TOPIC-STRENGTH IMPROVEMENT OF CONCRETE IN COMPRESSION & FLEXURAL STRENGTH BY USING HYPO SLUDGE AND POLYPROPYLENE FIBER

AUTHOR 1 - NAME-RAKESH KUMAR
ENROLLMENT-3IES22STE001
COLLEGE-IES UNIVERSITY, BHOPAL
AUTHOR 2 - GUIDE- JITENDRA SINGH YADAV
COLLEGE-IES COLLEGE OF TECHNOLOGY, BHOPAL

Abstract

The increasing amount of waste is a concerning reality that has arose the sustainability issues of the environment. Hypo plant in the paper industry generates a large volume of waste in the form of slurry, disposal of which causes environmental pollution. The production of cement also accounts for the global warming by releasing carbon dioxide in the atmosphere. Therefore, formulation of concrete with industrial waste can help in minimizing the environmental problems. In this study hypo sludge was used as a replacement of cement in concrete. Polypropylene fiber (PPF) is a synthetic hydrocarbon polymer which was added to augment the strength of the concrete. In present study, 450 specimens were prepared by varying percentage of hypo sludge (0%, 5%, 10%, 15% & 20%) and polypropylene fiber (0%, 0.25%, 0.5%, 0.75%&0.10%). The workability of concrete was tested immediately after preparing the concrete whereas the compressive strength and the splitting tensile strength of concrete tests were tested after 7,14 and 28 days of curing. Results indicate that the workability of concrete decreases from medium to low with an increase in content of hypo sludge and polypropylene fiber. The addition of both hypo sludge and polypropylene fiber increases the strength of concrete for all curing ages up to certain point. After that, there is an abrupt reduction in strength of the concrete. The combination of 10% hypo sludge and 0.5% polypropylene fiber is recommended for the maximum strength with minimum coefficient of brittleness. Incorporation of hypo sludge decreases the cost of concrete up to 18.35%.

Keywords: Hypo sludge, Polypropylene, workability, compressive strength, Flexural strength, concrete, fiber.

INTRODUCTION

Energy plays an important role in the era of developing countries like India. Therefore, it is essential to save energy and reduce carbon emission for the betterment of mankind. Concrete is a composite construction material made of cement, aggregate (generally fine aggregate such as sand plus coarse aggregate made of crushed rocks or gravels such as limestone or granite), water, and admixtures

By the incorporation of the industrial waste in concrete, the energy and the environment can be saved. The use of these by-products offers environmental advantages like diversion of the material from the waste bodies, reduction of the energy used in processing virgin materials, usage of virgin materials and decrease in pollution. To produce Ordinary Portland Cement (OPC), we use earth resources like limestone. During manufacturing of one tonne of OPC, an equal amount of carbon dioxide is released into the atmosphere which is harmful to the environment. So there is a need to choose an alternative. In urban cities, solid waste management is a very challenging task, which is a serious pollution problem due to the generation of large quantities of solid waste. Also, the cost of cement is also steadily increasing day by day. So, there is a great need to use industrial waste products in an appropriate manner to reduce the cost and environmental problems

Many research organizations are doing huge work on waste materials concerning. Paper mill sludge is a major environmental and economic issue for the board and paper industry. The material is a by-product of the de-inking and re-pulping of paper. The pulp and paper industry generates large volume of waste called Hypo sludge; which is technology- dependent. It is estimated around 18% of waste (sludge) is generated during the production of pulp.

Hypo sludge contributes advantageous properties to the concrete while helping to maintain the economy. Therefore, numerous contemporary research works have focused on the application of hypo sludge in cement and concrete production to attain sustainable development. Many researchers have investigated the feasibility of using the paper industry waste in concrete production as partial replacement of cement. Disposal cost of paper industries can be reduced by using hypo sludge in concrete and produced the green concrete for construction.

Polypropylene fibres have high melting point (165 °C) and its chemical neutrality makes it strong acidic and alkali resistant. Also, these fibres have hydrophobic levels, which protect them against wetting with cement paste. The hydrophobic nature of polypropylene has no effect on the amount of water needed for concrete

the present study was conducted with the following objectives:

i. To study the workability of concrete using hypo sludge (as partial replacement of cement) and polypropylene fibres (as an additive in concrete).

ii. To study the compressive strength of concrete using hypo sludge and polypropylene.

iii. To study the split tensile strength of concrete using hypo sludge and polypropylene.

Hypo Sludge

Hypo sludge produced in a large amount as by product of paper industry. Hypo sludge contains, low calcium and maximum calcium chloride and minimum amount of silica. Hypo sludge behaves like cement because of silica and magnesium properties. It improves the setting of the concrete. Paper sludge consists of cellulose china clay, fibres, calcium carbonate and residual chemicals which bound up with water. It is used in concrete construction as partial replacement of cement

Properties of Hypo Sludge

- Hypo sludge have silica and magnesia.
- Hypo sludge have the same property as cement.
- Hypo sludge have insulator properties.
- It has good specific gravity.

Advantages of Hypo Sludge

- Hypo sludge do not affect by water.
- It is easy to available and cheap.
- Hypo sludge do not affect by electricity.
- It can bear 600°c to 800°c temperature.

Uses of Hypo Sludge

- Hypo sludge is used as a binding material in place of cement in concrete.
- It can also use in mortar.
- It is used in tiles factories as a binding material.

Polypropylene Fibre

Polypropylene is an adaptable thermoplastic material, which is produced by the polymerizing process of polypropylene molecules in the presence of a catalyst under carefully, prevail heat and pressure. Propylene is an unsaturated hydrocarbon, containing only carbon and hydrogen atoms. It is very common to add polypropylene fibre into concrete for improve strength of concrete and for protection of concrete against micro cracks. Polypropylene fibres used in concrete to obtain a better stable surface and more resistant piece of concrete.

Properties of polypropylene fibre

- High tensile strength.
- Water resistance.
- Strong acidic and alkaline resistance.
- High temperature resistance.

Advantage of polypropylene fibre

- Control cracking
- Increase flexibility
- Reduction in water permeability
- Reduction in rebound loss in concrete

- Safe and easy to use

Uses of polypropylene fibre

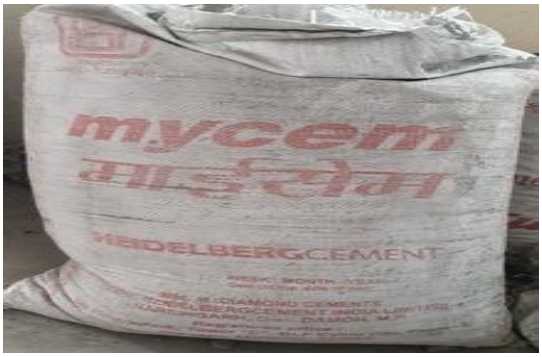
- PCC and RCC plastering
- Shotcrete and guniting.
- Slab, footing, foundation, walls and tank
- Pipes, prestressed beam
- Concrete block, manhole cover and tiles
- Road and pavements
- Bridge and dams.

MATERIALS

Cement

A cement is a binding material used in concrete for construction that sets harden and adheres to other materials binding them together. Common materials used to manufacture cement include limestone, shells, and chalk or marl combined with shale, clay, slate, blast furnace slag, silica sand and iron. Cement is primarily consisting of silicates and aluminates of lime obtained from limestone and clay. Cement is made by heating the above listed substances to 1450 °C in a kiln and this process is known as calcinations. The hard substance called clinker. A small amount of gypsum adds into a clinker and grinding to make OPC, the most commonly used type of cement (often referred to as OPC). The different types of cement as classified by Bureau of Indian Standards (BIS) are OPC, Portland Pozzolana Cement, Rapid Hardening, Portland cement, Portland Slag Cement, Hydrophobic Portland cement, Low Heat Portland Cement and Sulphate Resisting Portland Cement. OPC cement is obviously produced in the maximum quantity than other cements. OPC is classified into three grades namely 33 grades, 43 grade and 53 grade depending upon the compressive strength of cement at 28 days. OPC 43 grade was used in this study as shown in Figure

Figure 1: Mycem OPC 43 grade



Aggregate

Aggregates typically constitute 75% of concrete volume. Hence, aggregate types and sizes play an essential role in modifying the concrete properties. The broken stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20mm was used in the present work. The main

purpose of the aggregates is to provide a rigid skeletal structure and reduce the space occupied by the cement paste. Coarse aggregates and fine aggregates are required but the proportions of different sizes of coarse aggregate will vary depending on the particular mix required for each individual en. Generally, aggregates can be classified as normal weight aggregates, light weight aggregates and heavy weight aggregates. Normal weight aggregates can be further classified as natural aggregates and artificial aggregates.

Aggregates can also be specified on the basis of the size of aggregates as

coarse aggregates and fine aggregates.

Figure 2: Crushed stone aggregates of nominal size 10 mm and 20 mm

.

Figure 3: Fine aggregates

Hypo sludge

The process of formation of paper from palm includes the following process during which the Hypo sludge is formed as waste by-product is purely a chemical waste and do not contain any bio- degradable element. Most of the mills are using only woody raw material (bamboo, casuaring, poplar and other hardwood species) but some other mills are using bagasse in substantial quality as raw material. Hypo sludge contains low Ca and maximum $CaCl_2$ and minimum amount of SiO_2. Hypo sludge behaves like cement because of silica and magnesium properties. This silica and magnesium improve the setting of the concrete. The sludge is approximately 25–30% solids (cellulose) and remaining 70–75% water. The material is white in color, sticky and hard to dry and

can vary in viscosity and lumpiness. The total percentage of the three combinations of SiO2, Al2O3 and Fe2O3 was 45% and expected to possess low pozzolanic reactivity (50%). Hypo sludge is obtained from paper industry and used in construction work as partial replacement of cement.

Hypo sludge buying from **Adopt consultancy, Near Piplani Petrol Pump Bhopal MP** was used in this study shown in Figure 3.4. The properties of hypo sludge are given in Chapter IV.

Figure 4: Hypo sludge

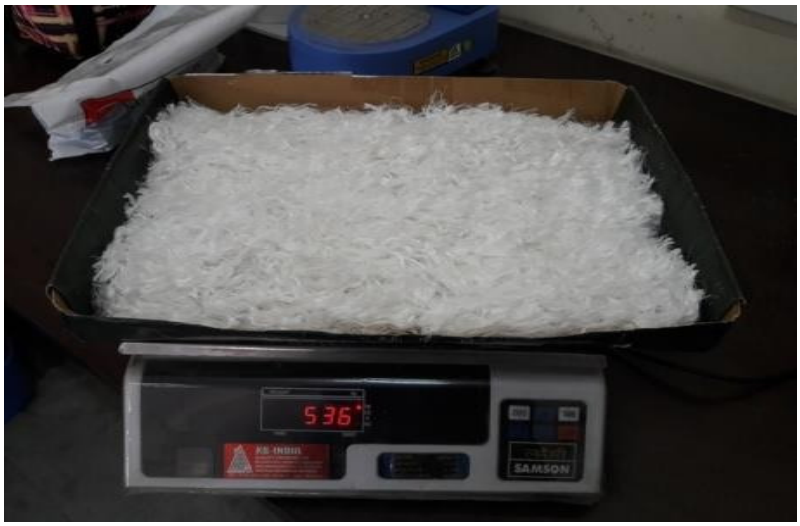
Polypropylene fibre

Polypropylene fibers are thermos plastics produced from Propylene gas. These are micro reinforcement fibers. They are 100% virgin homopolymer polypropylene graded monofilament fibers. The raw material of polypropylene is derived from monomeric C3H6 which is purely a hydrocarbon. These fibers have low-density of 0.9 gm/cc. They are highly crystalline, with high stiffness and excellent resistance to chemical and bacterial attack. Perfectly isotactic polypropylene has a melting point of 171°C while commercial isotactic polypropylene has a

melting point ranging from 160 to 166 °C. Polypropylene fibers are non-magnetic, rust free, alkali resistant, safe and easy to use. Addition of fibers increase ductility performance, pre-crack tensile strength, fracture strength, toughness, impact resistance, flexural strength resistance, fatigue performance etc. Polypropylene fibers are tough but have low tensile strength and modulus of elasticity Polypropylene fibers have been reported to reduce unrestrained plastic and drying shrinkage of concrete at fiber contents of 0.1 to 0.3% by volume.

Polypropylene fibers buying from **Khandelwal Fabrics, E-7, LIG-333, Mitramandal Society, Arera Colony, Bhopal MP** were used in this study shown in Figure 3.5

Figure 5: Polypropylene



Water

Fresh and clean tap water was used for casting the specimens in the present study. The water was relatively free from organic matter, silt, oil, sugar, chloride and acidic material20as per BIS: 456-2000.

RESULTS AND DISCUSSION

Properties of OPC

Table 1: Properties of OPC 43 grade cement

S NO	Characteristics	Values Obtained	Standard Value (IS: 8112-2013)
1	Normal Consistency	31.5%	-
2	Initial setting time	90 minutes	30 minutes(min)
3	Final setting time	380 minutes	600 minutes(max)
4	Fineness	2.5%	Less than 10%
5	Specific gravity	3.15	-

Properties of aggregates

Table 2: Properties of coarse aggregates

S NO	Specification	Obtained
	Type	Cursed
1	Colour	Grey
2	Shape	Angular
3	Maximum Size	20 mm
4	Specific Gravity	2.65
5	Water Absorption	1.0%

Properties of fine aggregates

Table 3: Physical properties of fine aggregates

S No	Characteristics	Values
1	Types	Natural Sand
2	Specific gravity	2.72
3	Grading Zone	II

5.1.1 Properties of polypropylene fibers

Table 4: Properties of polypropylene fibers

S No	Characteristics	Values
1	Material	Virgin homopolymer polypropylene
2	Colour	White
3	Specific gravity	0.91
4	Length	50mm
5	Acid /alkali resistance	Excellent

5.1.2 Properties of hypo sludge.

Table 5: Properties of raw hypo sludge (Reference: Solanki and Pitroda 2013b, Pitroda 2015, Alam and Berera 2015).

S No	Constituents	Percentage present
1	Moisture	55-60
2	Lime (CaO)	37-48
3	Silica (SiO_2)	3-12
4	Magnesium Oxide (MgO)	0.1-4
5	Los on Ignescent	27-39
6	Acid insoluble	10-12

Table 6: Comparison of the properties of hypo sludge with cement

S No	Constituents	Cement (%)	Hypo sludge(%)
1	Lime (CaO)	60-67	37-48
2	Silica (SiO_2)	17-25	3-12
3	Magnesium (MgO)	0.1-4	0.1-4
4	Aluminum (Al_2O_3)	3-8	2-7
5	Calcium Sulphate(Ca_2SO_4)	1.5-4	0.5-4.5

Testing of concrete

Table 7: Designation of concrete mix

Mixed	Fiber (%)	Hypo sludge (%)	Cement (%)
Mix1	0	0	0
Mix2	0	10	90
Mix3	0	20	80
Mix4	0.25	0	0
Mix5	0.25	10	90
Mix6	0.25	20	80
Mix7	0.50	0	0
Mix8	0.50	10	90
Mix9	0.50	20	80
Mix10	1.0	0	0
Mix11	1.0	10	90
Mix12	1.0	20	80

Mix design by Indian Standard Recommendations

Stipulation for proportioning

a) Grade designation : M-20

b) Type of cement : OPC 43 grade conforming to BIS: 8112

c) Maximum nominal size of aggregate: 20 mm

d) Minimum cement content : 320 kg/m^3

e) Maximum water-cement ratio : 0.55

f) Workability : 50 mm (slump)

g) Degree of supervision : Good

h) Type of aggregate : Crushed angular aggregate

i) Maximum cement content : 450 kg/m^3

Test data for materials

a) Cement used	:	OPC 43 grade conforming to BIS: 8112
b) Specific gravity of cement	:	3.15
c) Specific gravity of	:	
1) Coarse aggregate	:	2.65
2) Fine aggregate	:	2.72
d) Water absorption		
1) Coarse aggregate	:	0.5 %
2) Fine aggregate	:	1.0 %
e) Free (surface) moisture		
1) Coarse aggregate	:	Nil
2) Fine aggregate	:	Nil
f) Sieve analysis		
i.Coarseaggregate :		Confirming to IS: 383-1970 with 50:50proportion of10mm and 20mm aggregates.
ii. Fine aggregates:		Confirming to grading Zone II of table 4 of BIS 383-1970.

TARGET STRENGTH FOR MIX PROPORTIONING

$$\mathbf{f'_{ck} = f_{ck} + 1.65\sigma}$$

Where

f'_{ck} = target compressive strength at 28 days

f_{ck} = characteristic compressive strength at 28 days and

σ = standard deviation

From Table 5.13, Standard Deviation, σ = 4 N/mm^2

Therefore, target strength = 20 + 1.65 x 4 = 26.6 N/mm^2

Assumed Standard Deviation (4) (Table 8 of IS: 456-2000)

SELECTION OF WATER-CEMENT RATIO

Minimum cement content, maximum water-cement ratio and minimum grade of concrete for different concrete mix with normal weight aggregates of 20 mm nominal maximum size (Table 5 of IS:456-2000) maximum water-cement ratio is 0.55 for M 20.

Hence, adopt water-cement ratio = 0.55

SELECTION OF WATER CONTENT

Table 8: Maximum water content per cubic metre of concrete for nominal maximumsize of aggregate (Table 3 of IS: 10262-2009)

S No	Maximum Size of Aggregates(mm)	Maximum Water Content
1	10	208
2	20	186
3	40	165

From Table 5.11, maximum water content is 186 litre (for 25 to 50 mm slump range) for 20 mm aggregate. Hence adopt 186 kg.

CALCULATION OF CEMENT CONTENT

Water-cement ratio = 0.55

Cement content = 186÷0.55 = 338 kg/m^3

From Table 5.15, minimum cement content for mild exposure condition= 300 kg/m3.338 kg/m^3> 300 kg/m^3. Hence OK.

MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete : 1 m^3

b) Volume of cement : $\frac{\text{Mass of Cement}}{\text{Specific gravity of cement } 1000} \times \frac{1}{}$

$\frac{338}{3.15} \times \frac{1}{1000}$

=0.1073 m^3

c)Volume of water : $\frac{186}{1} \times \frac{1}{1000}$

=0.186 m^3

d) Volume of all in aggregate: (Total volume- Volume of Cement-Volume of water)

1-0.1073-0.186

=0.7067 m^3

e) Mass of coarse aggregate : Volume of all in aggregatexVolume of coarse aggregate x Specific gravity of coarse aggregate x 1000

= 0.7067 x 0.61 x 2.65 x 1000

= 1142.40 kg

e) Mass of Fine aggregate : Volume of all in aggregate x Volume of fine aggregate x Specific gravity of fine aggregate x 1000

= 0.7067 x 0.39 x 2.72 x 1000

= 749.70kg

Table 9: Proportion of different materials

Water	Cement	Fine aggregate	Coarse aggregate
186 liters	338 kg	749.70 kg	1142.40 kg
0.55	1	2.218	3.379

The proportion for concrete is determine as 1:2.218:3.379 by weight with W/C ratio 0.55.

4.2.2 Preparation of trial mixes

Table 10: Quantities per cubic meter for trial mixes (M20)

Mix No.	Water cement Ratio	Slump (mm)	Water (l/m3)	Cement (kg/m3)	Sand (kg/m3)	Coarse Aggregates (kg/m3)	Average cube strength at 7 days (MPa)	Average cube strength at 28 days (MPa)
M1	0.55	50	186	338	749.7	1142.4	15.48	26.90

Table 11: Mix proportions of different concrete mixes

Mix	W/C Ratio	Hypo sludge %	Fibre %	Hypo sludge kg/m^3	Fibre kg/m^3	Cement kg/m^3	Fine aggregates kg/m^3	Coarse Aggregate kg/m^3	Water l/m^3
Mix 1	0.55	0	0	0	0	338.0	749.7	1142.4	186
Mix 2	0.55	10	0	33.8	0	304.2	749.7	1142.4	186
Mix 3	0.55	20	0	67.6	0	270.4	749.7	1142.4	186
Mix 4	0.55	0	0.25	0	2.85	338.0	749.7	1142.4	186
Mix 5	0.55	10	0.25	33.8	2.85	304.2	749.7	1142.4	186
Mix 6	0.55	20	0.25	67.6	2.85	270.4	749.7	1142.4	186
Mix 7	0.55	0	0.50	0	5.71	338.0	749.7	1142.4	186
Mix 8	0.55	10	0.50	33.8	5.71	304.2	749.7	1142.4	186
Mix 9	0.55	20	0.50	67.6	5.71	270.4	749.7	1142.4	186
Mix 10	0.55	0	1.00	0	11.42	338.0	749.7	1142.4	186
Mix 11	0.55	10	1.00	33.8	11.42	304.2	749.7	1142.4	186
Mix 12	0.55	20	1.00	67.6	11.42	270.4	749.7	1142.4	186

5.3 Workability of concrete

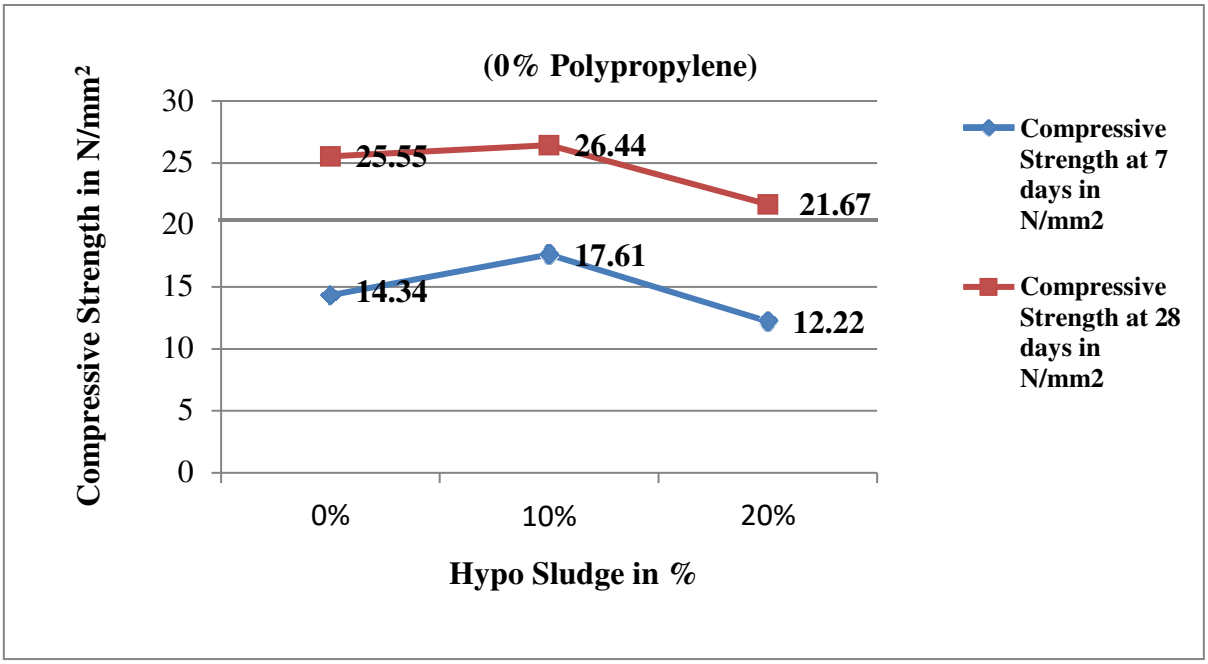
Table 12: Test results for workability of concrete

Mix	Hypo sludge%	Polypropylene fibre%	Slump(mm)	Degree of workability
Mix1	0	0	100	Medium
Mix2	10	0	90	Medium
Mix3	20	0	70	Medium
Mix4	0	0.25	90	Medium
Mix5	10	0.25	80	Medium
Mix6	20	0.25	60	Medium
Mix7	0	0.50	84	Medium
Mix8	10	0.50	70	Medium
Mix9	20	0.50	54	Medium
Mix10	0	1.00	55	Medium
Mix11	10	1.00	45	Low
Mix12	20	1.00	40	Low

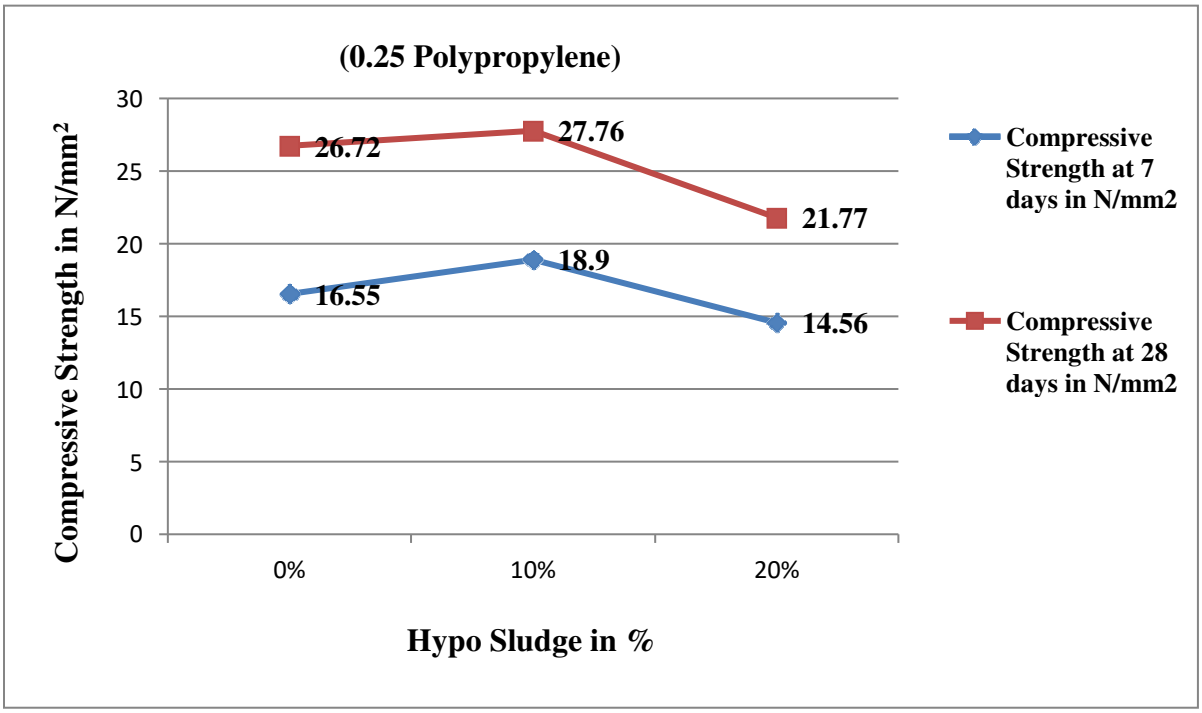
5.4 Compressive strength of concrete

. **Table 13: Test results for compressive strength of concrete at 7 days and 28 days**

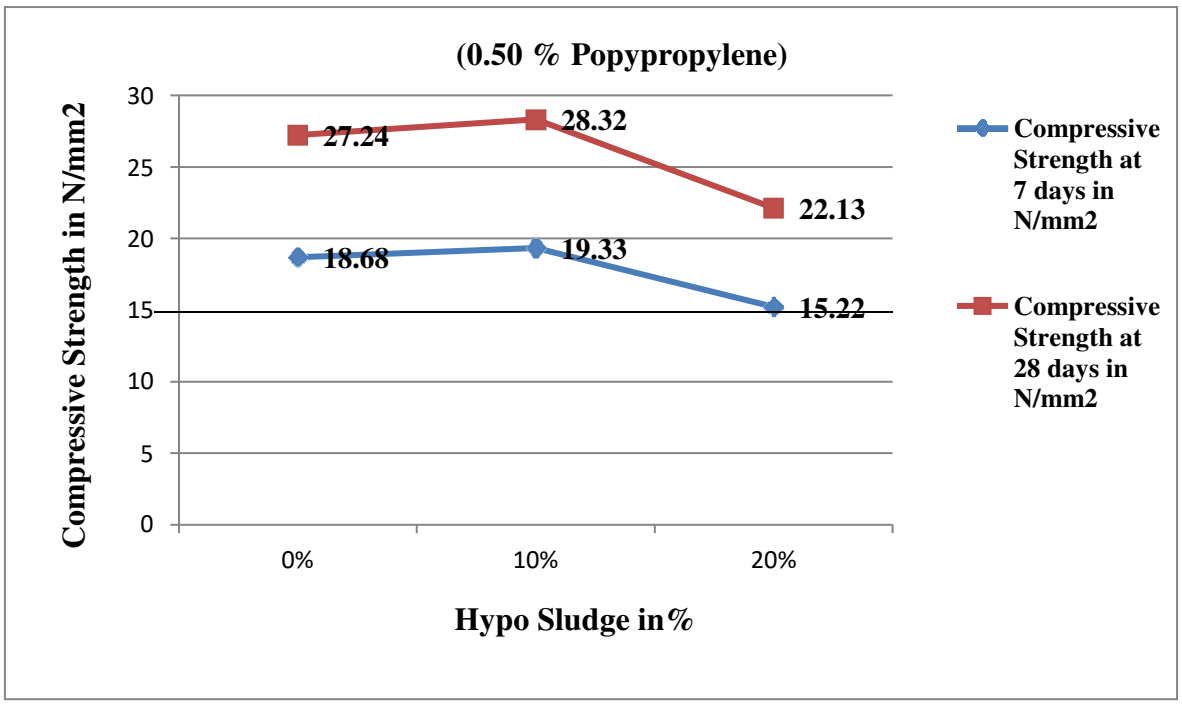
Mix	Hypo sludge%	Polypropylene fibre%	compressive strength after7 Days N/mm^2	compressive strength after28 Days N/mm^2
Mix1	0	0	14.34	25.55
Mix2	10	0	17.61	26.44
Mix3	20	0	12.22	21.67
Mix4	0	0.25	16.55	26.72
Mix5	10	0.25	18.90	27.76
Mix6	20	0.25	14.56	21.77
Mix7	0	0.50	18.68	27.24
Mix8	10	0.50	19.33	28.32
Mix9	20	0.50	15.22	22.13
Mix10	0	1.00	13.87	22.66
Mix11	10	1.00	15.47	23.17
Mix12	20	1.00	9.15	13.35



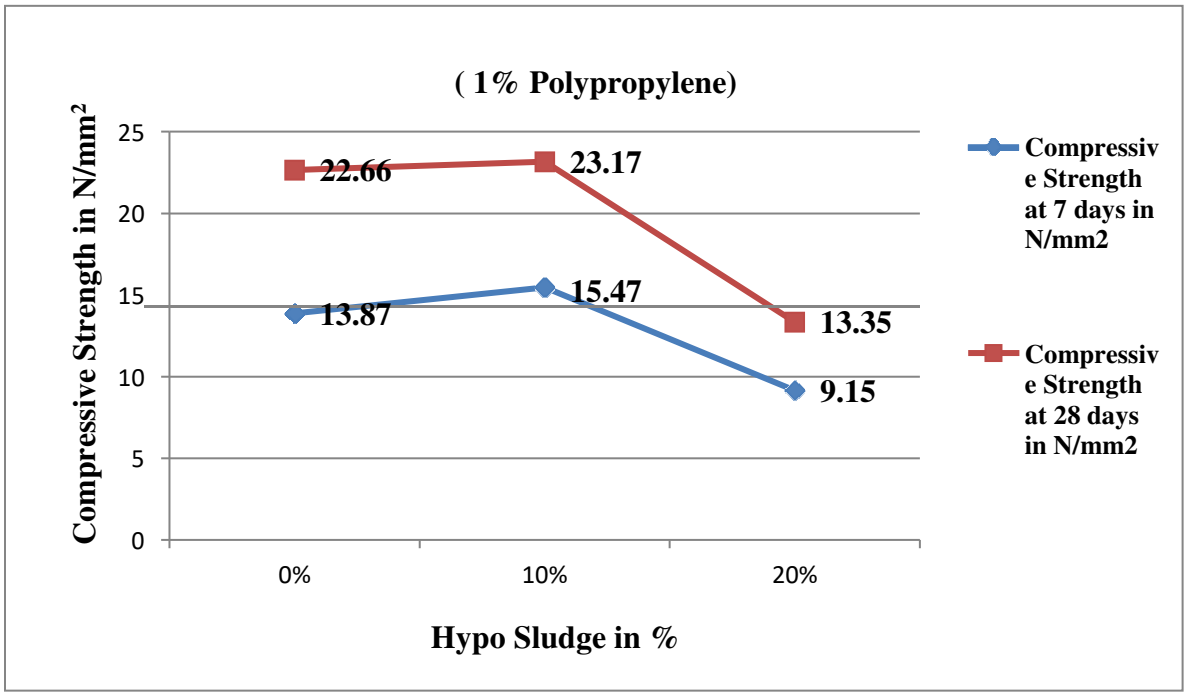
Graph: 1 Effect of Hypo sludge on compressive strength with o% polypropylene fiber



Graph: 2 Effect of Hypo sludge on compressive strength with 0.25% polypropylene fiber



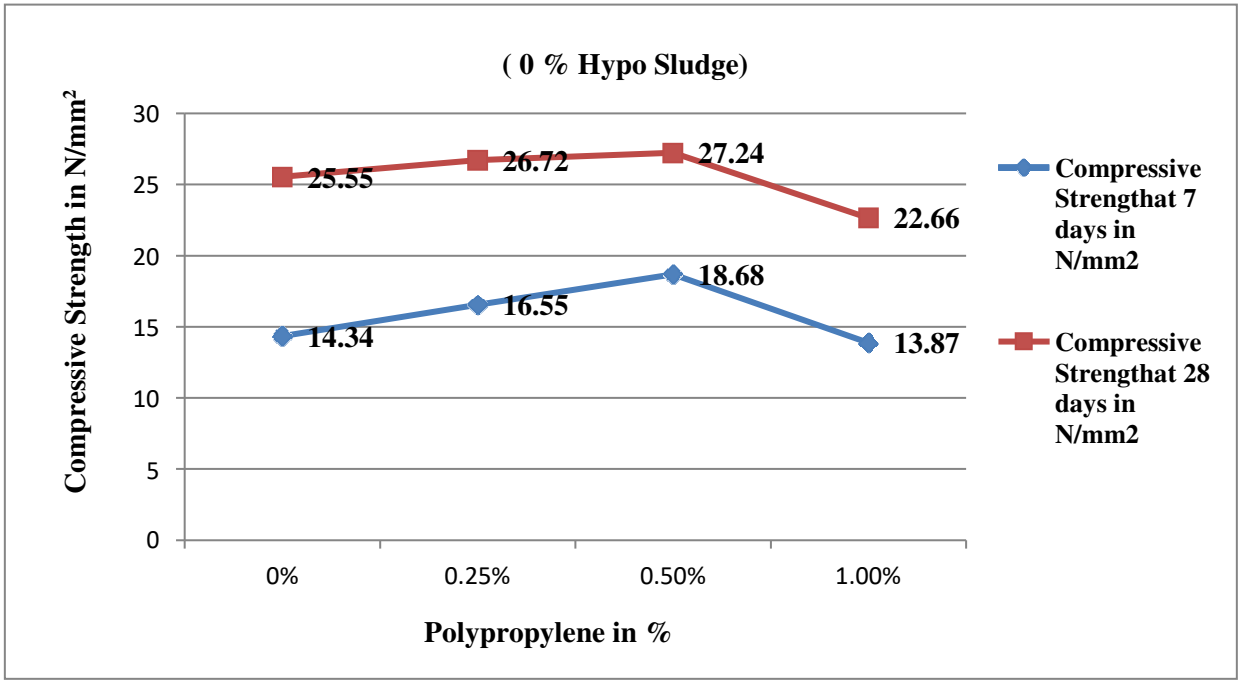
Graph: 3 Effect of Hypo sludge on compressive strength with 0.50% polypropylene fiber



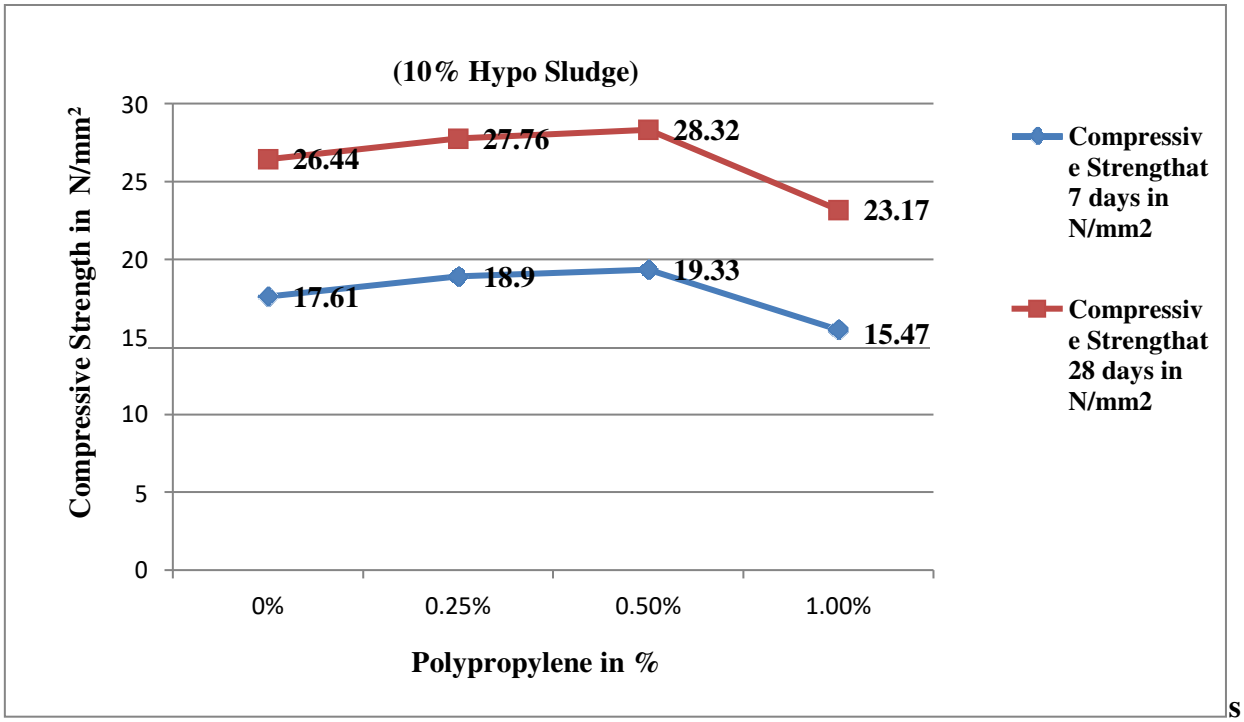
Graph: 4 Effect of Hypo sludge on compressive strength with 1% polypropylene fiber

Table 14 Can be written as

Mix	Hypo sludge%	Polypropylene fibre%	Compressive strength after7 Days N/mm^2	Compressive strength after28 Days N/mm^2
Mix1	0	0	14.34	25.55
Mix4	0	0.25	16.55	26.72
Mix7	0	0.50	18.68	27.24
Mix10	0	1.00	13.87	22.66
Mix2	10	0	17.61	26.44
Mix5	10	0.25	18.90	27.76
Mix8	10	0.50	19.33	28.32
Mix11	10	1.00	15.47	23.17
Mix3	20	0	12.22	21.67
Mix6	20	0.25	14.56	21.77
Mix9	20	0.50	15.22	22.13
Mix12	20	1.00	9.15	13.35

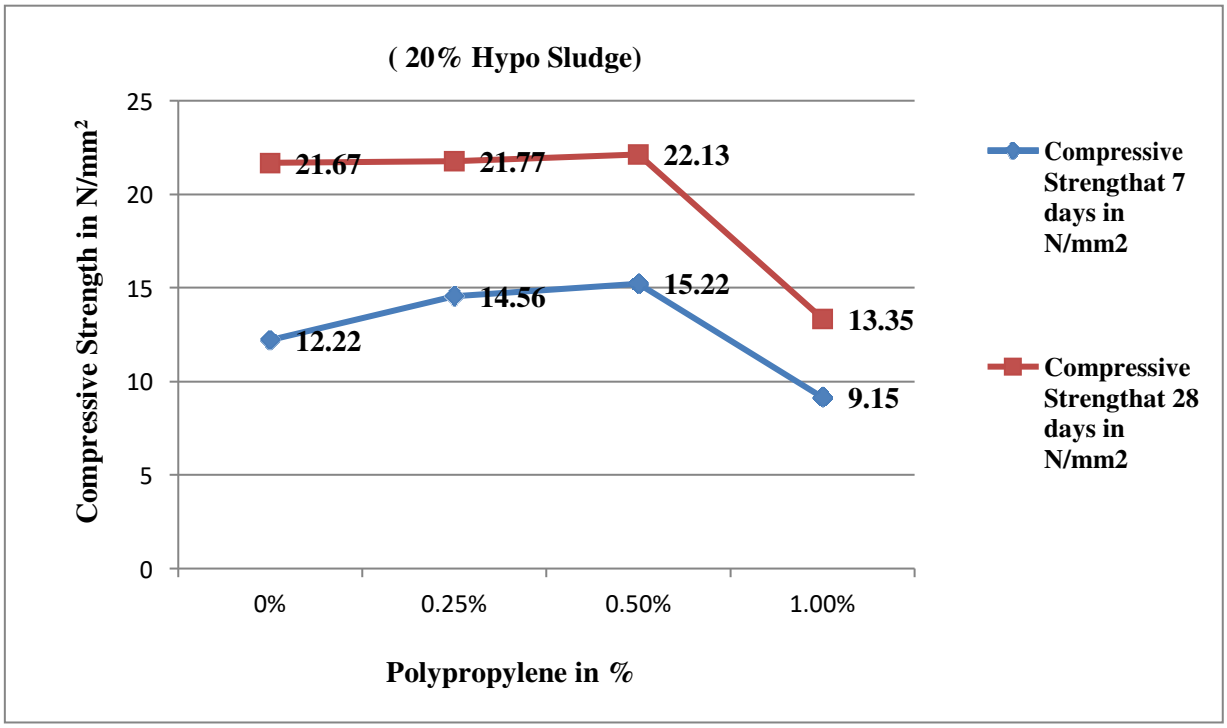


Graph: 5 Effect of Polypropylene fibre on compressive strength with 0% Hypo Sludge



s

Graph: 6 Effect of Polypropylene fibre on compressive strength with 10% Hypo Sludge

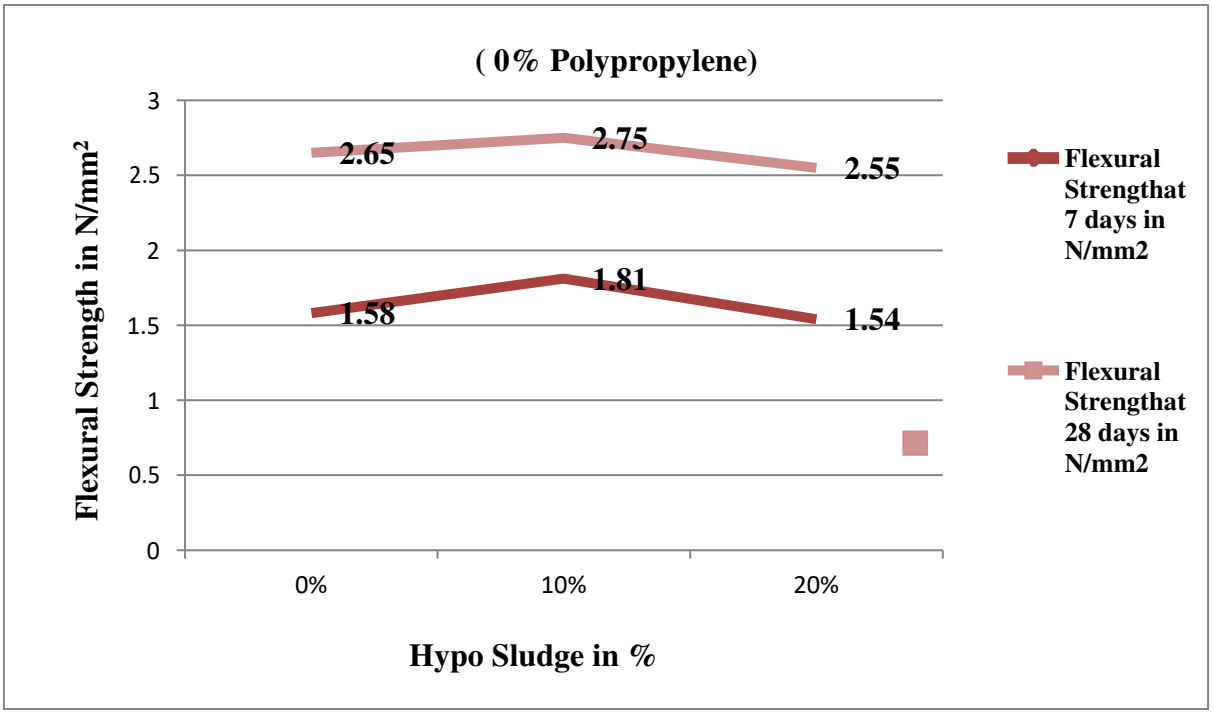


Graph: 7 Effect of Polypropylene fibre on compressive strength with 20% Hypo Sludge

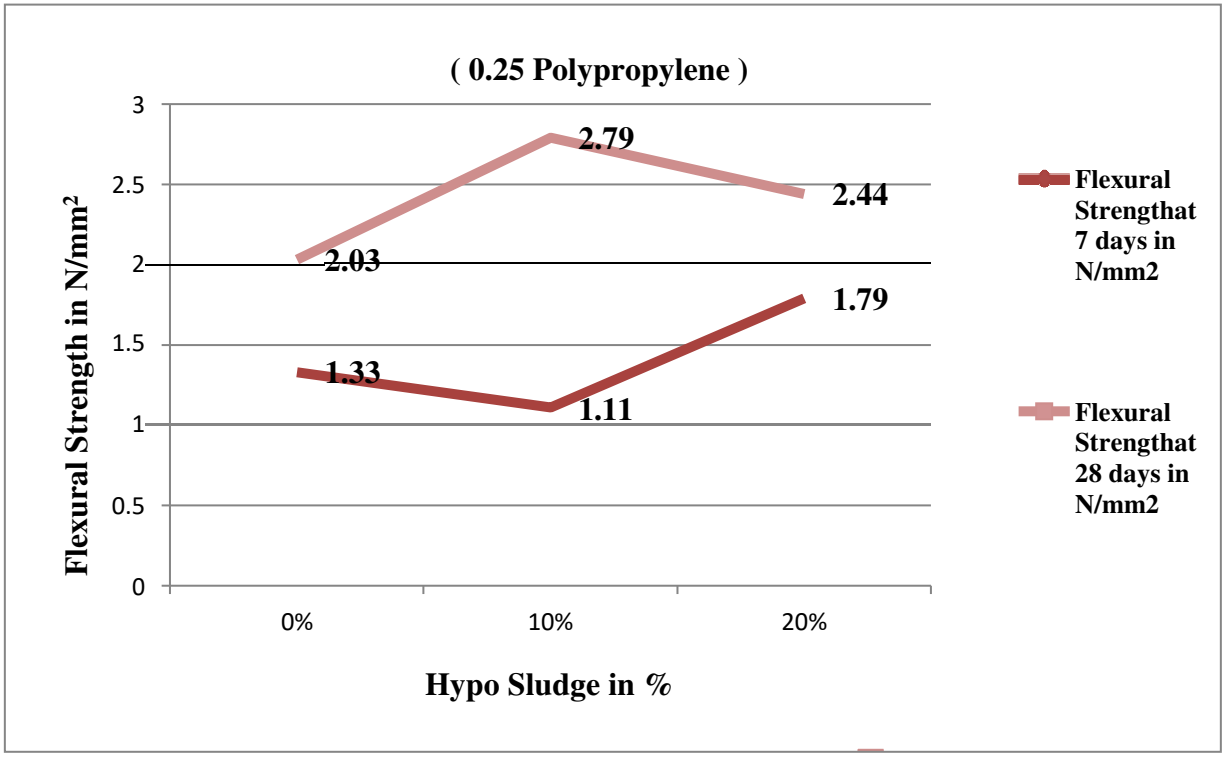
Flexural Strength of concrete

Tabe:15 Test result for Flexural strength at 7 days and 28 days curing

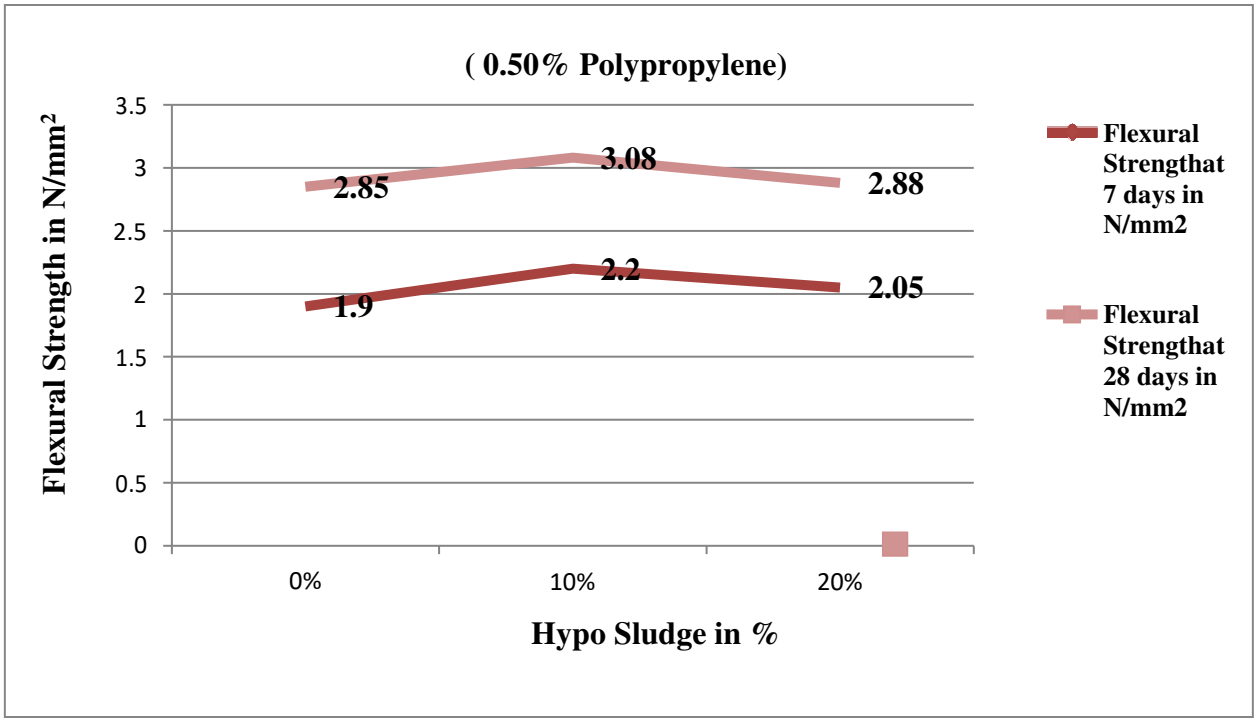
Mix	Hypo sludge (%)	Fibre (%)	Flexural strength after 7 days (N/mm^2)	Flexural strength after 28 days (N/mm^2)
Mix1	0	0	1.58	2.65
Mix2	10	0	1.81	2.75
Mix3	20	0	1.54	2.55
Mix4	0	0.25	1.33	2.03
Mix5	10	0.25	1.11	2.79
Mix6	20	0.25	1.79	2.44
Mix7	0	0.50	1.90	2.85
Mix8	10	0.50	2.20	3.08
Mix9	20	0.50	2.05	2.88
Mix10	0	1.00	1.25	2.25
Mix11	10	1.00	1.60	2.48
Mix12	20	1.00	1.40	2.18



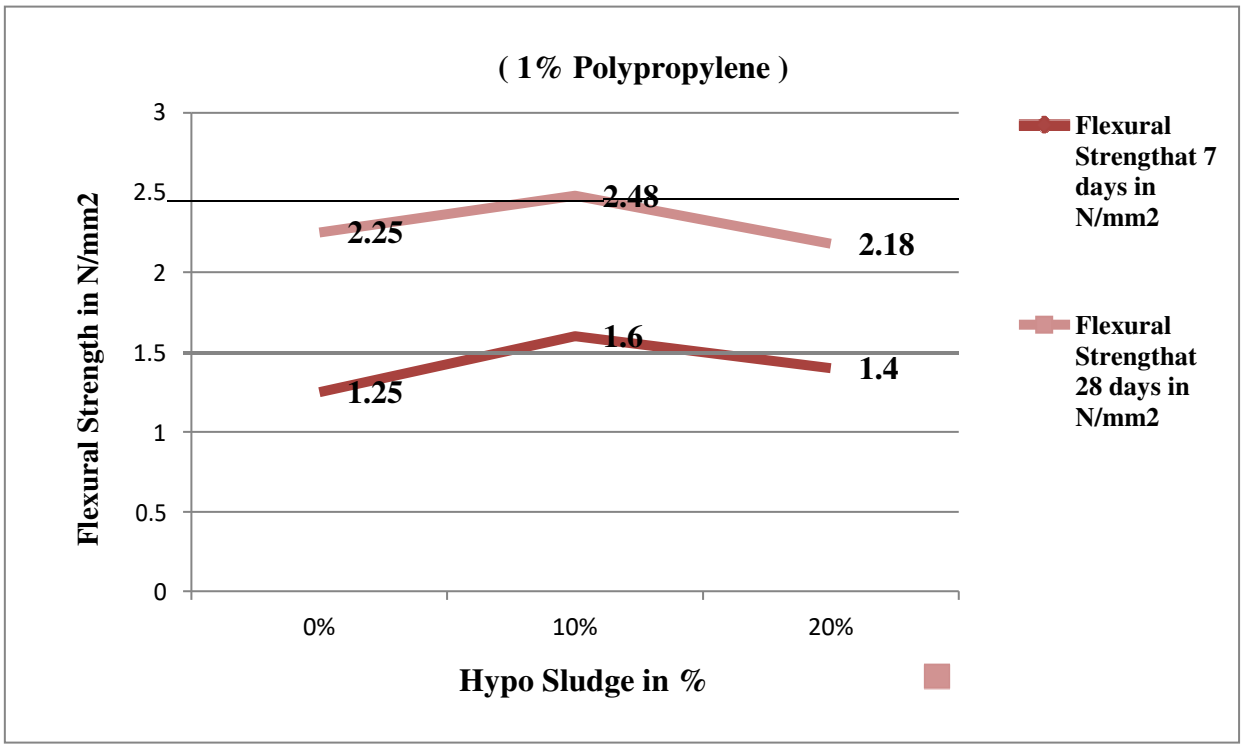
Graph: 8 Effect of Hypo Sludge on Flexural Strength with 0% Polypropylene Fiber



Graph: 9 Effect of Hypo Sludge on Flexural Strength with 0.25% Polypropylene Fiber



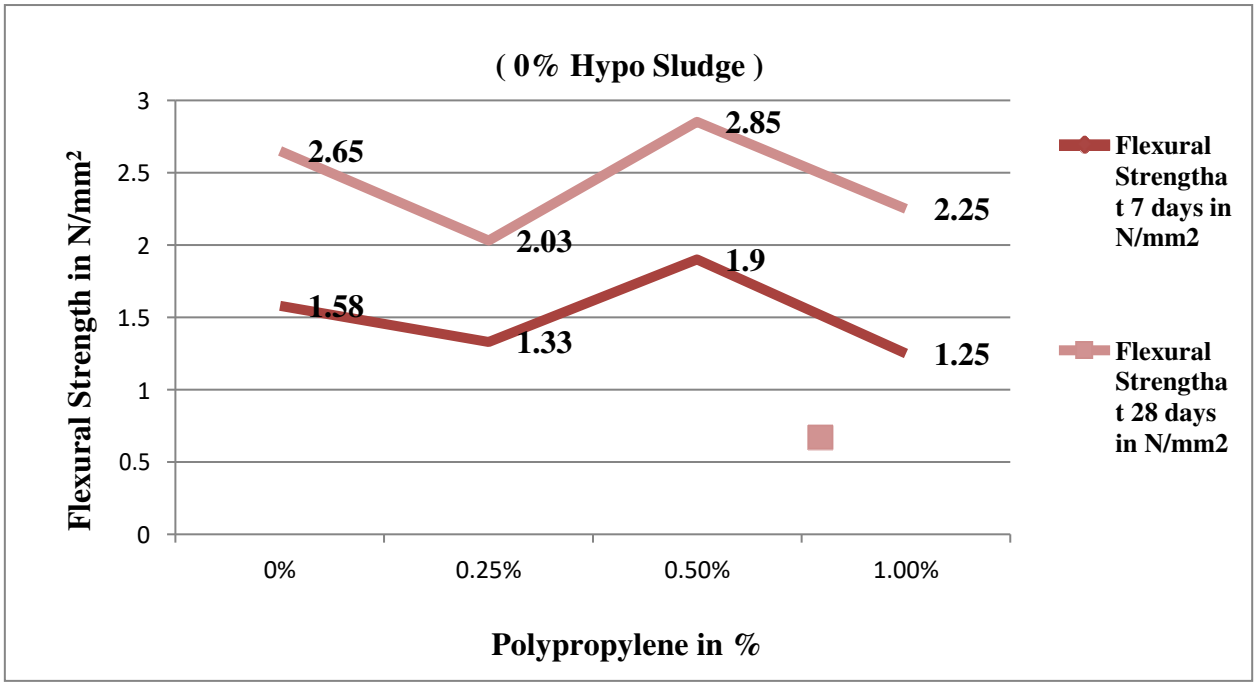
Graph: 10 Effect of Hypo Sludge on Flexural Strength with 0.50% Polypropylene Fiber



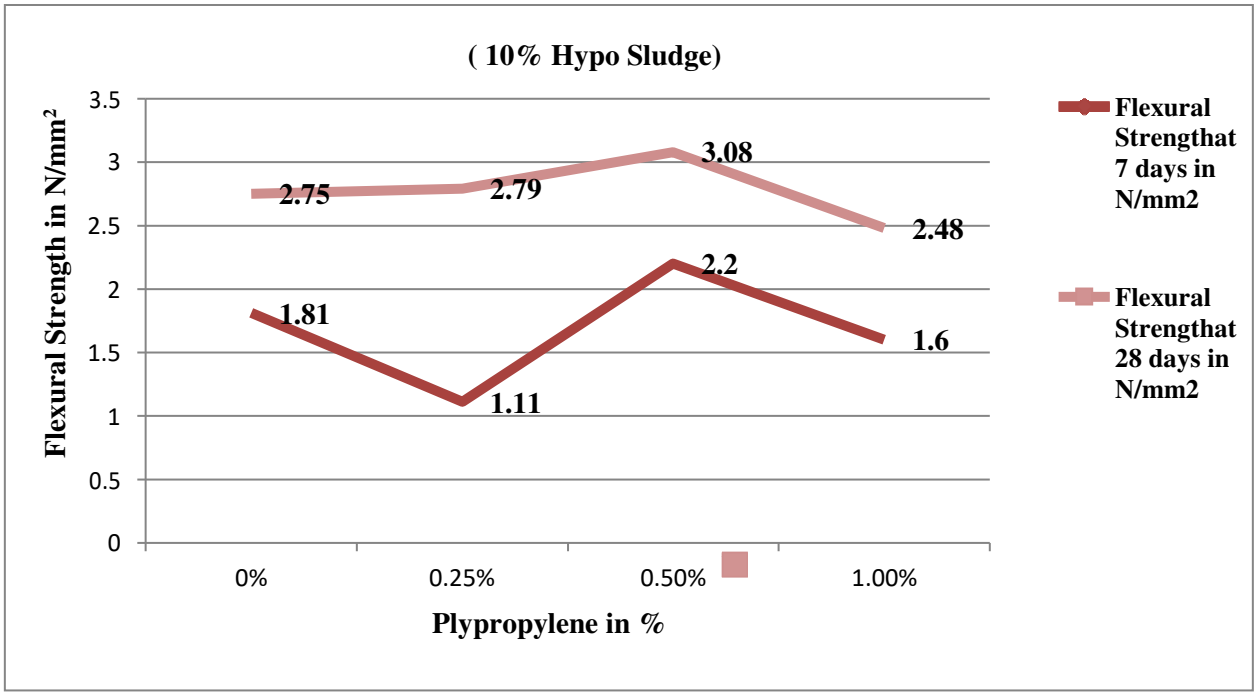
Graph: 11 Effect of Hypo Sludge on Flexural Strength with 0.50% Polypropylene Fiber

Table 16 Can be written as

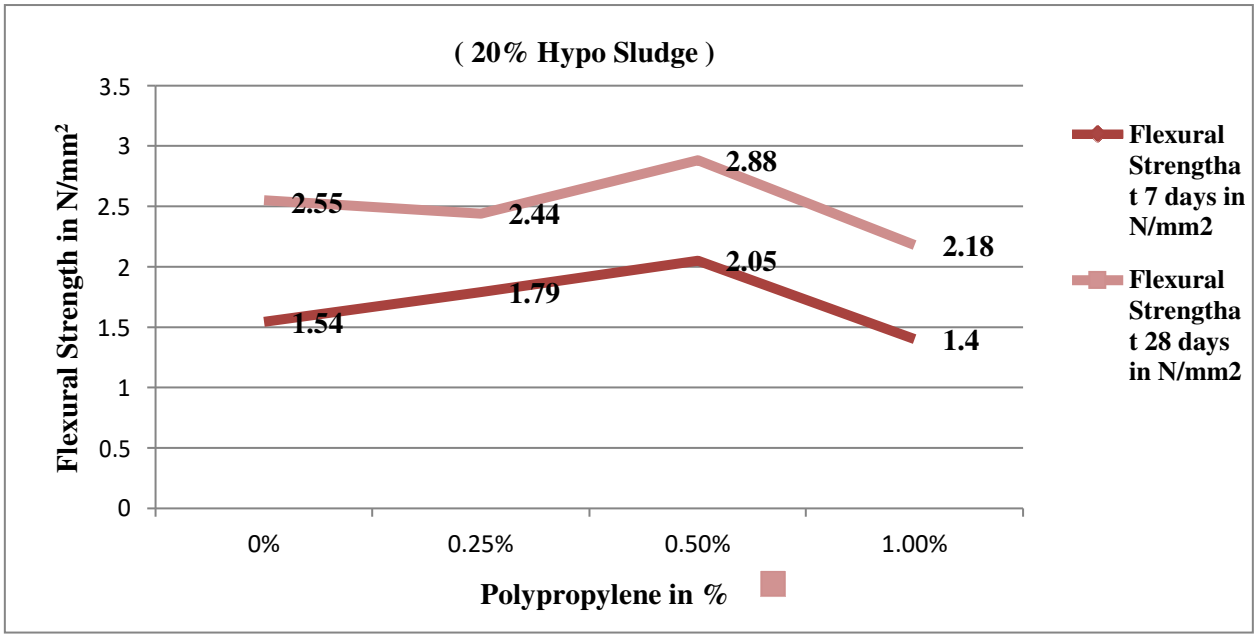
Mix	Hypo sludge%	Polypropylene fibre%	Flexural strength after 7 Days N/mm^2	Flexural strength after 28 Days N/mm^2
Mix1	0	0	1.58	2.65
Mix4	0	0.25	1.33	2.03
Mix7	0	0.50	1.90	2.85
Mix10	0	1.00	1.25	2.25
Mix2	10	0	1.81	2.75
Mix5	10	0.25	1.11	2.79
Mix8	10	0.50	2.20	3.08
Mix11	10	1.00	1.60	2.48
Mix3	20	0	1.54	2.55
Mix6	20	0.25	1.79	2.44
Mix9	20	0.50	2.05	2.88
Mix12	20	1.00	1.40	2.18



Graph:12 Effect of Polypropylene fibre on Flexural strength with 0% Hypo Sludge



Graph: 13 Effect of Polypropylene fibre on Flexural strength with 10% Hypo Sludge



Graph: 14 Effect of Polypropylene fibre on Flexural strength with 10% Hypo Sludge

Conclusion

The objectives of the study were to study the effect of partial replacement of hypo sludge with cement, with polypropylene fibers used as additive in concrete. 72 concrete specimens were prepared by partial replacement of cement with hypo sludge 0% to 20% and with polypropylene fiber 0% to 1%. After having trial of mixes, the water-cement ratio selected was 0.55 and it was kept constant for all the mixes. The workability of concrete was tested immediately after preparing the concrete whereas the compressive strength, splitting tensile strength and flexural strength of concrete was tested after 7 and 28 days of curing.

From the experimental investigations, it is concluded that:

- Polypropylene fibre addition improves the compressive and flexural strength of concrete.
- The addition of both hypo sludge and polypropylene fiber increases the strength of concrete for all curing ages up to certain point. After that there is an abrupt reduction in strength of the concrete. Because at higher dosage, concrete loses its ability to make a proper bond.
- The gradual increase was seen in compressive strength and splitting tensile strength of concrete blended with 0% to 10% of hypo sludge content for all curing ages. Beyond that there is significant reduction in strength. This is due to water absorbing capability of hypo sludge which disturbed the water-cement ratio.
- The gradual increase was seen in compressive strength, splitting tensile strength and flexural strength of concrete blended with 0% to 0.5% polypropylene fiber for all curing ages. Beyond that there is significant reduction in compressive strength. Because at higher dosage of fiber due to the formation of air voids, the concrete becomes stiff and difficult to compact which tend to decrease the strength.

7.1 Scope for the future

- Further studies need to be conducted for the test of durability, soundness, thermal insulation, sorptivity and water absorption of the concrete.
- Further studies need to be conducted by using hybrid fibres (combination of artificial and natural fibres) as reinforcement with steel fibre could increases tensile strength of concrete.

Refereces

1. Pitroda J and Umrigar F S (2013) Evaluation of modulus of elasticity of concrete with partial replacement of cement by thermal industry waste (fly ash) and paper waste industry (hypo sludge*). Int J Eng Sci Innov Technol* **2**(1): 133-38.

2. Shah R A and Pitroda J (2013) Effect of hypo sludge as partial replacement in mortar. *J Int Acad Res* **1**(4):195-05.

4. Alam M and Berera V (2015) An experimental study on use of hypo sludge in cement concrete. *Int J ProgrIn Civil Eng***2**(1): 1-23.

5. Solanki J V and Pitroda J (2013b) Investigation of low cost concrete using industrial waste as supplementary cementitious materials. *Int J Eng Sci Innov Technol* **2**(1): 81-88.

6. Solanki J V and Pitroda J (2013c) Study on modulus of elasticity of concrete with partial replacement of cement by hypo sludge waste from paper industry. *Global Res Anal***2**(1): 40-41.

7. Kakooei S, Akil H M, Jamshidi M and Rouhi J (2012) The effects of polypropylene fibres on the properties of reinforced concrete structures. *Constr Build Mater* **27**: 73-77.

8. Mazaheripour H, Ghanbarpour S, Mirmoradi S H and Hosseinpour I (2011) The effect of polypropylene fibres on the properties of fresh and hardened lightweight self compacting concrete. *Construction Build Mater* **25**: 351-58.

9. Ahmadi B and Khaja W (2001) Utilization of paper waste sludge in the building construction industry. Res ConservRecycl 32: 105-13.

10. Brown R, Shukla A and Natarajan K R (2002) Fibre Reinforcement of Concrete Structures. URITC Project no 536101. University of Rhode Island Transportation Center,Kingston, RI.