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RESEARCH ARTICLE

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A COMPARATIVE STUDY ON CONCRETE CONTAINING E- PLASTIC WASTE AND FLY ASH CONCRETE WITH CONVENTIONAL CONCRETE

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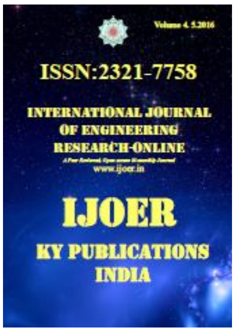


ABSTRACT

Utilization of waste materials is a partial solution to environment and ecological problems. Use of these materials not only helps in getting them utilized in cement, concrete and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects. Electronic waste, abbreviated as e –plastic waste, consist of discarded old computers, TV's, refrigerators, radios- basically any electrical or electronic appliance that has reached its end of life.

The waste material or by product from thermal plants such as fly ash as a partial replacement of cement in concrete helps in reduces the possibilities of environmental pollution. The inclusion of Fly ash affects all aspects of concrete. As a part of the composite concrete mass, it can be used both as a fine aggregate as well as a cementitious component. It influences the rheological properties of fresh concrete as well as the finished product. It improves the strength, finish and durability of the hardened mass. It reduces segregation, bleeding and lowers the heat of hydration apart from the energy and cost saving aspects.

This investigation covers the comparative study of e- plastic waste material as coarse aggregate replacement for 5%, 10%, 15%, and 20%, fly ash as cement replacement for 5%, 10%, 15%, 20% is done for M20 grade of concrete. The compressive strength, split tensile strength and flexural strength for different percentage of e-waste material and fly ash is compared with conventional concrete and corresponding results are graphically represented, and the optimum dosage of partial replacement is also suggested.

Keywords: e-plastic waste, fly ash, compressive strength, split tensile strength, flexural strength, different percentage of replacement, optimum dosage, M20 grade of concrete.

INTRODUCTION

Concrete is a composite construction material, composed of cement (commonly Portland cement) and other cementitious materials such as fly ash and slag cement, aggregate (generally a coarse aggregate made of gravel or crushed rocks such as granite, plus a fine aggregate such as sand), water and chemical admixtures.

Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration. The water reacts with the cement, which bonds the other components together, eventually creating a robust stone-like material. Concrete is used to make pavements, pipes, architectural structures, foundations, motorways/roads, bridges/overpasses, parking structures, brick/block walls and even boats.

The cement industry is one of two primary producers of carbon dioxide (CO_2), creating up to 5% of worldwide man-made emissions of this gas, of which 50% is from the chemical process and 40% from burning fuel. The CO_2 emission from the concrete production is directly proportional to the cement content used in the concrete mix; 900 kg of CO_2 are emitted for the production of every ton of cement.

It is widely known that water/cement ratio primarily governs the strength of concrete and lower water/cement ratio gives higher strength. Another important requirement is that the concrete should have adequate workability at the time of casting so that it can be properly compacted with minimum air voids.

FLY ASH: The inclusion of Fly ash affects all aspects of concrete. As a part of the composite concrete mass, it can be used both as a fine aggregate as well as a cementitious component. It influences the rheological properties of fresh concrete as well as the finished product. It improves the strength and durability of the hardened mass. It reduces segregation, bleeding and lowers the heat of hydration apart from the energy and cost saving aspects.

If the cement or fine aggregate is replaced, to improve the workability Super plasticizers are required. Super plasticizers are materials which when added in small volume to concrete or mortar can produce considerable improvements in their strength characteristics. It is also known that all the water added while mixing concrete is not completely utilized for hydration. Even with low water / cement ratio about half of the total water may still remain uncombined after long curing period, leading to porosity in the hardened concrete, resulting in poor performance. Therefore, it is necessary to keep the total water content to a limited level, resulting in lower workability, requiring better methods of compaction. This can be achieved by using suitable admixtures.

FLY ASH

There are inorganic materials that have pozzolanic or latent hydraulic properties. These very fine-grained materials are added to the concrete mix to improve the properties of concrete (mineral admixtures), or as a replacement for Portland cement. These are called as mineral admixtures. Admixtures are additions to the mix used to achieve or improve workability and other properties of concrete.

Fly ash use improves concrete performance, making it stronger, more durable, and more resistant to chemical attack. Its use also creates significant benefits for our environment. Fly ash is a by-product of coal-fired electric generating plants; it is used to partially replace Portland cement (by up to 60% by mass). The properties of fly ash depend on the type of coal burnt. In general, siliceous fly ash is pozzolanic, while calcareous fly ash has latent hydraulic properties. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants, and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash.

Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata. Since the particles solidify rapidly while suspended in the exhaust gases, fly ash particles are generally spherical in shape and range in size from 0.5 µm to 300 µm. Two classes of fly ash are defined by ASTM C618: Class F fly ash and Class C fly ash. The difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned.

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO). Other minor constituents include oxides of calcium, magnesium, titanium, sulphur, sodium and potassium. Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Fly ash produced from the burning of younger lignite or sub bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulphate contents are generally higher in Class C fly ashes

E-PLASTIC WASTE: During the past few decades, the phenomenon of premature deterioration of concrete structure is being witnessed .This has become a matter of concern in many countries bringing of the issue of durability of concrete in the fore front .Also the codes of practice in many countries including Indian Code IS 456-2000, have undergone changes Incorporating revised provisions pertaining to durability of concrete. In this context an attempt has been made to high light the method of combining certain waste e-products along with the conventional constituents of concrete which meets the requirements of special and uniformity that cannot always be achieved using the traditional methods of manufacturing of concrete.

The propose work aims at enhancing. The characteristics such as placement and compaction without segregation. It is aimed in the attempts made in this project to ensure long-term mechanical properties, early-age strength, toughness volume stability or service life in severe environments. E-waste describes loosely discarded, surplus, obsolete, broken, electrical or electronic devices. Rapid technology change ,low initial cost have resulted in a fast growing surplus of electronic waste around the globe .Several tones of E waste need to be disposed per year. Traditional landfill or stockpile method is not an environmental friendly solution and the disposal process is also very difficult to meet EPA regulations. How to reuse the non disposable E waste becomes an important research topic. However, technically, electronic waste is only a subset of WEEE (Waste Electrical and Electronic Equipment). According to the OECD any appliance using an electronic power supply that has reached its end of life would come under WEEE. E plastic waste is one of the fastest growing waste streams in the world. In developed countries, previously, it was about 1% of total solid waste generation and currently it grows to 2% by 2010.

E-PLASTIC WASTE

In developing countries, it ranges 0.01% to 1% of the total municipal solid waste generation. The e waste inventory based on this obsolescence rate and installed base in India for the year 2005 has been estimated to be 146180.00 tones. This is expected to exceed 8, 00,000 tones by 2016. In India, e-waste is mostly generated in large cities like Delhi, Mumbai and Bangalore. In these cities a complex e-waste handling infrastructure has developed mainly based on a long tradition of waste recycling. Sixty-five cities in India generate more than 60% of the total e waste generated in India. Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab in the list of e waste generating states in India. There are two small WEEE/E-waste dismantling facilities are functioning in Chennai and Bangalore. There is no large scale organized e-waste recycling facility in India and the entire recycling exists in unorganized sector.

IMPORTANCE OF THE PRESENT STUDY

E waste describes loosely discarded, surplus, obsolete, broken, electrical or electronic devices. Rapid technology change ,low initial cost have resulted in a fast growing surplus of electronic waste around the globe .Several tones of E waste need to be disposed per year. Traditional landfill or stockpile method is not an environmental friendly solution and the disposal process is also very difficult to meet EPA regulations. How to reuse the non disposable E waste becomes an important research topic. However, technically, electronic waste is only a subset of WEEE (Waste Electrical and Electronic Equipment). According to the OECD any appliance using an electronic power supply that has reached its end of life would come under WEEE. E plastic waste is one of the fastest growing waste streams in the world. In developed countries, previously, it was about 1% of total solid waste generation and currently it grows to 2% by 2010. In developing countries, it ranges 0.01% to 1% of the total municipal solid waste generation. The e waste inventory based on this obsolescence rate and installed base in India for the year 2005 has been estimated to be 146180.00 tones. This is expected to exceed 8, 00,000 tones by 2016. In India, e-waste is mostly generated in large cities like Delhi, Mumbai and Bangalore. In these cities a complex e-waste handling infrastructure has developed mainly based on a long tradition of waste recycling. Sixty-five cities in India generate more than 60% of the total e waste generated in India. Ten states generate 70% of the total e waste generated in India. Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab in the list.

CONCRETE MIX DESIGN (GRADE M20):

1. Characteristic compressive strength required in the field at 28 days. 20Mpa
2. Maximum size of aggregate 20mm
3. Degree of workability 0.90
4. Degree of quality control Good
5. Type of exposure Mild
6. Water cement ratio 0.50

B**. Test data for materials:**

1. Specific gravity of cement 3.15
2. Specific gravity of coarse aggregates 2.80
3. Specific gravity of fine aggregates 2.60
4. Water absorption:
   Coarse aggregate 0.50%
   Fine aggregate 1.0%
5. Free (surface) moisture:
   Coarse aggregate 0.25%
   Fine aggregate 2%
6. Fly ash: As per I.S.: 3812, specific gravity 2.25

Therefore, required sand content as percentage of total aggregate by absolute volume = 35-3.5
= 31.5%

Required water content = 186+5.58 =191.61kg/m^3

Determination of cement content:

Water-cement ratio = 0.50

Water =191.6 lit

Cement =191.6/0.50 =383 kg/m^3

This cement content is adequate for 'mild' exposure condition.

TABLE: 1 Determination of coarse and fine aggregate contents:

Maximum size of Aggregate (mm)	Entrapped air, as % of volume of Concrete
10	3
20	2
40	1

From the above table, for the specified maximum size of aggregate of 20mm, the amount of entrapped air in the wet concrete is 2 percent. Taking this into account and applying equations:

V = [W + C/Se+ 1/p × fa/Sfc] (1/1000)

0.98=[191.6+383/3.15+1/0.315 x fa/2.60] x 1/1000

fa =546Kg/m^3,

Ca = (l-p)/p × fa×Sca/Sfa

Ca=(1-0.315)/0.315x546x2.8/2.6

=1278.66Kg/m Ca=1188Kg/m^3

Water	=	191.6Kg
Cement	=	383Kg
Fine aggregate	=	546Kg
Coarse aggregate	=	1278.66Kg

TABLE: 2 the mix proportion then becomes:

Water	Cement	Fine aggregate	Coarse aggregate
191.6Kg	383Kg	546Kg	1188Kg
0.5	1	1.425	3.34

TABLE: 3 Comparison of plain concrete and fly ash concrete (kg/m^3)

Materials	Plain Concrete	Fly ash concrete (5%)	Fly ash concrete (10%)	Fly ash concrete (15%)	Fly ash concrete (20%)
Water (free)	191.6	182.02	182.02	182.02	182.02
OP Cement	383	363.85	344.7	325.55	306.4
Fine aggregate	546	546	546	546	546
Coarse aggregate	1278.66	1278.66	1278.66	1278.66	1278.66
	2399.26	2370.53	2351.38	2332.23	2313.08

TABLE: 4 Comparison of plain concrete and e-plastic waste concrete (kg/m^3)

Materials	Plain Concrete	E-plastic waste concrete (5%)	E-plastic waste concrete (10%)	E-plastic waste concrete (15%)	E-plastic waste concrete (20%)
Water (free)	191.6	191.6	191.6	191.6	191.6
OP Cement	383	383	383	383	383
Fine aggregate	546	546	546	546	546
Coarse aggregate	1278.66	1214.727	1150.794	1086.861	1022.928
	2399.26	2335.325	2271.394	2207.461	2143.528

EXPERIMENTAL WORK:

It was proposed to investigate the behavior of E-plastic as partial replacement of coarse aggregate in concrete and fly ash replaced cement in concrete it is compared with the conventional concrete mix.

TESTS ON CEMENT

The Ordinary Portland (OPC) cement of 43 grade conforming to IS: 8112 1989 was used for the present experimental study. The important properties of this cement have been tested using Vicat apparatus, Le chatelier flask

TABLE: 5 Consistency of cement

Sl. No	Weight of water in (gms) W_1	Weight of cement in (gms) W_2	(W_2/W_1) x 10	Depth of Penetration (mm)
1	75	300	40	6
2	78	300	38.4	5
3	81	300	37.03	6
4	84	300	35.7	6
5	87	300	34.48	5
6	90	300	33.3	6

TABLE: 6 Properties of Cement

S.NO	Characteristics	Values obtained	Standard values
1	Normal consistency	34mm	33 to 35 mm
2	Initial setting time	35 min	Not be less than 30mins
3	Final setting time	420 min	Not be greater than 600min
4	Fineness Test	2%	Not more than 10%
5	Specific gravity	3.15	3.12 to 3.19

TABLE: 7 Characteristics of Sand

S.NO	CHARACTERISTICS	VALUE
1	Specific gravity	2.6
2	Water absorption	1.85%
3	Fineness modulus	2.485

TABLE: 8 Characteristics of coarse aggregates

S.NO	CHARACTERISTICS	VALUE
1	Specific gravity	2.8
2	Water absorption	0.50%
3	Abrasion test	13.7

TABLE: 9 Physical properties of E-plastic waste

Properties	E-waste particle	Coarse aggregate
Specific gravity	1.01	2.65
Absorption (%)	<0.2	0.5
Color	Black & Dark	Dark
Shape	Angular	Angular
Crushing Value	<2%	24.20%
Impact value	<2%	22.73%

Workability test on concrete:

Result obtains from compaction factor show that the workability of concrete

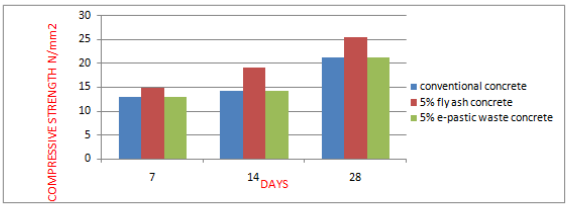
Compaction factor value = 82

COMPRESSIVE STRENGTH TEST:

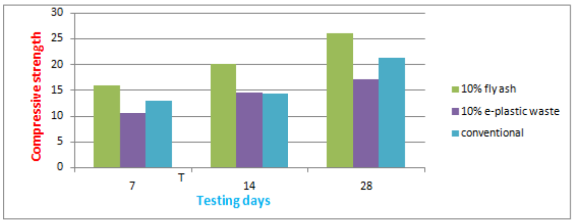
These results are obtained by testing the total 9 specimens for 7 days, 14 days and 28 days and by considering the average of the test results and that are tabulated in table

TABLE: 10 Compressive strength of fly ash and e-plastic for (5%, 10%, 15% and 20%) replacement in concrete with conventional concrete:

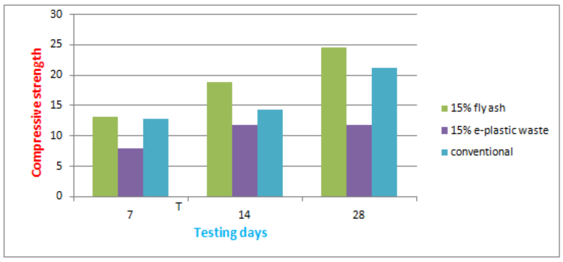
		% of replacement	Average Compressive strength in N/mm^2		
			7 days	14 days	28 days
Grade of Mix M20	For fly ash concrete	5%	14.87	19.19	25.47
		10%	15.89	20.14	26.01
		15%	13.2	18.87	24.59
		20%	13.18	17.5	21.57
	For E-plastic concrete	5%	13.2	14.75	19.66
		10%	10.58	14.45	17.14
		15%	7.91	11.78	11.87
		20%	4.47	7.9	9.62
	Conventional concrete		12.89	14.27	21.2



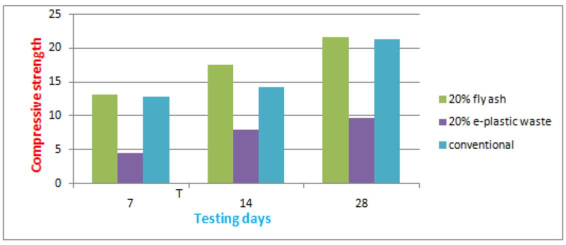
GRAPH: 1 Compressive strength of fly ash and e-plastic for 5% replacement in concrete with conventional concrete



GRAPH: 2 Compressive strength of fly ash and e-plastic for 10% replacement in concrete with conventional concrete



GRAPH: 3 Compressive strength of fly ash and e-plastic for 15% replacement in concrete with conventional concrete



GRAPH: 4 Compressive strength of fly ash and e-plastic for 20% replacement in concrete with conventional concrete

SPILT TENSILE TEST ON CYLINDER

The tensile strength of 150 mm diameter and 300mm height cylinder of M20 grade concrete with 5%, 10%, 15% and 20% of cement replaced with fly ash for 7days and 28days is done in laboratory. For the same percentage of replacement and same age of concrete the E-plastic waste as coarse aggregate were also examined and the corresponding tensile

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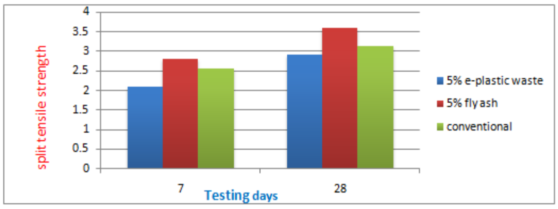
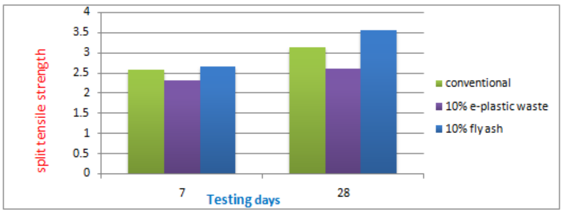
strength values of different proportions of replacement of fly ash and E-plastic wastes in concrete are tabulated and represented graphically.

TABLE: 11 Comparisons of spilt tensile strength for fly ash and e-plastic waste with conventional concrete

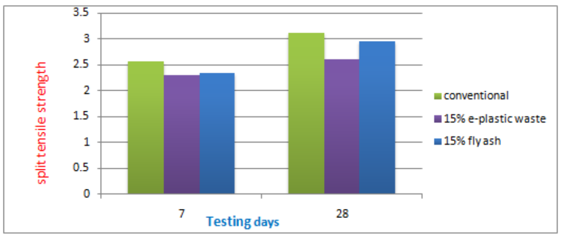
		% of replacement	Split tensile strength in N/mm2	
			7 days	28 days
Grade of Mix M20	For fly ash concrete	5%	2.8	3.6
		10%	2.65	3.55
		15%	2.35	2.95
		20%	2.2	2.8
	For E-plastic concrete	5%	2.08	2.9
		10%	2.3	2.6
		15%	1.6	2
		20%	1.25	1.85
	Conventional concrete	…….	2.57	3.12



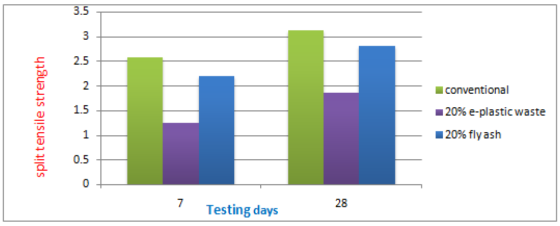
GRAPH: 5 Comparisons of spilt tensile strength for 5% replacement of fly ash and e-plastic waste with conventional concrete



GRAPH: 6 Comparisons of spilt tensile strength for 10% replacement of fly ash and e-plastic waste with conventional concrete

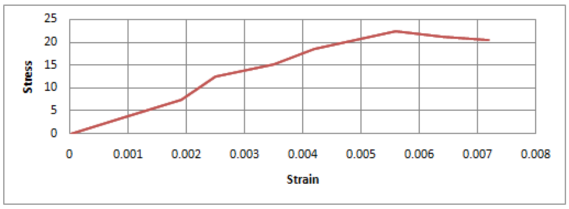


GRAPH: 7 Comparisons of spilt tensile strength for 15% replacement of fly ash and e-plastic waste with conventional concrete

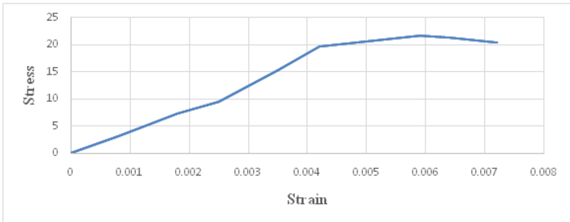


GRAPH: 8 Comparisons of spilt tensile strength for 20% replacement of fly ash and e-plastic waste with conventional concrete

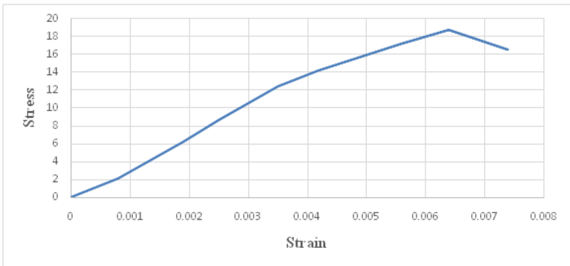
STRESS-STRAIN BEHAVIOURS



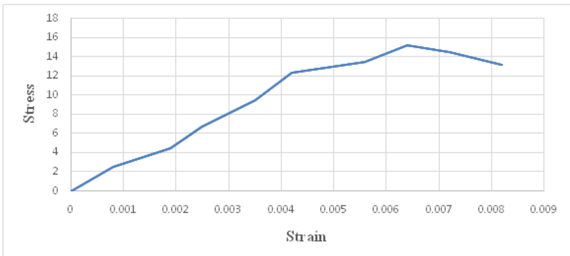
GRAPH: 9 Stress-strain curve of conventional cement concrete



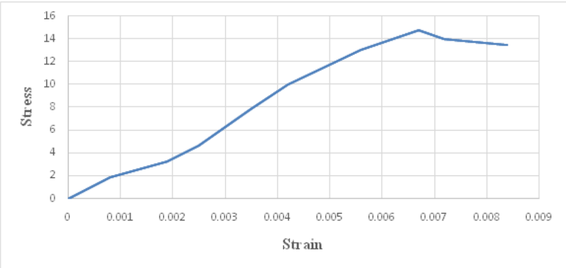
GRAPH: 10 Stress-strain curve of 5% of e-plastic waste cement concrete



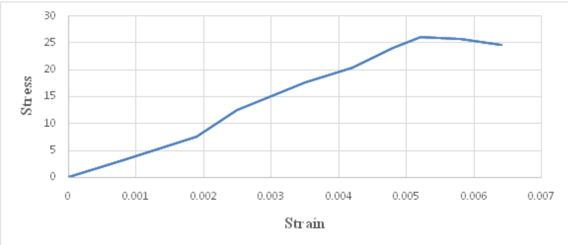
GRAPH: 11 Stress-strain curve of 10% of e-plastic waste cement concrete



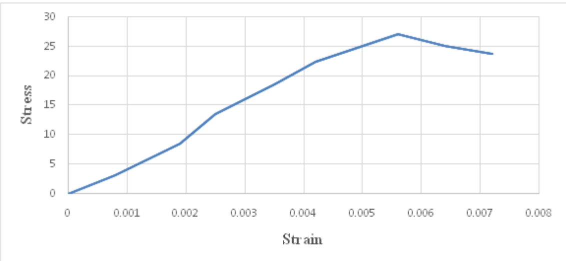
GRAPH: 12 Stress-strain curve of 15% of e-plastic waste cement concrete



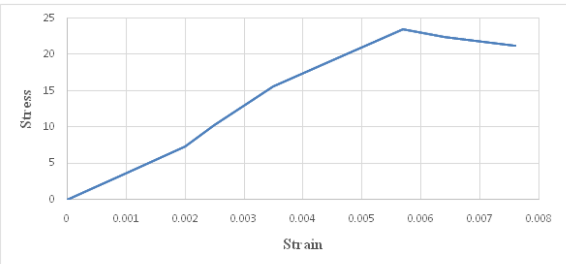
GRAPH: 13 Stress-strain curve of 20% of e-plastic waste cement concrete



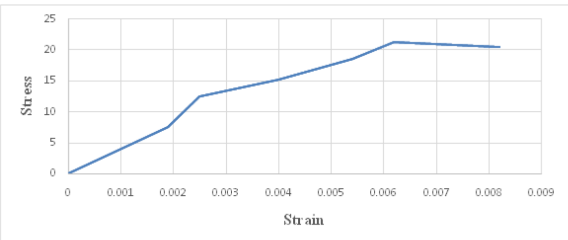
GRAPH: 14 Stress-strain curve of 5% of fly ash cement concrete



GRAPH: 15 Stress-strain curves of 10% of fly ash cement concrete



GRAPH: 16 Stress-strain curve of 15% of fly ash cement concrete



GRAPH: 17 Stress-strain curve of 20% of fly ash cement concrete

Table : 12 overall test results with youngs modulus and toughness

Description	Compressive stress(N/mm^2	Split tensile	Strain correspond	Maximum strain	Young's modulus	toughness
Conventional cement concrete	22.4	3.12	0.0056	0.0072	3972.72	0.4364
5% of e- plastic waste	21.64	2.9	0.0059	0.0072	4190	0.557
10% of e-plastic waste	18.75	2.6	0.0064	0.0075	3778.18	0.523
15% of e-plastic waste	15.25	2	0.0064	0.0082	1809.09	0.4034
20% of e-plastic waste	14.75	1.85	0.0067	0.0084	1190.9	0.3473
5% of fly ash	26.04	3.6	0.0052	0.0064	4250	0.6087
10% of fly ash	27.05	3.55	0.0056	0.0072	4900	0.6656
15% of fly ash	23.54	2.95	0.0057	0.0076	3725	0.5464
20% of fly ash	21.24	2.8	0.0062	0.0082	3645	0.3467

CONCLUSIONS

FOR E-PLASTIC WASTE

An analysis was made on the strength characteristics by conducting the test on e- waste concrete with e plastic aggregate the results revealed that up to 5% replacement e-waste concrete is giving improvement compression, tensile and flexural strength. Graphs show the compressive, tensile and flexural strength of e plastic concrete with mixing ratio of e-plastic waste with coarse aggregate. However an increase in the content of e plastic aggregates gradually enhanced 7 days, 14 days and 28 days compressive, tensile, stress – strain, young's modulus and toughness up to 10% replacement in the case of conventional concrete.

This study intended to find the effective ways to reutilize the hard plastic waste particles as concrete aggregate. Analysis of the strength characteristics of concrete containing recycled waste plastic gave the following results.

1. It is identified that e-waste can be disposed by using them as construction materials.
2. The compressive strength and tensile strength of concrete containing e plastic aggregate is retained More or less in comparison with controlled concrete specimens. However strength noticeably decreased when the e plastic content was more than 10%.
3. It has been concluded that 10% of E-waste aggregate can be incorporated as coarse

aggregate Replacement in concrete without any long term detrimental effects and with acceptable strength Development mechanism.

4. The young's modulus of e-waste concrete will be increases up to 5% only after increasing e-plastic waste the young's modulus will be falling down.
5. The toughness value will be increases up to 10%.

FOR FLY ASH CONCRETE

An analysis was made on the strength characteristics by conducting the test on fly ash concrete with fly ash replaced by the cement. The results revealed that up to 10% replacement fly ash concrete is giving improvement compression, tensile, stress- strain and toughness. Graphs show the compressive, tensile, stress-strain of fly ash concrete with mixing ratio of fly ash. However an increase in the content of fly ash gradually enhanced 7 days, 14 days and 28 days compressive, tensile, stress-strain and toughness up to 15% replacement in the case of conventional concrete.

1. Low volumes of fly ash improve the compressive strength of concrete.
2. Fly ash replacement with 10% produced highest compressive strength.
3. The young's modulus value will increases up to 10%, after exceeds 10% of fly ash in concrete it will be falling down.
4. The toughness value will be increases in up to 15% of fly ash concrete.
5. Young's modulus has shown improvement with the decrease of fly ash content.

COMPARISONS OF E-PLASTIC WASTE AND FLY ASH CONCRETE

From this project I conclude that the mechanical properties of the concrete, such as compression, tensile, stress-strain and toughness has been found to be fly ash concrete will give 5% more strength compare to e-plastic waste concrete for all percentage of replacement.

SCOPE OF FUTURE WORK

- Use of increase in percentage of e-plastic waste as coarse aggregates aggregate replacement up to 5% in concrete mix results in good strength gain comparative to conventional mix
- Silica fumes and metakaoline may include in fly ash concrete to enhance the strength behavior of concrete.
- Durability test may also conduct.
- Add fibers like glass, steel, polyethylene fiber which may increase the crack resistance.
- We can opt M20 grade of concrete for better test result.

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