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AN EXPERIMENTAL INVESTIGATION ON CONCRETE INCORPORATING INDUSTRIAL WASTES (Red Mud, Glass Powder & Crushed Ceramic Tile)

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Abstract - *With the advent of modernization and industrialization, there has been immense impact of man on the natural environment. Today globally, India is facing with many pollution related problems. One of the problem is the land pollution. The main reason behind land pollution is the dumping/disposal of waste as landfills. The major contribution is from construction industry in the form of waste from demolition of buildings and industrial wastes. Thus, to control this pollution, the need of the hours is to find sustainable ways to manage these waste materials. One of the suggested ways is to use these material as a partial replacement of aggregates in concrete. This approach have many benefits.*

1. Waste management and reduces emissions.
2. Reduce natural resources consumption.
3. Cheap reduces cost.

The sole aim of my research is to find out the use of these waste materials at a higher grade i,e M30 grade of concrete and to find the optimum replacement percentage for better workability, strength and durability. The concrete made is durable and resistant to chemical attack and showed that optimum strength achieved at replacement of 25% of natural coarse aggregates with ceramic coarse aggregates, 10% in case of cement replacement with red mud, 10% in case of glass powder used as replacement of fine aggregates and above it reduces significantly.

***Key Words*: Workability, Strength, Durability, Chemical attack.**

1. INTRODUCTION

1.1 CONCRETE

Concrete may be defined as the composite mixture of various substances used in definite proportion. Various ingredients are cement, coarse aggregates, fine aggregates, water, admixture. India is the 2nd largest producer of concrete in the word after China. The major drawbacks of concrete is its high self weight. The unit weight varies from 2400 kg/m to 2500 kg / m^3 from PCC to RCC. If the loads are reduced, reduced sections of structural elements are to be designed to carry reduced loads. **Green concrete** is a new revolutionary technique in the history of concrete industry and used since Roman civilization. . It is defined as the technique of incorporation of those materials in the manufacturing of concrete which are otherwise regarded as a waste material. It is nothing but a topic of environment consideration into concrete manufacturing. These materials on one hand are cheap, easily available and retarding pollution from waste materials on the other hand. In this dissertation report, M30 grade of concrete is designed and all experiments are carried out on M-30 grade of concrete.

So, the goal of my work is "An experimental investigation on concrete by partial replacement of cement by red mud and aggregates with industrial and demolish wastes in concrete by replacing aggregates both coarse and fine aggregates in concrete". The concrete made is resistant to chemical attack and showed that optimum strength achieved at replacement of 25% and above it reduces significant and 10% in case of red mud and glass powder.

1.4 WASTE MATERIAL IN INDIA:

INDIA can be called as the major producer of waste materials in the world and it is only due to the lack and negligence of the techniques for the disposal of these waste materials. These waste materials may be broadly classified into

1. Industrial waste materials.
2. Construction related wastes or Waste materials from demolishing of construction.

1.4.1 INDUSTRIAL WASTES

In INDIA, industrial processes contribute about (70-75%) of total waste material in the country and related pollution is much more than this value. In aggregate about 2500 million tons of waste material is produced every year and there is no proper disposal of this waste. The agricultural waste also included in the above said quantity. These materials are of no use and dumped into land without any kind of treatment rather burn in the agricultural fields. These materials are toxic in nature to the soil and water resources creating land degradation and water resource pollution. These waste materials when used in concrete manufacturing in the form of partial replacement adds much more to the properties of concrete by making it durable and resistant to be attacked by chemicals.

ADVANTAGES OF USING INDUSTRIAL WASTES IN CONCRETE

1. Use of waste materials in concrete reduces waste generation and reduces cost incurred in treatment and disposal of waste.

2. Recycling of waste materials reduces energy consumption by limiting manufacturing processes.

3. Concrete incorporating waste materials have excellent durability as it exhibits low shrinkage and creep properties.

4. The concrete incorporating inert waste materials possess better acid and alkali resistance.

5. Compressive strength, flexural strength, split tensile strength and toughness properties are modified.

6. The concrete manufactured is cheap, cost efficient as these wastes available free of cost from manufacturing units.

7. Concrete manufactured is light in weight and reduced size of structural supporting elements have to be provided.

1.4.2 WASTE FROM DEMOLISH OF CONSTRUCTION

INDIA is the second largest producer of concrete next to China globally. This is evident by the rapid growth of commercialization and industrialization in the country. The waste material generated after the dismantling and demolishing of old structure is thrown out and it is not used in any way though it has remarkable properties if reused, adds much more to the properties of concrete if used as a partial replacement of aggregates and achieve economy in construction. Ceramic wastes can be used as a replacement of both coarse and fine aggregates.

2.LITERATURE REVIEW

G.Sai Chand et al, 2017 – A research paper on utilization of crushed ceramic tile waste as a partial replacement of coarse aggregate. Workability increases with increase in tile aggregate replacement and use of granite powder acting as admixture. M25 grade of concrete is designed. M3 mix which is 30% replacement of coarse aggregate produces maximum strength.

P. Rajalakshmi et al, 2016 - This research paper suggests that the replacement of coarse aggregate in concrete have major benefit in terms of environmental consideration and cost too. The ceramic tile aggregate concrete possess better workability, durability, mechanical properties and thermal resistance. The fine aggregates also replaced by ceramic tile fine aggregates for a constant range of 10% by weight and coarse aggregate by varying amount of 30%, 60% and 100% by weight. The grade of concrete used is M30.

Mannava Anusha et al, 2016 - This research paper is based on the use of glass powder as a partial replacement of Fine aggregates in high performance concrete. The fine aggregates was replaced upto 30% with glass powder. The results of strength parameters shows better properties for 10% replacement with glass powder. There is 9% rise in compressive strength, 23% rise in durability, 74% rise in flexural strength after 28 days compared with standard mix.

Er. Vedpal Nain, Er. Mohd. Usman, Er. Ayay kumar, Er. Sanjay Sangwan et al, 2015 - A study presented on the use of red mud admixed concrete and comparison has been done with plain cement concrete and fly ash replaced concrete individually. M20 grade of concrete is being tested. The red mud admixed concrete is superior in durability, corrosion, permeability, impact on environment, resistance to cracking and strength aspects. The red mud bricks shows superior properties like low water absorption and higher compressive strength as compared to clay bricks.

Daniyal and Ahmad et al, 2015: They also checked the suitability of ceramic waste as replacement of crushed stone aggregate and found that these wastes have a potential to be used as a replacement of natural coarse aggregates.The compressive and flexural strength 30% replacement concrete was compared to that of the conventional concrete and results show that there is 5.43% and 32.2% increase in strength than conventional concrete respectively.

Sunitha M.Pujar et al, 2014 - A research paper on partial replacement of cement by red mud in which the cement is replaced by washed and unwashed red mud individually upto 20%. All the properties of concrete is higher at a cement replacement of 2% by unwashed red mud. Above this replacement level strength parameters decreases suddenly. The water absorption and sorptivity of concrete decreases upto 8% and 2% replacement in case of washed red mud and unwashed red mud and above this increases.

Er. Akash Agrawal, Dr. V.Srivastava, Er. A.Harison, Dr. S.Suryavanshi et al. - This research paper reviews the use of ceramic and plastic wastes in concrete and its effect on compressive strength, modulus of elasticity, split tensile strength, impact resistance, bulk density, air content, permeability and abrasion resistance of concrete. This paper is based on conclusion that the ceramic wastes can be used as a partial replacement of cement upto 10% and 30% for both fine and coarse aggregates.

Naveen Prasad et al, 2014 - In this research paper crushed waste tiles from industries and demolishing of construction have been used to replace coarse aggregates and granite powder is used in place of fine aggregate. Both the coarse and fine aggregate were replaced upto 40%. M25 grade of concrete is designed. The test results shows that workability increases with increase in granite powder and ceramic aggregates. The compressive strength is more and optimum replacement is 30%.

Malik et al, 2013 - This research paper explains the utilization of waste glass as fine aggregate upto 40% replacement. Fine aggregates when replaced by glass powder at 30% shows 9.8% increase in compressive strength after 28 days of age. As the glass content increases water absorption reduces and workability increases.

S.Suganya, Banu Priya et al, 2011 - This research examines the possibility of using GP as fine aggregate replacement in concrete. Natural sand was partially replaced (0%-30%) with Glass powder and M50 grade of concrete is used. There is 74% rise in flexural strength, 9% rise in compressive strength, 23% rise in tensile strength after 28 days as compared with conventional concrete.

Juan et al, 2010: They studied the reuse of ceramic wastes in construction industry and investigated that the introduction of recycled ceramic aggregates has no negative effects on cement hydration. This mix may also used for structural concrete because characteristic compressive strength exceeds 25 N/mm^2 greater than minimum strength required for structural concrete.

Chen et al, 2006 - This research paper reviews the use of waste E-glass as fine aggregate replacement in concrete. The use of glass powder shows excellent mechanical properties particularly compressive strength, split tensile strength and durability properties.

Shehata et al, 2005 - This research paper shows a comparative study of using waste glass as partial volume replacement of fine aggregates. The glass powder replaced concrete shows high modulus of rupture as compared to normal mix. Excellent cracking control and tremendous interfacial bond between cement paste and glass powder.

3. MATERIALS AND PROPERTIES

3.1 MATERIALS USED: Following are the materials used

1) Ordinary Portland cement of grade 53 having brand named Ambuja cement conforming to IS: 169-1989.
2) Fine aggregates.
3) Coarse aggregates.
4) Red mud as a replacement of cement.
5) Glass powder as a replacement of fine aggregate.
6) Ceramic tile waste as a replacement of coarse aggregate.
7) Water.

3.1.1 CEMENT:

Cement is obtained by burning together a mixture of naturally occurring argillaceous and calcareous material in a definite proportions at a 1450 degree celcius fusion temperature. The cement used in this work is 53 grade OPC Ambuja cement as shown in figure-1

Table-1 Physical properties of cement.

S.No	Properties	Test results	IS: 169-1989
1.	Normal consistency	0.32	-
2.	Initial setting time	55min	Minimum of 30min
3.	Final setting time	340min	Maximum of 600min
4.	Specific gravity	3.14	-
5.	Compressive strength		
	3days strength	27.4 Mpa	Minimum of 27Mpa
	7days strength	43.8 Mpa	Minimum of 40Mpa
	28days strength	55.2 Mpa	Minimum of 53Mpa

3.1.2 FINE AGGREGATES :

Fine aggregates are those aggregates which passes through 4.75mm IS sieve. River sand is generally used as a fine aggregate having particle size of 0.07mm. Following types of fine aggregates are : Crushed Stone sand, Crushed Gravel sand and Natural sand. The fine aggregates may be coarse, medium and fine depending on size. IS: 383-1970 provides guidelines for fine aggregates and divides it into four zones.

Properties of Fine aggregates :

Table 2: Properties of Fine Aggregate

S.No	Description Test	Result
1	Sand zone	Zone- II
2	Specific gravity	2.60
3	Free Moisture	1%
4	Bulk density of fine aggregate (poured density) Bulk density of fine aggregate (tapped density)	1268 kg/m3 1546 kg/m3

Fig-2 Fine aggregate

Fig 3 Coarse Aggregates

3.1.3 COARSE AGGREGATES:

Coarse aggregates are those aggregates which retains on 4.75mm IS sieve. Crushed stones are generally used as a coarse aggregate and generally described by its nominal size of 40mm, 20mm, 16mm and 12.5mm. Types of coarse aggregates are : Uncrushed gravel or stone as a result of disintegration of rock, Crushed gravel or stone as a result of crushing of gravel or hard stone, Partially crushed gravel or stone as a result of blending of above two types.

Table 3: Properties of Coarse Aggregate

S.No	Description	Test Results
1	Nominal size used	20mm
2	Specific gravity	2.74
3	Impact value	11.8
4	Water absorption	0.2%
5	Sieve analysis	20mm
6	Aggregate crushing value	23.24%
7	Bulk density of coarse aggregate (Poured density) Bulk density of coarse aggregate (Tapped density)	1737.71kg/m3 1878.7 kg/m3

3.1.4 RED MUD:

Red mud may be defined as by product during manufacturing of aluminium by Bayer's process. it has been land filled into the useful agricultural lands making it unfit for crop production. This is the major grave menace problem in recent times till date.

PROPERTIES OF RED MUD:

1. Red mud is a good binding material as it contains mix of solids and metal oxides having excellent binding properties.
2. The mechanical properties of concrete increases tremendously by the incorporation of red mud in concrete.
3. Available free of cost so economical in one hand and conserve environment on the other hand.
5. It reduces capillary pores and hence reduces permeability.
6. Its PH value varies from 10-12, as a result it does not cause corrosion of reinforcement.
7.Good binder, prevents early fading of colour, serves as decorative material, it is economical costs less.

DRAWBACKS

1. Red mud is highly alkaline in nature so it damages agricultural land if dumped.
2. It contaminates ground water table because of high alkalinity, it disposed underground.

Table-4 Physical Properties of red mud.

S.No	Description	Test Results
1	Specific gravity of red mud	2.97
2	Particle size	<300 micron
3	Fineness	2550sqcm/gm
4	pH	11.7

Table 5. Composition of the dry red mud

Components	Weight %
Al_2O_3	20-22%
SiO_2	40-45%
Fe_2O_3	12-15%
CaO	1.8-2.0%
Na_2O	1.0-2.0%
TiO_2	4-5%

3.1.5 GLASS POWDER :

Glass is an inorganic fusion product and is a super-cooled liquid. Glass Powder is a material formed by crushing of glass pieces to a powder like form. Glass. Glass is obtained from process called smelting called combination of melting and solidification. Glass Powder when used as a replacement of fine aggregates improves the strength, durability, resistance to be attacked by chemicals by increasing workability and density of concrete and reducing porosity.

Table-6 Properties of glass powder

S.No	Description	Test Results
1	Specific gravity of glass powder	2.9
2	Water absorption of glass powder	0.11%
3	Moisture content	Nil

Fig-4 Glass Powder

3.1.6 CERAMIC TILE COARSE AGGREGATES:

Ceramic tile coarse aggregates are the crushed pieces of waste ceramic tiles having sizes which are passing from 12.5mm sieve but retained on 10mm sieve. These aggregates are added in place of coarse aggregates for different replacement percentages upto 40%. These tile aggregates are much hard, tough, strong and durable than normal stone aggregates and resistant to be attacked by chemicals.

ADVANTAGES OF CONCRETE INCORPORATING BROKEN CERAMIC TILE AGGREGATES

1. The concrete manufactured by the replacement of aggregates with ceramic tile aggregate shows increased workability with increase in percentage of tile aggregates.

2. The ceramic tile aggregate concrete undergo least shrinkage strain and creep parameters are also less. Due to this it can been regarded as a durable material.

3. The ceramic tile aggregates are easily available from the industrial units or demolish construction site as which is free of cost. Thus economy in construction is achieved.

4. The ceramic tile aggregates are light in weight which reduces the dead weight of the structure.

5. The strength parameters flexural strength, split tensile strength and compressive strength are also modified by achieving more dense mix.

Table-7- Properties of ceramic aggregates

S. No.	Description	Test Results
1	Impact value of crushed tiles	11.5%
2	Specific gravity of crushed tiles	2.39
3	Water absorption of crushed tiles	0.17%

Fig-5 Ceramic Tiile Coarse Aggregates

3.1.7 WATER:

Clean water free from organic, inorganic impurities and other suspended and colloidal particles is used in concrete. The water used should have Ph in the range of (7-8).

4.1 METHODOLOGY ADOPTED:

The methodology adopted is shown in flowchart.

1. Collection of materials. Study of physical properties of materials. Mix design.
2. Casting of specimens. Curing of specimens. Testing of Specimens.
3. Tests on Hardened Concrete Compressive Strength, Split Tensile Strength. Flexural strength.
4. Analysis and Discussion of Test Results.
5. Conclusion and Future Scope.

4.2 CONCRETE MIX DESIGN (AS PER Reference of IS:10262-2009)

MIX DESIGN FOR M30 GRADE OF CONCRETE

MIX CODE 1 – C:0% RM : F.A:0% GP : C.A:0% CTA

Mix Proportions:

C : FA : C.A : WATER

390 : 671.22 : 1254.70 : 158.3

1 : 1.72 : 3.22 : 0.41

MIX CODE 2 – C:10% RM : F.A:10% GP : C.A:5%CTA

Mix Proportions:

C : RM : F.A : GP : C.A : CTA : WATER

351 : 39 : 604.09 : 67 : 1191.96 : 62 : 158.3

0.9 : 0.1 : 1.55 : 0.1 : 3.06 : 0.16 : 0.41

MIX CODE 3 – C:10% RM : F.A:10% GP : C.A:10% CTA

Mix Proportions:

C : RM : F.A : GP : C.A : CTA : WATER

351 : 39 : 604.09 : 6 : 1129.23 : 125.4 : 158.3

0.9 : 0.1 : 1.55: 0.17 : 2.90 : 0.32 : 0.41

MIX CODE 4 – C:10% RM : F.A:10% GP : C.A:15% CTA

Mix Proportions:

C : RM : F.A : GP : C.A : CTA : WATER

351 : 39 : 604.09 : 67 : 1066.50 : 188 : 158.3

0.9 : 0.1 : 1.55 : 0.17 : 2.74 : 0.48 : 0.41

MIX CODE 5 – C:10% RM : F.A:10% GP : C.A:20% CTA

Mix Proportions:

C : RM : F.A : GP : C.A : CTA : WATER

351 : 39 : 604.09: 67 : 1003.80 : 251 : 158.3

0.9 : 0.1 : 1.55 : 0.17 : 2.58 : 0.64 : 0.41

MIX CODE 6 – C:10% RM : F.A:10% GP : C.A:25% CTA

Mix Proportions:

C : RM : F.A : GP : C.A : CTA : WATER

351 : 39 : 604.09 : 67 : 941 : 314 : 158.3

0.9 : 0.1 : 1.55 : 0.17 : 2.42 : 0.80 : 0.41

MIX CODE7 – C:10% RM : F.A:10%GP : C.A:30% CTA

Mix Proportions:

C : RM : F.A : GP : C.A : CTA : WATER

351 : 39 : 604.09 : 67 : 878.30 : 376 : 158.3

0.9 : 0.1 : 1.55 : 0.17 : 2.26 : 0.96 : 0.41

MIX CODE8 – C:10% RM : F.A:10% GP : C.A:35%CTA

Mix Proportions:

C : RM : F.A : GP : C.A : CTA : WATER

351 : 39 : 604.09 : 67 : 815.60 : 439 : 158.3

0.9 : 0.1 : 1.55 : 0.17 : 2.09 : 1.13 : 0.41

MIX CODE 9 – C:10% RM : F.A:10% GP : C.A:40% CTA

Mix Proportions:

C : RM : F.A : GP : C.A : CTA : WATER

351 : 39 : 604.09: 67 : 752.80 : 502 : 158.3

0.9 : 0.1 : 1.55 : 0.17 : 1.93 : 1.29 : 0.41

5. DETAILS OF EXPERIMENTS PERFORMED

Various experiments performed are as follows:

1. **Workability test.**
   a) **Slump cone test.**
2. **Compressive strength test.**
3. **Split Tensile strength test.**
4. **Flexural strength test.**

Total 9 mix codes are prepared which are abbreviated as MC-1 to MC-9. MC-1 mix designates 0% replacement of cement, coarse aggregates and fine aggregate while MC-9 mix designates cement to be replaced 10% by weight of red mud, coarse aggregates to be replaced by 40% by crushed ceramic tile aggregates and crushed glass powder is added 10% by weight of fine aggregates. The coarse aggregates are replaced by 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40%.

6. TEST RESULTS AND DISCUSSION

6.1 WORKABILTY:

6.1.1 Slump Cone Test:. Workability is defined as the ease of doing work with concrete.The test was conducted for fresh concrete prepared before the moulding process. A total of 9 concrete mixes are prepared.

Table8:Test results from slump cone test for workability

S.no	Mix Codes	Cement & Aggregate Percentage Replacement proportions in % (C:RM : FA:GP : CA:CTA)	Workability (mm)
			Grade M30
1	MC1	(100:0 : 100:0 : 100:0)	61
2	MC2	(90:10 : 90:10 : 95:5)	63
3	MC3	(90:10 : 90:10 : 90:10)	67
4	MC4	(90:10 : 90:10 : 85:15)	70
5	MC5	(90:10 : 90:10 : 80:20)	74
6	MC6	(90:10 : 90:10 : 75:25)	76
7	MC7	(90:10 : 90:10 : 70:30)	82
8	MC8	(90:10 : 90:10 : 65:35)	89
9	MC9	(90:10 : 90:10 : 60:40)	98

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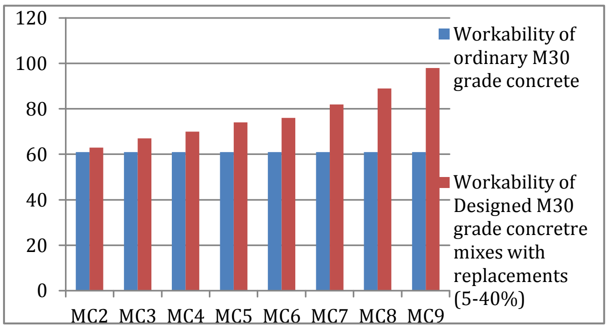


Chart-1 : Workability variation of designed concrete having replacements with conventional concrete.

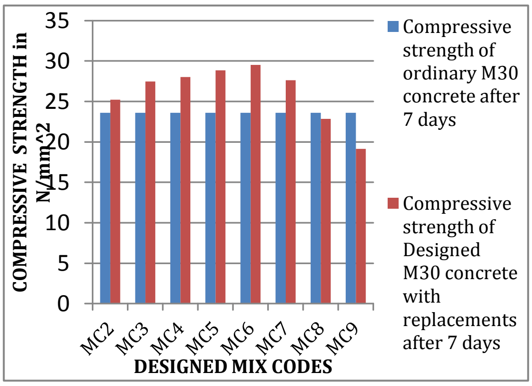
6.2 Compressive strength:

It is defined as the ability of concrete to withstand under the influence of compressive forces. A total of 81 cubes of size 150 x 150 x 150mm were casted and tested for 7 days, 14 days and 28 days each for compressive strength tests. Compressive strength = Load/Area in N/sq mm.

Table-9: Compressive strength results of M30 grade concrete for 7, 24 and 28 days

Mix Codes	Cement&Aggregate Percentage Replacement proportions in % (C:RM : FA:GP : CA:CTA)	Compressive strength of M30 grade in N/mm²		
		7 days	14 days	28 days
MC1	(100:0:100:0:100:0)	23.60	32.18	37.74
MC2	(90:10:90:10 : 95:5)	25.21	33.79	39.85
MC3	(90:10:90:10:90:10)	27.47	35.72	42.15
MC4	(90:10 : 90:1 :85:15)	28.02	37.40	44.21
MC5	(90:10:90:10:80:20)	28.86	38.74	45.92
MC6	(90:10:90:10:75:25)	29.52	39.47	46.72
MC7	(90:10:90:10:70:30)	27.63	36.34	41.57
MC8	(90:10:90:10:65:35)	22.87	32.07	38.02
MC9	(90:10:90:10:60:40)	19.14	29.27	33.62

Chart-2 : Compressive strength results of M30 grade concrete for 7 days



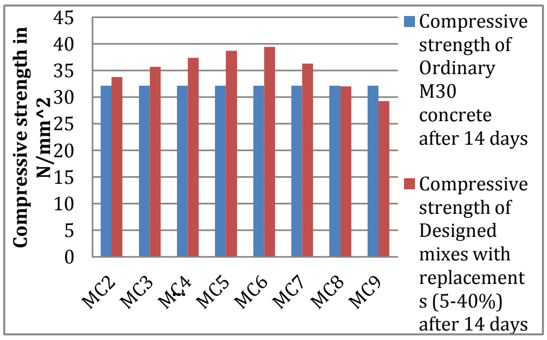


Chart-3 : Compressive strength results variation of M30 grade concrete after 14 days

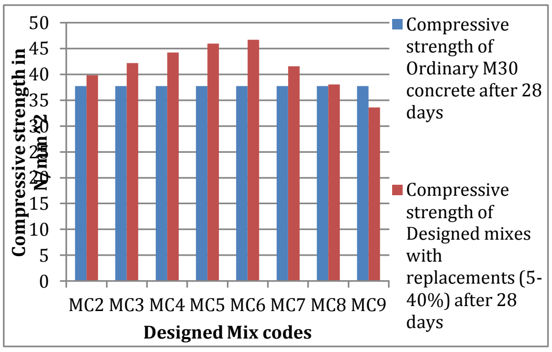


Chart-4 : Compressive strength results variation of M30 grade concrete after 28 days

6.3 Split Tensile strength:

It is defined as the ability of concrete to withstand under the influence of axial tensile forces. The Split tensile strength is obtained by dividing the load to the bearing area of specimen

Resultant Split tensile strength = $2P/\pi DL$ in N/sq mm.

Table10: Split tensile strength results for M30 grade of concrete after 7, 14 and 28 days

Mix Codes	Cement & Aggregate Percentage Replacement proportions in % (C:RM FA:GP:CA:CTACA:CTA)	Split Tensile Strength of M30 grade in N/mm²		
		7 days	14 days	28 days
MC1	(100:0 : 100:0 :100:0)	1.69	2.21	2.60
MC2	(90:10 : 90:10 : 95:5)	1.69	2.22	2.61
MC3	(90:10 : 90:10 : 90:10)	1.72	2.23	2.63
MC4	(90:10 : 90:10 : 85:15)	1.74	2.25	2.66
MC5	(90:10 : 90:10 : 80:20)	1.77	2.27	2.69
MC6	(90:10 : 90:10 : 75:25)	1.78	2.28	2.71
MC7	(90:10 : 90:10 : 70:30)	1.71	2.21	2.63
MC8	(90:10 : 90:10 : 65:35)	1.68	2.18	2.53
MC9	(90:10 : 90:10 : 60:40)	1.61	1.78	2.02

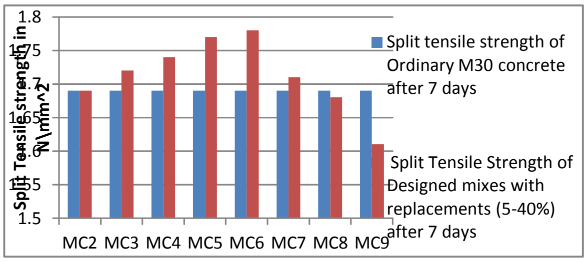


Chart-5 : Split tensile strength results variation of M30 grade concrete after 7 days

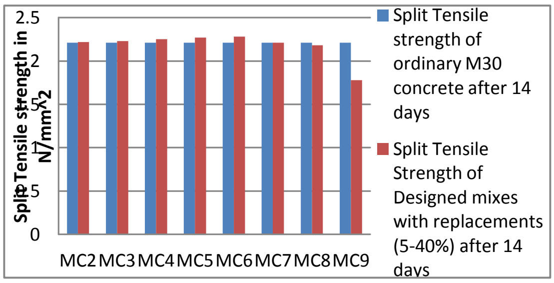


Chart-6 : Split tensile strength results variation for M30 grade after 14 days

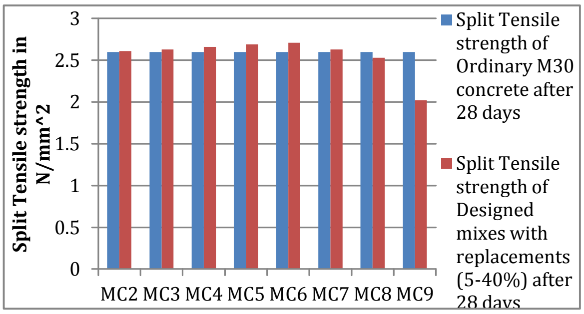


Chart-7 : Split tensile strength results variation for M30 grade after 28 days

6.4 Flexural Strength:

It is defined as the ability of concrete to withstand under the influence of bending stresses. If 200>a>170mm for 150mm specimen and 133>a>110 for 100mm specimen, then

Flexural strength/modulus of rupture = 3Pa/bd^2 N/mm^2

Table-11: Flexural strength results of M30 grade concrete after 7, 24 and 28 days

Mix Codes	Cement & Aggregate Percentage Replacement proportions in % (C:RM:FA:GP:CA:CTA)	Flexural Strength of M30 grade in N/mm^2		
		7 days	14 days	28 days
MC1	(100:0 : 100:0 :100:0)	8.77	9.17	9.98
MC2	(90:10 : 90:10 : 95:5)	8.83	9.21	10.19
MC3	(90:10 : 90:10 : 90:10)	8.88	9.46	10.41
MC4	(90:10 : 90:10 : 85:15)	8.93	9.77	10.66
MC5	(90:10 : 90:10 : 80:20)	9.00	9.97	10.81
MC6	(90:10 : 90:10 : 75:25)	9.07	9.56	10.93
MC7	(90:10 : 90:10 : 70:30)	8.93	8.97	10.47
MC8	(90:10 : 90:10 : 65:35)	8.79	8.76	9.74
MC9	(90:10 : 90:10 : 60:40)	8.61	8.59	9.58

Chart-8 :Flexural test results variation for M30 grade after 7 days

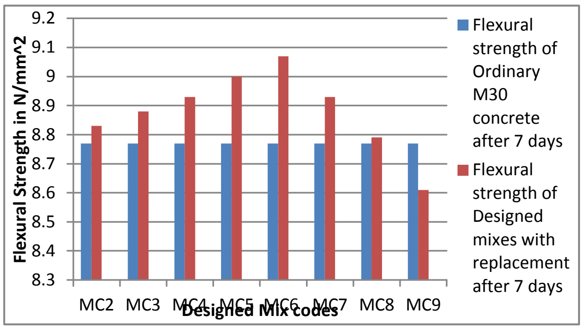


Chart-9 :Flexural test results variation for M30 grade after 14 days

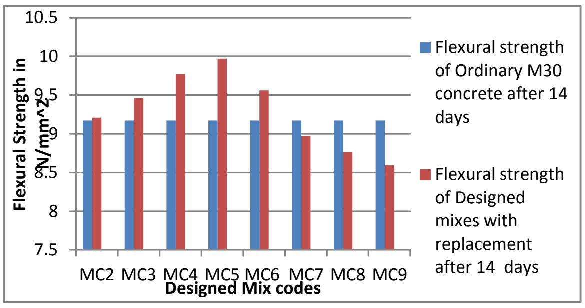
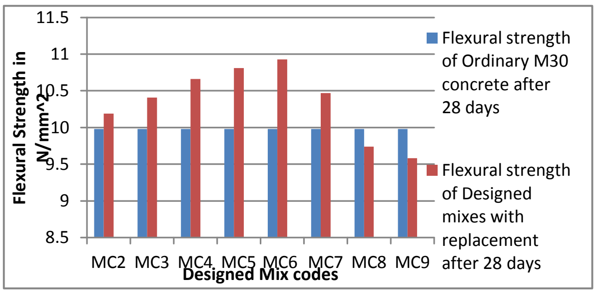


Chart-10 :Flexural test results variation for M30 grade after 28 days



DISCUSSION

7.1 WORKABILITY:

7.1.1 Slump cone test

Table 12: Percentage increase in workability for slump cone test.

Mix Codes	Cement & Aggregate Percentage Replacement proportions in % (C:RM : FA:GP :CA:CTA)	Percentage increase in Workability (in %)
MC1	(100:0 : 100:0 : 100:0)	-
MC2	(90:10 : 90:10 : 95:5)	3.2%
MC3	(90:10 : 90:10 : 90:10)	9.8%
MC4	(90:10 : 90:10 : 85:15)	14.7%
MC5	(90:10 : 90:10 : 80:20)	21.3%
MC6	(90:10 : 90:10 : 75:25)	24.5%
MC7	(90:10 : 90:10 : 70:30)	34.4%
MC8	(90:10 : 90:10 : 65:35)	45.9 %
MC9	(90:10 : 90:10 : 60:40)	60.6%

7.2COMPRESSIVE STRENGTH TEST:

Table-13: Percentage increase in Compressive strength for 7, 24 and 28 days

Mix Codes	Cement & Aggregate Percentage Replacement proportions in % (C:RM : FA:GP : CA:CTA)	Percentage increase in Compressive strength of M30 grade		
		7 days	14 days	28 days
MC1	(100:0 : 100:0:100:0)	-	-	-
MC2	(90:10 : 90:10 : 95:5)	6.8%	5%	5.59%
MC3	(90:10 : 90:10 :90:10)	16.3%	11%	11.6%
MC4	(90:10 : 90:10 :85:15)	18.7%	16.2%	17.1%
MC5	(90:10 : 90:10 :80:20)	22.2%	20.3%	21.6%
MC6	(90:10 : 90:10 :75:25)	25.08%	22.6%	23.7%
MC7	(90:10 : 90:10 :70:30)	17.07%	12.9%	10.14%
MC8	(90:10 : 90:10:65:35)	-3.09%	-0.34%	0.74%
MC9	(90:10 : 90:10:60:40)	-18.8 %	-9.04%	-10.9 %

7.3 SPLIT TENSILE STRENGTH

Table 14: Percentage increase in Split tensile strength for 7, 14 and 28 days

Mix Codes	Cement & Aggregate Percentage Replacement proportions in % (C:RM : FA:GP : CA:CTA)	Percentage increase in Split tensile strength of M30 grade in %		
		7 days	14 days	28 days
MC1	(100:0 : 100:0 :100:0)	-	-	-
MC2	(90:10 : 90:10 : 95:5)	0%	0.45%	0.38%
MC3	(90:10 : 90:10 : 90:10)	1.7%	0.90%	0.76%
MC4	(90:10 : 90:10 : 85:15)	2.9%	1.8%	2.3%
MC5	(90:10 : 90:10 : 80:20)	4.7%	2.7%	3.4%
MC6	(90:10 : 90:10 : 75:25)	5.3%	3.1%	4.2%
MC7	(90:10 : 90:10 : 70:30)	1.18%	0%	1.15%
MC8	(90:10 : 90:10 : 65:35)	-0.59%	-1.3%	-2.6%
MC9	(90:10 : 90:10 : 60:40)	-4.7%	-8.5%	-22.3%

7.4 FLEXURAL STRENGTH

Table 15: Percentage increase in Flexural strength for 7, 14 and 28 days

Mix Codes	Cement & Aggregate Percentage Replacement proportions in % (C:RM : FA:GP : CA:CTA CA:CTA)	Percentage increase in Flexural Strength in %		
		7 days	14 days	28 days
MC1	(100:0 : 100:0 : 100:0)	-	-	-
MC2	(90:10 : 90:10 : 95:5)	0.6%	0.4%	2.1%
MC3	(90:10 : 90:10 :90:10)	1.2%	3.1%	4.3%
MC4	(90:10 : 90:10 85:15)	1.8%	6.5%	6.8%
MC5	(90:10 : 90:10 :80:20)	2.6%	8.7%	8.3%
MC6	(90:10 : 90:10 :75:25)	3.4%	4.2%	9.5%
MC7	(90:10 : 90:10 :70:30)	1.8%	-2.1%	4.9%
MC8	(90:10 : 90:10 :65:35)	0.2%	-4.4%	-2.4%
MC9	(90:10 : 90:10 :60:40)	-1.8%	-6.3%	-4.0%

8. SUMMARY AND CONCLUSION

8.1 General:

The primary goal of the research is to make a concrete which is cheap, light in weight, reduces energy consumption and emissions and conserve environment. The percentage increase of workability, compressive strength, split tensile strength and flexural strength has already been quoted and comparison has been made with conventional mix of concrete in which no replacement has been done.

8.2 Conclusions:

RED MUD

1) The bonding capability of cement increases with incorporation of red mud as a replacement of cement upto 10% into it. The reason behind it is that the free Sio2 present in red mud combines with calcium oxide present in cement resulting into the formation of calcium-silica compound which has excellent bonding and strength parameters.

a) This practice leads to the formation of better bond between the mortar and the particles of coarse aggregates which leads to the development of high strength upto 10% replacement.

b) Workability, compressive strength and flexural strength also increase in the same manner as stated above.

GLASS POWDER:

Though glass is an inert material and it has no bonding capabilities and strength parameters yet it also enhances the properties of concrete when used as a replacement for sand. The properties modified on the basis of mineralogical and chemical properties of glass which act as a filler in concrete making the concrete more compact and dense. The modified properties are:

Workability, Compressive strength, Split tensile & Flexural strength.

CRUSHED CERAMIC TILE AGGREGATES:

The use of crushed waste ceramic tile aggregate as a replacement of coarse aggregates has already been shown by many researchers but upto grade M25. In this research the suitability of crushed ceramic wastes is evaluated for M30 grade and for use in multistorey construction.

1) Workability increases with increase in replacement of these waste aggregates.

2) The compressive strength also increases linearly upto 25% replacement showing peak at 25% and reduces above it.

3) The split tensile strength and flexural strength also increases significantly due to superior properties of these aggregates and more compactness by the use of glass powder as a filler.

8.3 FUTURE SCOPE OF WORK

The use of industrial and construction wastes in concrete for use in multistorey building is a new emerging technology and has not been used in India since times. The further scope of research in this field is stated under

1) The use of light weight industrial waste aggregates in concrete reduces the dead weight considerably. This reduction of dead weight at each storey for multistorey buildings can be estimated.
2) The reduction in size, material and steel used for making the reduced size of structural elements would be assessed.
3) The maximum storey levels for which the applicability of using these industrial wastes into concrete can be evaluated based on structural performance of components under loads.
4) The maximum grade of concrete for which this technology can be used can be assessed in future.
5) The recycling of demolish construction wastes in high strength applications can be evaluated in future.

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