EXPERIMENTAL STUDY ON BEHAVIOUR OF CONCRETE WITH CETP (COMMON EFFLUENT TREATMENT PLANT) SLUDGE

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***Abstract*— Leaving the waste material to the environment directly cause environmental problems. Rapid Industrialization and Urbanization is causing serious environmental problems to the environment. One of the major concerns amongst these is safe and sound disposal of solid wastes. The treatment of effluents from the production of industries results in sludge generation from the treatment plant which poses a huge challenge for its disposal. Therefore, an attempt is made to initialize them in an effective way. In this experimental investigation, an attempt has been made to investigate the behavior of concrete and its mechanical properties with replacement of cement with CETP sludge. The outcomes show there is a possibility in accommodating the sludge in concrete by solidification. This report is meant for discussion of beneficial utilization of CETP sludge waste with conventional building material in Construction application. From this study, the use of the CETP sludge will be identified for structural and non-structural applications by conducting future experimental studies. To evaluate the effect of dry sludge on concrete performance, its physical and mechanical properties were studied. In this research an attempt is taken to bring into play the sludge waste in various proportions so that the final product property of concrete mixture is same as the control mix. Waste sludge material will be replace cement in various percentages such as 40%,30%,20%,15%,10%,5%and0%.Reference concrete mix is to be also made for comparative reasons. Test will be conducted on fresh and harden concrete. Cube, cylinder and beam will be casted for grade M20 and M30 for the determination of workability, compressive strength, tensile strength and flexure strength**

***Index Terms*— CETP sludge waste, Cement, workability, compressive strength, tensile strength, flexure strength**

I. INTRODUCTION

VAPI GIDC Estate is "Pronounced Chemical Estate" lodging more than 1400 businesses, two third are compound related units. Practically 80% of the enterprises have a place with Small Scale Sector. The quick industrialization was the objective and the national and state financial arrangement was to energize SSI division for most extreme work at least capital.Common effluent treatment plant Vapi having capacity 55 MLD containing waste water of chemical and biochemical industry. Which produce 200 metric tons sewage sludge every day. This sludge is used to deposit in sand bag and used for land filling. The enormous issue of testimony and treatment of ooze amid downpour it causes condition contamination

II. LITERATURE REVIEW

A.Yagie, S.Yagie, E.Vazqeze. (2004)[1]had studied on the dry sewage sludge and determines its compatibility with cement. The dry sewage sludge was replaced to cement. The proportions of dry sewage sludge were taken as 0%, 2.5%, 5%, and 10% to the weight of the cement. The dry sludge concrete specimens were compared with the control specimen and also ones which were submerged in seawater and in fresh water. The strength of concrete with 2.5% and 5% of sludge addition were almost similar. The strength decrease by addition of 10% of dry sludge. As per his study the strength of concrete containing sludge was acceptable as compared to control concrete.

Kartini K, Dahila Lema.et.al (2015)[2] had conducted study on domestic waste sludge powder (DWSP). The wet sludge was dried in natural sunlight and then it was dried in furnace for 72 hours to remove moisture, dried sludge was crushed into Los Angeles Abrasion test machine and sieved through 90μm.The dry sludge powder was used as a cement replacement and taken as 3%, 5%, 7%, 10% and 15% proportion to the weight of cement. Grade 30, 40 and 50 with w/c ratio=0.60. The compressive strength was checked for 7, 28&60 days. For grade 30, the strength of specimen at 28 day of specimen containing 3% and 15% sludge was below control concrete specimen. For grade 40, the strength of specimen containing 5% and 7% sludge was optimum and for grade 50, the strength of specimen containing 10% and 15% of sludge was

low. As sludge may contain S03 which retard the setting of the concrete.

M.Alqedra, Maraca, M.Mattar (2011)[3] had studied on influence of low and high organic wastewater sludge on concrete. The low organic is the sun dried sludge, contains high sand contain and high organic sludge is the sludge taken from secondary pond, can be used as an additive in concrete mixes. Both sludge was taken as proportion 0%, 2.5% and 10%. The strength was checked at 28&90 days' age. The result shows that the strength of specimen containing sludge was higher at 90 days for the low organic sludge used as a sand replacement and that of compressive strength of high organic strength at 90-day age shows acceptable strength with2.5% and 5% sludge.

HaiderMohammed Owaida, et.al (2013)[4] had carried out experimental work on use of alum sludge as partial cement replacement and compressive strength, splitting tensile strength and flexural strength of concrete block was checked. The Ordinary Portland Cement and admixture as added. The chemical characteristic of alum sludge was carried before using as cement replacement. The alum sludge powder was taken to weight of cement as 0%, 6%, 9%, 12% and 15% mixproportions with water cement ratio=0.33. The compressive strength and splitting tensile strength was checked at 3, 7 and 18 days and that of flexural strength at 28days.Results shows that higher strength was obtained at 6% addition of sludge because of presence of silica, alumina and ferric oxide in alum sludge and cement too.

ShayanPirouz, SeyedMostafaKhezri, (2015)[5] had conducted study on sludge from filtration plant. The dry sludge was taken as 0%, 10%, 20%, 30%, 40% and 50% mix proportions to the weight of cement with water to cement ratio=0.60. The concrete specimen was cured for 7, 28and 90 days. The compressive strength of concrete specimen were tested and result shows that strength at 90 day age higher than 28 day age and that of 28 and 90 days strength was higher than 7 day age strength. Therefore increasing curing period strength will increase.

Balasubramanian et.al[6] examined the potential reuse of textile effluent treatment plant (ETP) sludge in building materials. The tests were conducted as per Bureau of Indian Standards (BIS) specification codes to evaluate the suitability of the sludge for structural and non-structural application by partial replacement of up to 30% of cement.

D. Mandlik, Prof. S. A. Karale[7] 2018) This study utilized replacement of 5%, 10 %, 15 % and 20% by weight of OPC with water binder (w/c) ratio of 0.50 and 0.45 for Grade 20 and Grade 30 respectively. The performance of sludge concrete in terms of its compressive strength, split tensile strength test, flexure strength test was investigated. All values of compressive strength for sludge concrete were lower compared to the OPC control, and the strength decreased as the percentage of replacement with sludge increased for Grade 20 and Grade 30, at replacement of 10 %. Meanwhile, water absorption and water permeability for the sludge concrete increased as the replacement increased. Overall, with further research in producing quality, the potential of using this waste as a cement replacement material is very promising

III. MATERIAL AND QUANTITY

LIST OF MATERIALS

Cement Fine aggregate, Course aggregate, Water, CETP sludge, Polypropylene fiber (additive)

CEMENT- Ordinary Portland cement of 53 grade as per IS 12269-1987 standards will be used in this experimental works. The cement is tested in lab for its physical characteristics and found to be confirming to the requirements as per IS 12269-1987

SLUDGE

QUANTITY OF MATERIAL AND TEST TO BE CONDUCTED-

The concrete mix design was proposed by using IS10262:2009.The grade of concrete used was M20 with water to cement ratio 0.5. The mix design proportions for 1 m3 of concrete. When sludge girt increases then the percentage of the cement ratio get decreases. In which ratio is constant & also F.A (kg/m^3), C.A (kg/m^3), Water (kg/m^3) is constant

Cement: Sand: Coarse Aggregate: w/c = (1: 2.4: 3. 54: 0.5)

QUANTITIES REQUIRED FOR M20 GRADE CONCRETE

Sludge %	W/C ratio	Cement (kg/m^3)	F.A (kg/m^3)	C.A (kg/m^3)	Water (kg/m^3)	Sludge (kg/m^3)	Polyprpelyene fiber Additive 0.5%
0	0.5	290	696	1026	145	….	10.06
5	0.5	275.5	696	1026	145	14.5	10.06
10	0.5	261	696	1026	145	29	10.06
15	0.5	246.5	696	1026	145	43.5	10.06
20	0.5	232	696	1026	145	58	10.06
30	0.5	203	696	1026	145	87	10.06
40	0.5	174	696	1026	145	116	10.06

DESIGN MIX METHODOLOGY M30

The concrete mix design was proposed by using IS10262:2009.The grade of concrete used was M30 with water to cement ratio 0.45. The mix design proportions for 1 m3 of concrete. When sludge girt increases then the percentage of the cement ratio get decreases. In which ratio is constant & also F.A (kg/m^3), C.A(kg/m^3), Water (kg/m^3) is constant

Cement: Sand: Coarse Aggregate: w/c = (1:1.87:3.37:0.45)

QUANTITIES REQUIRED FOR M30 GRADE CONCRETE

Sludge %	W/C ratio	Cement (kg/m^3)	F.A (kg/m^3)	C.A (kg/m^3)	Water (kg/m^3)	Sludge (kg/m^3)	Polyprpelyene fiber Additive 0.5%
0	0.45	380	710	1280	171	….	12.5
5	0.45	361	710	1280	171	19	12.5
10	0.45	342	710	1280	171	38	12.5
15	0.45	323	710	1280	171	57	12.5
20	0.45	304	710	1280	171	76	12.5
30	0.45	266	710	1280	171	114	12.5
40	0.45	228	710	1280	171	152	12.5

IV. TESTING METHODOLOGY AND EXPRIMENT RESULT

CASTING OF SPECIMENS

The properties of materials such as cement, fine aggregate, coarse aggregate and cetpsludge are determined and Calculation of M20,M30 mix design was done.

The size of cube, cylinder and were kept as per is codal provision.

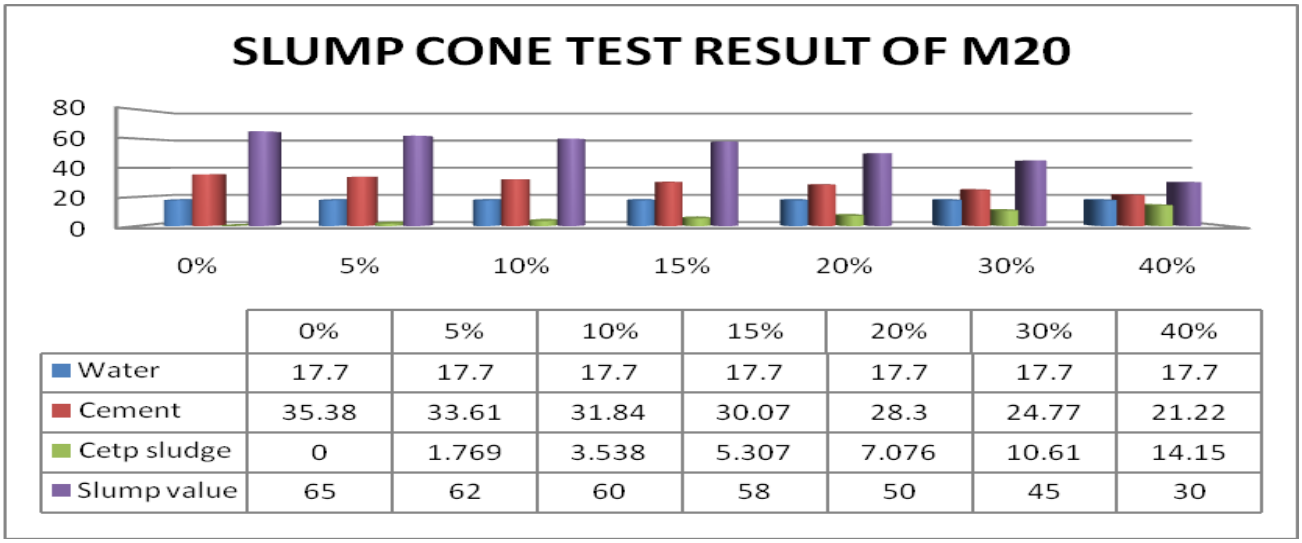
The experimental investigation was carried out on casted specimens. The experiment is carried out by partially replacing cement with cetp sludge and adding the polypropylene.

As per table 12 cubespecimens qty, table 13beam specimens qty, table 14 cylinder specimens qty a set of three samples for different percentages of CETP SLUDGE added to concrete is casted for compressive strength, Split Cylinder strength and flexural strength test. Cured for 7 days, 14 days, 28 days and 56 day and tested for fresh and hardened properties & Durability of concrete

SLUMP CONE TEST

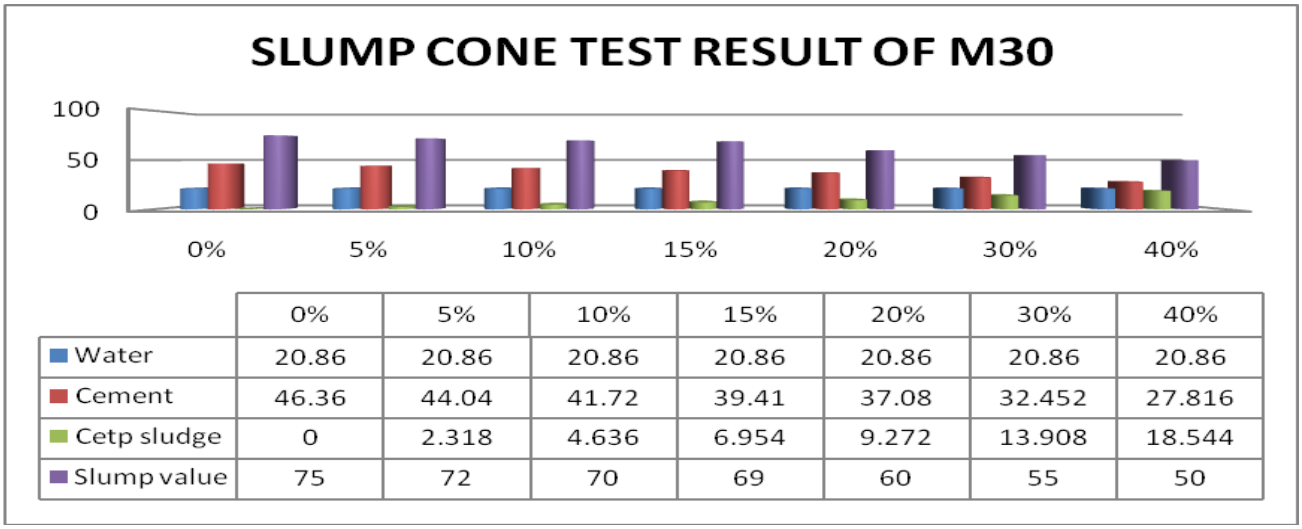
Determines the consistency and workability of all concrete mixtures. Slump cone test utilizing a metallic slump mould. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured.

SLUMP CONE TEST RESULT OF M20



	0%	5%	10%	15%	20%	30%	40%
Water	17.7	17.7	17.7	17.7	17.7	17.7	17.7
Cement	35.38	33.61	31.84	30.07	28.3	24.77	21.22
Cetp sludge	0	1.769	3.538	5.307	7.076	10.61	14.15
Slump value	65	62	60	58	50	45	30

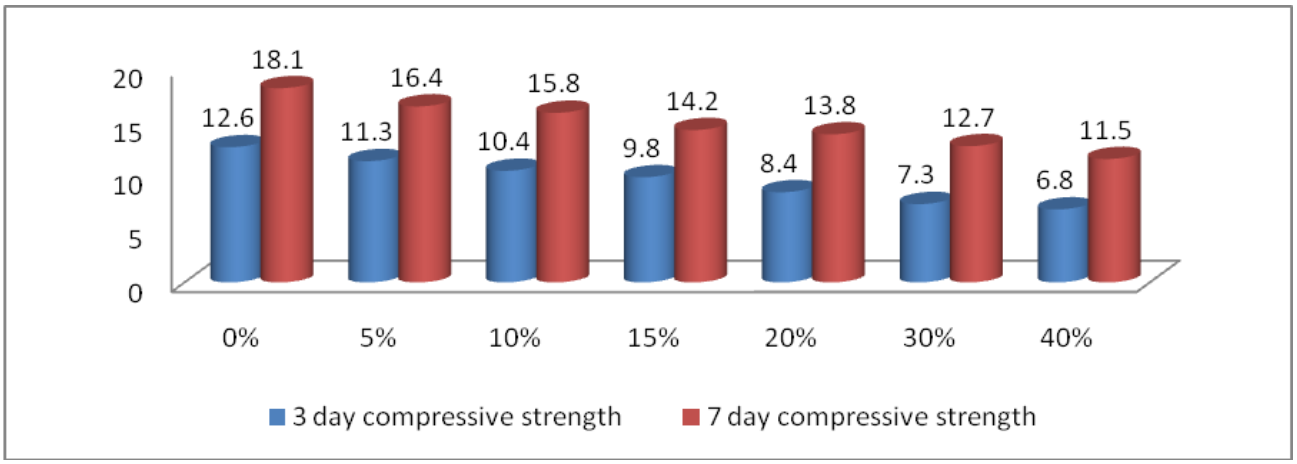
SLUMP CONE TEST RESULT OF M30



	0%	5%	10%	15%	20%	30%	40%
Water	20.86	20.86	20.86	20.86	20.86	20.86	20.86
Cement	46.36	44.04	41.72	39.41	37.08	32.452	27.816
Cetp sludge	0	2.318	4.636	6.954	9.272	13.908	18.544
Slump value	75	72	70	69	60	55	50

COMPRESSIVE STRENGTH OF CEMENT SLUDGE MORTAR CUBE

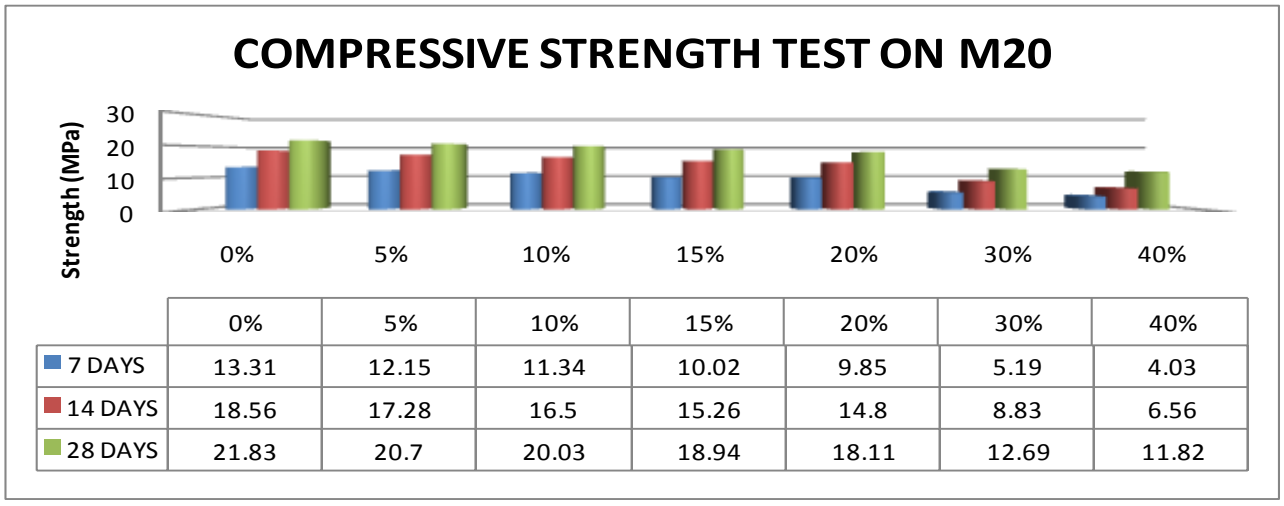
Experiments were carried out on cement mortar cubes of 1:3 mix ratios. The percentage of cement partially replaced with sludge added to the mix varied from 0%, 10%, 15%, 20% and 30% 40% .For all the ratios, the sample cubes were casted and subjected to curing for 3 days and 7 days. All the experiments were carried out in triplicates and the average values were calculated



COMPRESSIVE STRENGTH TEST REFERENCE CODE (IS-516:1959)

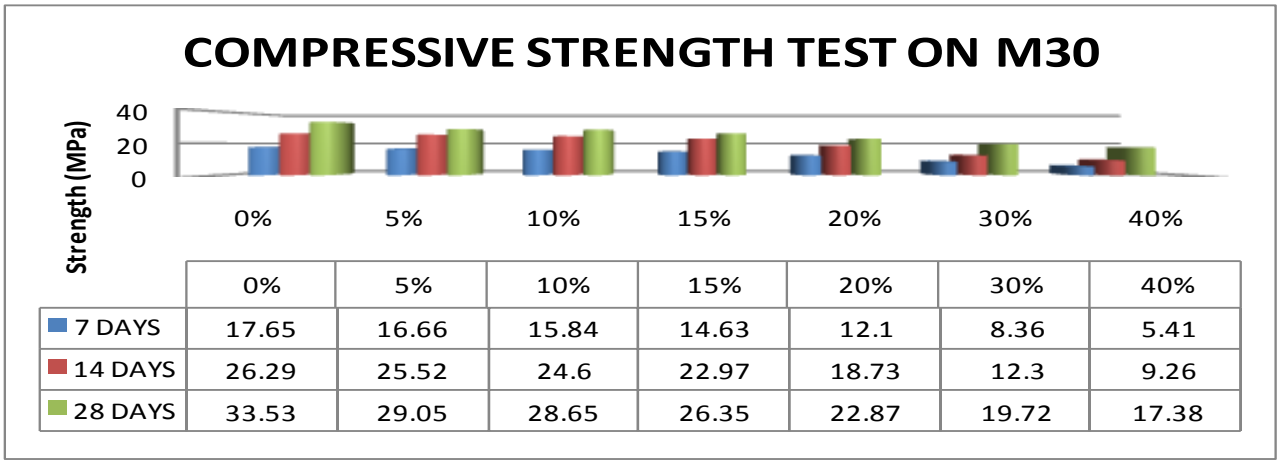
Compression test is the largely recognizable test performed on hardened concrete, partly since it is an easy test to be accepted and partly because most of the enviable characteristic properties of concrete are qualitatively linked to its compressive strength.These kinds of tests are usually performed on cylindrical and cubical specimens. The sides of the mould and base plates were oiled before casting to prevent bonding between the mould and concrete. The cube was then stored for 24 hours undisturbed at temperature of l8°C to 22°C and a relative humidity of not less than 90% (IS 516-1959).

COMPRESSIVE STRENGTH TEST ON M20 CUBE (Mpa)



	0%	5%	10%	15%	20%	30%	40%
7 DAYS	13.31	12.15	11.34	10.02	9.85	5.19	4.03
14 DAYS	18.56	17.28	16.5	15.26	14.8	8.83	6.56
28 DAYS	21.83	20.7	20.03	18.94	18.11	12.69	11.82

COMPRESSIVE STRENGTH TEST ON M30 CUBE (MPa)

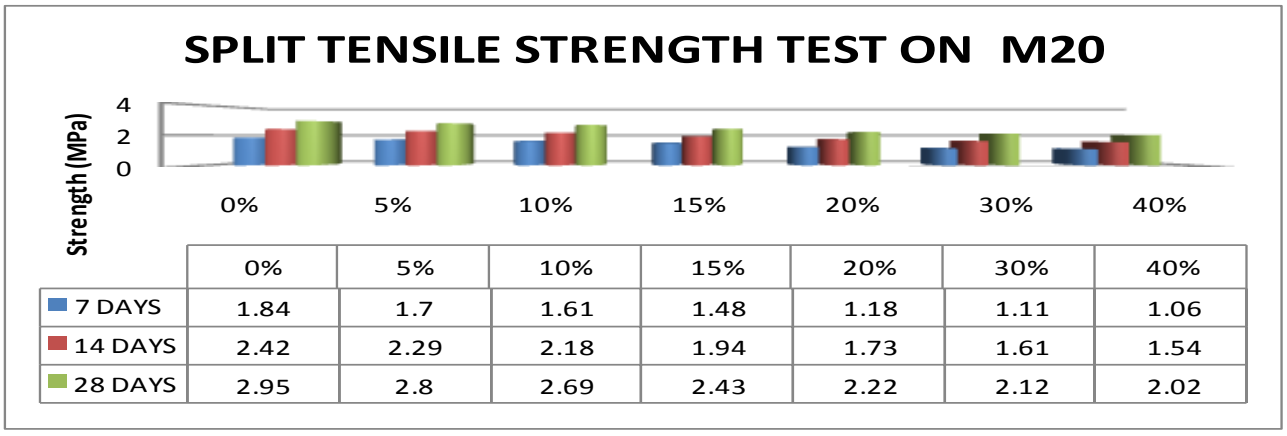


	0%	5%	10%	15%	20%	30%	40%
7 DAYS	17.65	16.66	15.84	14.63	12.1	8.36	5.41
14 DAYS	26.29	25.52	24.6	22.97	18.73	12.3	9.26
28 DAYS	33.53	29.05	28.65	26.35	22.87	19.72	17.38

SPLITTING TENSILE TEST REFERENCE CODE (IS 5816-1999)

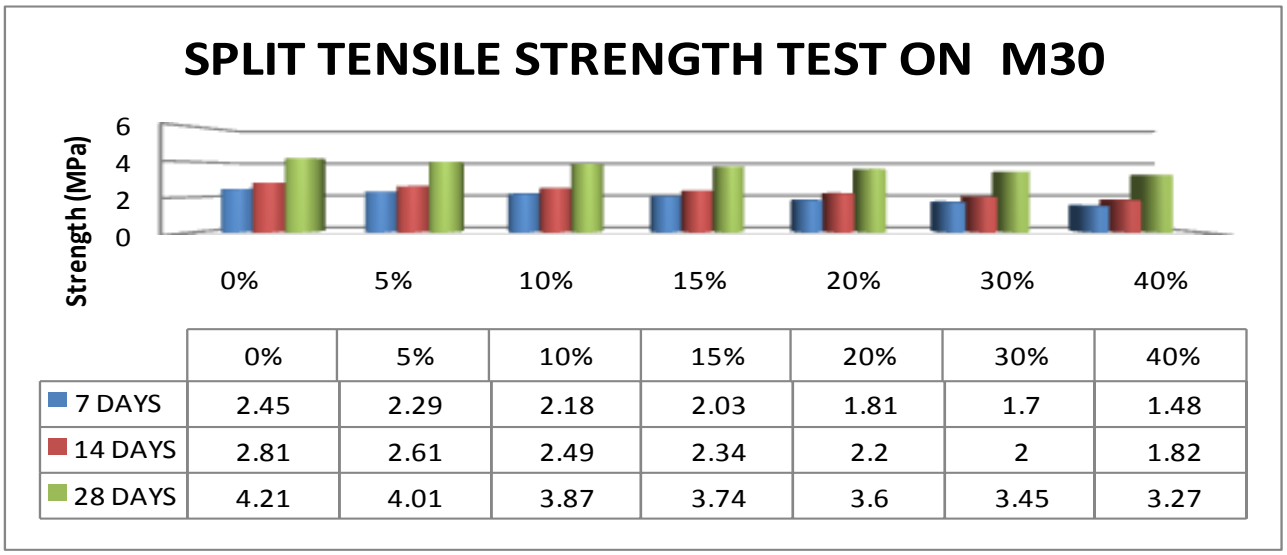
The test was conducted as per IS 5816:1999 [23]. For tensile strength test, cylindrical specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens were remolded after 24 hours of casting and were transferred to curing tank wherein they were allowed to cure for 7, 28 and 56 days. In each category, three cylinders were tested and their average value was reported using digital compression machine having 2000 KN capacity.

SPLIT TENSILE STRENGTH TEST ON CYLINDER M20 (MPa)



	0%	5%	10%	15%	20%	30%	40%
7 DAYS	1.84	1.7	1.61	1.48	1.18	1.11	1.06
14 DAYS	2.42	2.29	2.18	1.94	1.73	1.61	1.54
28 DAYS	2.95	2.8	2.69	2.43	2.22	2.12	2.02

SPLIT TENSILE STRENGTH TEST ON CYLINDER M30 (MPa)

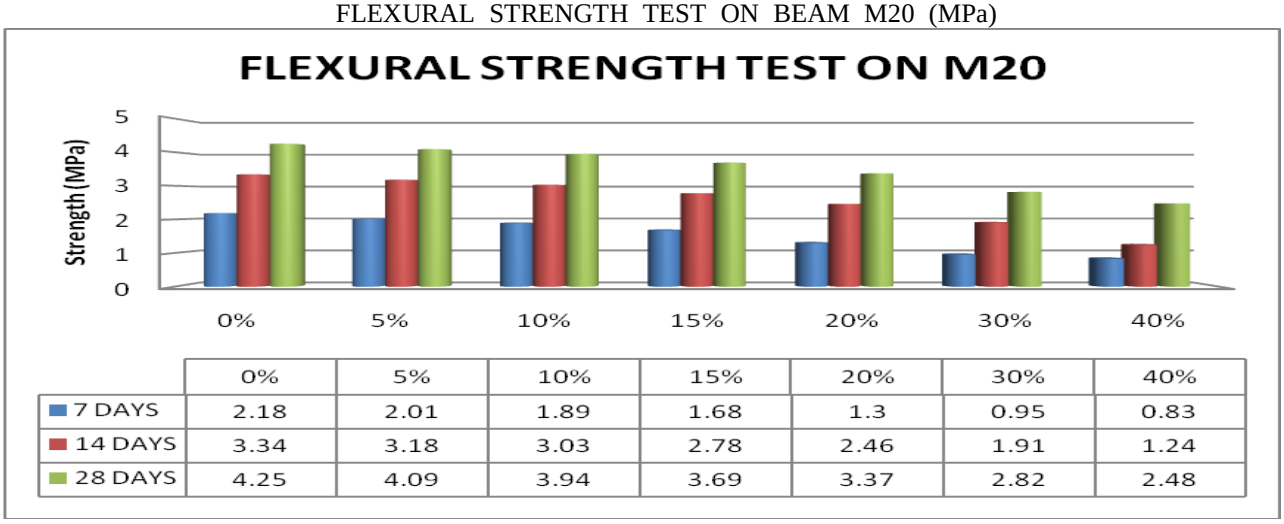


	0%	5%	10%	15%	20%	30%	40%
7 DAYS	2.45	2.29	2.18	2.03	1.81	1.7	1.48
14 DAYS	2.81	2.61	2.49	2.34	2.2	2	1.82
28 DAYS	4.21	4.01	3.87	3.74	3.6	3.45	3.27

FLEXURAL STRENGTH TEST [IS 10262: 2009]

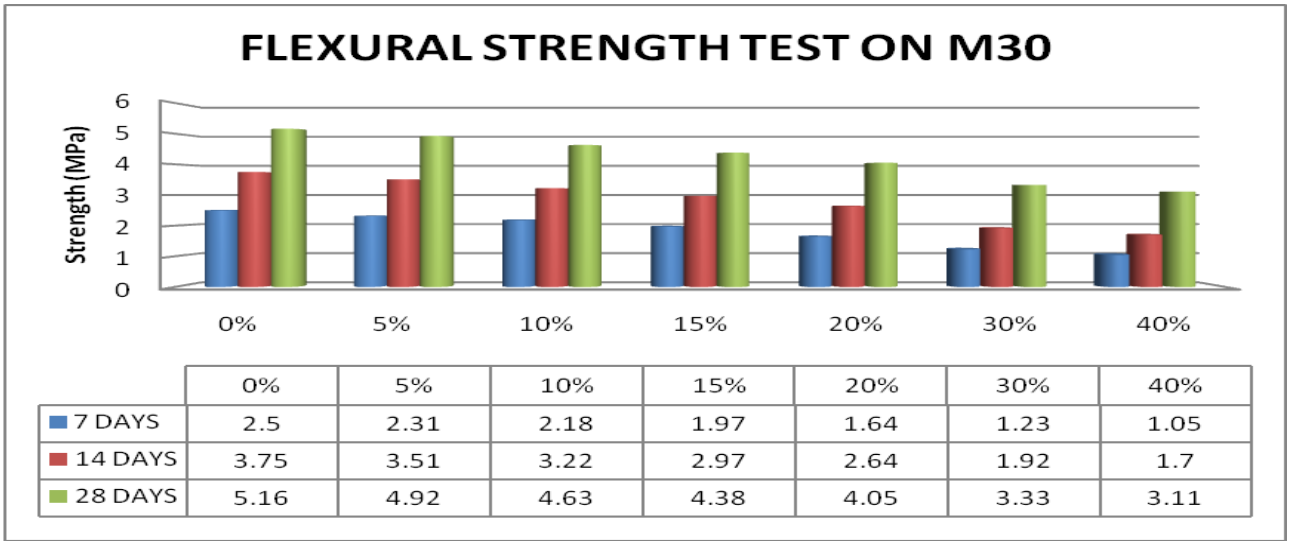
The flexural tensile strength test was performed on 150*150*700 and 100*100*500 mm prismatic specimens by using the beam method according to IS 516:1959 at which load is applied at one third points of the specimen. Two prismatic specimens were produced for each series. The tests were carried out by using a closed loop deflection-controlled loading frame of 250 KN capacity and loading rate was 0.5 mm/min. The deflections at the mid-span of bottom surface and the supports of beams were simultaneously recorded during the test. The net mid-span deflection of the beam was obtained by taking the difference between mid-span deflection and the average of the support deflections. A load–deflection curve for each specimen was also obtained graphically

FLEXURAL STRENGTH TEST ON BEAM M20 (MPa)



	0%	5%	10%	15%	20%	30%	40%
7 DAYS	2.18	2.01	1.89	1.68	1.3	0.95	0.83
14 DAYS	3.34	3.18	3.03	2.78	2.46	1.91	1.24
28 DAYS	4.25	4.09	3.94	3.69	3.37	2.82	2.48

FLEXURAL STRENGTH TEST ON BEAM M30 (MPa)



	0%	5%	10%	15%	20%	30%	40%
7 DAYS	2.5	2.31	2.18	1.97	1.64	1.23	1.05
14 DAYS	3.75	3.51	3.22	2.97	2.64	1.92	1.7
28 DAYS	5.16	4.92	4.63	4.38	4.05	3.33	3.11

V. DURABILITY TEST RESULT

CARBONATION TEST

The majority of research works on concrete carbonation use a phenolphthalein indicator to assess carbonation depth. This involves spraying concrete broken faces after flexural strength tests with 1% phenolphthalein in 70% ethyl alcohol.

1. When the pH of the pore solution is less than 7.5, the degree of carbonation of the specimen is 100%.
2. PH value of the pore solution is between 7.5 and 9.0, the degree of carbonation is 50– 100%.
3. PH of the pore solution is 9.0–11.5, the degree of carbonation is 0–50%
4. PH of the pore solution exceeds 11.5, the specimen is not carbonated.

RAPID CHLORIDE PENETRATION TEST(ASTM C1202)

Concrete disc specimens of size 100mm diameter and 50mm thick were cast for various replacement percentages of sand andcement with CETP sludge in concrete. After 24 hours, the disc specimens wereremoved from the mould and subjected to curing for 28 days in chloride freedistilled water. After curing, the specimens were tested for chloridepermeability. All the specimens were dried free of moisture before testing The test set up is called Rapid Chloride Penetration Test (RCPT) assembly. This is two-compartment cell assembly. Disk specimen is assembled between the two compartments cell assembly and checked for air and watertight. The cathode compartment is filled with 3%NaCl solution and anode compartment is filled with 0.3 normality NaOH solutions. Then, the concrete specimens were subjected to RCPT by impressing a 60V from a DC power source between anode and cathode. Current recorded over a period of 6 hours at an interval of 30 minutes as per the procedure given in ASTM C1202

From the current values, the chloride permeability is calculated in terms of coulombs at the end of 6 hours by using the following equation

$Q = 900 (I0 + 2I30 + 2I60 + 2I90 + \ldots\ldots\ldots\ldots + 2I300 + 2I330 + 2I360)$

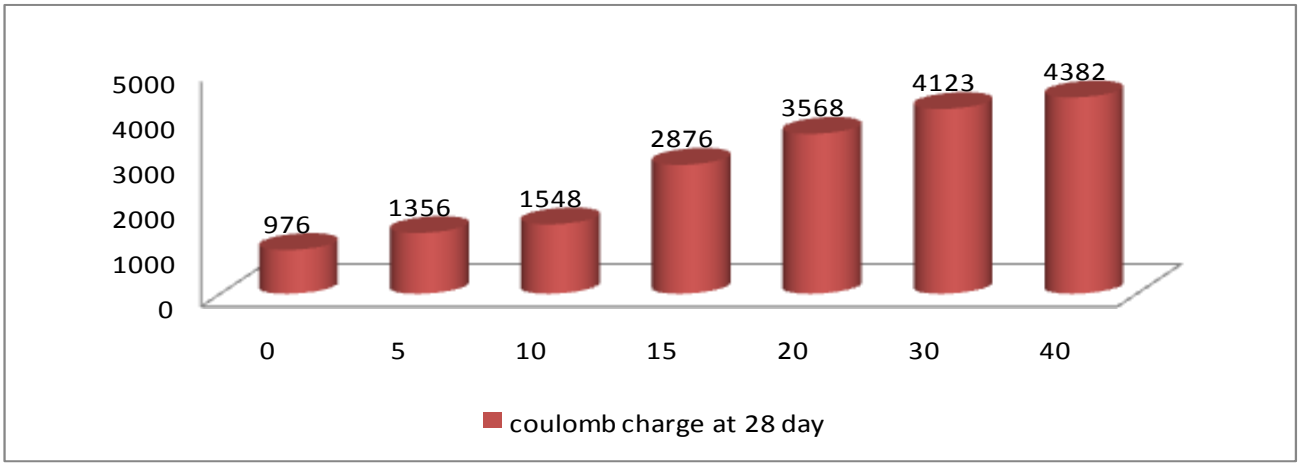
Where,

Q = Charge passed (Coulombs)

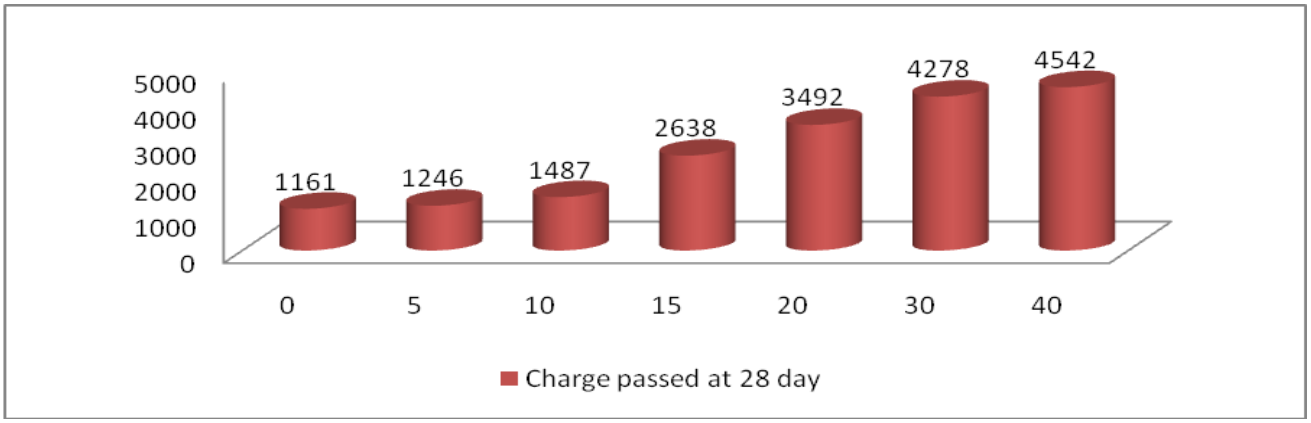
I0 = Current (amperes) immediately after voltage is applied

It = Current (amperes) at t minutes after voltage is applied

RCPT TEST RESULT FOR M20 GRADE CONCRET



RCPT TEST RESULT FOR M30 GRADE CONCRETE



ACCELERATED CORROSION PROCESS:

GRAVIMETRIC WEIGHT LOSS METHOD

This investigation was carried out as per ASTM G1-90. The weighed TMT steel specimens were embedded in concrete cylinder of size 150mm diameter and 300 mm height. The reinforced concrete samples were subjected to alternate wetting and drying exposure in 3.5% NaCl solution.Regular D.C power supply of 12V is supplied continuously throughout the corrosion period of 15 days. Positive terminal of voltmeter is connected with soldered wires and negative terminal is connected with copper plate (cathode).After the process of accelerated corrosion, all the specimens were disconnected and removed from tank. After the corrosion period, the rod was taken out and weighed. The loss in weight was calculated. From the weight loss values, (ASTM G-1) the corrosion rates were obtained from the relationship

Corrosion rate = (K * W) / (A*T*D) mm/yr

Where K is a constant, K =87.6 in case of expressing corrosion rate in mm/yr

T is the exposure time expressed in hours, A is the surface area in cm2,W is the mass loss in milligram and D is the density of the corroding metal (7.85g/cm3

Actual mass of rust Mac= (Wi - Wf) *F/π D L g/cm2

Mac= actual mass of rust per unit surface area of bar (g/cm2)

Wi= Initial weight of bar before corrosion (g)

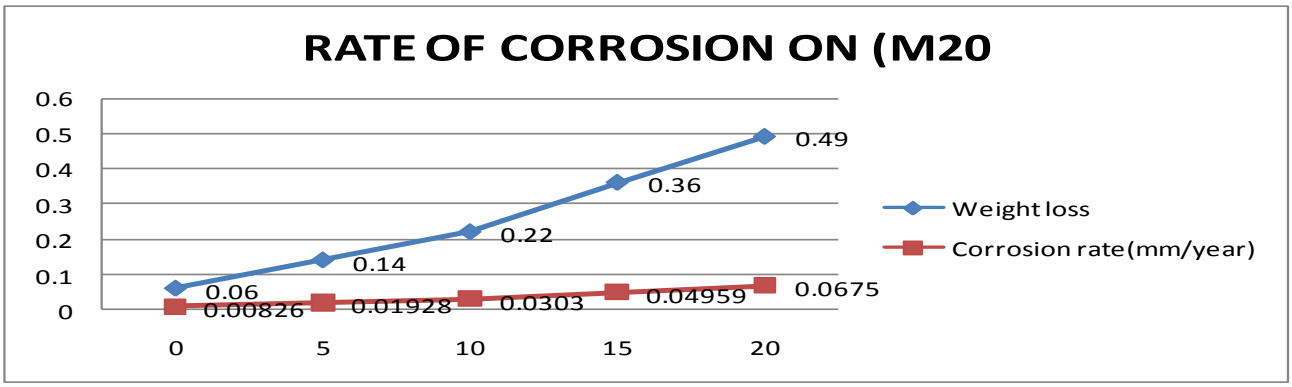
Wf= Weight after corrosion (g)

F= faraday constant (96487 amp/sec)

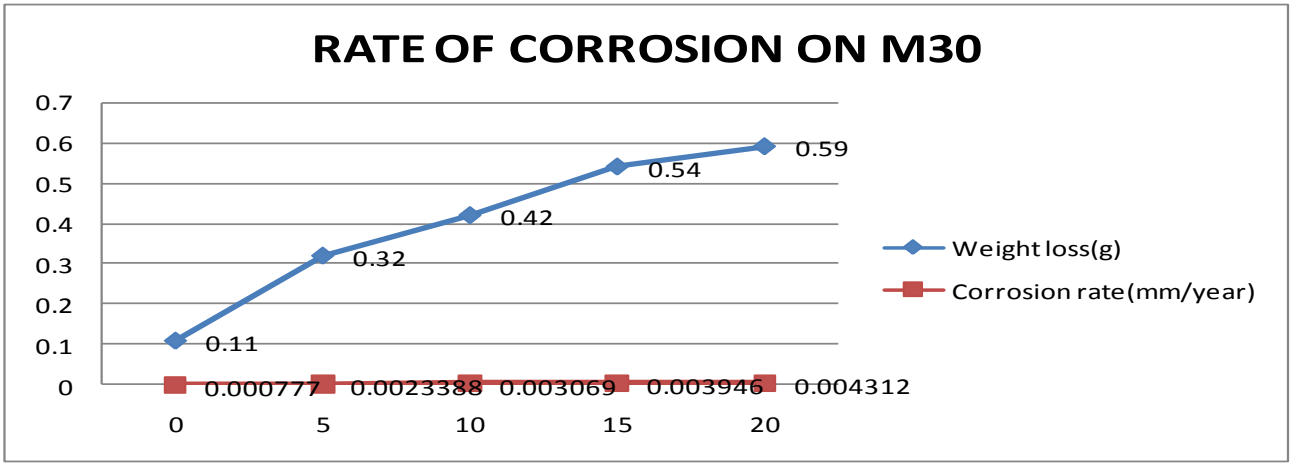
D= diameter of rebar (cm)

L= length of rebar sample (cm)

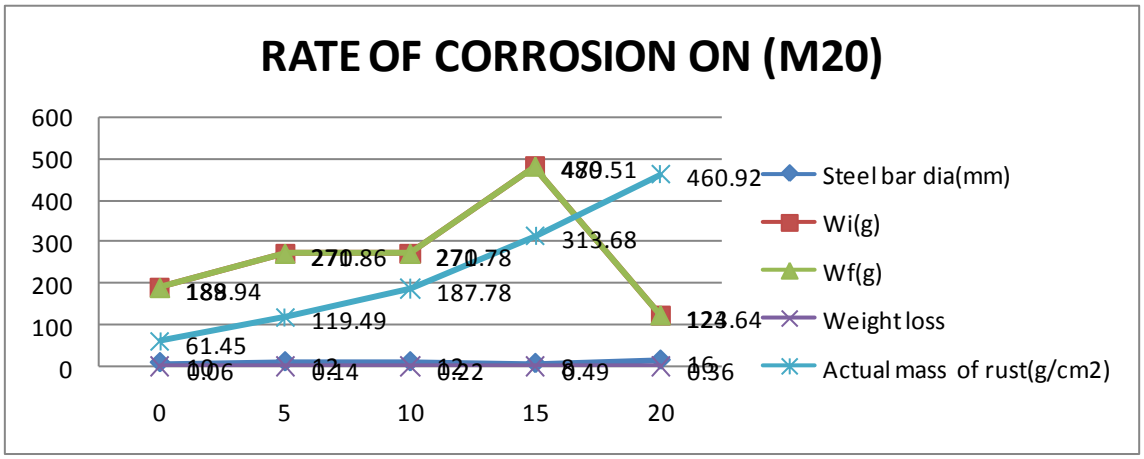
RATE OF CORROSION ON (M20) CUBE SAMPLE



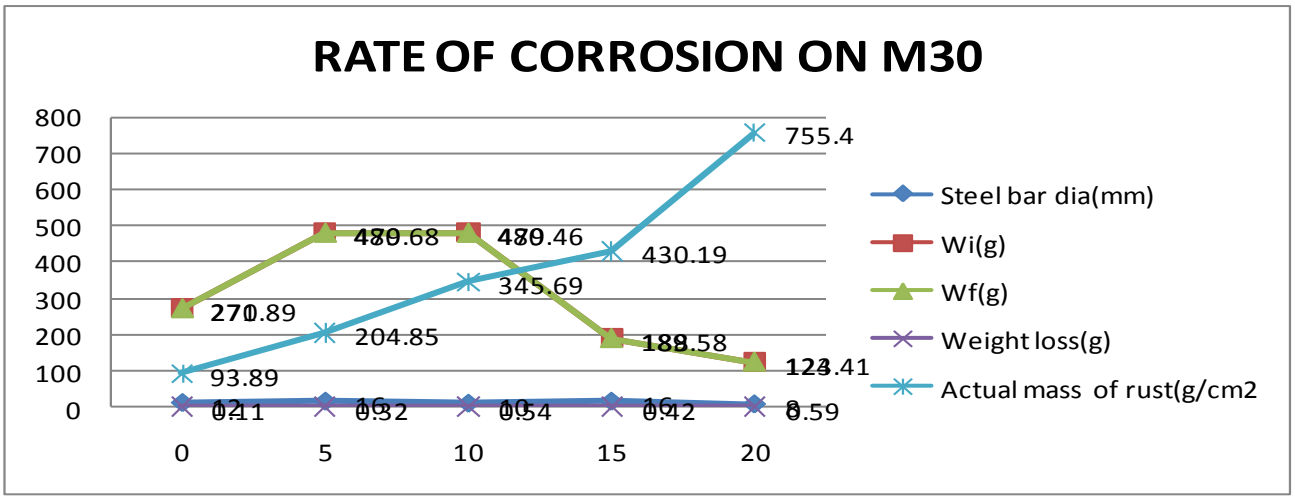
RATE OF CORROSION ON M30 CYLINDER SAMPLE



RATE OF CORROSION ON (M20) CUBE SAMPLE



RATE OF CORROSION ON M30 CYLINDER SAMPLE



VI.CONCLUSION OF PROJECT AND DISCUSSION

1. As per the chemical analysis of sludge some harmful ingredient is presenting very less parameter. Some are like sulphide,mercury cyanide below detectable limit and amount of lead is 0.7 mg/kg which is harmful to human body. Sludge also having calcium, chloride and magnesium having similar properties like cement. So it may be useful in concrete where direct contact of human being is prohibited. Hence we can use the sludge concrete in where there is no direct contact with environment.
2. As per above workability result the conclusion is that up to 15% for both m20 and m30 concrete its degree of workability is medium and its consistency is plastic concrete we can use this concrete for reinforced concrete in slab,beam,wall,column
3. After 15% the degree of workability is low and the consistency of concrete is dry such type of concrete advised to use mass concrete, light reinforced section, canal lining, hand placed pavement, strip footing
4. Up to 5% replacement value of compressive strength on cube , Split tensile strength on cylinder and Flexural strength test beam for M20 and M30 sludge concrete gave nearest result with conventional concrete.
5. So it is advised to use sludge up to 5% replacement with cement in concrete
6. By spraying phenolphthalein indicator on surface of cube there is no change of color of surface it denotes that surface is fully carbonated. Depth of carbonation is very low it is less than 0.5mm.
7. According to rapid chloride permeability test the chloride permeability is increase as the replacement of sludge increase. As per result the chloride permeability is very low in conventional concrete and high in 40% replacement in M20 concrete.
8. In case of M30 concrete the chloride permeability as per ASTM is low and increases as the percentage of sludge increase. Chloride permeability is high in 40% replacement.
9. Rate of corrosion is increase as the percentage of sludge increase in both M20 and M30 concrete. rate of corrosion(mm/year) is low in conventional and 5% replacement of cement with sludge.
10. Rate of corrosion is increase as the percentage of sludge increase in both M20 and M30 concrete. rate of corrosion(mm/year) is low in conventional and 5% replacement of cement with sludge

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