A COMPARITIVE STUDY ON CONCRETE WITH PARTIAL REPLACEMENT OF HYPO SLUDGE AND MANUFACTURED SAND IN CEMENT AND FINE AGGREGATE EXPOSED TO ELEVATED TEMPERATURES

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Abstract

This investigation is focused on the evaluation of strength of concrete specimen in which ordinary Portland cement is partially replaced by hypo sludge and fine aggregate by manufactured sand. In addition to that the specimens were also tested for fire resistance. In this investigation cement is replaced by 20 percent of hypo sludge and fine aggregate by manufactured sand at 75 percent replacement. The tests were carried out to evaluate the mechanical properties like compressive strength and split tensile strength at 7 days and 28 days for the concrete mix M35 in which cement replaced by hypo sludge via 5%, 10%, 15%, and 20% and at the same time for the concrete mix M35 in which cement is replaced by hypo sludge via 5%, 10%, 15% and 20% and fine aggregate by manufactured sand via 15%, 30%, 45%, 60% and 75%.

Keywords: *Hypo waste, compressive and split tensile test and elevated temperatures, m35 grade, manufactured sand*

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1. INTRODUCTION

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc.., to meet the requirements of globalization, in the construction of buildings and other structure concrete plays the rightful role and a large quantum of concrete is being utilized. To produce 1 ton of Ordinary Portland Cement manufactures use earth resources like limestone, etc and during manufacturing of 1 tone of Ordinary Portland Cement an equal amount of carbon - dioxide is released into the atmosphere which is harmful to the environment. Energy plays an important role in era of developing countries like cement, the energy and credit by using industrial waste (hypo sludge) for Building Materials like cement, the energy and environment can be saved. To save energy and to earn carbon credit is very much essential for the betterment of mankind. On the other hand large amount of Industrial wastes are being produced per annum by chemical and agricultural process in India. These materials possess problems of disposal, health hazards and aesthetic problem.

One of them was waste from the paper industry. Paper fibers can be recycled only a limited number of times before they become too short or weak to make high quality paper. It means that the broken, low quality paper fibers are separated out to become waste sludge. Paper sludge behaves like cement because of silica and magnesium properties which improve the setting of the concrete.

The quantity of sludge varies from mill to mill. The amount of sludge generated by a recycle paper mill is greatly dependent on the type of furnish being used and end product being manufactured. About 300Kg of sludge is produced for each ton of recycled paper. This is a relatively large volume of sludge produced each day that makes making landfill uneconomical as paper mill sludge is bulky. Thus by replacing cement partially by hypo sludge in concrete mix helps in reduction of solid waste in environment and reduction in usage of quantity of cement in construction field.

River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. In the backdrop of such a bleak atmosphere, there is large demand for the materials from industrial waste. To achieves the economy. We have to look for the material which is replacement of fine aggregate at the same time is to be capable of enhancing strength to the concrete. The crushing for coarse aggregate results in a fine byproduct called screenings, sometimes also referred as manufactured sand (MS) or manufactured sand fine aggregate. Crushed powder, a quarry waste as a partial replacement of sand gives a remarkable increase in strength to the concrete.

2. METHODOLOGY

The methodology involves evaluation of strength of specimens in which cement and fine aggregate were replaced by sludge and manufactured sand at different proportions. The specimens were also subjected to the different temperature conditions at variable time intervals. The compressive and split tensile strengths were evaluated after conducting the respective strength tests at laboratory.

2. MATERIALS

2.1 Cement

Ordinary Portland cement of 53 grade from a single batch was used for the entire work and care has been taken that it is to be stored in air tight containers to prevent it from being affected by the atmospheric and monsoon moisture and humidity .The cement procured was tested for physical requirements in accordance with IS:12269-1987.

2.2 Fine Aggregate

The river sand, passing through 4.75mm sieve and retained on 600micro meters sieve, conforming to Zone II as per IS 383-1970 was used as fine aggregate in the present study. The sand is free from clay, silt and organic impurities .The aggregate was tested for its physical requirements such as gradation, finess modulus, specific gravity and bulk modulus in accordance with IS:2386-1963.clay, sit and organic impurities. The aggregate was tested for its physical requirements such as gradation , fineness modules , specific gravity and bulk modules in accordance with IS:2386-1963.

2.3 Coarse Aggregate

A crushed coarse aggregate of 20mm produced from the local crushing plant was used throughout the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modules, specific gravity and bulk density in accordance with IS: 2386-1963 and IS: 383-1970.

2.4 Hypo Sludge

The process of formation of paper from pulp includes the following process during which the Hypo sludge is formed as waste by-product is purely a chemical wastes and do not contain any bio-degradable element, Most of the mills are using only woody raw material (bamboo, eucalyptus, casuarinas, poplar and other hardware species), but some other mills are using bagasse in substantial quality as raw materials.

2.5 Manufactured Sand

The crushing for coarse aggreagate results in a fine byproduct called screening, sometimes also referred as Manufactured sand(MS) or manufactured sand fine aggregate. As compared to natural sands, screening aregeneraly characterized as having: Sharp, angular shaped particles High fines content(particles passing a no.200 sieve)and Large nos. of flat and elonged parties These properties thus results in higher water demand and thus in higher water demand and concrete that are generally hard to pump or finish. These deficiencies can be avoided with proper proportioning of concrete which may also include making changes to the current specification requirement for sand used in concrete by allowing higher percent passing no. 200 sieve and implementation of new test methods to evaluate screenings characteristics. And these in were also avoided by using proper super plasticizers . Here in this investigation SP430 is used as a super plasticizer.

2.6 Super Plasticizer

In order to improve the workability of high-performance concrete, super plasticizer in the form of sulphonated naphthalene polymers complies with IS9103;1999 and ASTM C 494type F as a high range water reducing admixture (COMPLAST SP 430) was used. This had 40%active solids in solution. The specific gravity is 1.22.It is a brown dispensable in water.

2.7 Water

Fresh portable water free from organic matter and oil is used in mixing the concrete. Water in required quantities is measured by graduated jar and added in concrete. The rest of materials required for the concrete mix were taken by weigh batching.

2.8 Concrete Mix Design (as per 10262:2009)

In the present investigation mix proportioning is done by BIS method for M35 grade concrete. The resulting mixes are modified after conducting trails at laboratory by duly following the Indian standards guidelines by mix proportion by weight.

A-1 Stipulation for proportioning

1	Grade Designation	: M35
2	Type of cement	: OPC 53(IS-12269-1987)
3	Maximum Aggregate Size	: 20mm
4	Minimum Cement Content	: 340 kg/m3
5	Maximum Water cement Ratio	: 0.45
6	Workability	: 0-75 mm (slump)
7	Exposure Condition	: very severe
8	Degree of Supervision	: Good
9	Type of Aggregates	: Crushed Angular Aggregate
10	Maximum Cement Content	: 450 kg/m3
11	Chemical Admixture Type conforming to IS-9103	: Super plasticizer

A-2 Test Data for Materials

1	Cement used	: OPC 53 grade
2	Sp.Gravity of cement	: 3.15
3	Sp.Gravity of Water	: 1.00
4	Chemical Admixture	: CONPLAST SP 430
5	Sp. Gravity of 20 mm Aggregate	: 2.72
6	Sp.Gravity of sand	: 2.557
7	Water Absorption of 20mm Aggregate	:0.5%
8	Water Absorption of Sand	: 1%
9	Free (surface) Moisture of 20mm Aggregate	: Nil
10	Free (surface) Moisture of sand	: Nil

A-3 Target Strength of concrete

1	Target Mean Strength	: 43.25 N/mm2
2	Characteristic Strength @ 28 days	: 35N/mm2

A-4 Selection of water Cement Ratio

1	Maximum water cement ratio	: 0.45
2	Adopted water cement ratio	: 0.411

A-5 Selection of water content

1	Maximum water cement ratio	: 186Lit
2	Estimated water content	: 174 Lit
3	Super plasticizer Used	: 2% by wt. of cement

A-6 Calculation of cement content

1	Water Cement Ratio	: 0.411
2	Cement Content (174/0.411)	:423 kg/m3 (>340 kg/m3)

A-7 Proportion of volume of coarse Aggregates &Fine Aggregate Content

1	Vol.of C.A. as per table 3 of IS 10262	:62%
2	Adopted Vol.of coarse Aggregate	: 64%
3	Adopted Vol.of Fine Aggregate	: 36%

A-8 Mix Calculation

1 Volume of concrete in m3 :1.00

2 Volume of concrete in m3 : 0.1342
(Mass of cement)/(Sp . Gravity of Water)*1000

3 Volume of concrete in m3 : 0.174
(Mass of water)/(Sp . Gravity of cement)*1000

4 Volume of Admixture @2% in m3 :0.006
(Mass of Admixture)/(Sp . Gravity of Admixture)*1000

5 Volume of all in aggregates inm3 :0.6858
(Sr.no. 1-(Sr.no.2+3+4))

6 Volume of all in aggregates inm3 :0.438
(Sr.no. 5*0.64)

7 Volume of Fine aggregates inm3 :0.246
(Sr.no. 3*0.36)

8 Mass of the coarse aggregate in Kg : 1193.84
(sr.no 6*specific gravity *1000)

9 Mass of the Fine aggregate in Kg : 629.56
(sr.no 6*specific gravity *1000)

A-9 Mix Proportions of concrete

1	Mass of cement in Kg/m3	: 423
2	Mass of water in Kg/m3	: 174
3	Mass of Fine aggregate in Kg/m3	: 629.56
4	Mass of coarse aggregate in Kg/m3	: 1193.84
5	Mass of Admixture in Kg/m3	: 7.00
6	Water cement ratio	: 0.411

3. RESULTS AND DISCUSSIONS

Physical Properties of Hypo sludge:

S.No	Property	Test Results
1.	Mean Particle size	0.1-0.2um
2.	Particle Shape	Spherical
3.	Specific Gravity	2.8
4.	Fineness(90microns)	2
5.	Color	Milk White

Physical Properties of Natural Sand:

Property	Natural Sand
Specific gravity	2.60
Bulk density(kg/m3)	1460
Fineness modulus	2.89
Water Absorption	6.5%
Fine particle less than 0.075mm (%)	6
Moisture content	1.8%

Physical properties of Manufactured Sand:

Property	Manufactured Sand
Specific gravity	2.82
Bulk density (kg/m3)	1750
Fineness Modulus	2.84
Moisture Content (%)	Nil
Fine particles less than 0.075mm (%)	14
Water Absorption	5.6%

Physical properties of fine and coarse aggregates:

Property	Fine aggregate	Coarse aggregate
Specific gravity	2.6	2.75
Water absorption	6.5%	2.5%
Fines modulus	2.89	7.16

Sieve analysis of natural sand:

S.No	IS sieve	Weight retained(gm)	Percentage wt retained	Cumulative wt retained	Percentage passing
1	4.75mm	20	2	4	96
2	2.367mm	56	5.6	7.6	92.4
3	1.18mm	188	18.8	26.4	73.6
4	600um	286	28.6	55	45
5	300um	290	29	84	16
6	150um	160	16	100	0

Weight of sample taken =1000gms

Fine modulus=∑cumulative percentage retained /100

=277/100

Zone =II

Sieve Analysis of Manufactured Sand:

S.No	Is sieve No	Weight retained(gm)	% wt retained	Cumulative %retained	% passing
1	4.75mm	0	0	0	100
2	2.36mm	120	12	12	88
3	1.18mm	182	18.2	30.2	69.8
4	600µm	320	32	62.2	37.8
5	300µm	200	20	82.2	17.8
6	150µm	178	17.8	100	0

Wt of sample taken= 1000gms

Fineness modulus =∑cumulative percentage retained/100

=286/100

=2.86

Zone=II

Sieve Analysis of Coarse Aggregate:

S.No	I.S Sieve No:	Weight retained(gm)	Percentage weight retained	Cumulative percentage retained	Percentage passing
1.	40mm	0	0	0	100
2.	20mm	725	85.1	99.6	0.4
3.	10mm	4255	85.1	99.6	0.4
4.	4.75mm	20	0.40	100	0
5.	2.36mm	0	0	100	0
6.	1.18mm	0	0	100	0
7.	600µm	0	0	100	0
8.	300µm	0	0	100	0
9.	150µm	0	0	100	0

Weight Of sample taken = 5000gm

Fineness modulus =∑cumulative percentage retained/100

= 714.4/100

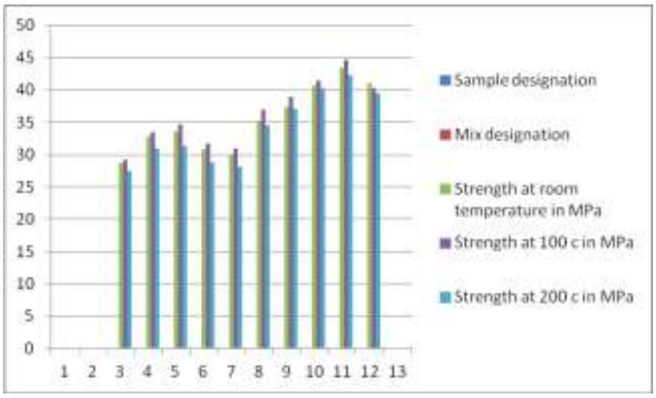
=7.14

Mix proportions by weight:

Cement	Fine aggregate	Coarse aggregate	w/c ratio
423	629.56	1193.84	174
1	1.48	2.82	0.411

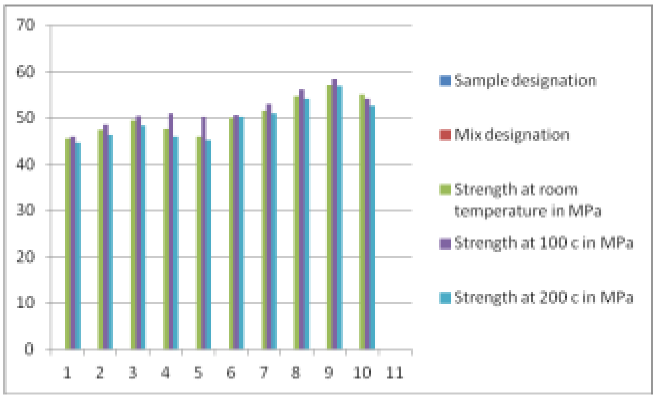
Compressive strength results of cubes partially replaced by hypo sludge and manufactured sand for 7 days at room temperature, 100 c and 200 c

Sample designation	Mix designation	Strength at room temperature in MPa	Strength at 100 c in MPa	Strength at 200 c in MPa
S1	Conventional mix	28.63	29.21	27.46
S2	Concrete mix(5%hypo)	32.84	33.45	30.95
S3	Concrete mix(10%hypo)	33.57	34.69	31.39
S4	Concrete mix(15%hypo)	30.81	31.72	28.77
S5	Concrete mix(20%hypo)	29.93	30.89	28.12
S6	Concrete mix(5%hypo,15%MS)	35.17	36.88	34.49
S7	Concrete mix(10%hypo,30%MS)	37.35	38.92	37.06
S8	Concrete mix(15%hypo,45%MS)	40.69	41.42	40.33
S9	Concrete mix(20%hypo,60%MS)	43.45	44.72	42.29
S10	Concrete mix(20%hypo,75%MS)	41.09	40.22	39.45



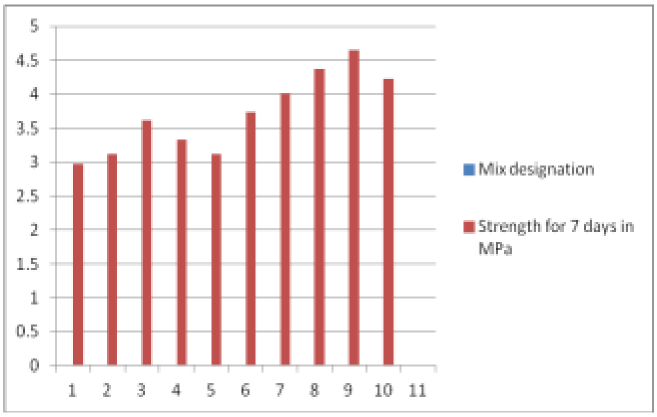
Compressive strength results of cubes partially replaced by hypo sludge and manufactured sand for 28 days at room temperature, 100 c and 200 c

Sample designation	Mix designation	Strength at room temperature in MPa	Strength at 100 c in MPa	Strength at 200 c in MPa
S1	Conventional mix	45.48	45.99	44.69
S2	Concrete mix(5%hypo)	47.37	48.61	46.21
S3	Concrete mix(10%hypo)	49.55	50.35	48.39
S4	Concrete mix(15%hypo)	47.52	51.01	45.99
S5	Concrete mix(20%hypo)	45.92	50.14	45.12
S6	Concrete mix(5%hypo,15%MS)	49.99	50.57	50.14
S7	Concrete mix(10%hypo,30%MS)	51.59	52.97	51.01
S8	Concrete mix(15%hypo,45%MS)	54.64	56.24	54.06
S9	Concrete mix(20%hypo,60%MS)	57.11	58.42	56.89
S10	Concrete mix(20%hypo,75%MS)	55.09	54.23	52.63

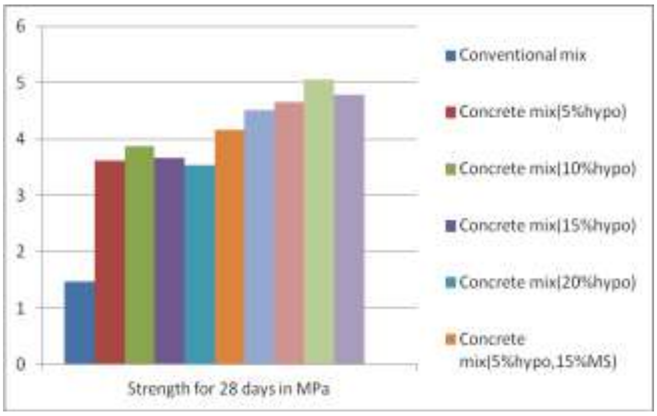


Split tensile strength results of Cylinders partially replaced by hypo sludge and manufactured sand for 7 days and 28 days at room temperature

Sample designation	Mix designation	Strength for 7 days in MPa	Strength for 28 days in MPa
S1	Conventional mix	2.98	1.47
S2	Concrete mix(5%hypo)	3.12	3.61
S3	Concrete mix(10%hypo)	3.61	3.88
S4	Concrete mix(15%hypo)	3.33	3.67
S5	Concrete mix(20%hypo)	3.12	3.54
S6	Concrete mix(5%hypo,15%MS)	3.74	4.16
S7	Concrete mix(10%hypo,30%MS)	4.02	4.51
S8	Concrete mix(15%hypo,45%MS)	4.37	4.65
S9	Concrete mix(20%hypo,60%MS)	4.65	5.06
S10	Concrete mix(20%hypo,75%MS)	4.23	4.78



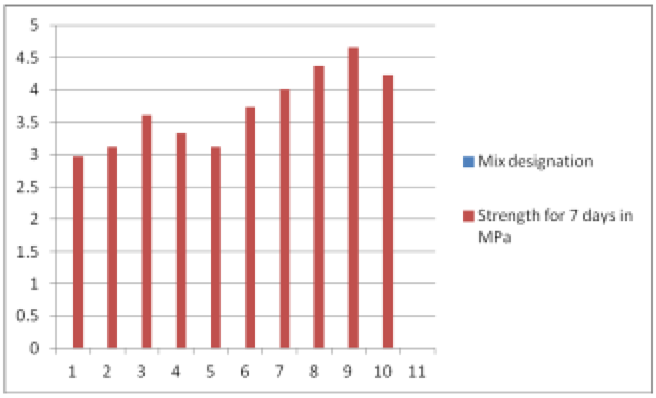
Split tensile strength result of cylinders partially replaced by hypo sludge for 7days at room temperature



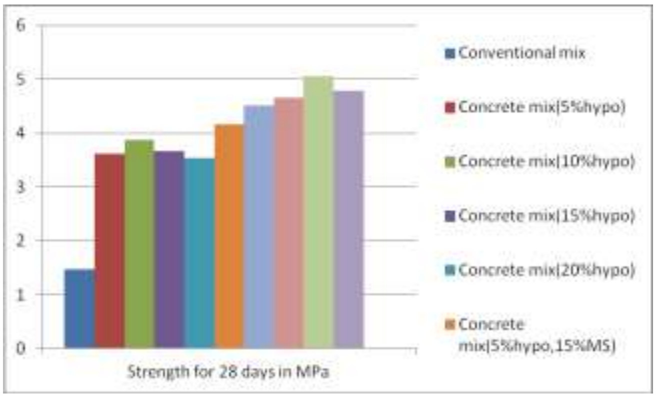
Split tensile strength result of cylinders partially replaced by hypo sludge for 28days at room temperature

Variation in compressive strength in strength of cubes and cylinders replaced by hypo sludge in manufactured sand with respect to conventional concrete for 7 days and 28 days

Sample designation	Mix designation	% Increase at 100 c		% Decrease at 200 c	
		7 days	28 days	7 days	28 days
S1	Conventional mix	2.02	1.12	4.08	1.73
S2	Concrete mix(5%hypo)	1.85	2.61	5.75	2.44
S3	Concrete mix(10%hypo)	3.33	1.61	6.49	2.34
S4	Concrete mix(15%hypo)	2.95	7.42	6.62	3.21
S5	Concrete mix(20%hypo)	3.20	9.18	6.04	1.74
S6	Concrete mix(5%hypo,15%MS)	4.86	1.16	1.93	0.30
S7	Concrete mix(10%hypo,30%MS)	4.20	2.67	0.77	1.12
S8	Concrete mix(15%hypo,45%MS)	1.79	2.92	2.66	0.88
S9	Concrete mix(20%hypo,60%MS)	2.92	2.29	2.66	0.385
S10	Concrete mix(20%hypo,75%MS)	•	•	3.99	4.46



Compressive strength result of cylinders partially replaced by hypo sludge and manufactured sand for 7 days at room temperature



Compressive strength result of cylinders partially replaced by hypo sludge and manufactured sand for 28 days at room temperature

4. DISCUISSIONS

The physical properties of ordinary Portland cement used in the present investigation are confirming to IS specifications. Zuari cement of 53 grade is used.

The hypo sludge is used in investigation was collected from delta paper industries. The physical properties of hypo sludge are given in above table. The chemical composition of hypo sludge were given in above table. The presence of silica and magnesium content in hypo sludge make it suitable for replacement in cement.

The manufactured sand used in this investigation was collected from varma sand suppliers company, Bhimavaram. The physical properties are given in above table . The chemical composition was given in above table. the fineness modules of sand is 2.7.7. and fineness module manufacture sand is 2.8.6. which shows the both are related to same zone that is Zone II. Silica content is manufactured sand which is main reason for replacement.

Compressive strength for specimen replaced by hypo sludge in cement upto 10% have shown maximum strength. Compressive strength for specimen replaced by hypo sludge manufactured sand in cement and find aggregate gave maximum strength at 20% and 60% increases in strength for both cubical and cylindrical specimens was decreased from 7 days to 28 days.

Fire resistance test was conducted on all cubical specimens which shown that there is an increasing strength at 100c exposed at for 1 hour and the strength decreased when the specimens are tested at 200c for 2 hours.

The maximum increase in strength of concrete when replaced by hypo sludge in cement was observed at 15% replacement when tested at 100c for 1 hour. This shows that increase in strength with percentage replacement varies at variable temperatures.

5. CONCLUSION

1. The compressive strength of concrete cube specimens in which cement is replaced by hypo sludge via 5%,10%,15%,20% gave maximum strength at 10% replacement and the increase in strength is 8.94% compared to conventional mix.
2. The compressive strength of concrete cube specimens in which cement is replaced by hypo sludge via 5%,10%,15%,20%and fine aggregate replaced by manufacture send via 15%30%45%60% and 75% gave maximum strength at 20% and 60% replacement. The strength incremented 20 and 60 replacement is 25.57% when compared to conventional mix.
3. The split tensile strength cylindrical specimens partially replaced by hypo sludge in cement and partially replaced by hypo sludge in cement and manufactured sand in fine aggregate shows an increase in strength compared to strength of conventional mix .
4. The split tensile strength cylindrical specimens partially replaced by hypo sludgevia 5%,10%,15%,20% gave maximum strength at 10% replacement and the increase in strength is 11.8% compared to conventional mix.
5. The split tensile strength cylindrical specimens partially in which cement is replaced by hypo sludge via 5%,10%,15%,20% and fine aggregate replaced by manufacture send via 15%30%45%60% and 75% gave maximum strength at 20% and 60% replacement. The strength incremented 20 and 60 replacement is 45.8% when compared to conventional mix.
6. The split tensile strength cylindrical specimens partially in which cement is replaced by hypo sludge via 5%,10%,15%,20% shows an increase in strength at 100c for 1 hour when compared to the strength evaluated at room temperature . The maximum percentage increase in strength was observed at 20% replacement and increase in strength 9.18.
7. The compressive strength of concrete cube specimens in which cement is replaced by hypo sludge via 5%,10%,15%,20% and fine aggregate replaced by manufacture send via 15%30%45%60% and 75%shows an increase in strength compared to the strength evaluated at room temperature when subjected to 100c for 1 hour. The maximum increment in strength was observed at 15&45% replacement and increase in strength 2.92%.

8. The compressive strength of concrete cubes specimens in which cement is replaced by hypo sludge via 5%,10%,15%,20% showed a decrement in strength compared to strength evaluated at room temperature when subjected to200c for 2 hours.
9. The compressive strength of concrete cubes specimens in which cement is replaced by hypo sludge via 5%,10%,15%,20%and fine aggregate replaced by manufacture send via 15%30%45%60% and 75% shows an decrease in strength compared to the strength evaluated at room temperature when subjected to 200c for 2 hour.
10. When the concrete mix is partially replaced by hypo sludge in cement the strength is gradually increased upto 10% and then strength is gradually decreased
11. When the concrete mix is partially replaced by hypo sludge and manufactured sand cement and fine aggregate respectively the strength is gradually increased upto 20% and 60% then strength is decreased.
12. Thus, from the above observation we can conclude that the percentage replacement of hypo sludge in cement was increased to 20% when replaced along with manufacture sand in fine aggregate.
13. The strength of concrete mix partially replaced by hypo cement was maximum at 15% replacement when subjected to 100c for 1 hour. Thus , there is an increases in percentage replacement of hypo sludge when compared to room temperature.
14. Thus , to increase in strength in structures and at the same time to decrease the quantity of cement and natural sand we can partially replace them by hypo sludge and manufactured sand respectively upto 20% and 75% , When the cement alone have to be replaced by hypo sludge at these conditions it should be replaced upto 20%.
15. The optimum valve for hypo sludge and manufactured sand to be replaced in cement and fine aggregate were 20% and 75% respectively.

REFERENCES

[1] Amon, k., and Handassa , B., ‘ Effect of high levels of fines content on concrete properties,’ ACI Material journal, V.103, November –December 2006, pp.474-481.’

[2] Arundeb Gupta Somnath Gosh &Soraj Mandal, COATED RECYCLED AGGREGATE CONCRTE EXPOSED TO ELEVATED TEMPERTURE”, Global Journal of Reserches in Engineering, Vol.16, No.6.December 2004, pp 556-565.