EXPERIMENTAL STUDY ON THE BEHAVIOUR OF M20 GRADE CONVENTIONAL CONCRETE AS A PARTIAL REPLACEMENT OF FINE AGGREGATE WITH IRON SLAG

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ABSTRACT:

Due to growing environmental awareness, as well as stricter regulations on managing industrial waste, the world is increasingly turning to researching properties of industrial waste and finding solutions on using its valuable component parts so that those might be used as secondary raw material in other industrial branches. Although iron and steel slag is still today considered waste and is categorized in industrial waste catalogues in most countries in the world, it is most definitely not waste, neither by its physical and chemical properties nor according to data on its use as valuable material for different purposes Moreover, since the earliest times of the discovery and development of processes of iron and other metals production, slag as by-product is used for satisfying diverse human needs, from the production of medicines and agro-technical agents to production of cement and construction elements Considering the specificity of physical and chemical properties of metallurgical slags and a series of possibilities for their use in other industrial branches and in the field of civil constructions, this report demonstrates the possibilities of using iron slag as partial replacement of sand in concrete Iron and steel making slag are by products of the iron making and steelmaking processes.. The fine aggregate has been replaced by iron slag accordingly in the range of 0%,5%,10% 15%,20%,25%,30% is by weight of sand for M20 mix The test have been made to study for 3 days ,7 days ,14 days and 28 day.

1.0 INTRODUCTION

Cement concrete is a versatile building construction material in civil engineering and it is also one of the world's most extensively used construction material around the world in almost all construction projects and in many construction applications. Construction activities and projects are increasing around the world which has resulted into the excessive extraction and utilization of naturally available materials like natural river sand, stones and rocks, lime, clay, water etc. Currently the problems faced by the use of cement concrete includes high demand of cement concrete, cost of cement and concrete making materials, pollution, excessive extraction and utilization of natural river sand and stones, water etc. Because the sand is being extensively extracted from the river bed deposits, it is depleting at a faster rate. Hence it is necessary to find an alternative material such as industrial waste slag and waste pieces of stones from the stone quarries in the cement concrete production. This dissertation work deals with the study of partial replacement of natural fine aggregate by steel slag and natural coarse aggregate by waste limestone aggregate in M20 grade of cement concrete. Steel slag is a waste by-product obtained from the iron and steel plants and waste limestone aggregates are the waste broken pieces of limestone obtained from the limestone quarries. In this work, we have made an attempt to study the compressive, split tensile and flexural strength of M20 grade cement concrete by using steel slag and waste limestone aggregate as partial replacement to fine aggregates and coarse aggregates.

2.0 LITERATURE REVIEW

DeepaBalakrishnan et.al (2012) had studied the work ability and strength characteristics of self-compacting concrete containing fly ash and dolomite powder. she made high volume fly ash self-compacting concrete with12.5percent, 18.75percent, 25percent and 37.5percentof the cement (by mass) replaced by fly ash and 6.25percent, 12.5percent and 25percent of the cement replaced by dolomite powder The mixes were then tested for mechanical properties like, cube compressive strength at 7th day, 28th day and 90th day, cylinder compressive strength at 28th day, split tensile strength, and flexural strength at 28th day. From the results she concluded that better mechanical and physical properties of concrete can be obtained with the replacement of cement with fly ash from 12.5% to 18.75%

Felixkala T. and Partheeban P (2010)evaluated the bond strength of self-compacting concrete mixes containing dolomite powder. Either silica flume or fly ash was used along with dolomite powder to increase the bond strength considerably. Seven mixes were proportioned and push-out test was carried out. The variation of the bond strength for different mixes was evaluated. The steel concrete bond adequacy was evaluated based on normal bond strength. The result showed that the bond strength increased as the replacement of Portland cement with dolomite powder increased. All SCC mixes containing dolomite powder up to 30 % yielded bond strength that is adequate for design purpose. The availability of this type of concrete provided unique merits for faster construction. From the results he concluded that the shear strength of RC beams were better than that of the conventional SCC without dolomite powder.

Milosz Szybilski et.al (2013) studied the effect of dolomite additive on cement hydration. The effect of dolomite on a lite hydration was investigated in order to elucidate the effect of dolomite addition in cement hydration. The rate of heat evolution both in cement-dolomite and alite-dolomite system was taken as a starting point. Subsequently the chemical shrinkage, conductivity of liquid phase and rheological parameters of pastes were characterized. The observations of micro structure were carried out under SEM and the hydration degree of alite was determined by XRD. The accelerating effect of additive was proved. At low percentage dolomite plays a role of cement replacement, at higher dosage the dilution effect can be observed. However, increasing dolomite content is accompanied by higher amount of hydration products, as a results of crystallization on the fine dolomite grains and better absorption of water. The hydration degree of alite increases as well.

AtulDubey, Dr.R.Chandak, Prof. R.K. Yadav (2014) had studied the compressive strength of concrete with dolomite powder and crushed tiles Her study aim is to create a better concrete in low cost and is focused on the compressive strength of the concrete by partially replacing cement with dolomite powder and coarse aggregates with crushed tiles. In first phase the coarse aggregate was replaced with crushed ceramic tiles at 10%, 20%, 30% and 40%. The test results showed that the compressive strength increased at 30% replacement of coarse aggregate with crushed ceramic tiles. In second phase the optimum strength obtained by replacing coarse aggregate is kept constant and the cement is replaced with dolomite powder at 5%, 10%, 15% and 20%. The test results showed that the compressive strength increased at 30% replacement of coarse aggregate and 10% replacement of cement studied the sustainable studies on concrete with GGBS as a replacement material in cement. His paper deals with the effort to quantify the strength of ground granulated blast furnace slag (GGBS) at various replacement levels and evaluate its efficiencies in concrete. His research evaluates the strength and strength efficiency factors of hardened concrete, by partially replacing cement by various percentages of ground granulated blast furnace slag for M35 grade of concrete at different ages. From his study, it can be concluded that, since the grain size of GGBS is less than that of ordinary Portland cement, its strength at early ages is low, but it continues to gain strength over a long period.

B.Mangamma, Dr N.Victorbabu (2016)in his paper entitled "Effect of Using Crushed Limestone in Concrete mixes as fine aggregates on Compressive strength and Workability". In this investigation work, two types of cement concrete mixes were prepared such as concrete mix with crushed limestone as fine aggregate and the second type was conventional concrete containing natural river sand as fine aggregates. After conducting the desired tests on the prepared concrete mixes, test results obtained showed that concrete mix containing crushed limestone as fine aggregates requires more water content than the conventional concrete mix to obtain and maintain the same workability. But its test results also showed that the concrete containing crushed limestone as fine aggregates gave more compressive strength than the conventional concrete and it was found that the increase in the compressive strength depends upon the water cement ratio, type of cement concrete mix and the age of cement concrete in days. Finally this investigation concluded that crushed limestone waste can be used for preparing the good quality of cement concrete which might be suitable for paving blocks for footpaths, gardens, bus stops and any other public places.

3.0 METHODOLOGY

Concrete is the most widely used construction material today. The constituents of concrete are coarse aggregate, fine aggregate binding material and water. It is conventional that sand is being used as fine aggregate in concrete. For the past some years, the escalation in cost of sand due to administrative restrictions in India, demands comparatively greater cost at around two to three times the cost of quarry dust even in places where river sand is available nearby. The materials usually researched for replacement purpose are either by-product materials or even sometimes manufactured aggregates Quarry dust, a by-product from the crushing process during quarrying activities is one of those materials being studied, especially as substitute material to sand as fine aggregates. It has been proposed as an alternative to river sand that gives additional benefit to concrete. Quarry dust is known to increase the strength of concrete over concrete made with equal quantities of river sand. They have been used for different activities in the construction industry such as for road construction and manufacture of building materials such as lightweight aggregates, bricks, tiles and autoclave blocks. High percentage of dust in the aggregate increases the fineness and the total surface area of aggregate particles. The main objective is to provide more information about the effects of various proportion of dust content as partial replacement fine aggregate on workability, air content, compressive strength, tensile strength, water absorption, percentage of concrete. Iron slag is a byproduct obtained in the manufacture of iron in the blast furnace and is produced by the blend of down to earth constituents of iron ore with limestone flux. Mostly, the slag consists of magnesium, aluminum silicates calcium and manganese in various arrangements. The history of the use of iron and steel slag dates back a long. The present research work mainly deals with the influence of different replacement proportion of sand with quarry dust and iron slag on the properties of concrete. The present study is planned to study the effects of quarry dust and iron slag addition in normal concrete and to assess the rate of compressive strength development

CHEMICAL COMPOSITION OF OPC

Cement is a complicated mixture of chemical compounds, OrdinaryPortlandcement consists of following major compounds:

- Tri Calcium silicate – $(CaO)_3SiO_2$ –denoted by C_3S
- Di Calcium Silicate – $(CaO)_2SiO_2$ –denoted by C_2S

- Tri calcium aluminate -- $(CaO)_3\ Al_2O_3$ -- denoted by C_3A
- Tetra calcium alumino ferrite -- $(CaO)_4Al_2O_3$ – denoted by C_4AF

About 70% to 80% of cement is contributed by C_3S and C_2S which areresponsible for the strength of cement. These compounds provide to cement the property to resist the attacks of acids and alkalies and make the cement durable. C_3S has the property of hydrating rapidly and is responsible to provide not only early strength but also ultimate strength. C_2S has the property of hydrating less rapidly and provides the strength after duration of 7days C_3A gets hydrated rapidly and is found responsible to provide early strength but is found to slightly retard the ultimate strength. This compound is susceptible to be attacked by salts and alkalies.

TEST RESULTS OF CEMENT

TESTS ON AGGREGATE:

Aggregates are the important constituents in concrete. They give strength and effect economy of the construction. Earlier aggregate are considered as inert materials but now it has been recognized that some of the aggregates are chemically active and also that aggregates posses chemical bond at the interface of the aggregate and the paste. Major portion of concrete is occupied by aggregate i.e. up to 70 to 80 % of volume.

SIZE OF AGGREGATE:

Aggregates are classified as different categories based on the size as discussed earlier, max size of aggregate that can be used 80 mm for concrete making. Using maximum size will result in

- Reduction of the cement content
- Reduction of water content
- Reduction of drying shrinkage

Generally, the maximum size of aggregate should be as large as possible within the limits specified, but in any case not greater that the one-fourth of the minimum thickness of the member. For heavily reinforced concrete member the nominal size of aggregate should be usually be restricted to 5mm less than the minimum clear distance between the main bars or 5mm less than minimum cover to the reinforcement, whichever is smaller but various other practical considerations, for reinforced concrete works, aggregates having size of 20mm are generally considered.

FINENESS MODULUS OF FINE AGGREGATE:

The aggregate that pass through the IS sieve 4.75mm is called as fine aggregate. Sieve analysis is carried out for the determination of fine aggregate by using sieves of different sizes i.e. 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ conforming to IS: 460-1962 shall be usedThe sample shall be brought to air dry condition before weighing and sieving. The sample is sieved and the sieving is started with the largest size of sieve at top. Each size of sieve is done over a clean tray by shaking good for not less than 2minutes. The shaking is done by a varied motion of forward and backward, left and right and rotated in clockwise and anti clockwise direction uniformly. In the below table we can see the values of sieve analysis.

Sieve size (mm)	Weight of sand retained on each sieve (g)	Cumulative weight retained (g)	Percentage Cumulative weight retained (∑F)	Percentage Cumulative weight passing
4.75	0	0	0	0
2.36	2	2	1	99
1.18	11	13	6.5	93.5
0.6	26	39	19.5	80.5
0.3	83	122	61	39
0.15	62	184	92	8
PAN	14	198	99	1

SIEVE ANALYSIS OF FINE AGGREGATE

Fineness modulus = ∑F/ 100

=272/100

SPECIFIC GRAVITY OF SAND:

Specific gravity is the ratio of weight of aggregate maintained for 24± ½ hrs at a temperature of 100° C to 110° C to the weight of equal volume of water displaced by saturated surface dry aggregate and volume of all pores both impermeable and permeable.

Procedure:

Take about 500g of sample and place it in the pycnometer. Pour distilled water into it until it is full. Eliminate the entrapped air by rotating the pycnometer on its side, the hole in the apex of the cone being covered with a finger. Wipe out the outer surface of pycnometer and weigh it (W).Transfer the contents of the pycnometer into a tray, care being taken to ensure that all the aggregate is transferred. Refill the pycnometer with distilled water to the same level .Find out the weight (W1). Place the sample in oven in a tray at a temperature of 100ºC to 110º C for 24±0.5 hours, during which period, it is stirred occasionally to facilitate drying. Cool the sample and weigh it (W2)

Apparent specific gravity =
(weight of dry sample/weight of equal volume ofwater)
= W2/ (W2- (W-W1))
= 2.62.

3.4 TESTS ON COARSE AGGREGATE:

The following tests are conducted on the coarse aggregate:

a. Fineness modulus test

b. Specific gravity of coarse aggregate.

3.4.1 FINENESS MODULUS TEST:

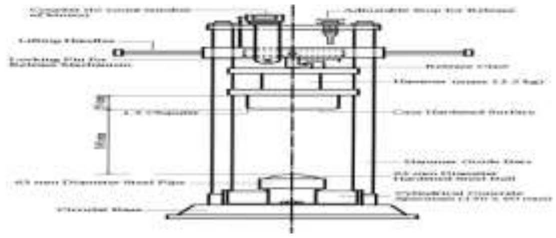
The aggregate which retained on the IS sieve 4.75mm is called as coarse aggregate. Sieve analysis is carried out for the determination of coarse aggregate by using sieves of different sizes i.e. 80mm, 40mm, 25mm, 20mm, 12.5mm, 10mm, and 4.75mm conforming to IS: 460-1962 shall be used. The sample shall be brought to air dry condition before weighing and sieving. The sample is sieved and the sieving is started with the largest size of sieve at top. Each size of sieve is done over a clean tray by shaking good for not less than 2minutes. The shaking is done by a varied motion of forward and backward, left andright and rotated in clockwise and anti clockwise direction uniformly. In the below table we can see the values of sieve analysis. Find the % weights retained on each sieve.

Fineness modulus = (105.75 + 500)/ 100

for 20mm F.M = (102.5 + 500)/100=6.20

AGGREGATE IMPACT TEST:

This test is done to determine the aggregate impact value of coarse aggregates as per IS: 2386 (Part IV) – 1963. The apparatus used for determining aggregate impact value of coarse aggregates is Impact testing machine.



AGGREGATE IMPACT VALUE APPARATUS

The fraction retained on the sieve is also weighed and if the total weight of the fractions passing and retained on the sieve is added, it should not be less than the original weight of the specimen by more than one gram; if the total weight is less than the original by over 1gm, the result should be discarded and a fresh test made.The aggregate impact value is expressed as the percentage of fines formed in terms of the total weight of the sample. Let the original weight of the oven dry sample be w1g and the weight of fraction passing 2.36mm IS sieve be w2g.

Aggregate impact value = w2/w1×100%

Method of Salinity Measurement	Percision
Hand-held refractometer	1 part in 70
Laboratory titration	1 part in 350
Modern salinometer (conductivity)	1 part in 40,000

(From Pilson, 1998)

TESTS FOR SALINITY IN SEA WATER:

Salinity is often measured by measuring how well electricity travels through the water. This property of water is called conductivity. Water that has dissolved salt in it will conduct electricity better than water with no dissolved salt. The more salt that is dissolved in the water, the better the water conducts electricity. The salt content of the water can be measured very precisely using the conductivity method Salinity can also be measured with a hand held refract meter. The pencil appears to bend where it enters the water. The pencil is not really bent. The light we see has bent as it moves from water to air. A refractometer is the best choice for measuring salinity when only approximate values are needed. Refractometers are easy to use in the field and relatively inexpensive.

RESULT: The salinity present in taken sea water sample is **1%**

4.0 DESIGN OF CONCRETE MIX

The fundamental requirement of a concrete mix is that it should be satisfactory both in the fresh as well as in the hardened state, possessing certain minimum desirable properties like workability, strength and durability. Besides these requirements it is essential that the concrete mix is prepared as economically as possible by using the least possible amount of cement content per unit volume of concrete, with due regard to the strength and durability requirements. Since concrete is produced by mixing several discrete material, the number of variables governing the choice of mix design are necessarily large. However continuous research work in this field by various investigators, has helped to identify the major parameters controlling the proportions of ingredients in the mix.

4.3 Mix Design Procedure

Target mean strength

$F_t = f_{ck} + 1.65 \times S$

Where,

F_t = Target mean strength at 28 days in N/mm^2

f_{ck} = Characteristic compressive strength at 28 days in N/mm^2

S = Standard deviation

This ratio should be selected based upon the relationship between target mean compressive strength of concrete and Compressive strength of cement. IS: 10262-1982 fig. 2 gives the values of water-cement ratio for various cements. The water-cement ratio can also be taken from table (5) of IS:456-2000 for particular environmental exposure conditions as starting point. The supplementary cementitious material that is mineral admixtures shall also be considered in water-cement ratio calculations.

<u>MIX DESIGN FOR M20 GRADE CONVENTIONAL CONCRETE:</u>

PROPERTIES OF CONCRETE:

Maximum size of aggregates - 20 MM (angular)

Degree of workability - 0.90 compacting factor

Degree of quality control - good

Test data for materials:

1. specific gravity of cement -3.15

2.specific gravity (a) coarse aggregate -2.60(b) fine aggregate-2.60 (a) coarse aggregate -0.5%(b) fine aggregate -1.0% (c).water cement ratio -0.5(d). free moisture (a) Coarse aggregate – NIL (e) Fine aggregate-2.0%

SELECTION OF WATER AND SAND CONTENT:

From IS :10262-1982

SIZE OF AGGREGATE(MM)	WATER CONTENT PER CUBIC METER OF CONCRETE(KG)	TOTAL VOLUME OF FINE AGGREGA TE BY ABSOLUT E
10	208	40
20	186	35
40	165	30

Their fore, required sand content as % of total aggregate by absolute volume = 35-3.5 = **31.5%**

Required water content = $186+\frac{186*3}{100}$

= 186+5.58

= 191.61 litre/ m^3

DETERMINATION OF CEMENT CONTENT:

Water cement ratio = 0.50

Water = 191.61

Cement = 191.6/0.50

= 383 kg/ m^3

DETERMINATION OF COARSE AND FINE AGGREGATE CONTENT:

From IS:10262-1982 of table 3, for the specified maximum size of aggregate of 20 mm, the amount of entrapped air in the wet concrete is 2% i.e 1-0.02=0.98 cubic meter.

CALCULATION OF AGGREGATE CONTENT :

$V = [W+\frac{C}{SC}+ \times \frac{fa}{sfa}] \times {}^{1}/_{1000}$,and

$V = [W+\frac{C}{SC}+\frac{1}{1-p}\frac{ca}{sca}] \times {}^{1}/_{1000}$

Where,

V = absolute volume of fresh concrete(m^3)

W = mass of water (kg/ m^3)

C = mass of cement (kg/ m^3 of concrete)

Sc = specific gravity of cement

P = ratio of fine aggregate to total aggregate by absolute volume

F_a,C_a= total masses of fine aggregate and coarse aggregate(kg/ m^3 of concrete)

S_{fa},S_{ca} = specific gravity of saturated surface dry fine aggregate and coarse aggregate

$0.98m^3 = [191.6+\frac{383}{3.15}+\frac{1}{0.315}\times\frac{Fa}{2.60}] \times {}^{1}/_{1000}$

Fa = 546 kg/m^3

$0.98\ m^3 = [191.6+\frac{383}{3.15}+\frac{1}{0.685}\times\frac{ca}{2.60}] \times {}^{1}/_{1000}$

Ca = 1187 kg/ m^3

The mix proportion then becomes

WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
191.61	383 KG	546KG	1187KG

Then the ratio becomes as follow

WATER = 191.61/383 =0.5

CEMENT = 383.00/383 =1

FINE AGGREGATE = 546/383 =1.42

COARSE AGGREGATE = 1187/383 =3.09

1 : 1.42: 3.09

Step – 2: Calculation of Water – Cement Ratio:

Various parameters like type of cement, aggregate etc are influencing the strength of concrete, when water-cement ration remain constant, hence it is desirable to establish a relation between concrete and w/c ratio with material and condition to be used actually at site. In the absence of such relation, free w/c ratio corresponding to the strength may be determined using the graph given in IS code.The graph is draw b/w w/c ratio and the strength in N/mm^2. Using the target mean strength w/c ratio is selected. In the present case it is selected as 0.43.

SIEVE ANALYSIS FOR GRADATION OF SAND

Sand used in this test are tested and test result foe fineness modulus of fine aggregate are compared with IS code recommended values of percentage passing weight for different sieves size and the sand is confined to **ZONE3**

3.0 METHODOLOGY OF RESEARCH

WORK DISCRIPTION: In this chapter we are going to discuss about the research methodology that has been carried out. The entire procedure is explained in the flow chart given below

FLOW CHART OF WORK DESCRIPTION

As above mentioned flow of procedure in the previous chapter we have discussed about the mix design of the concrete for grade of concrete i.e. M_{20}, M_{25}. The proportions of the mix are targeted to obtain the strength of 20 and 25 Mpa at the end of 28days at different water ratios. This research was processed by using Iron Slag as the replacement material at different percentages of 0, 5, 10, 15, 20 %. Concrete has been prepared in the required mix proportion and as soon as it is prepared and tested for workability.

TESTS ON FRESH CONCRETE:

Keeping in view of importance for workability the following tests are done on concrete and these are found to have acceptance all over.

- Slump test
- Compaction factor test.

SLUMP TEST:

Slump test is the most commonly used method for checking the consistency of concrete which can be tested in laboratory or in field. For the present work, slump test were conducted as per IS: 1199-1959 for all mixes. It is not suitable method for very wet and very dry concrete. This method is suitable for medium slump. It does not measure all factors for workability, nor is it always representative of place ability of concrete. However it is used conveniently as a control test and gives an indication of the uniformity of the concrete from mix to mix.

The apparatus for conducting the test essentially consists of a metallic mould in the form of frustum of a cone having dimensions mentioned below.

Bottom diameter = 20cm
Top diameter = 10 cm
Height = 30 cm

The other dimension is shown in the figure given below. A steel tamping rod is present on which a scale is present to measure slum value in the field with a diameter of 16mm and 0.6m long. And a base plate is present on which slump cone is fixed. The procedure is as follows

SLUMP CONE APPARATUS

Concrete is filled in four layers by giving each layer with 25blows distributed evenly and this is continued until till it reach top. Then the cone is removed and height of slum is measured.

DIFFERENT MEASURE OF SLUMPS

COMPACTION FACTOR TEST:

Compacting factor of fresh concrete is done to determine the workability of fresh concrete. The compacting factor Test is designed primarily for use in laboratory but it can also be used in the field. It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability as are normally used when concrete is to be compacted by vibration. Such dry concrete is insensitive to slump test.

This test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. The degree of compaction, called the compacting factor is measured by the density ratio i.e., the ratio

DIMENSIONS OF COMPACTION FACTOR APPARATUS of the density actually achieved in the test to density of same concrete fully compacted.Essential dimension of the compacting Factor Apparatus for use with aggregate not exceeding 40 mm Normal Mix size

PROCEDURE:

a. The sample of concrete is placed in the upper hopper up to the brim.

b. The trap-door is opened so that the concrete falls into the lower hopper.

c. The trap-door of the lower hopper is opened and the concrete is allowed to fall into the cylinder.

Compacted concrete)

The weight of fully compacted concrete can also be calculated by knowing the proportion of materials, their respective specific gravities, and the volume of the cylinder. It is seen from the experience, that it makes very little difference in compacting factor value, whether the weight of fully compacted concrete is calculated theoretically or found out actuallyafter100% compaction.

PREPARING TEST CUBES:

The size of the mould used to produce the cubes was 150 x 150 x 150 mm. twelve cubes were used for each concrete mix. The concrete was poured into the mould in two layers where each layer was compacted using a steel bar. The cubes were removes from the moulds after 24 hours and cured using different types of curing techniques.

MOULDS OF 150 × 150 × 150 MM

Description of apparatus	Dimensions
Upper Hopper, A	
Top Internal Diameter	25.4
Bottom Internal Diameter	12.7
Internal Height	27.9
Lower Hopper, B	
Top Internal Diameter	22.9
Bottom Internal Diameter	12.7
Internal Height	22.9
Cylinder,C	
Internal Diameter	15.2
Internal Height	30.5
Distance between bottom of upper hopper and top of lower hopper	20.3
Distance between bottom of lower hopper and top of cylinder	20.3

MOULDS FILLED WITH CONCRETE

DESIGNATION FOR CONCRETE MIXES:

As the experiment is connected with a number of test mixes of different grades for the simplicity and easy understanding each mix is designated with a specified code and the codes are given in the table...

DESIGNATION FOR CONCRETE MIXES

CURING OF CONCRETE CUBES:

In the present condition the performance of concrete was tested in different curing conditions. Two curing techniques were used from water curing and also the cubes are cured in marine water to analyze the performance of MK on attack of marine water. The method of curing is immersion type i.e. with normal and sea water curing.

TESTS ON HARDENED CONCRETE:

As stated earlier, this study focuses on the performance of concrete blended with Iron Slagin term of its compressive strength. The compression test is an important concrete test to determine the strength development of the concrete specimens. Compressive strength tests were performed on the cube specimens at the ages of 7, 14 and 28 days.

Testing was conducted immediately after the specimens were removed from the curing sacks. The compression load was applied using compression machine applying load constantly. Three specimens were tested at each age to compute the average strength. Additional specimens were tested if any individual strength result deviated substantially from the mean. A new average was computed based on the three closest strength results. The results are recorded for further analysis.

Compression testing machine

In the above figure we can see the specimen is placed for the testing.

TESTED CUBES AND CYLINDERS

In this figure we can c the tested cubes. The cubes are deformed out of shape due to the load applied on them

RESULTS OF COMPRESSIVE STRENGTH OF HARDENED CONCRETE: Results of cubes cured under normal water curing (immersion type)

COMPRESSIVE TEST:

MIX ID	AGE (DAYS)	COMPRESSIVE STRENGTH (Mpa)			
		CUBE-1	CUBE-2	CUBE-3	AVERAGE

A_0	03	19.1	19.4	19.0	19.16
A_0	07	19.5	19.8	19.3	19.53
A_0	14	20.58	20.60	20.40	20.52
A_0	28	25.79	25.80	25.30	25.63
A_1	03	19.3	19.4	19.30	19.33
A_1	07	19.9	19.12	19.80	19.60
A_1	14	21.0	21.60	21.30	21.3
A_1	28	26.0	26.80	26.70	26.5
A_2	03	22.0	22.90	22.80	22.56
A_2	07	24.0	24.70	24.40	24.3
A_2	14	27.0	27.60	27.20	27.2
A_2	28	28.0	28.40	28.50	28.3
A_3	03	23.0	23.20	23.30	23.1
A_3	07	26.0	26.70	26.40	26.3
A_3	14	28.0	28.80	28.70	28.6

Formulas:

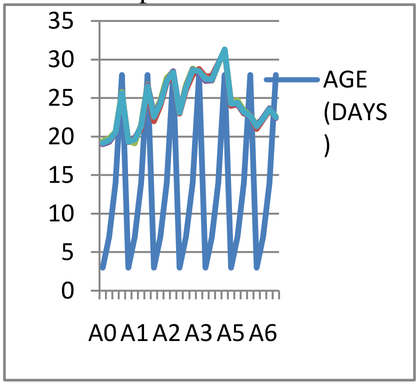
Tensile strength of a cylinder = $\frac{maximumload}{crosssectionalarea}$

compressive strength of a cube = $\frac{maximumload}{crosssectionalarea}$

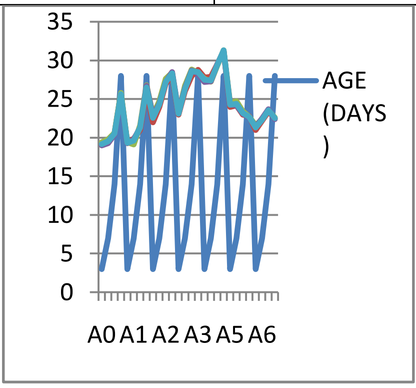
Cross sectional area of a cylinder = $\frac{\pi}{4}d^2$

Cross sectional area of a cube = l*b

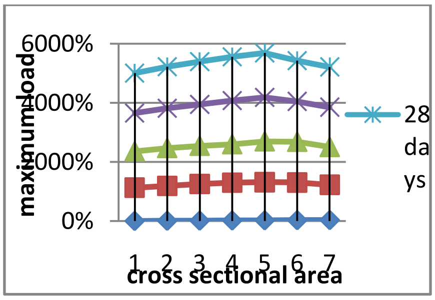
Graphs for Cubes:



graph 1:Results of cub es cured under normal water curing different variations



Graph no:2
Representation of 5 % replacement of iron slag with fine aggregate for various ages



4.0 CONCLUSIONS

- Studies on Creep and Shrinkage properties may be carried out
- Studies on replacement of cement by any other pozzolanic material and fine

aggregate by manufactured sand can be made

- Comparing to the conventional concrete, Partial replacement of iron slag in concrete increases for 30% by 1.3% and decreases for 20%, 40%, 50% by 0.9%, 26%, 38% respectively for cube compression strength.

- Comparing to the conventional concrete, Partial replacement of iron slag in concrete increases for 30% by 7.6% and decreases for 20%, 40%, 50% by 0.66%, 7.3%, 10% respectively for split tensile strength

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