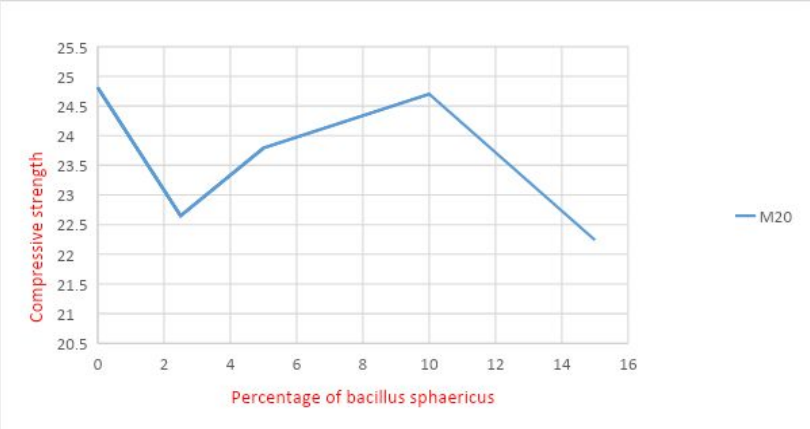
Percentage of bacillus sphaericus used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)
0	**3.32**
2.5	**3.04**
5	**3.27**
10	**3.08**
15	**2.89**



7.1.4.COMPRESSIVE STRENGTH TEST

The experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of bacillus sphaericus used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)
0	24.81
2.5	22.65
5	23.79
10	24.70
15	22.24



7.1.5.RESULTS AND DISCUSSION

- The tensile strength, flexural strength and compressive strength were increased due to the incorporation of bacteria.
- It reduces the cracks formation and improves the durability.

7.2.ESCHERICHIA COLI

7.2.1.INTRODUCTION

Fig 7.2 Escherichia coli

Escherichia coli is a type of bacteria that normally lives in our intestines.These are harmless and even help keep our digestive tract healthy.It can be used in self healing concrete to repair cracks and increase the durability of structure.

7.2.2.PREPARATION OF CONCRETE

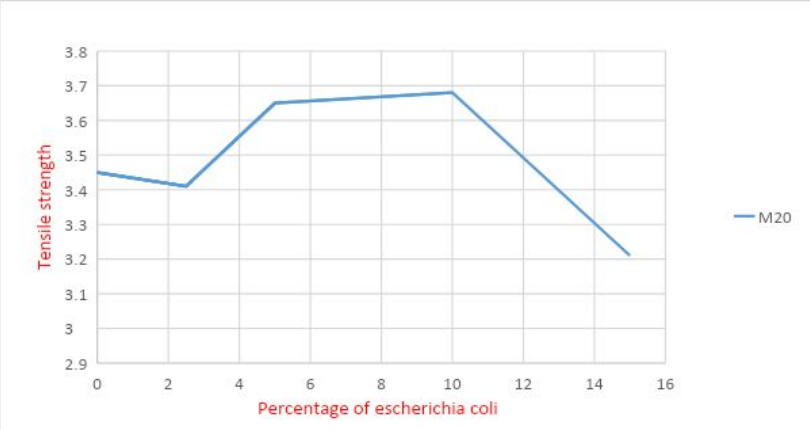
The bacteria used in our experiment was already cultivated one.It is mixed and placed in agar plate.Then,the media was heat sterilized by autoclave.Finally,the colony isolated from other colonies in air flow incubator were taken.In our experiment,IS method has been used to get proportions for M20 grade of concrete.Portland pozzolana cement(PPC) was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.70.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

The main purpose of this experiment is to estimate the optimum amount of escherichia coli that can be added.Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test,standard metal moulds(l=300 mm,d=150 mm) for split tensile strength test and standard metal moulds(150 mm x 150 mm x 700 mm) for flexural strength test.Finally,samples are removed from water and dried for one day.

7.2.3.SPLIT TENSILE STRENGTH TEST

The experimental investigation for split tensile strength has been carried out as per IS:5816-1999.

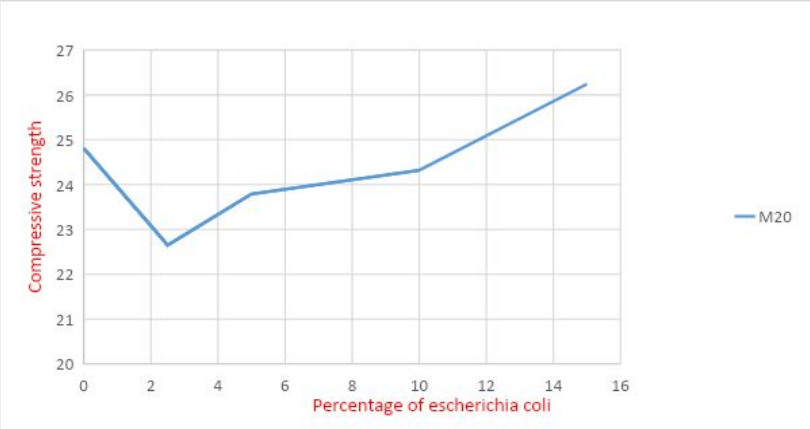
Percentage of escherichia coli used as replacement with cement	Tensile strength of M20 grade of concrete(N/mm^2)
0	3.45
2.5	3.41
5	3.65
10	3.68
15	3.21



7.2.4.COMPRESSIVE STRENGTH TEST

The experimental investigation has been carried out as per IS:516-1959.

Percentage of escherichia coli used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)
0	24.81
2.5	22.65
5	23.79
10	24.32
15	26.24



7.2.5.RESULTS AND DISCUSSION

- The tensile strength increases upto replacement of 10 percent of escherichia coli and decreases further replacement.
- The compressive strength increases upto replacement of 20 percent of escherichia coli.
- We can use the bacterial concrete to get more strength and stability.

7.3.BACILLUS SUBTILIS

7.3.1.INTRODUCTION

Fig 7.3 Bacillus subtilis

Bacillus subtilis is a gram-positive bacteria found in soil.It is used as a soil inoculant in agriculture.

7.3.2.PREPARATION OF CONCRETE

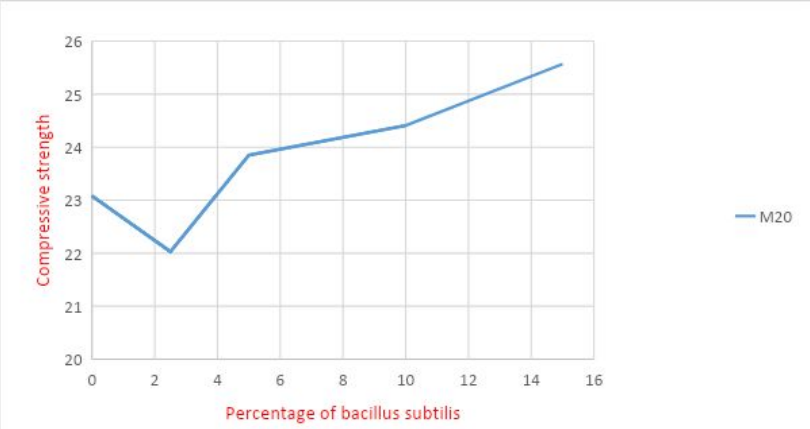
The bacteria used in our experiment was already cultivated one.It is mixed and placed in agar plate.Then,the media was heat sterilized by autoclave.Finally,the colony isolated from other colonies in air flow incubator were taken.In our experiment,IS method has been used to get proportions for M20 grade of concrete.Portland pozzolana cement(PPC) was used as per IS:12269.Zone of fine aggregate was zone 2.Size of coarse aggregate was 20 mm and specific gravity was 2.73.Aggregates were tested as per IS:383-1970.Water-cement ratio was kept constant in all mixes.

Concrete mix has been put in the standard metal moulds(150 mm x 150 mm x 150 mm)for compressive strength test.Finally,samples are removed from water and dried for one day.

7.3.3.COMPRESSIVE STRENGTH TEST

The experimental investigation for compressive strength has been carried out as per IS:516-1959.

Percentage of bacillus subtilis used as replacement with cement	Compressive strength of M20 grade of concrete(N/mm^2)
0	**23.08**
2.5	**22.03**
5	**23.85**
10	**24.41**
15	**25.57**



7.3.4.RESULTS AND DISCUSSION

- The compressive strength increases upto replacement of 20 percent of bacillus subtilis.
- We can use the bacterial concrete to get more strength and stability.

CHAPTER EIGHT:ADVANTAGES AND RECOMMENDATIONS

8.1.ADVANTAGES OF GREEN CONCRETE

- It leads to sustainable development.
- It saves energy,emissions and waste water.
- It reduces the consumption of cement and reduces CO2 emissions.
- It leads to low protection cost.
- It is one of the solutions to reduce the global waste such as industrial waste, agricultural waste,construction waste etc.
- It gives better workability.
- It gives high durability.
- Strength characteristics of green concrete is fairly equal to that of conventional concrete.

8.2.CONCLUSION

Our experiment results show there is a significant potential in waste materials to produce green concrete.It helps us to dispose the wastes.Partial replacement of different waste materials such as industrial waste,agricultural waste,construction waste gives us to make green and sustainable concrete.It shows better strength characteristics.We have already seen the strength characteristics for each partial element.

Green concrete has a huge advantages.One of the main advantages is it reduces environmental impacts and leads to sustainable development.

Our project gives awareness to those who work in concrete.We should encourage the concept of green concrete to come forward and help it reach a large group of people.

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