AN EXPERIMENTAL INVESTIGATION OF STRENGTH AND MECHANICAL PROPERTIES OF LIME SLUDGE BY PARTIAL REPLACEMENT OF CEMENT IN CONCRETE

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ABSTRACT

The global cement industry contributes about 90% if greenhouse gas emission to the earth atmosphere and industrial wastes are being produced by 420 million tonnes per annum by chemical process in India. In order to reduce cement manufacturing and disposal problem of paper waste, there is a need to develop alternative binders in construction field. Utilization of industrial waste products as Supplementary Cementitious Material(SCM) in concrete is very important aspects in view of economical, environmental and technical reasons. This work examines by using paper waste (lime sludge) as partial replacement of cement & it is most essential to develop profitable building materials from lime sludge. It is directed towards developing low cost concrete and light weight concrete from paper industry waste. The use of lime sludge in concrete formulations as SCM was tested as an alternative traditional concrete. These tests were carried out to evaluate the mechanical properties like compressive strength and split tensile strength up to 7 days, 14 days and 28 days. In this work, M_{30} grade concrete was developed by replacing cement via 5%, 10%, 15% and 20% of lime sludge. The strength on concrete made with lime sludge are compared with normal concrete.

This paper presents is the experimental of effect of industrial waste material namely lime sludge on compressive strength, split tensile strength, flexural strength of M_{30} grade concrete. And also to finding the optimum percentage of lime sludge using in concrete to casting reinforced beam and finding the deformation (deflection).

INTRODUCTION

1.1 GENERAL

Paper waste (lime sludge) is a waste from paper industry. It is estimated that in India 0.7% of total urban waste generated comprises of paper waste. Paper sludge is a major economics and environment problem for the paper industry. Paper sludge are varies with strong and weak fibers. Strong fibers of waste are taken for the recycling process to make recycled paper and the weak fibers are taken to the disposal site.

Due to this disposal, It causes a severe problem of air pollution, water pollution and soil pollution. To reduce the disposal problem, paper sludge are replaced with cement because of silica and magnesium properties which improves the setting time of cement. Lime sludge was originally introduce as artificial pozzolana in which it consists of minimum amount of silica, magnesium and considerable amount of lime which is the main property of cement.

Lime sludge is used as a replacement in producing mortar and was investigated on its mechanical, physical and chemical properties. Substitution of waste materials will avoid environmental benefits of supplementary cementitious materials use and study the design parameters of concrete on inclusion of paper waste as partial replacement of cement.

1.2 LIME SLUDGE FROM PAPER INDUSTRY

1.2.1 NEED FOR LIME SLUDGE UTILIZATION:

While producing paper the various wastes are comes out from the various processes in paper industries. From the preliminary waste named as paper sludge, due to its low calcium is taken out for our project to replace the cement utilization in concrete. Due to the cement production greenhouse gases are emitted in the atmosphere. For producing 4 million tons of cement, 1 million tons greenhouse gases are emitted. Also, to reduce the environmental degradation, this sludge has been avoided in mass level disposal in land. To eliminate the ozone layer depletion, production of cement becomes reduced. For this, lime sludge is used as partial replacement in the cement as high performance concrete. By utilizing this waste the strength will be increased and also cost reduction in the concrete is achieved.

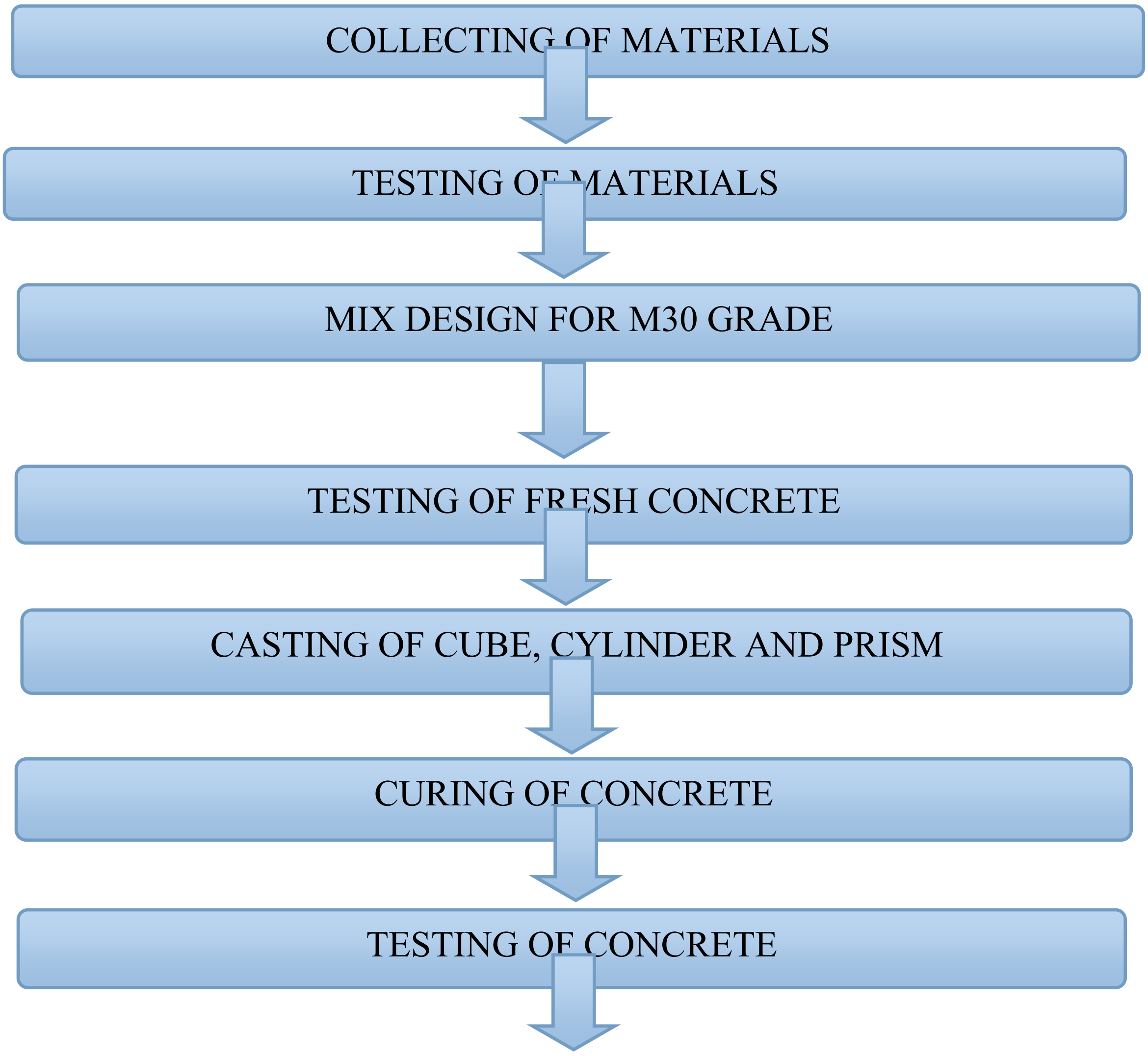
1.2.2 OBJECTIVES:

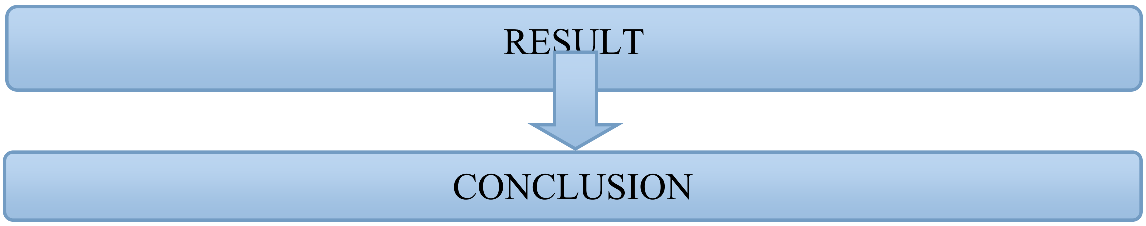
To investigate the utilization of lime sludge as supplementary cementitious material (SCM) and influence of these lime sludge on the strength on concrete made with difference cement replacement levels.

1.2.3 SCOPE:

1. To provide a most economical concrete.
2. Using the wastes in useful manner.
3. To reduce the cost of construction.
4. To find the optimum strength of the partial replacement of
   Concrete .
5. Minimize the maximum demand for cement
6. Minimize the maximum degradation in environment due to cement and safeguard the ozone layer from greenhouse gases.
7. To promote the low cost housing.

1.2.4 METHODOLOGY:





LITERATURE REVIEW

Experimental investigation in developing low cost concrete from paper industry waste R.Srinivasan , K.Sathiya and M.Palanisamy , 2010.

Over 300 million tonnes of industrial wastes are being produced per annum by chemical and agricultural process in India. These materials pose problems of disposal and health hazards. The wastes like phosphogypsum, fluorogypsum and red mud contain obnoxious impurities which adversely affect the strength and other properties of building materials based on them.

Utilization of waste paper pulp by partial replacement of cement in concrete Sumith A Balwalk; S P Raut, ISSN: 2248-9622

The use of paper mill pulp in concrete formulations was investigated as an alternative to landfill disposal. The cement has been replaced by waste paper sludge accordingly in the range of 5% to 20% by weight for M30 mix. By using adequate amount of the waste paper pulp and water, concrete mixtures were produced and compared in terms of slump and strength with the conventional concrete.

I.Veges, J.Urreta et al,.(2012)

In general which each group of concrete mixtures containing the fibrous residuals from pulp and paper mills, density, compressive strength and split tensile strength of concrete decreased with the increase in the amount of residuals in concrete. Several concrete mixtures containing the residuals showed higher strength than the concrete without the residuals. The strong correlation was observed between the compressive strength and splitting tensile strength of concrete containing pulp and paper mill residuals. Overall, a low correlation was observed between W/C and strength of concrete containing residuals. By achieving equivalent density of concrete the strength of concrete containing residuals may be made equivalent to that of concrete without the residuals.

Sumith A Balwa Lk; S P Raut (2019)

The use of paper mill pulp in concrete formulations was investigated as an alternative to land fill disposal. The cement has been replaced by waste paper sludge accordingly in the range of 5% to 20% by weight of M_{30} mix. By using adequate amount of the waste paper pulp and water, concrete mixtures were produced and compared in terms of slump and strength with the conventional concrete.

J.N.Akhtar et al (2011)

In this study, six different mix proportions were computed by utilizing the paper pulp and industrial by products like flyash, rice husk and also due to the addition of paper pulp the bricks have low thermal conductivity, and it reduce the energy requirement for temperature control while using the paper pulp to make the bricks, it will reduce approximately 50% of weight of the brick.

Akinwumi (2014)

The water absorption and fire resistance of papercrete were found to be high and increased with increasing waste paper content while the bulk density and compressive strength of papercrete were low and decreased with increasing waste paper content. Papercrete was recommended to be a effective and sustainable material for the production of light weight and fire resistance hollow or solid blocks to be used to make partition walls of especially high rise building

Fuller et al (2006)

Formulated that for decades intrepid environmentalisthave been building homes and other structures with materials that recycle waste paper into alternative construction, rather than skill- based, but care is needed when selecting volumes and placing them into positions.

I.Veges,J.Urreta et al.,(2012)

Concrete mixtures containing the fibrous residual from paper mills, density, compressive strength and spilt tensile strength of the concrete decreased with increased in the amount of residuals in concrete. By achieving equivalent density of concrete the strength containing residuals may be made equivalent to that of concrete without the residuals.

Ms.S.Suganya (2012)
Bricks are relatively light weight, good sound absorbent and more flexible but it has high percentage of water absorption than conventional bricks it can be easily cut into a desirable shape.

Jayaraj et al (2013)
All done experimental investigation on strength of concrete and optimum percentage of partial replacement by preparing a mix M_{30} grade was designed as per IS method and the same was used to prepare the test samples.in the test performed the optimum compressive stress obtained by utilizing paper waste was at 30% replacement that compared values of cost show gradual decrement in total cost of per cubic meter concrete.

Jayesh Kumar Pitroda et al (2013)
All focused on investigation of strength of concrete and optimum percentage of partial replacement by replacing cement 10%, 20%, 30% of hypo sludge. Keeping on this view the aim of investigation is the behavior of concrete by adding of waste with different proportions of hypo sludge in concrete by using test like compression test and split tensile strength.

Rushabh Shan J Pitroda (2013)
Study the results of cement mortar of mix proportions 1:3 in which the cement is partially replaced with hypo sludge as 0%,10%,20%,30% by weight of cement.Test results indicates the decreases in the strength properties of mortar with the hypo sludge for strength at 7,14,28 days as partial replacement with the cement in cement mortar 1:3.

R. Balamurugan and R.Karthik Raja (2014)
Producedlow cost concrete by blending various ratio of cement with hypo sludge .work is concerned with experimental investigation on strength of concrete and optimum percentage of partial replacement by replacing cement by 5%,10%,15% and 20% of hypo sludge.

MATERIALS USED

The materials used are

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Lime sludge
5. Water

3.1 PROPERTIES OF MATERIALS:

3.1.1 CEMENT

Fig No 3.1: CEMENT

Cement may be desired as a material with adhesive and cohesive properties that make it capable of bonding minerals fragments (aggregates) into compact whole. In this process, it impact strength and durability to the hardened mass called concrete. The cement used in the making of concrete are called hydraulic cements so named, because they have the property of reacting chemically with water in an exothermic (heat generating) process called hydration that results in water-resistant products.

The most common type of hydraulic cement used in the manufacturing of concrete is known as Portland cement, which is available in various forms. Portland cement is made by burning together, to about 1400 degree Celsius, intimate mixture (in the form of slurry) of lime stone with alumina, silica and iron oxide composition, were not found to be sufficient. Resources have been taken to add one or more new materials, known as additives, to the clinkers at the time of grinding, or to the use of entirely different basic or row materials in the manufacture of cement.

TABLE NO 3.1: PHYSICAL PROPERTIES OF CEMENT

S.no	property	Result
1	Consistency	30%
2	Fineness	4.33%
3	Specific gravity	3.1
4	Initial setting time	32.51 min
5	Final setting time	537.49 min

3.1.2 FINE AGGREGATE:

Fig No 3.2: Manufactured Sand

Manufactured sand (M-Sand) is a substitute of river sand for concrete construction .Manufactured sand is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges,washed and graded to as a construction material .M-Sand is an inert occurring material of size less than 4.75mm.

Specifications for M-sand to be suitable for the concrete are that it should be free from all these injurious materials. Further the percentage of the clay and silt content are restricted to maximum 5% and it should be free from organic impurities such as tannin acid derived surface vegetation.

TABLE NO 3.2: PHYSICAL PROPERTIES OF FINE AGGREGATE

S.no	Property	Result
1	Specific gravity	2.63
2	Fineness modulus	2.5
3	Water absorption	2 %

3.1.3 COARSE AGGREGATE:

Fig No 3.3: Coarse Aggregate

As explained aggregate used for concrete production is classified as fine aggregate and coarse aggregate depending on its particle size. Aggregate of size more than 4.75mm, is called coarse aggregate and is one of the most important ingredient of concrete. It gives strength to the concrete and constituents about 70 to 75 percent volume of concrete. Crushed stone in general used as coarse aggregate which is black in color, angular and in local name known as black metal or 'Gitti'. Coarse aggregate are generally derived crushing natural available.

TABLE NO 3.3: PHYSICAL PROPERTIES OF COARSE AGGREGATE

S.no	Properties	Result
1	Specific gravity	2.80
2	Impact value	28.57%
3	Water absorption	2.0%

3.1.4 LIME SLUDGE:

Fig No 3.4: lime sludge

Lime sludge is a waste material collected from the paper industry. Hypo sludge behaves like cement because of silica and magnesium properties. It is a good binding chain material for the concrete. The chains also pack regularly in places to form hard, stable crystalline region that gives the bundle chains even more stability and strength. Lime sludge is used in concrete with the replacement of cement of 5%, 10%, 15% and 20%. The compressive strength and split tensile strength was also determined in 7days, 14days and 28days.

TABLE NO 3.4: PHYSICAL PROPERTIES OF LIME SLUDGE

S.no	Properties	Result
1	Specific gravity	1.42

TABLENO3.5: CHEMICAL PROPERTIES OF LIME SLUDGE

S.no	Constituent	Lime sludge (%)
1	Moisture	56.8
2	Magnesium oxide (MgO)	4.5
3	Calcium oxide (CaO)	46.1
4	Silica (Sio_2)	4.0
5	Loss of ignescent	27
6	Acid insoluble	12.12
7	R_2O_3	3.6

3.1.5 WATER:

The quality of mixing water for concrete has a visual effect on the reducing hardened concrete. Impurities in water may interface with setting of cement & will adversely affect the strength and durability of concrete with steel slag. Fresh and clean water is free from organic matter, silt, oil, and acid materials as per standards issued for casting and curing the specimens. Water that is piped from the public supplies is used.

TABLE NO 3.6: PROPERTIES OF WATER

S.no	Parameters	Result	Limits
1	pH	6.92	6.5 - 8.5
2	Chloride	52mg/l	2000mg/l 500mg/l
3	Alkalinity	7ml	<25ml
4	Sulphate	128mg/l	400mg/l
5	Fluorides	0.04mg/l	1.5mg/l
6	Organic solids	56mg/l	200mg/l
7	Inorganic solids	129mg/l	3000mg/l

3.2 TESTING OF MATERIALS

3.2.1 CEMENT TEST

3.2.1.1 CONSISTENCY TEST ON CEMENT

The standard consistency ofcement is that consistency, which permit the vicat plunger to penetrate to a point 5 to 7mm from the bottom of the vicat mould when tested.The time of gauging should not be less than 3 minutes and not more than 5 minutes. Gauging time is the time elapsing from the time of adding water to the dry cement until commencing to fill the mould.

TABLE NO 3.7: CONSISTENCY TEST ON CEMENT

Trial No	**Weight of cement taken(g)**	**Quantity of water added**		**Penetration index reading (mm)**
		%	**G**	
1	250g	20	50	43
2	250g	22	55	37
3	250g	24	60	19
4	250g	26	65	15
5	250g	28	70	8
6	250g	30	75	6

RESULT

The percentage of water required for obtaining cement paste of standard consistency is 30%.

3.2.1.2 FINENESS TEST ON CEMENT

Fineness of cement is property of cement that indicate particle size of cement and specific surface area and indirectly effect heat of hydration. Finenessof Cement is measured by sieving cement on standard sieve. The proportion of cement of which the cement particle sizes are greater than the 90 micron is determined.

TABLENO3. 8: FINENESS TEST ON CEMENT

S.no	DESCRIPTION	TRIAL-1	TRIAL-2	TRIAL-3
1	Weight of cement in gm(W)	100	100	100
2	IS. Sieve size in micron	90	90	90
3	Sieving time in minutes	15	15	15
4	Weight retained on sieve in gm(W_1)	4	5	4
5	% weight retained on sieve W_1/W*100	4%	5%	4%
The mean percentage of fineness = 4.33%				

CALCULATION:
Sample of cement = weight of residue / original weight * 100
Sample of cement = W_1/W * 100
= 5/100 * 100= 5%

RESULT:
Average fineness of cement is 4.33%.

3.2.1.3 SPECIFIC GRAVITY OF CEMENT

The specific gravity is normally defined as the ratio between theweightof a given volume of material and weight of an equal volume of water. Specific gravity is normally used in mixture proportioning calculations.

CALCULATION:
Weight of cement taken (W_2) = 100g
Weight of cement left over (W_2)= 38g
Weight of cement Lechatlier (W_3)= W_2 - W_1
= 100 - 38 = 62g
Rise of kerosene = 20ml
Volume of cement = 20cc
Specific gravity of cement = W_3 / volume
= 62/20 =3.1

RESULT:
Specific gravity of cement = 3.1

3.2.1.4 INITIAL AND FINAL SETTING TIME OF CEMENT

Initial setting time of concrete is the timewhen cement paste starts hardening while final setting time is the time when cement paste has hardened sufficient. The time at which cement completely loses its plasticity and became hard is a final setting time of cement. The time taken by cement to gain its entire strength is a Final setting time of cement. For Ordinary Portland Cement, The Final Setting Time is 600 minutes (10hrs).

TABLE NO 3. 9: INITIAL SETTING TIME

S.no	TIME AT WHICH WATER IS FIRST ADDED(T_1)			TIME AT WHICH PENETRATION READING ARE TAKEN(T_2)		
	HOURS	MIN	SEC	HOURS	MIN	SEC
1	-	2	0	-	35	50
2	-	2	58	-	35	56
3	-	2	55	-	35	40

CALCULATION
Time when needed fails to penetration
a) 5mm to 6mm the bottom of the mould (T_2) = 35.48min
b) Time at when water is first added (T_2) = 2.57min
C) Initial setting time (T_2-T_1) = 32min

TABLE NO 3.10: FINAL SETTING TIME:

S.no	RECORD OF PENETRATION READING
1	6mm
2	5.20mm
3	5mm

a) Time when the needle make impression (T_3)= 570mm

b) Final setting time = (T_3-T_1) = (570-32.9)= 537.32min

RESULT:

1) Initial setting time = 32.51 min

2) Final setting time = 537.49 min

3.2.2 FINE AGGREGATE

3.2.2.1 SPECIFIC GRAVITY OF FINE AGGREGATE

Manufactured sand have been regularly used to make quality concrete.

Results indicated that river sand can be entirely replaced by M Sand however; water reducing admixtures need to be added as required. Further, the compressive strength of the concrete with M sand was exceeded that of the concrete with natural sand at the same w/c ratio. In contrast, slump values gradually decrease with the increasing of MSand in concrete due to the higher angularity of the manufactured sand particles.

CALCULATION

Specific gravity of sand =dry wt of sand / weight of equal volume of water

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

Trial 1 = 1607-697/ (1578-697)-(2099-1606)= 2.62

Trail 2 = 1785-697/ (1456.5-697)-(2183-1785)= 2.78

Average = 2.62+2.78/2 = 2.70

TABLE NO 3.11: SPECIFIC GRAVITY OF FINE AGGREGATE

WEIGHT	TRAIL 1	TRAIL 2
Weight of empty Pycnometer (W_1g)	697	697
Weight of empty Pycnometer + dry sand (W_2g)	1606	1785
Weight of empty Pycnometer + sand +water (W_3g)	2099	2183
Weight of empty Pycnometer +water (W_4g)	1578	1486.5
Specific gravity of sand= Dry weight of sand / weight of equal volume of water	2.62	2.78

RESULT:

Specific gravity of fine aggregate = 2.70

3.2.2.2 FINENESS MODULUS OF FINE AGGREGATE

Fineness modulus of fine aggregate represents the mean size of the particles in M Sand. The cumulative percentage retained on each sieve is added and subtracted by 100 gives the value of fineness modulus. Fine aggregate means the aggregate which passes through 4.75mm sieve.Concentrated on gradation of fine aggregate to get required quality by examine the effect of different fineness modulusof MSand.

TABLE NO 3.12: FINENESS MODULUS OF FINE AGGRAGATE

S. No	Sieve designation	Aperture size	Weight residue in (g)	%of weight retained	%of passing
1	10mm	7	7	0.7	99.3
2	4.75mm	29.5	36.5	3.65	96.35
3	2.36mm	30	66.5	6.65	93.35
4	1.18mm	113	179.5	17.95	82.05
5	600mic	340	519.5	51.95	48.05
6	300mic	258	777.5	77.75	22.25
7	150mic	172.5	950	95	5
Receiver	-	0	50	-	-
	Total	1000	Total	253.65	253.65

CALCULATION

Total cumulative % of retained = 253.65

Fineness modulus of aggregate = total cumulative % retained / 100= 253.65/100= 2.53

RESULT:

The fineness modulus of the following of the given sample of fine aggregate is 2.53.

3.2.2.3 WATER ABSORPTION OF FINE AGGREGATE

Water absorption of MSand is determined according to SS-EN 1097-6 and for the fine aggregate. It is determined by first water saturating the aggregate (for 24 hours) and then by drying the aggregate so that it becomes water saturated but surface remains dry.

3.2.3 COARSE AGGREGATE

3.2.3.1 SPECIFIC GRAVITY OF COARSE AGGREGATE

The specific gravity of a coarseaggregate sample is determined by the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. It is similar in nature to the fine aggregate specific gravity test.

CALCULATION:

Specific gravity of sand = dry wt of sand / wt of equal volume of water

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

Trial 1= 2206-810.5/(2112.5-810.5)-(3002-2206) = 2.75

Trail 2 = 2111.5-681.5/(2099.5-681.5)-(3030-2111.5) = 2.85

TABLE NO 3. 13: SPECIFIC GRAVITY OF COARSE AGGREGATE

WEIGHT	TRAIL 1	TRAIL 2
Weight of empty Pycnometer (W_1g)	810.5	681.5
Weight of empty Pycnometer+dry coarse aggregate (W_2g)	2206	2111.5
Weight of empty Pycnometer+coarse aggregate+water (W_3g)	3002	3030
Weight of empty Pycnometer+water (W_4g)	2112.5	2099.5
Specific gravity of coarse aggregate =Dry weight of C.A./weight of equal Volume of water =(W_2-W_1)/(W_4-W_1)-(W_3-W_2)	2.75	2.85

RESULT:

Specific gravity of coarse aggregate = 2.80

3.2.3.2 IMPACT TEST ON COARSE AGGRAGATE

Impact test on the coarse aggregate iscarried out to evaluate the resistance to impact of aggregates. The crushed aggregate is allowed to pass through 2.36 mm IS sieve. And the impact value is measured as percentage ofaggregates passing sieve to the total weight of the sample.

TABLE NO 3.14: IMPACT TEST ON COARSE AGGREGATE

S.no	Total weight of aggregate sample filling the cylinder measured (W_1g)	Weight of aggregate passing 2.36mm sieve after the test (W_2g)	Total weight of dry sample (W_3g)	Aggregate impact value $W_3/(W_3-W_2)*100$
1	1000	100	350	28.57%

CALCULATION

Aggregate impact value = 100/350*100 = 28.57%

RESULT:

Aggregate impact value is 28.57%

3.2.3.3 WATER ABSORPTION TEST ON COARSE AGGREGATE

Water absorption test is determined to calculate the saturation of aggregate in water at an attained duration to increase its strength. Water absorption shall not be more than 0.6 per unit by weight.

TABLE NO 3.15: WATER ABSORPTION TEST ON COARSE AGGREGATE

S. no.	Weight of saturated specimen (W_1g)	Weight of saturated specimen (W_2g)	Weight of water absorption (W_1g-W_2g)	Percentage of water absorption $(W_2-W_1)/W_1*100$
1	306	300	6	2.0

RESULT:

Water absorption of the coarse aggregate = 2.0%

MIX DESIGN

4.1 MIX DESIGN INTRODUCTION:

General:

Mix design is the process of selecting suitable ingredients, if concrete determine their relative proportions with the object of certain minimum strength and durability as economically possible.

Objectives:

1) The first objective is to achieve the stipulated minimum strength.

2) The second objective is to make the concrete in the most economical manner. Cost wise all concrete depend primarily on two factors, namely cost of materials, of labour cost, by way of formworks, batching, mixing, transporting and curing same for good concrete.

Therefore attention is mainly directed to the cost of materials. Since the cost of cement is many times more than cost of their ingredients, optimum usage of cement is sought for by designing the mix.

4.2 MIX DESIGN FOR M30 GRADE CONCRETE:

1) Grade designation - M_{30}

2) Characteristic compressive strength - $30N/mm^2$

3) Type of cement - Ordinary Portland cement

4) Maximum nominal size of aggregate - 20mm

5) Minimum cement content - 360kg/m^3

6) Maximum water cement ratio - 0.45

7) Workability - (40-50) mm slump

8) Exposure condition - severe

9) Degree of supervision - Good

10) Type of aggregate - Crushed angular aggregate

Fig No 4.1: Mixing of concrete

Test data for materials:

Cement used - OPC 43 grade

Specific gravity:

Cement -3.1

Fine aggregate - 2.70

Coarse aggregate - 2.8

Water absorption:

Fine aggregate - 1%

Coarse aggregate - 0.5%

Free (surface) moisture:

Fine aggregate - Nil

Coarse aggregate - Nil

Target strength for mix proportioning:

f_{ck} = f_{ck} + 1.65 S, from Table no. 1 of IS: 10262-2009,

S (Standard deviation) = 5N/mm^2

Target strength = 30 + 1.65 (5)

= 38.25N/mm^2

Selection of water cement ratio:

From Table No. 5 of IS: 456-2000, water cement ratio = 0.52

(Using data from Target mean strength)

Maximum water cement ratio specified for durability condition = 0.45

Water cement ratio to be adopted for concrete= 0.45 (lower of 0.52)

Selection of water content:

From Table No. 2 of IS: 10262-2009, water content from Table No.3.5

= 186 (for a workability of 0.80 C F)

Sand as percentage of total aggregate by absolute volume from Table no. 5

= 35% for W/C ratio of 0.60

Adjustment of water content (using table no.3.7) (for C F of 0.90)

= 186 + 0.03 * 186 = 191.6 liters

Adjustment for MSand content

35% - 3.0% = 32 %(for W/C of 0.45)

Modified water content = 191.6 liters

Modified sand content = 32%

Calculation of cement content:

Volume of cement = 191.6/0.45

= 350kg/m^3 (from Table No.3.3 specified for durability condition) = 425.8kg/m^3 (higher of min cement 350kg/m^3)

Entrapped air, as percentage of volume of concrete = 2%

Proportion of volume of coarse aggregate and fine aggregate:

From Table No. 3 of IS 10262-2009, volume of coarse aggregate corresponding to 20mm size of aggregate and fine aggregate (zone-II) for water cement ratio 0.45

Coarse aggregate = 0.68

Fine aggregate = 1-0.68

= 0.3**Mix calculation:**

Mix calculation per unit volume at concrete.

1) Volume of concrete = $1m^3$

2) Mass of fine aggregate = $[W+(C/S_c)+ (1/P) x(F_a / SF_a)]x(1/1000)$

$[1-0.02]=[191.6+(425.8/3.1)+(1/0.32)x (f_a/2.70)] x (1/1000)$

$f_a = 573.91kg/m^3$

3) Mass of coarse aggregate =

$[W +(C/S_c)+(1/(1-P))x(C_a/SC_a)]x(1/1000)$

$[1-0.02]$

$= [191.6+ (425.8 /3.1 + (1/0.68) x (C_a/2.80)] *(1/1000)$

$c_a = 1294.11kg/m^3$

Mix proportion:

Cement= 425.8 kg/m^3
Water= 191.6 liters
Fine aggregate= 573.91 kg/m^3
Coarse aggregate= 1294.11 kg/m^3
Water cement ratio= 0.45
M_{30} mix ratio= 1: 1.38: 2.64

TABLE NO 4.1: MIX FOR 0% OF LIME SLUDGE:

S.no	Name of mould	Quantity of material				
		Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (ml)	Lime sludge (kg)
1	Cube	2.87	3.84	8.69	1290	0
2	Cylinder	4.51	6.04	13.66	2020	0
3	Prism	4.25	5.69	12.87	1910	0

TABLE NO 4.2: MIX FOR 5% OF LIME SLUDGE:

S.no	Name of mould	Quantity of material				
		Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (ml)	Lime sludge (kg)
1	Cube	2.727	3.84	8.69	1290	0.143
2	Cylinder	4.285	6.04	13.66	2020	0.225
3	Prism	4.038	5.69	12.87	1910	0.212

TABLE NO 4.3: MIX FOR 10% OF LIME SLUDGE:

S.no	Name of mould	Quantity of material				
		Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (ml)	Lime sludge (kg)
1	Cube	2.583	3.84	8.69	1290	0.287
2	Cylinder	4.059	6.04	13.66	2020	0.451
3	Prism	3.825	5.69	12.87	1910	0.425

TABLE NO 4.4:MIX FOR 15% OF LIME SLUDGE :

S.no	Name of mould	Quantity of material				
		Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (ml)	Lime sludge (kg)
1	Cube	2.44	3.84	8.69	1290	0.430
2	Cylinder	3.824	6.04	13.66	2020	0.676
3	Prism	3.613	5.69	12.87	1910	0.637

TABLE NO 4.5:MIX FOR 20% OF LIME SLUDGE :

S.no	Name of mould	Quantity of material				
		Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (ml)	Lime sludge (kg)
1	Cube	2.296	3.84	8.69	1290	0.574
2	Cylinder	3.608	6.04	13.66	2020	0.902
3	Prism	3.400	5.69	12.87	1910	0.850

TABLE NO 4.6: MIX FOR 25% OF LIME SLUDGE:

S.no	Name of mould	Quantity of material				
		Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (ml)	Lime sludge (kg)
1	Cube	2.153	3.84	8.69	1290	0.717
2	Cylinder	3.383	6.04	13.66	2020	1.127
3	Prism	3.188	5.69	12.87	1910	1.062

TABLE NO 4.7: MIX FOR 30% OF LIME SLUDGE:

S.no	Name of mould	Quantity of material				
		Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Water (ml)	Lime sludge (kg)
1	Cube	2.009	3.84	8.69	1290	0.861
2	Cylinder	3.157	6.04	13.66	2020	1.353
3	Prism	2.975	5.69	12.87	1910	1.275

RESULT

5.1 COMPRESSIVE STRENGTH TEST OF CONCRETE:

The compressive strength of concrete is the most common performance measure used by the engineer in designing buildings and other structures. The compressive strength is measured by breaking cubical concrete specimens in a compression testing machine.

Fig no 5.1: Compressive Strength Testing Machine

TABLE NO 5.1.1: COMPRESSIVE STRENGTH AT 7DAYS

Partial replacement of lime sludge (%)	Ultimate load (KN)	Ultimate compressive strength(N/mm^2)
0	180	7.63
5	320	13.78
10	370	15.26
15	430	18.66
20	460	19.99
25	320	13.78
30	230	19.85

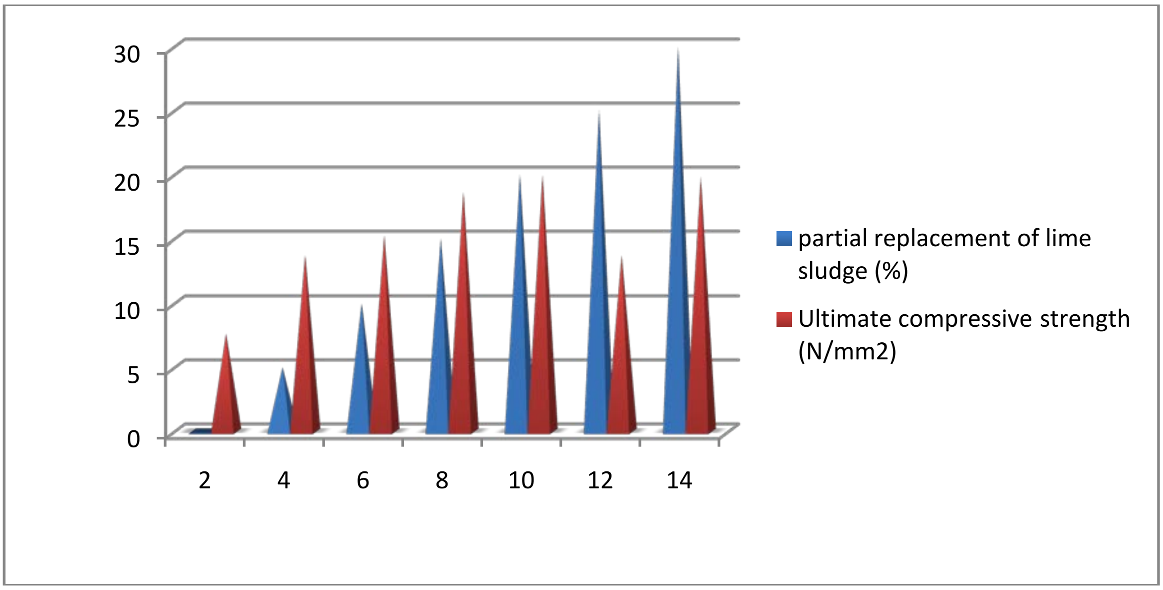


FIG NO 5.2: COMPRESSIVE STRENGTH AT 7 DAYS

TABLE NO 5.1.2: COMPRESSIVE STRENGTH AT 14 DAYS

Partial replacement of lime sludge (%)	Ultimate load (KN)	Ultimate compressive strength(N/mm^2)
0	350	14.89
5	620	22.22
10	570	24.59
15	690	29.92
20	730	31.70
25	520	22.67
30	590	16.44

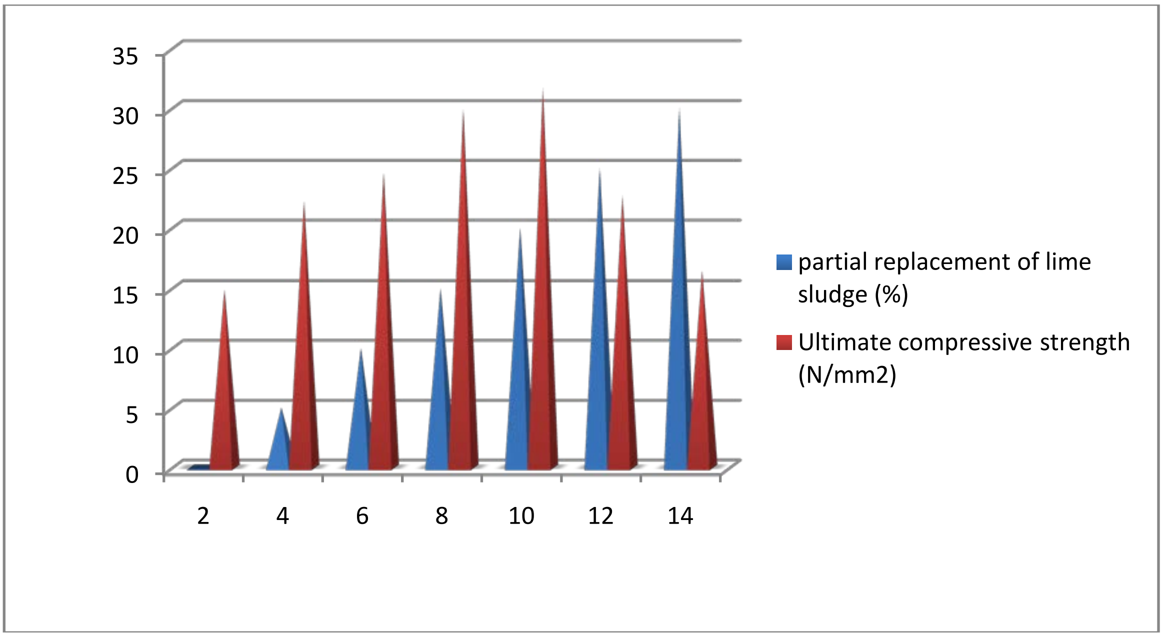


FIG NO 5.3: COMPRESSIVE STRENGTH AT 14 DAYS

TABLE NO 5.1.3 : COMPRESSIVE STRENGTH OF AT 28 DAYS

Partial replacement of lime sludge (%)	Ultimate load (KN)	Ultimate compressive strength(N/mm^2)
0	500	21.33
5	730	31.99
10	750	32.74
15	945	40.96
20	1030	45.03
25	720	31.70
30	530	22.96

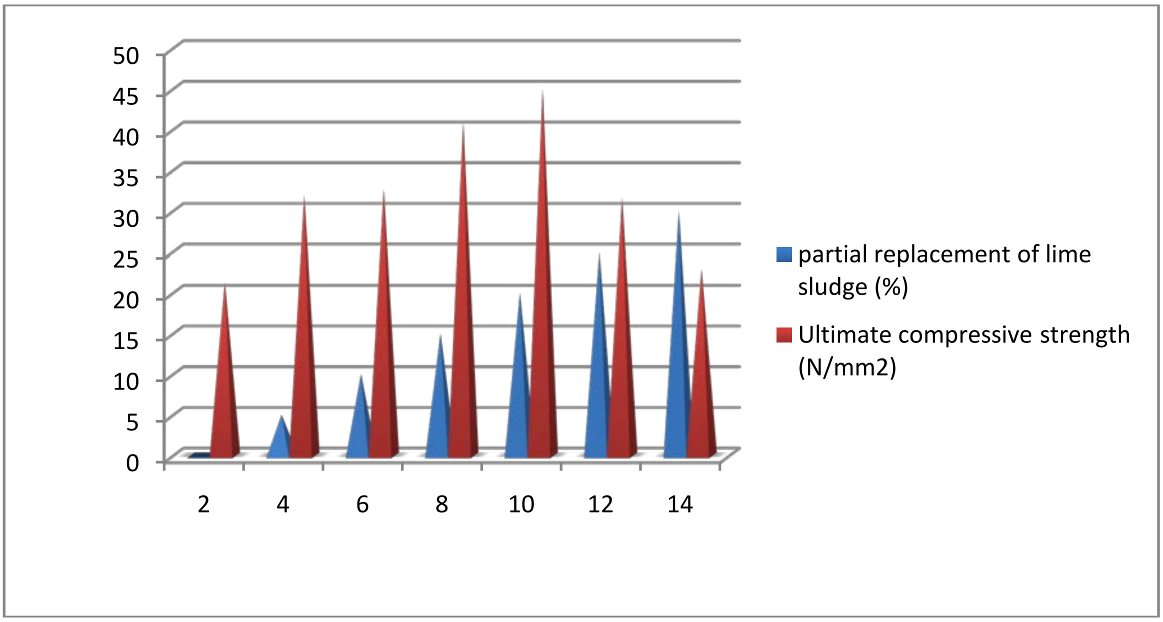


FIG NO 5.4: COMPRESSIVE STRENGTH AT 28 DAYS

5.2 SPLIT TENSILE STRENGTH TEST:

Direct measurement of tensile strength of concrete is difficult. The value of the modulus of rupture depends on the dimensions of the beam and manner of loading. Normally cracking in concrete occurs when tensile strength exceeds its limiting value.

Figure no 5.5:Split Tensile Strength Testing Machine

TABLE NO 5.2.1: SPLIT TENSILE STRENGTH AT 7 DAYS

Partial replacement of lime sludge(%)	Ultimate load (KN)	Ultimate split tensile strength(N/mm^2)
0	80	1.01
5	85	1.13
10	90	1.22
15	90	1.27
20	95	1.34
25	70	0.91
30	60	1.80

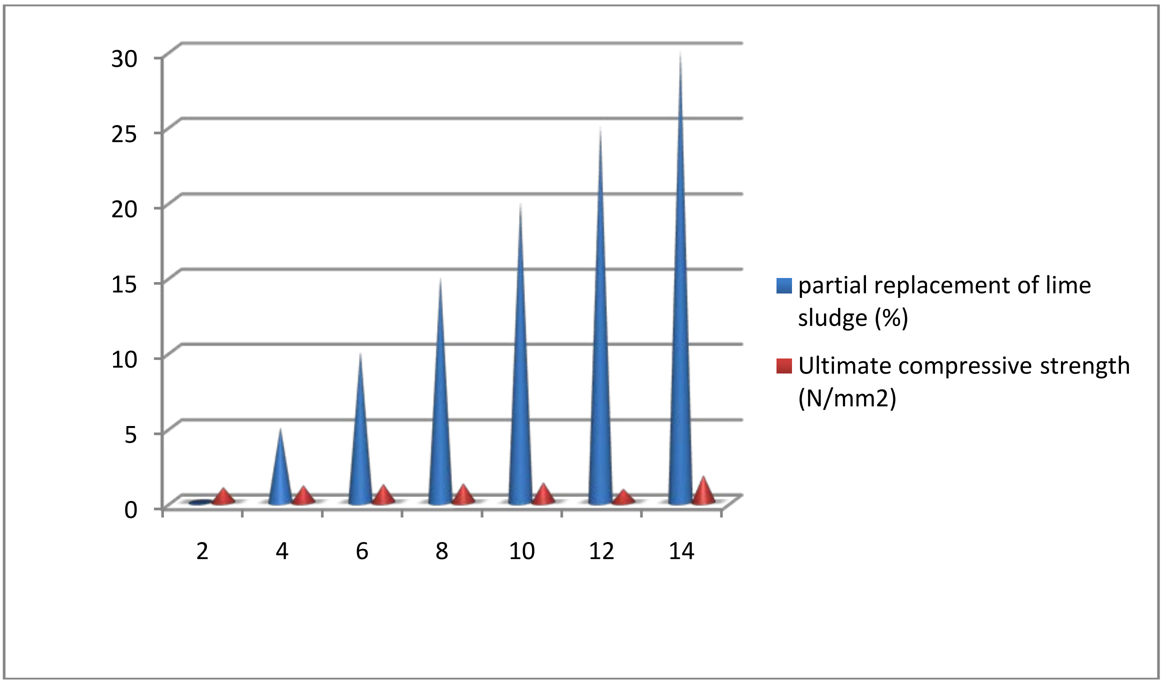


FIG NO 5.6: SPLIT TENSILE STRENGTH AT 7 DAYS

TABLE 5.2.2: SPLIT TENSILE STRENGTH AT 14 DAYS

Partial replacement of lime sludge(%)	Number of specimens	Ultimate load (KN)	Ultimate split tensile strength(N/mm^2)
0	3	110	1.48
5	3	140	1.93
10	3	150	2.05
15	3	150	2.07
20	3	160	2.16
25	3	95	1.29
30	3	90	1.25

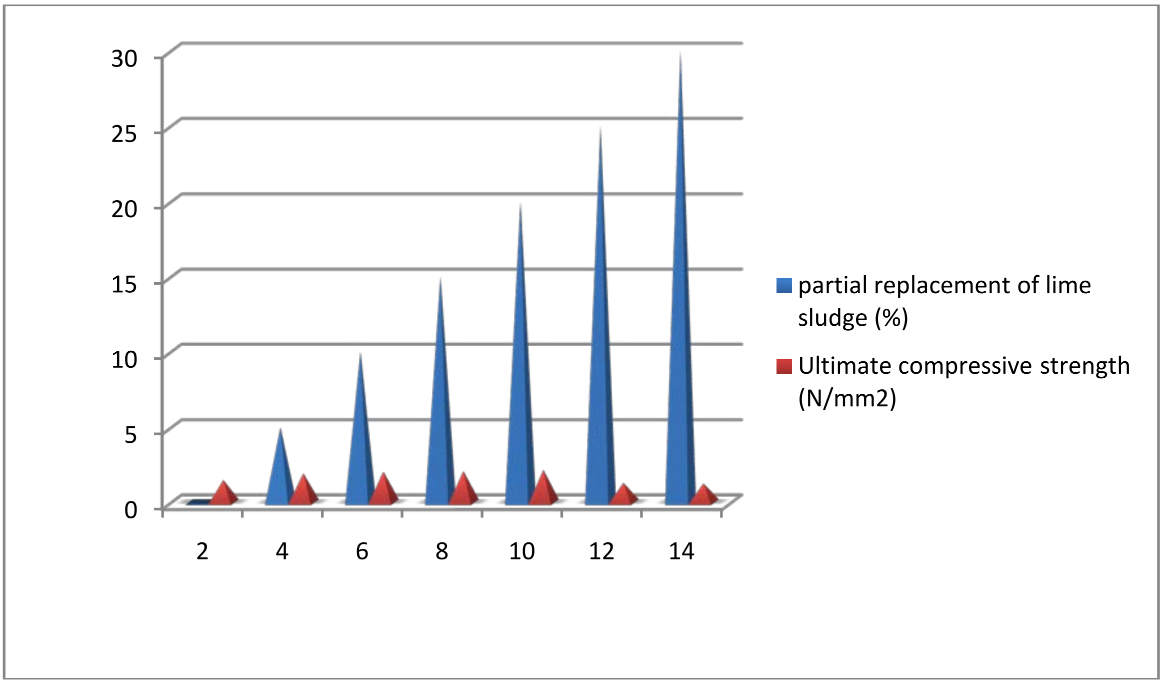


FIG NO 5.7: SPLIT TENSILE STRENGTH AT 14 DAYS

TABLE NO 5.2.3: SPLIT TENSILE STRENGTH AT 28 DAYS:

Partial replacement of lime sludge(%)	Ultimate load (KN)	Ultimate split tensile strength(N/mm^2)
0	145	2.00
5	195	2.69
10	200	2.76
15	210	2.87
20	210	2.97
25	130	1.70
30	120	1.69

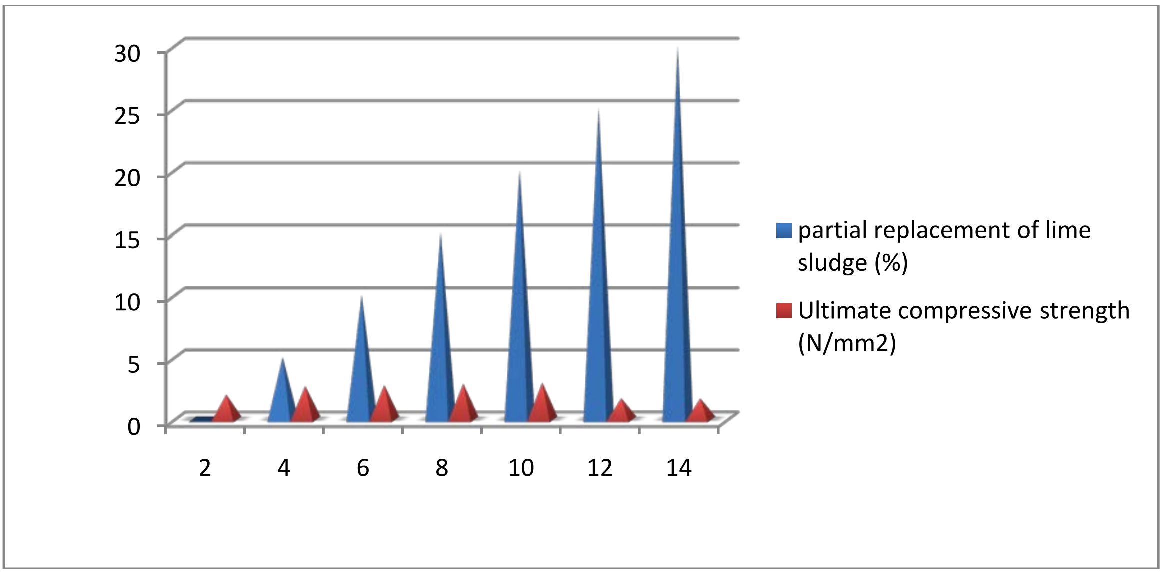


FIG NO 5.8 : SPLIT TENSILE STRENGTH AT 28 DAYS

5.3 FLEXURAL STRENGTH TEST:

The flexural test evaluates the tensile strength of concrete indirectly. It test the ability of unreinforced concrete beam or slab to withstand failure in bending

Figure no 5.9:Flexural Testing Machine

TABLE NO 5.3.1: FLEXURAL STRENGTH AT 7 DAYS

Partial replacement of lime sludge (%)	Ultimate load (KN)	Ultimate flexural strength(N/mm^2)
0	500	1.85
5	550	2.03
10	600	2.22
15	680	2.51
20	730	2.70
25	620	2.29
30	580	2.14

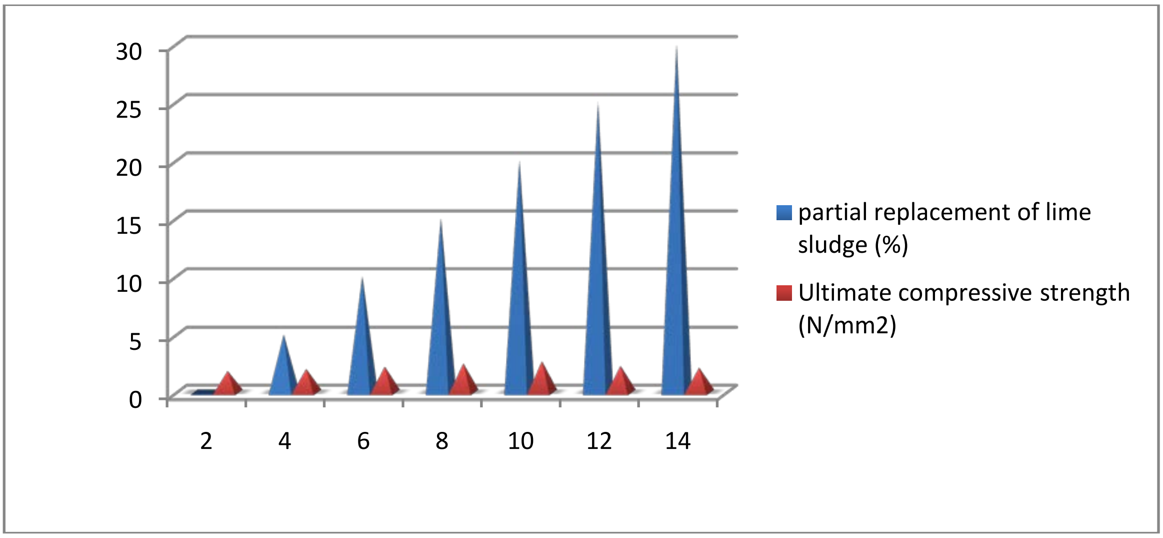


FIG NO 5.10: FLEXURAL STRENGTH AT 7 DAYS

TABLE NO 5.3.2: FLEXURAL STRENGTH AT 14 DAYS

Partial replacement of lime sludge (%)	Ultimate load (KN)	Ultimate flexural strength(N/mm^2)
0	600	2.22
5	650	2.40
10	690	2.55
15	730	2.70
20	870	3.22
25	680	2.51
30	610	2.25

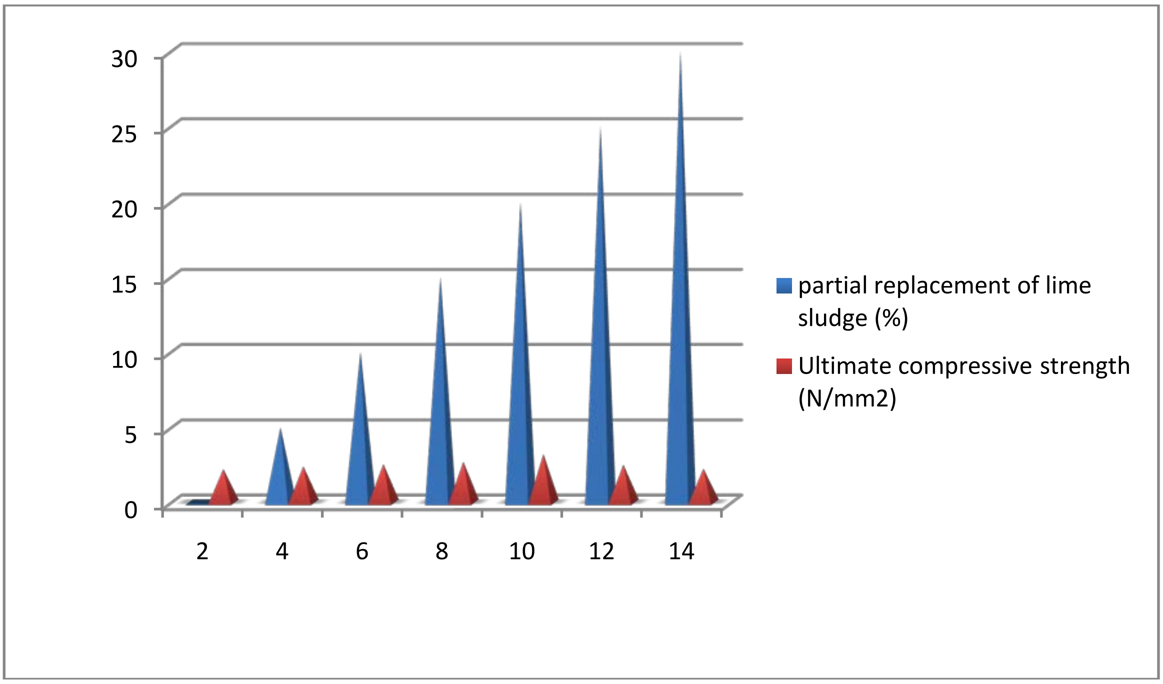


FIG NO 5.11: FLEXURAL STRENGTH AT 14 DAYS

TABLE NO 5.3.3: FLEXTURAL STRENGTH AT 28 DAYS

Partial replacement of lime sludge (%)	Ultimate load (KN)	Ultimate flexural strength(N/mm^2)
0	700	2.59
5	750	2.71
10	790	2.92
15	830	3.07
20	970	3.59
25	780	2.89
30	710	2.62
35	690	2.50

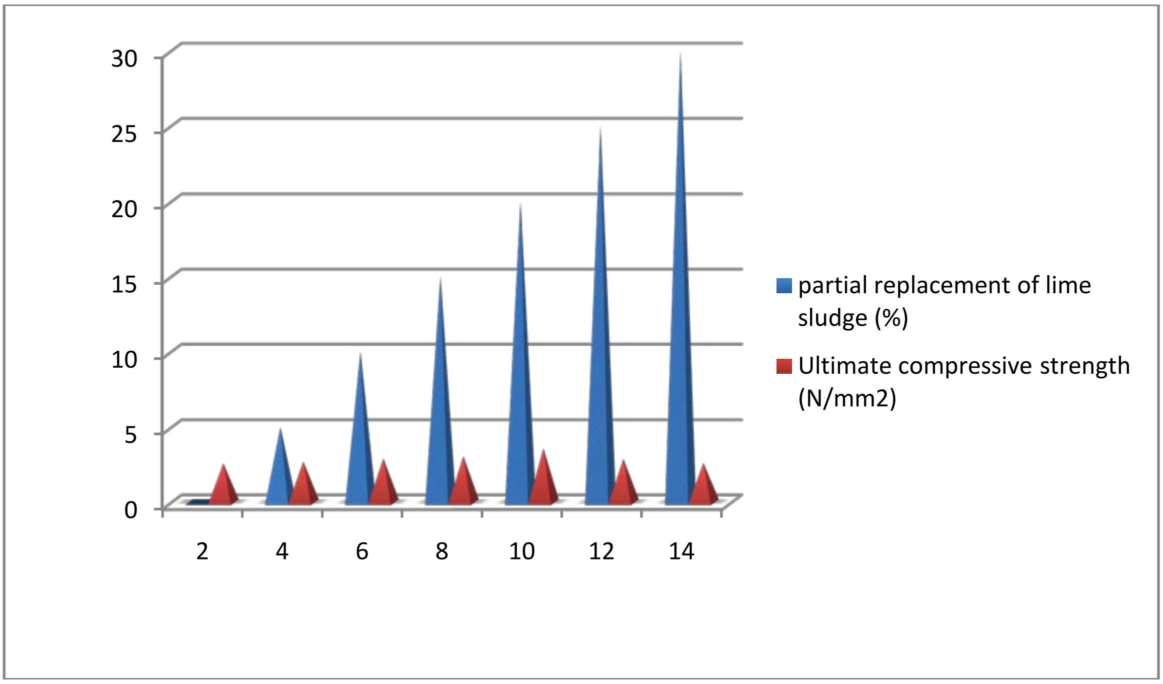


FIG NO 5.12: FLEXTURAL STRENGTH AT 28 DAYS

Fig No 5.13 :Testing of cube Specimen

Fig No 5.14 :Testing of Cylindrical specimen

Fig No 5.14 : Testing of prism specimen

CONCLUSION

The pardigram of information reported here under regarding the utilization of lime sludge by construction industry. Shows a strong technical feasibility for its reuse especially in production of concrete as supplementary cementitious material, mineral admixtures, partial replacement of cement in ternary blends cements as activator, and also as raw material for clay brick manufacturing, production of structural ceramics, soil stabilization in road works.

- ❖ Finally we conclude our project with various mixes with curing periods of 7 days, 14 days and 28 days by partial replacement of cement with lime sludge.
- ❖ Testing of cubes and cylinders in compression testing machine with capacity of 1000 KN.
- ❖ The compressive strength of concrete increases as the curing period for M_{30} grade concrete and the replacement of lime sludge is done from 0%, 5%, 10%, 15%, 20%, 25%, and 30%.
- ❖ The maximum compressive strength of concrete is achieved in 20% of replacement of cement and starts decreasing in strength from 25% to 30%, The maximum split tensile strength of concrete is achieved in 20% of replacement of cement and starts decreasing in strength from 20% to 30%, and the maximum flexural strength of concrete is achieved in 20% of replacement of cement and starts decreasing in strength from 20% to 30% Therefore, environmental effect from wastes and minimum amount of cement manufacturing is reduced through this project.

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