International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Experimental Investigation on Properties of Concrete using Lime Sludge from Sugar Industry

Dr. R. Shanumugam., Ph.D.[1], Mrs. C. Sowmitha., B.E.[2], Mr. M. Chandran.[3], Mr. V. Manimuthu., M.E.[4]

Detp. of Civil Engineering, Sakthi Polytechnic College, Erode, Tamilnadu 638315, India
Detp. of Civil Engineering, Sakthi Polytechnic College, Erode, Tamilnadu 638315, India
Detp. of Civil Engineering, Sakthi Polytechnic College, Erode, Tamilnadu 638315, India
Detp. of Civil Engineering, Sakthi Polytechnic College, Erode, Tamilnadu 638315, India

ABSTRACT

The sand requirement for construction activities increased proportionately but, all the materials required for producing cement and concrete are obtained from the earth's crust only. Hence, the natural resources are exploited in an extremely high manner and resulted in depletion of the same and creating environmental strain. The increase in demand for the ingredients of concrete is met by partial replacement of the materials by the solid waste products obtained by means of human activities on the earth. Lime sludge is one of such waste material obtained from agricultural industry by processing sugarcane. The annual production of sugar in our country comes around 110 million tons. For every 660 tons of sugar cane crushed, about 2 tons of lime sludge is produced.

Experimental investigations have been made to study the suitability of the use of lime sludge as a waste material from sugar industry for sand replacement in concrete in order to reduce the environmental problems. This experimental study is aimed to utilize such lime sludge as a partial replacement material for sand in concrete and to study the suitability of this waste material for sand replacement. M20 grade of concrete is taken for investigation. The sand is replaced by lime sludge from 0% to 30% with an increment of 5%. The concrete mix design is done as per IS 10262-1982 for various percentage of replacement of sand. The properties studied include the workability characteristics of fresh concrete such as slump, compaction factor, strength properties of hardened concrete include compressive strength, split tensile strength and durability tests such as acid resistance and rapid chloride penetration for various percentage of replacement of sand by lime sludge. The investigations show that the lime sludge can be effectively used in concrete up to 10% replacement of sand without affecting much of its strength characteristics

Keywords: Effects of waste, lime sludge, durability aspects.

1. INTRODUCTION

India being an agricultural based country, a lot of Agro Industries have come up. The sugar and paper industries are generating a huge quantity of lime sludge as waste, creating ecological problems because of dumping in open places causing environmental pollution. The lime sludge obtained from sugar factory normally contains calcium carbonate and small amount of free lime. Hence lime sludge can be utilized in concrete and in construction industry. In this project work, it has been planned to use it in concrete with the partial replacement of sand by using lime sludge added as an additional ingredient in different proportions to enhance the binding property of concrete.
The experimental studies are conducted for workability characteristics of fresh concrete and mechanical properties of hardened concrete with lime sludge. From the results the optimum replacement of lime sludge is determined and durability studies also carried out to check the viability.

RESEARCH SIGNIFICANCE

MANUFACTURING PROCESS:
SUGAR MANUFACTURING –SAKTHI SUGARS LTD.,
Prepared cane is transferred to mills through rake type carrier and the extracted juice is screened and juice is pumped to the process house and is weighed, added Phosphoric acid for better juice clarification. The juice is pumped to Vapour line juice heater and Dynamic juice heater to heat about 70oC thereby achieve maximum steam economy. The partially heated juice is subjected to simultaneous liming and sulphitation to precipitate colloidal and fine suspended impurities.

The treated juice from secondary juice heater is passed to juice clarifier where the precipitated impurities (lime sludge) which settle at the clarifier is collected.

CAPACITY OF M/S SAKTHI SUGARS LTD.,

Sugarcane crushing = 7000 tons / day
Sugar produced = 660 tons / day
Bagasse produced = 2100 tons / day
Lime consumed = 0.25% on cane
= 17.5 tons / day
Lime sludge produced = 2 tons /day

REACTIONS OF LIME

Lime is the oldest and cheapest chemical used in sugar manufacturing process as a Juice clarifier. Lime is the main reaction compound responsible for juice clarification. The calcium present in milk of lime reacts with soluble phosphate from juice to form insoluble precipitate of Tricalcium phosphate.

Lime neutralizes the free organic acids present in cane juice forming calcium organic salts. Lime unites with phosphoric acid present in juice and forms calcium phosphate. Lime combines with nitrogenous impurities which are partly precipitated. Due to action of heat and lime, most of the colloidal non sugar are coagulated which tends to settle down.

PROPERTIES OF CONCRETE (Strength and Durability)

Strength and Durability are the two important properties of concrete. But, something cannot be said with regard to durability, because of the rapid deterioration in environmental conditions and the use of concrete has spread to much more hostile regions than ever before. All that is written is a scientific exposition at macro and micro-level of durability problem. It will give an in depth knowledge and better understanding for making good standard concrete for our infrastructural development which we have just started.

It may not be out of place to emphasize that we, civil engineers, common builders, site engineers, concrete technologists and all other who are involved in making concrete, have a lot of responsibilities for making durable concrete for which our country spends about 25 percent of nation's annual budget. Which other section of our society has more responsibility than we-friends of concrete

FORMATION OF LIME SLUDGE

General

As we know lime is a good binding material used in building construction as lime mortar, lime surki concrete, etc. Lime may be mixed with some of the industrial waste products such as fly ash, Gypsum, Rice husk ash, Saw dust, etc along with sand, to produce building blocks. The following articles show some of the potential application of lime with waste materials. In this project work we have made on attempt to utilize lime sludge in place of sand in the manufacture of concrete.

Availability of lime sludge

Lime sludge which essentially contains calcium carbonate with varying amounts of free lime is a waste product from sugar, paper, fertilizer and calcium carbide industries. The annual production of lime sludge is approximately 4.8mt. The utilities lime sludge for the manufacture of cement and lime have been investigated for commercial exploitation.

FORMATION OF LIME SLUDGE

The lime sludge is a solid residue obtained from sugar factory. Free lime is being added in sugar processing for cleaning the juice. Fig - 1 shows the feeding of raw lime to sulphitation process. The residue obtained along with some soil and cane pith is called lime sludge. It contains a small percentage of free lime which has binding property. This can be utilized with some aggregate for making concrete or building blocks. In this project work we have obtained the lime sludge from Sakthi Sugars Ltd., Sakthi Nagar.Fig-1 shows the formation of lime sludge in sugar industry.

Fig. 1-Process of making Milk of Lime and Outlet of Lime Sludge

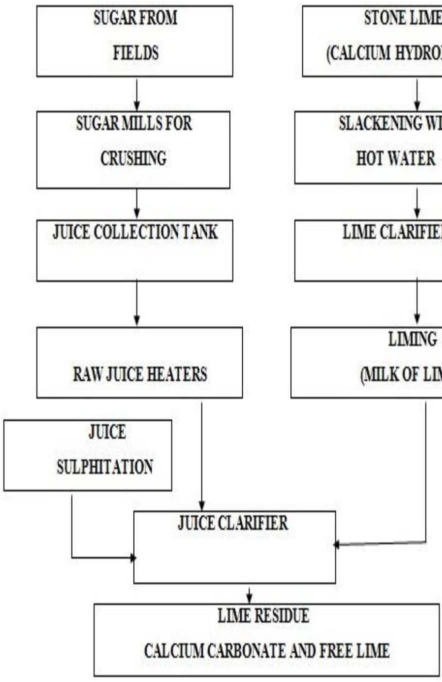

Fig -2. Flow chart for formation of sludge in Sugar Industry

Manufacturing of plantation white sugar involves some mechanical means like
i.) Cane preparation device ii.) Mills iii.) DSM screen iv) Juice collection tank
v) Juice weighing scale vi) Raw juice heaters vii) Juice sulphitation unit
viii) Secondary juice heaters ix) Mud collection tank (Formation of Lime sludge)

ADDITION OF MINERAL ADMIXTURES

Admixture is a material other than cement, water and aggregates that is used as an ingredient of concrete and it is added to the batch immediately before or during mixing. Admixtures are added in concrete to improve workability and durability. In this project, admixtures like fly ash, silica fume and rice husk ashes are used

Artificial pozzolanic admixtures

The following are the artificial pozzolanic admixtures used in high performance concrete. They are fly ash silica fume and rice husk ash.

Fly ash

Fly ash is finely divided residue resulting from the combustion of powdered coal. It is transported by the flue gases and collected by electrostatic precipitator. The action of fly ash is similar to the action of super plasticizers with respect to water demand. The fly ash dispersed and adsorb the particles of Portland cement. Fly ash is an industrial waste, its use in concrete significantly improve the long term strength and durability and reduce the heat of hydration. Good fly ash will be an indispensable mineral admixture for high performance concrete.

Silica fume

Silica fume, also referred to as micro silica or condensed silica fume, is another material that is used as an artificial pozzolanic admixture. It is a product resulting from reduction of high purity quartz with coal in a electric arc furnace in the manufacture of silicon or ferrosilicon alloy. Silica fume rises as an oxidized vapour.

Rice husk ash

Rice husk ash is obtained by burning rice husk in a controlled manner without causing environmental pollution. When properly burnt it has high SiO2 content and can be used as a concrete admixture. Rice husk ash exhibits high pozzolanic properties and contributes to high strength and high impermeability of concrete.

LITERATURE REVIEW

Prof. M. S. Shetty has mentioned that the durability deals with fundamental considerations of volume change and cracks in concrete, leading to permeability, in an unconventional manner. Latest methods of Mix Design as per ACI methods and British methods (DOE method) have been pointed out.

A. K. Mullick describes the characteristics of cementitious system required to meet the diverse requirements of strength and durability of concrete and high lights the advantages of part replacement of OPC by fly ash, graduated slag either singly or in combination in ternary blends.

S. Gopalakrishnan said that reinforced concrete is the most extensively used material for construction worldwide. A particle substitution of cement by an industrial waste such as fly ash is not only economical but also improves the properties on fresh and hardened concrete and enhances the durability characteristics. The reactive silica component present in them companies with the free calcium hydroxide, liberated during hydration of cement, to form additional calcium-silicate-hydrate (CSH), which otherwise would have reached out and increasing the porosity of the cement matrix. The additional CSH increases the denseness of the matrix and refines the pore structure. Hence the use of supplementary cementitious materials in concrete can lead to enhanced durability characteristics. It also improves the rheology of the fresh mixes, enhances the strength of concrete and reduces the cost.

Dr. Perumal in his research study, the movement of ions in a porous medium under a concentration gradient is called diffusion. It is often necessary to ascertain the impermeability of concrete to chloride ions as a quality control measure and also for assessment of improvements effected in properties of new concretes. Measurement of chloride diffusion co-efficient requires a long time for establishment of steady state conditions. Therefore, a direct current (DC) potential is usually applied to accelerate migration of ions.

CHARACTERISTICS OF LIME SLUDGE

PHYSICAL PROPERTIES

- Presence of Sio_2 and Al_2O_3
- inert materials
- impart strength
- impart workability
- Acts as a filler material
- Acidic in nature
- Presence of ca o
- Imparts strength
- Increases strength with age
- Easily combines with basic oxides to form various silicates
- Basic in nature

CHEMICAL PROPERTIES

Presence of Al2o3

- Oxidizing agent (trivalent oxide)
- Supplies oxygen to metals
- Refractive material
- Withstand high temperature
- In Portland cement 5 to 10 percentage available

Presence of Sio2

- Hard solid with high melting, boiling point and Stable solid
- Role in the manufacturing of industrial products like
- Glass, cement and abrasives
- Acidic oxide (tetravalent oxide)
- In Portland cement 20 to 25 percentage available

Presence of Ca O

- Easily combines with basic oxides to form various silicates
- Silicate is a very important material named as cement, glass, abrasive refractories and slag
- In Portland cement 50 to 60 percentage available

Presence of Mgo

- Insoluble in water
- Highly instable in nature

EXPERIMENTAL INVESTIGATIONS

MATERIAL USED: Lime sludge

The lime sludge is a solid residue obtained from sugar factory. Free lime is being added in sugar processing for cleaning the juice. The residue obtained along with some soil and cane pith is called lime sludge. It contains a small percentage of free lime which has binding property. This can be utilized with some aggregate for making concrete or building blocks. In this project work we have obtained the lime sludge from Sakthi Sugars Ltd. Sakthi Nagar.
The lime sludge is a solid residue obtained from sugar factory. Free lime is being added in sugar processing for cleaning the juice. The residue obtained along with some soil and cane pith is called lime sludge. It contains a small percentage of free lime which has binding property. This can be utilized with some aggregate for making concrete or building blocks. In this project work we have obtained the lime sludge from Sakthi Sugars Ltd. Sakthi Nagar.

Test report: Given By Associated Cement Company Laboratory, Coimbatore

	LIME SLUDGE (%)	ORDINARY CEMENT (%)
SiO_2	21.1	20
Al_2O_3	10.6	6
Fe_2O_3	1.5	3
CaO	43.0	63
MgO	1.0	1.5
Loss of Ignition	20.8	Less than 5

Table 1- Chemical composition of lime sludge.

Sand

Sand is either round or angular grains and is often found mixed in various gradation of fineness. A brick made from sand consisting of rounded grains is as good as that in which the grains are angular. The river or pit sand should be used and not sea sand as it contains salt and other impurities which will after the structure. In this project work, Bhavani river sand has been used.

Water

In general, for mixing of ingredients water is used. Excess of acidity or alkalinity in water is to be avoided. Potable water from Bhavani river is used for this work.

Cement

Cement is a binding material in concrete which is used in all building elements. Ordinary Portland Cement 43 grade is used for casting the cubes.

Aggregates

These are the inert or chemically inactive materials which form the bulk of cement concrete. The aggregates are bound together by means of cement. The aggregates to be used for cement concrete work should be hard, durable and clean and free from lumps of clay, organic and vegetable matter, fine dust, etc. The presence of all such debris prevents adhesion of aggregates and hence, reduces the strength of concrete. A good quality of aggregates with adequate particle distribution, from Uttuguli area is used for this project work.

PROPERTIES OF MATERIALS

CEMENT

The cement used for the manufacture of concrete cubes is of 53 grade ordinary cement. The properties of Cement like consistency, Initial setting time, final setting time and fineness modulus are tested for the samples and the results are given below.

- Consistency

  Standard consistency = 48 %.

- Initial setting time

The initial setting time of cement = 68 min

- Final setting time

  The final setting time of cement = 5 hrs 38 min

- Specific gravity

  The specific gravity of cement = 3.15

- Fineness of cement

  The fineness of cement = 2.0%.

FINE AGGREGATE

The fine aggregate is one of the most important constituent of the concrete. The properties fme aggregate is listed below.

- Sieve analysis

  Fineness modulus of fine aggregate = 1.97

  The grade zone of the given fine aggregate = Grading zone -3

COARSE AGGREGATE

Fineness modulus of coarse aggregate = 6.99

- Crushing test

  The crushing value of an aggregate = 39.05%.

- Impact value test

  The impact value for the aggregate = 7.143%

- Attrition test

  The attrition value of coarse aggregate = 14.8%.

- Specific gravity test

  Specific gravity of sand = 2.70

  Specific gravity of coarse aggregate = 2.62

WATER

The water is one of the most important constituent of the concrete. Water is responsible for setting of cement by the process of hydration. The water used in concrete should be portable water.

- Alkalinity

  Alkalinity due to OH_ =95 mg / lit

  Alkalinity due to CO3 =190 mg / lit

  Alkalinity due to HCO3 = 480 mg / lit

- Chlorides

  The amount of chlorides present in given sample =144.95 mg / lit

- Hardness

  The hardness of the given sample = 615 mg / lit

- Ph value

  The pH value of a given sample = 7.1 PPM.

SPECIFIC GRAVITY OF LIME SLUDGE AND SAND

Identification	Ratio of Sand with Lime Sludge	Specific Gravity
A	95% Sand + 5% Lime sludge	2.652
B	90% Sand + 10% Lime sludge	2.625
C	85% Sand + 15% Lime sludge	2.604
D	80% Sand + 20% Lime sludge	2.594
E	75% Sand + 25% Lime sludge	2.545
F	70% Sand + 30% Lime sludge	2.521

Table 2- Specific Gravity of Lime Sludge and Sand

MIX DESIGN OF CONCRETE

As per IS code IS 10262 - 1982

MIX DESIGN (GRADE M20)

a) Design stipulations

i) Characteristic compressive strength required in the field at 28 days
ii) Max size of aggregate = 20(mm angular)
iii) Degree of workability = 0.90(compacting factor)
iv) Degree of Quality control = Good
v) Type of exposure = Mild

b) Test data for materials

i) Specific gravity of cement = 3.15
ii) Compressive strength of cement at 7 days satisfies the requirement of IS269 - 1989
iii) 1. Specific gravity of coarse aggregate = 2.62
2. Specific gravity of fine aggregate = 2.70
iv) Water absorption
1. Coarse aggregate = 0.50%
2. Fine aggregate = 1.00%
v) Free moisture
1. Coarse aggregate = NIL
2. Fine aggregate = 2.0%

c) Target mean strength for specified characteristic cube strength is

20 + 1.65 x 4 = 26.6 Mpa (Refer Tables)

d) Selection of water cement ratio:

From fig, the w/c ratio required for the target mean strength of 26.6 Mpa is 0.50. This is lower than the max. value of 0.55 prescribed for mild exposure.

Adopt w/c ratio = 0.50

e) Selection of water and sand content:

From table, for 20 mm max. size aggregate, sand conforming to grading zone- II, water content per cubic meter of concrete = 186 kg and sand content as % of total aggregate by absolute volume -35% = 35 – 3.5 = 31.5 %

Therefore, the required water content = 186 + 5.58 = 191.6 lt/m3

f) Determination of cement content:

w/c ratio = 0.50
water = 191.6 lt
cement = 191.6 / 0.5 = 383 kg/ m3

This cement content is adequate for mild exposure condition

g) Determination of coarse and fine aggregate content:

From table, for the specified max. size of aggregate of 20mm, the amount of entrapped air in the wet concrete is 2%. Taking this into account and applying equation,

0.98 = 191.6 + (383/3.15 +1/0.315 x fa/2.62) x 1/1000
fa = 546.56 kg/m3 and
Ca = 1 – 0.315/ 0.315 x 546.56 x 2.62/2.70
= 2.174 x 546.56 x0.97
Ca = 1153.01 kg /m3

h) The mix proportions then become

Water	Cement	Fine aggregate	Coarse Aggregate
191.6kg	383 kg	547 kg	1153kg
0.5	1.	1.43	3.01

Table 3-Mix proportions

The mix proportions **1: 1.43: 3.010**

Adopt M20 concrete

Proportion **1 : 1.43 : 3.01**

Cement used PPC 43 GRADE
Aggregate used 10 to 20 mm sieve size
Sand used Bhavani river sand
Water used Bhavani river water
Cube mould used 150 mm size
Test conducted Compression test

SCHEDULE OF CASTING

Casting of cubes

- Take Lime sludge as partial replacement of sand by 0%, 5%, 10%, 15%, 20%, 25%, 30%
- Adopt water cement ratio 0.50
- Period of curing 28 days
- Size of moulds 150mm x 150mm x 150mm

EXPERIMENTAL PROGRAM

Tests conducted

1. Slump test and compaction factor test
2. Compressive strength test and split tensile strength
3. Split tensile test

SLUMP TEST AND COMPACTION FACTOR TEST

Slump test as per IS code IS 456 - 2000

- ✓ A concrete mix of M20 with 0% to 30% partial replacement of lime sludge is filled in three layers compacted with tamping rod.
- ✓ Top surface is leveled and mould is raised vertically.
- ✓ The slump which is the difference in height between the top of the mould and the highest point on the subsided concrete is measured.

COMPACTION FACTOR TEST AS PER IS CODE IS 10262 - 1982

- ✓ A concrete mix of M20 with 0% to 30% partial replacement of lime sludge is filled in upper hopper of compaction factor apparatus.
- ✓ The trap door is opened so that the concrete falls into the lower hopper and bottom hopper.
- ✓ The excess concrete is removed and find the weight of concrete placed in cylinder.
- ✓ The cylinder is again refilled with full compaction and find the weight of concrete.
- ✓ The compaction factor is the ratio between partial and full compaction concrete.

COMPRESSION TEST

- ✓ Compression test as per IS code clause 6.2 of IS456-2000
- ✓ The required quantity of ingredients was weighed and were prepared cubes with the help of moulds and cured for 7 days and 28 days.
- ✓ At the end of curing period, the cube was placed in between the compression plates of the Universal Testing Machine and apply load gradually.
- ✓ The reading was noted at the time of first crack and at the time of failure.
- ✓ The compressive strength can be calculated by ratio of compressive load and area of the cube.

SPLIT TENSILE TEST

- ✓ The required quantity of ingredients was weighed and were prepared cylinders with the help of moulds and cured for 7 days and 28 days.
- ✓ At the end of curing period, the cylinders were placed in between the compression plates of the Universal Testing Machine and apply load gradually.
- ✓ The reading was noted at the time of first crack and at the time of failure.
- ✓ The tensile strength can be calculated by using formula Tensile strength = 2P/3.14xD x L N/mm2
  where P-compressive load, D-Dia of cylinder mould, L-Length of cylinder

DURABILITY TESTS

ACID TEST as per IS code clause 8.2.2.4 of IS 456 - 2000

- ✓ The specimen 150 mm x 150 mm cube 28days curing was taken
- ✓ The weight of the cube was measured
- ✓ The cubes were immersed with 1% by weight of sulphuric acid for 90 days
- ✓ The loss in weight of cube and its compressive strength was measured

Fig.3- When Immersed in Acid

Fig.4 - After 90 Days

CHLORIDE TEST as per IS clause 8.2.8 of IS 456 - 2000

- ✓ The specimen 150 mm x 150 mm cube 28 days curing was taken
- ✓ The weight of the cube was measured
- ✓ The cubes were immersed with 1% by weight of sodium chloride for 90 days
- ✓ The gain in weight of cube was measured
- ✓ The compressive strength of immersed cubes was noted

Fig.8- When Immersed in Chloride

Fig.9 - After 90 Days

RAPID CHLORIDE PENETRATION TEST

Corrosion of reinforcement in reinforced concrete structures is one of the most hazardous durability problems in the country; one of the principal sources of this problem is the ingress of chloride ions into porous concrete. Movement of ions in a porous medium under a concentration gradient is called diffusion. It is often necessary to ascertain the impermeability of concrete to chloride ions as a quality control measure and also for assessment of improvements effected in properties of new concretes. Measurement of chloride diffusion co-efficient requires a long time for establishment of steady state conditions. Therefore, a direct current (DC) potential is usually applied to accelerate migration of ions.

In this present study, the rapid chloride penetration test (RCPT) was performed as per ASTM C 1202 to determine the electrical conductance of the 10% partial replacement of sand with lime sludge mixes at the age of 28 days curing and to provide a rapid indication of its resistance to the penetration of chloride ions . The test method consists of monitoring the amount of electrical current passed through 51 mm thick slices of 102 mm nominal diameter of cylindrical specimens for a duration of six hours. The specimens for RCPT and the test set up for RCPT with necessary settings are shown in Figures and Figure shows the specimens, after testing RCPT.

Fig.10- View of rapid chloride penetration test set up

The RCPT apparatus consists of two reservoirs. The specimen was fixed between two reservoirs using an epoxy bonding agent to make the test set up leak proof. One reservoir (connected to the positive terminal of the DC source) was filled with 0.3 N sodium hydroxide solution and the other reservoir (connected to the negative terminal of the DC source) with three percent sodium chloride solution. A DC of 60 V was applied across the specimen using two stainless steel electrodes (meshes) and the current across the specimen was recorded at 30 minutes' interval for a duration of six hours.

The total charge passed during this period was calculated in terms of coulombs using the trapezoidal rule as given in the ASTM C 1202,

$$Q = 900 (I_o + 2 I_{30} + 2 I_{60} + \ldots\ldots\ldots + 2 I_{330} + 2 I_{360})$$

where Q = charge passed (coulombs)

I_o = current (amperes) immediately after voltage is applied, and

I_t = current (amperes) at 't' minutes after voltage is applied.

Fig.11- Specimens Before Test

Fig.12- Specimens After Test

If the specimen diameter is other than 95 mm, the value for total charge passed must be adjusted. The adjustment is made by multiplying the value established as above by the ratio of the cross - sectional areas of the standard and the actual specimens.

That is; Qs = Qx (3.75 x)2

whereQs=charge passed (coulombs) through a 95mm diameter specimen

Qx = charge passed (coulombs) through x inch diameter specimen, and

x = diameter (inch) of the non - standard specimen.

The concrete quality (degree of chloride ion penetrability) can be assessed based on the limits as given in ASTM C 1202,

Charge passed (coulombs)	**Chloride ion penetrability**
> 4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very low
< 100	Negligible

Table 4- Chloride ion penetrability based on charge passed

Mix Designation	A 0%	B 5%	C 10%	D 15%	E 20%	F 25%	G 30%
SLUMP (in mm)	20	19	18	16	14	11	11
COMPACTION FACTOR	0.90	0.86	0.85	0.83	0.78	0.75	0.70

Table 5- Results of Slump and Compaction factor test

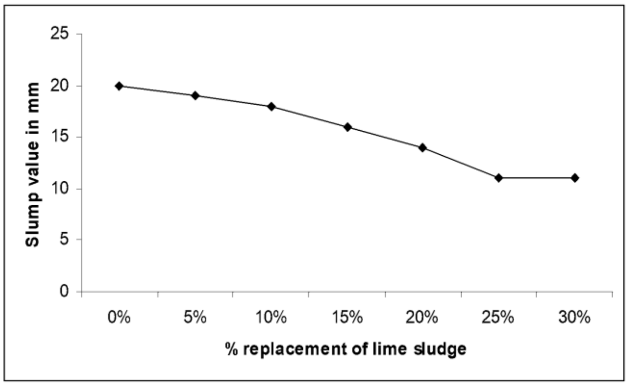

Fig.13- Slump value at various replacements of lime sludge

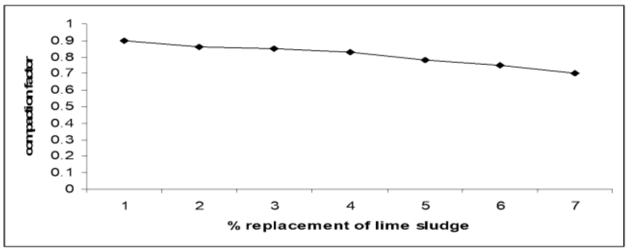

Fig.14-Compactor factor at various replacements of lime sludge

Discussions:

- The slump value reduced when the percentage of lime sludge increased due to more powder content and also absorb water in concrete.
- Reduce fine aggregate by adding lime sludge as a filler material.

Discussions:

- The compaction factor reduced due to increasing percentage of lime sludge so that the powder content need more compaction.
- Reduce fine aggregate by adding lime sludge as a filler material

COMPRESSION TEST

Sl. No	Description	Area of moulds	Compressive load kN	Compressive strength N/mm^2
1	Normal concrete 0%lime sludge	150mmx150mm	310	13.78
2	5 % lime sludge replacement	150mmx150mm	335	14.88
3	10%lime sludge replacement	150mmx150mm	350	15.55
4	15%lime sludge replacement	150mmx150mm	395	17.55
5	20%lime sludge replacement	150mmx150mm	405	18.00
6	25%lime sludge replacement	150mmx150mm	415	18.44
7	30%lime sludge replacement	150mmx150mm	405	18.00

Table 6-Test Result – Lime Sludge 7 Days Curing

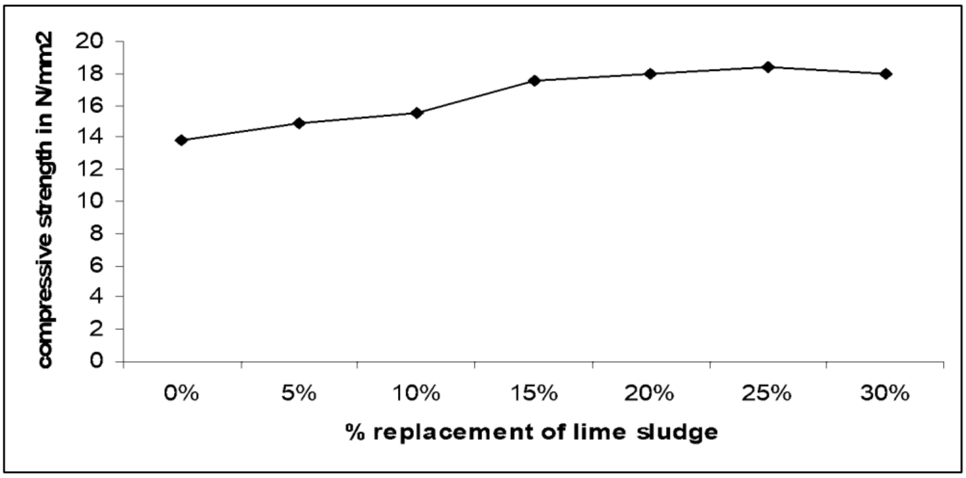

Fig.15 - Compressive strength of concrete at various replacement of lime sludge at 7 days

Sl. No	Description	Area of moulds	Compressive load kN	Compressive strength N/mm^2
1	Normal concrete 0%lime sludge	150mmx150mm	480	21.33
2	5 % lime sludge replacement	150mmx150mm	480	21.33
3	10%lime sludge replacement	150mmx150mm	570	25.33
4	15%lime sludge replacement	150mmx150mm	530	23.55
5	20%lime sludge replacement	150mmx150mm	410	18.22
6	25%lime sludge replacement	150mmx150mm	430	19.11
7	30%lime sludge replacement	150mmx150mm	410	18.22

Table 7 - Test Result – Lime Sludge 28 Days Curing

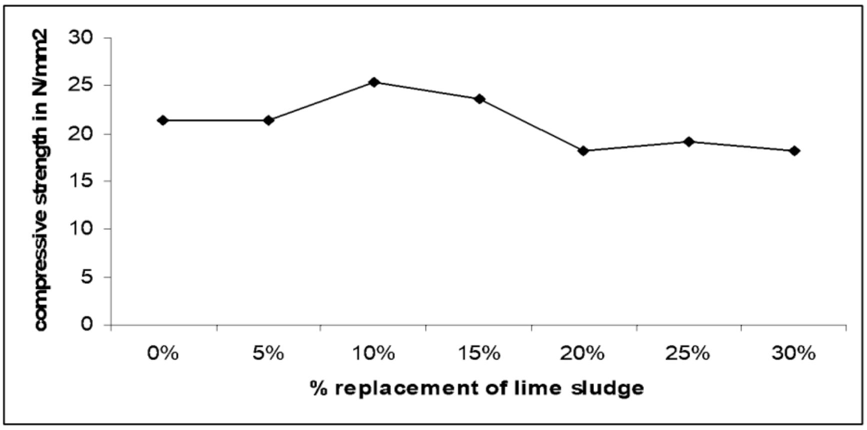

Fig.16 - Compressive strength of concrete at various replacement of lime sludge at 28 days

Discussion about test results (7 days curing)

- 25 percent partial replacement gives more strength than other percentage
- Addition of more percentage of lime sludge reduces its strength

Discussion about test results (28 days curing)

- 10 percent partial replacement gives more strength than other percentage
- It is due to the presence of calcium carbonate and better go for adding mineral admixture
- The reason may be due to the slow pozzolanic reaction of lime sludge, but the strength gain at 28 days is not much affected.
- Based on the test results it can be concluded that lime sludge can be effectively used up to 25 % replacement without much affecting the strengths of concrete.
- The durability of concrete will improve due to the addition of lime sludge, since the concrete becomes more impermeable due to filler action.
- 10 percent partial replacement of lime sludge gives more strength than normal concrete
- Addition of more percentage of lime sludge subsequently reduces its strength, it may be due to higher amount of calcium oxide present in lime sludge

Sl. No	Description	Split tensile load kN (P)	Tensile strength N/mm^2 = 2P/3.14xD x L
1	Normal concrete 0%	260	3.68
2	5 % lime sludge replacement	240	3.36
3	10%lime sludge replacement	220	3.08
4	15%lime sludge replacement	220	3.08

5	20%lime sludge replacement	210	2.94
6	25%lime sludge replacement	200	2.80
7	30%lime sludge replacement	180	2.52

Table 8- Split Tensile Test Report(28 Days Curing)

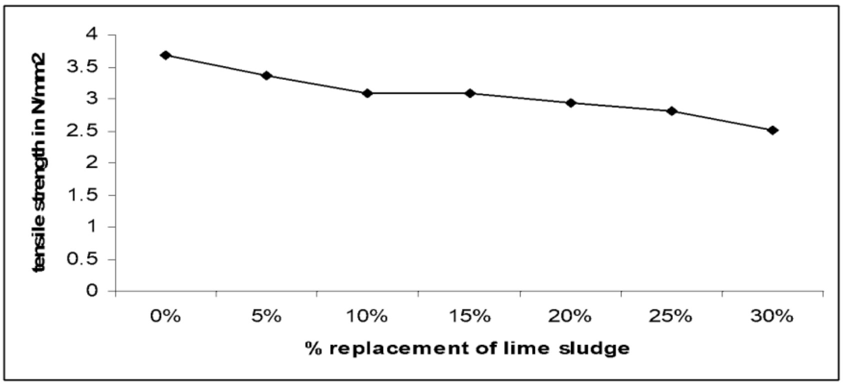

Fig.16 - Tensile strength of concrete at various replacement of lime sludge at 28 days

Discussions:

- ❖ The tensile strength also decreases with increase of lime sludge
- ❖ This is because of lime brittle in nature which reducing the tensile strength and also increase of powder content also in cumulative behaviour.

ACID TEST

The results of the acid resistance tests of 10% partial replacement of sand with lime sludge at the age of 90 days are given in Table 9.

Mix	Weight before immersion in kg	Weight loss in gm	% of loss in weight	Compressive strength immersed in Acid N/mm^2	Compressive strength immersed in water N/mm^2
DESIGN MIX	8.36	62	0.78 %	28.90	24.86
10% REPLACE MENT	8.03	56	0.70 %	24.88	25.77
15% REPLACE MENT	7.89	52	0.65%	22.96	23.55

Table 9 - Acid Test Report After 90 Days Immersion

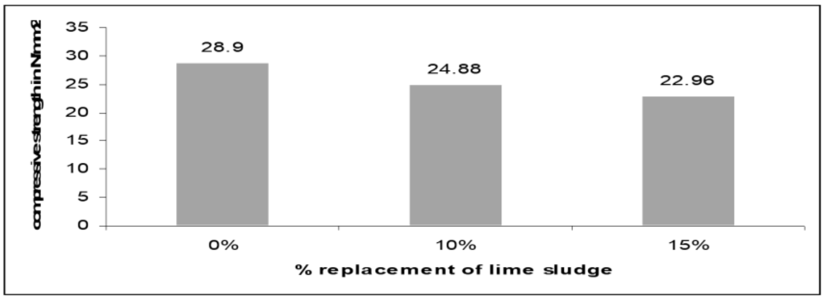

Fig.17 - Compressive strength of concrete at various replacement of lime sludge at 90 days' immersion in Acid

DISCUSSIONS:

- ❖ After 90 days immersed in acid, the compressive strength is not much affected compared with M20 concrete due to presence of calcium oxide which imparts strength with age.
- ❖ It is due to lime sludge act as a filler material easily combines with basic oxides to form various silicates thereby increasing impermeable nature
- ❖ The compressive strength decreased from 28.9 N/mm2to 22.96 N/mm2 as the % of lime sludge increased.

CHLORIDE TEST

The results of the chloride resistance tests of 10% partial replacement of sand with lime sludge at the age of 90 days are given in Table 10.

Mix	Weight before immersion in kg	Weight gain in gm	% of gain in weight	Compressive strength immersed in Chloride N/mm^2	Compressive strength immersed in water N/mm^2
DESIGN MIX	**8.32**	**48**	**0.58%**	**25.14**	**27.60**
10% REPLACEMENT	**8.14**	**42**	**0.52 %**	**25.77**	**26.66**
15% REPLACEMENT	**7.96**	**50**	**0.62%**	**23.12**	**24.16**

TABLE 10 The results of the chloride resistance tests of 10% partial replacement of sand with lime sludge at the age of 90 days.

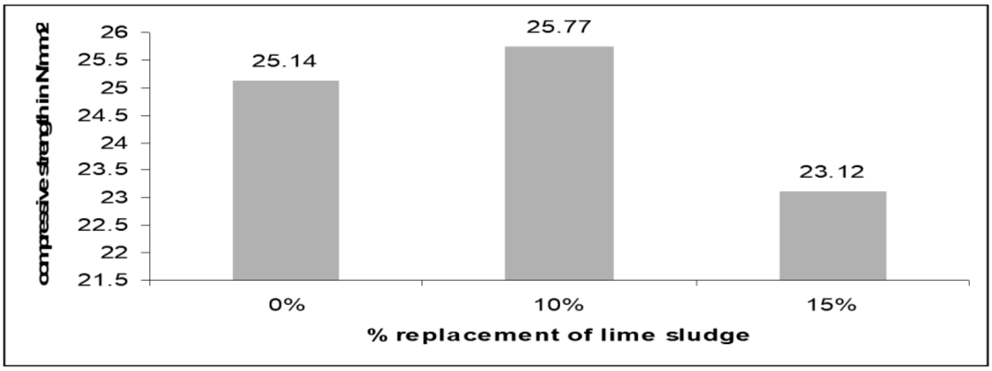

Fig.17 - Compressive strength of concrete at various replacement of lime sludge at 90 days' immersion in Chloride

DISCUSSIONS:

- After 90 days immersed in chloride, the compressive strength is not much affected compared with M20 concrete due to presence of calcium oxide which imparts strength with age.
- It due to sodium chloride react with calcium oxide to form various silicates which will act as densible nature.
- The compressive strength increased from 0% to 10% and decreased to 15% due to presence of calcium carbonate.

RAPID CHLORIDE PENETRATION TEST

CHLORIDE IONS PENETRABILITY CHARACTERISTICS

Specimen	Weight before RCPT	Weight after RCPT	Increase in weight in gms	% of gain in weight
Specimen – I (10% replacement)	1.060 kg	1.078 kg	18	1.7%
Specimen-II (10% replacement)	1.085 kg	1.108 kg	23	2.12%
Specimen-III (10% replacement)	1.050 kg	1.062 kg	12	1.14%
M_{20} concrete (0% replacement)	1.130 kg	1.150 kg	20	1.77%

Table 11 Gain In Weight Characteristics

Fig.18 - Specimen after Rapid Chloride Penetration Test

Discussions:

- From the weight gain in concrete, chloride penetration for normal concrete gives more when compared with lime sludge in concrete
- Chloride penetration in 10 % replacement of lime sludge gives a low penetration due to increase of powder content and filler effect.

MEASUREMENT OF CHLORIDE IONS PENETRABILITY

Period of measurement In minutes	Current in amperes (60 v DC)			
	Specimen (M_{20} concrete mix)	Specimen I	Specimen II	Specimen III
0	**0.060**	**0.020**	**0.035**	**0.045**
30	**0.080**	**0.040**	**0.040**	**0.050**
60	**0.090**	**0.050**	**0.045**	**0.055**
90	**0.100**	**0.060**	**0.045**	**0.065**
120	**0.105**	**0.062**	**0.055**	**0.065**
150	**0.105**	**0.063**	**0.055**	**0.070**
180	**0.110**	**0.070**	**0.060**	**0.072**
210	**0.115**	**0.080**	**0.065**	**0.075**
240	**0.120**	**0.080**	**0.075**	**0.075**
270	**0.130**	**0.080**	**0.080**	**0.085**
300	**0.135**	**0.080**	**0.085**	**0.085**
330	**0.140**	**0.082**	**0.085**	**0.095**
360	**0.150**	**0.085**	**0.090**	**0.095**

Table 12- Current Penetrability Characteristics

10% PARTIAL REPLACEMENT CONCRETE

Q1 = 900 (Io + 2 I30 + 2 I60 + ……… + 2 I330 + 2 I360) ---- (1)
= 900(0.02+2(0.04+0.05+0.06+0.062
+0.063+0.07+0.08+0.08+0.08+0.08+0.082+0.085)
= 1515.6 coulombs

CHLORIDE ION PENETRABILITY - LOW

Q2 = 900 (Io + 2 I30 + 2 I60 + ……… + 2 I330 + 2 I360) ---- (2)
= 900 (0.035+2(0.04+0.045+0.045+0.055+0.055
+0.060+ 0.065+0.075+ 0.08+0.085+0.085+0.09)
= 1435.5 coulombs

CHLORIDE ION PENETRABILITY - LOW

Q3 = 900 (Io + 2 I30 + 2 I60 + ……… + 2 I330 + 2 I360) ---- (3)
= 900(0.045+2(0.05+0.055+0.065+0.065+0.070+0.072+0.075
+0.075+0.085+0.085+0.095+0.095
= 1637.1 coulombs

CHLORIDE ION PENETRABILITY - LOW

AVERAGE CURRENT = 1909.8 coulombs
AVERAGE CHLORIDE PENETRABILITY - LOW

0% PARTIAL REPLACEMENT CONCRETE

Q M20 =900 (Io + 2 I30 + 2 I60 + ……… + 2 I330 + 2 I360) ---- (4)
=900(0.06+2(0.08+0.09+0.1+0.105+0.110+0.115
+0.120+0.130+0.135+0.140+0.150)
= 2349 coulombs

CHLORIDE ION PENETRABILITY - MODERATE

Quality of concrete can be assessed on the basis of chloride penetrability. The average chloride penetrability is low, the quality is assessed good

Conclusion:

Chloride ion penetrability - low

quality of concrete - good

Specimen	Charge passed in coulombs	Chloride ion penetrability
10% lime sludge replacement	1909.8	**LOW**
0% lime sludge replacement	2349.0	**MODERATE**

Table 13- Comparison Of Chloride Ion Penetrability

Discussions:

- ❖ Overall quality of concrete with 10% partial replacement of sand with lime sludge seems to be good

COMPARATIVE STUDY OF CURRENT WITH TIME

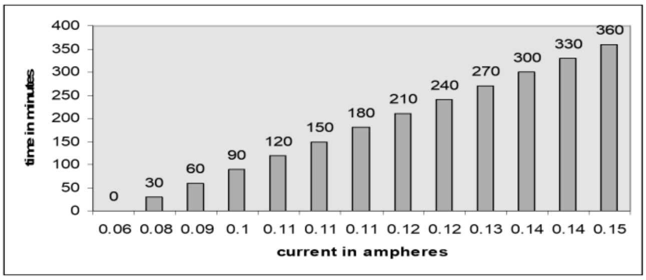

Fig.19 - Normal concrete (M20 mix)

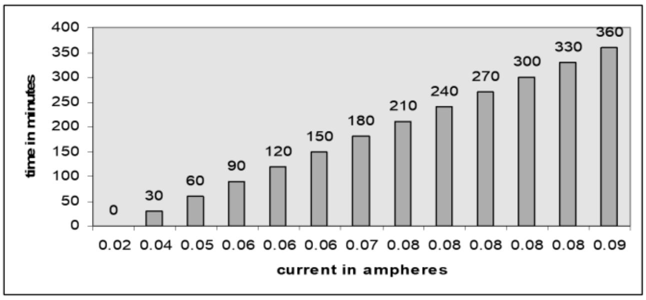

Fig.20 - 10% lime sludge replacement (SPECIMEN – I)

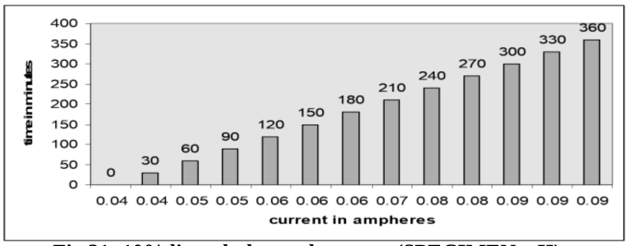

Fig.21- 10% lime sludge replacement (SPECIMEN – II)

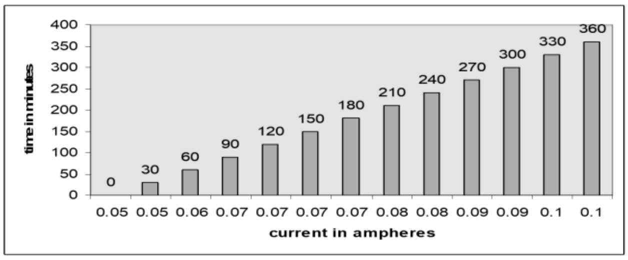

Fig.22-10% lime sludge replacement (SPECIMEN – III)

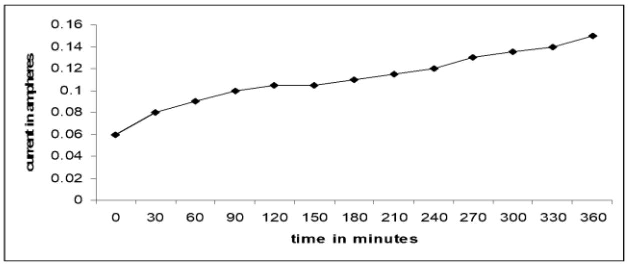

Fig.23 -Normal concrete (M20 mix)

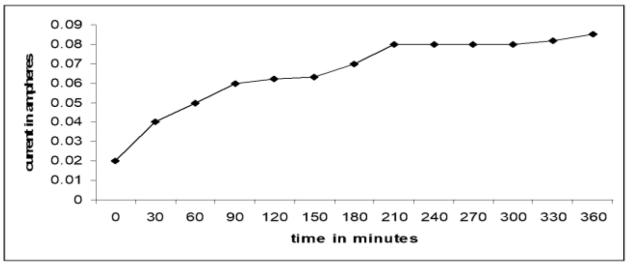

Fig.20 -10% lime sludge replacement (SPECIMEN – I)

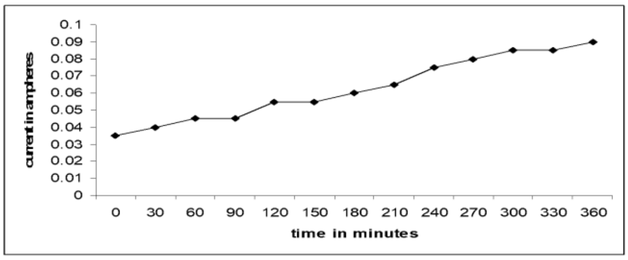

Fig.25- 10% lime sludge replacement (SPECIMEN – II)

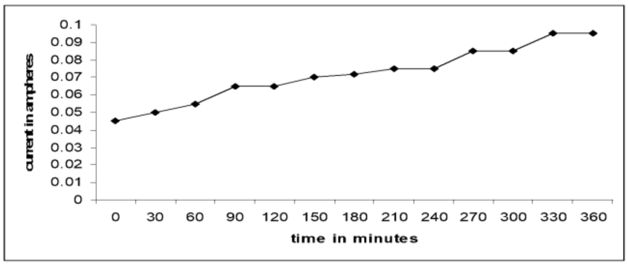

Fig.26- 10% lime sludge replacement (SPECIMEN – III)

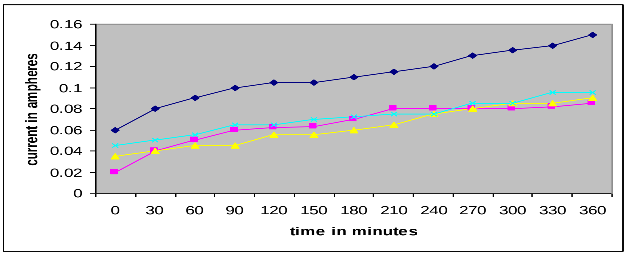

Fig.27-Comparative penetration characteristics of concrete

Discussions:

- The value of current in amperes is increased with time due to the penetration of chloride ion in concrete
- Chloride ion reduces the resistance of concrete.
- Normal concrete the chloride ion penetrability is more compared with lime sludge replacement
- It is due to increase of impermeability by adding lime sludge act as a filler material.

CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

CONCLUSION

As we aware that a lot of waste material are being generated from Industries and dumped in thousands of hectares of land causing environmental pollution. Those materials could only be utilized in construction industry. In this project work it has been found that the lime sludge from sugar industry could be utilized to make use in concrete works for all construction works.

From our experimental study the following conclusions were drawn,

- The compressive strength of concrete cubes increases upto 10% replacement of lime sludge then decreases.
- The cubes made with 10% lime sludge gives optimum compressive strength 28 days.
- The strength of 25%,30% 35% of lime sludge cubes almost equal to strength of clay brick and slightly lower than that of fly ash brick.
- The lime sludge is free of cost and concrete made with is cheap when compare with fly ash brick and clay brick. Hence the cost of construction will be reduced.
- Addition of more percentage of lime sludge reduces strength of concrete due to higher amount of calcium oxide present in lime sludge
- Lime sludge can also be used as a substitute material for weathering course replaced by pure lime there by reducing cost of construction.
- Durability tests show that no variation in durability by adding lime sludge and can be used in any area of construction.
- Even though the workability is reduced by adding lime sludge, but the compressive strength is increased upto 10% replacement.
- Durability tests shows that 10% replacement is not much affected due to acid and chloride penetrations compared with normal concrete.

REFERENCES

1. Hadi Bahmani S0950061825003502, 2025 Sustainable high-performance concrete with sugar factory lime waste -activated slag and fiber reinforcement: Mechanical properties and environmental impact.
2. Fatma didem Tunçez, June 2017, The Use of Sugar Factory Sludge as Alternative Raw Material for Sustainable Cement Producing with Industrial Symbiosis.
3. ACI 363 R-92 (1993) “State-of-the Art Report on High Strength Concrete”. ACI Manual of Concrete Practice, Part-I, Materials and General properties of concrete. pp55
4. ACI Committee 211, 1-91 (1993).” Standard Practice for Selecting Proportions for Normal, Heavy Weight and Mass Concrete”, ACI Manual of Concrete Practice, Part –I ISSN 0065-7875, pp211.1-1to 211.1-38
5. CEB-FIP (1994)” Application of high performance concrete”, Report pf CEB-FIP working group on HS/HPC, pp 69
6. IS: 516-1959, “Methods of tests for strength of concrete”, Bureau of Indian Standards, New Delhi, India.
7. IS:456-2000 “Plain and Reinforced Concrete Code of Practice” 4th revision, Bureau of Indian Standards, New Delhi, India.
8. IS:10262-1982 “Mix Design Procedures”, Bureau of Indian Standards, New Delhi, India.
9. M.S. Shetty (2003) “Concrete Technology Theory and Practice” – S. Chand & Company Ltd, pp 399-400,429-438.
10. IS 10079 (1982), Indian Standard specification for cylindrical metal measures for use in tests of aggregates and concrete September 1982. Indian Standard Institution New Delhi-110 002.
11. IS 10086 (1982), Indian Standard specification for moulds for use in tests of cement and Concrete-V Reprint December 1995, Bureau of Indian Standard, New Delhi-110 002.
12. IS 5515 (1983), Indian Standard Specification for compacting factor apparatus. I revision 1983, Indian Standard Institution.
13. IS 5816 (1970), Indian Standard Method of tests for splitting tensile strength of concrete cylinders III print October 1985. Indian Standard Institution.
14. ASTM Designation (496-66), Splitting tensile strength of moulded concrete cylinders. American Society for Testing and Materials.
15. BS 1881 (Part IV-1970), Methods of testing concrete for strength. British Standards/Institution.
16. A written copy from “M/s Sakthi Sugars Ltd” Preparation of properties of lime and milk of lime, etc.,
17. Hugot in “Cane Sugar Manufacturing” the properties of lime and milk of lime, etc.,
18. Manufacturing manual of plantation white sugar by SAKTHI SUGARS LTD
19. Sirawan Ruangehuey a paper presentation on “Treatment and Disposal of Bagasse, fly ash which absorb Cr. Using cementitious Chulalongkorn University, Bangkok, Thailand
20. Dr.Perumal (2007) research study “Development of High Performance Concrete using partial replacement of cement by silica fume and study on its strength and durability properties” in chapter 7
21. Gopalakrishnan.S, N.P.Rajamane, M.Neelamegam, J.A.Peter and J.K.Dattatraya “Effect of partial replacement of cement with fly ash on the strength and durability of HPC” Indian Concrete Journal, May 2001, pp335-341
22. Mullick. A.K.,’ performance of concrete with binary and ternary cement blends’, The Indian Concrete Journal, January,2007, pp 15-22