ISSN: 2348-2079

Volume-11 Issue-2

International Journal of Intellectual Advancements and Research in Engineering Computations

Experimental Investigation on Usage of Hypo sludge And Polypropylene Fiber in Pavement Quality Concrete

Bogi Veera Adithya[1], B. Ramesh[2]

[1]*M.Tech Student, Transportation Engineering, Pydah College of Engineering, Kakinada, Andhra Pradesh.*
[2]*Assistant Professor, Transportation Engineering, Pydah College of Engineering, Kakinada, Andhra Pradesh.*

***Corresponding Author: Bogi Veera Adithya**
Published on :03.06.2023

ABSTRACT

Hypo sludge in the paper industry creates a significant amount of trash in the form of slurry, and its disposal pollutes the environment. The production of cement releases carbon dioxide into the atmosphere, which furthers the problem of global warming. The growing amount of trash is a worrying fact that has brought up environmental sustainability concerns. As a result, making concrete from industrial waste might help to ease environmental problems. Hypo sludge was used in this experiment to make concrete for CC Pavements in place of cement. A synthetic hydrocarbon polymer called polypropylene fibre (PPF) was added to the concrete to increase its strength. The percentages of hypo sludge (0%, 5%, 10%, 15%, and 20%) and polypropylene fibre (0%, 0.25%, 0.5%, 0.75%, and 0.10%) varied in the current research. While the workability of concrete was examined immediately after the preparation of the concrete, the compressive strength and split tensile strength of concrete samples were measured 7, 14, and 28 days after curing. For all curing ages and to a certain extent, the introduction of hypo sludge and polypropylene fibre increases the strength of concrete. After then, the concrete's strength dramatically decreases. For optimal strength with a low coefficient of brittleness, a mixture of 10% hypo sludge and 0.5% polypropylene fibre is advised.

Keywords: Hypo sludge, Polypropylene fiber, Workability, Compressive strength, Splitting tensile strength

INTRODUCTION

Pavement quality concrete refers to a specialized type of concrete used in the construction of roadways, highways, airport runways, and other transportation infrastructure where high durability and performance are required. It is designed to withstand heavy traffic loads, resist wear and tear, and provide a safe and smooth riding surface for vehicles. Roads constructed with cement, aggregates, and water are known as cement concrete (CC) roads. Due to their dependability, robustness, and little maintenance needs, they are often utilised in the construction of roads, highways, airports, and other infrastructure projects. Compared to other forms of pavement.

Statement of the Problem

The numerous wastes generated by the various operations in the paper industry are produced during the paper-making process. Following are some of the significant issues brought on by this waste:

Since the majority of wastes are disposed of in a wet form, plans must be created for their extraction and delivery in a dry state, which is expensive. Open waggons used to transport dry garbage incur significant transportation losses. The maximum distance that may be economically travelled by the wastes. One of the main issues with garbage use in bulk is variation in waste quality. Primary waste known as hypo sludge has a low calcium content, a high calcium chloride content, and a low silica content. Due to the characteristics of silica and magnesium, hypo sludge acts like cement. The silica and magnesium in this mixture help the concrete set more quickly. Industries that produce cement release greenhouse gases into the environment. A million tonnes of greenhouse gases are released in the production of 4 million tonnes of cement. The production of cement must be reduced to prevent the ozone layer from being destroyed. For this, hypo sludge is used in place of some of the concrete's cement. Utilizing this debris helps to maintain some of the concrete's strength while also generating savings.

MATERIALS

Hypo sludge

"Hypo sludge" refers to a type of industrial waste material that can be used as a partial replacement for cement in concrete production. It is also known as "paper mill sludge" or "paper industry waste sludge. "Hypo sludge is generated as a byproduct in the paper-making industry during the clarification and filtration processes of paper mill wastewater. It is primarily composed of cellulose fibers, clay particles, fillers, and residual chemicals used in the paper production process. When properly processed and treated, hypo sludge can be utilized as a supplementary cementitious material in concrete. By replacing a portion of cement with hypo sludge, it offers several potential benefits.

Table 1: Properties of hypo sludge

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	Loss on Ignescent	27 – 39
6	Acid insoluble	10 – 12
7	R_2O_3	2 – 4

Table 2: Comparison of properties of hypo sludge and cement

CONSTITUENTS	CEMENT (%)	HYPO SLUDGE (%)
LIME	62	46.2
SILICA	22	9
ALUMINA	5	3.6
MAGNESIUM	1	3.33
CALCIUM SULPHATE	4	4.05

Cement

Cement is a powder that is made by calcining lime and clay and is used with water to make mortar or sand, gravel, and water to make concrete. Cement is often made from limestone, shells, chalk, or marl combined with shale, clay, and other minerals. Slate, silica sand, iron ore, and blast furnace slag. Silicates and aluminates of lime produced from clay and limestone are the major ingredients in cement.

Polypropylene Fiber

The synthetic fibres known as polypropylene fibres are created from the thermoplastic polymer known as polypropylene. In order to boost the strength, hardness, and fracture resistance of concrete, these fibres are often utilised as a reinforcing material. Small amounts of polypropylene fibres are added to concrete mixes (typically less than 1% by volume) and are uniformly dispersed during mixing. The fibres generally have a diameter of between 0.3mm and 1.5mm and are between 6mm and 50mm in length. Concrete performs better as a whole when polypropylene fibres are introduced because they create a three-dimensional network inside the mixture. The fibres serve as reinforcement, giving the concrete more tensile strength and lowering the possibility of cracking from shrinkage or heat pressures. Additionally, they increase the concrete's hardness and impact resistance, strengthening its defences against environmental elements including weathering and high traffic. Numerous concrete applications, including as flooring, precast concrete products, shotcrete, and other building projects, may benefit from the usage of polypropylene fibres.

Table 3: Properties of Polypropylene

S.No	Material	Virgin homopolymer polypropylene
1	Colour	White
2	Specific gravity	0.91
3	Length	38 mm
4	Acid /alkali resistance	Excellent

Coarse Aggregate

Coarse aggregates are defined as those aggregates that are mostly retained on a 4.75-mm BIS Sieve. Crushed stone aggregates with nominal sizes of 20 mm and 10 mm were used 50/50 throughout the experiment. The aggregates were cleaned to get rid of dirt and dust, and after they were cleaned, they dried out before the top layer of the substance was completely dry.

Fine aggregate

Aggregates that generally pass a 4.75-mm BIS Sieve are referred to as fine aggregates. i) Natural sand: Fine aggregates left behind from the dissolution of rock that streams or glaciers have left behind. According to BIS: 383-1970, the fine aggregates are separated into zone I, zone II, zone III, and zone IV grading zones based on the particle size distribution This investigation, employed sand that confirmed to zone II.

Super Plasticizer

If we add more water, it creates slurry that will fill the spaces, making it possible to produce workable concrete. This affects both the strength and workability of the concrete. Conplast SP 430 super plasticizer from FOSROC Constructive Solution Company is utilized in this study to improve the workability and strength of the concrete. Based on sulphonated naphthalene formaldehyde, which is a liquid that is brown in color and dispersible in water, it is used. The amount of water needed in Pavement quality concrete is significantly decreased by the use of super plasticizer. Conplast, a brown liquid, is added to the total amount of binder material in this investigation at a rate of 0.6%

Water

The specimens in the current investigation were cast using fresh, pure tap water. Organic particles, silt, oil, sugar, chloride, and acidic substances were comparatively rare in the water.

i) Hypo sludge **ii) Cement** **iii) PPF** **iv) CA** **v) Super plasticizer**

Objectives

i. To produce efficient Pavement Quality concrete by accumulation of Hypo sludge and in replacement of cement.
ii. To verify that hypo sludge is appropriate for a certain application
iii. Improve the strength properties of M40 grade concrete to introduce Polypropylene fiber into the mix
iv. To select optimum mix proportion of concrete
v. To determine compressive strength and split tensile strength and Coefficient of brittleness of Concrete.

RESEARCH METHODOLOGY

- First, ascertain the characteristics of each individual material, including cement, polypropylene fibre, coarse aggregate, and fine aggregate.
- Calculate the mix design for pavement concrete of M40 grade;
- Substitute 5%, 10%, 15%, and 20% of hypo sludge for cement, and create a combination of 0.25%, 0.5%, 0.75%, and 1% of polypropylene fibre.
- By performing compression testing, split tensile tests, and coefficient of brittleness, you may choose the optimal mix for pavement based on the findings.

RESULTS AND DISCUSSION

Properties of OPC

The investigation utilised OPC of Grade 53 from a single batch. It was lump-free and brand-new. To avoid having its qualities deteriorate from exposure to moisture, cement was carefully kept. Table 4 lists the physical characteristics of the cement as determined by several tests, together with the matching standard for that characteristic according to BIS: 12269-1987.

Table 4: Properties of OPC 53 grade cement

S.No.	Characteristics	Value Obtainedexperimentally	Value specified
1.	Specific Gravity	3.15	-
2.	Standard Consistency	31.5%	-
3.	Initial Setting Time	40 minutes	30 minutes (min)
4.	Final Setting Time	270 minutes	600 minutes (max)
5.	essive Strength 3 days 7 days	28.60 N/mm^2	27 N/mm^2

28 days	39.87 N/mm^2	37 N/mm^2
	58.45 N/mm^2	53 N/mm^2

The values are conforming to specifications given in BIS: 12269-1987

Properties of aggregates

Properties of coarse aggregates

The coarse aggregates were a 50:50 blend of two sizes of crushed stone that were readily accessible locally: 10 mm and 20 mm. After being cleaned to get rid of dirt and dust, the aggregates were dried until the surface was dry. The sieve analysis of coarse aggregates was performed, and the results of the sieve analysis are provided in Table 4.2, along with the specific gravity and other parameters of coarse aggregates. After proportioning coarse aggregates, the fineness modulus was determined as reported in Tables 5 and 6, respectively.

Table 5: Properties of coarse aggregates

Property	20 mm	10 mm
Color	Grey	Grey
Shape	Angular	Angular
Maximum Size	20 mm	10 mm
Specific Gravity	2.834	2.790
Water Absorption	1.16%	1.15%
Fineness Modulus	6.61	6.60

Table 6: Properties of Fine aggregates

Bulk density(g/cc)	1.78
Specific Gravity	2.509
Water Absorption	0.80%
Fineness Modulus	3.1

Impact Value Test Results

Table 7: Aggregate Impact value test results

OBSERVATIONS	Aggregates
wt. of container+ aggregate in g=	1089. 8
wt. of container in g=	742.6
wt. of aggregate in gW1=	347.2
wt. of container+ agg retained in2.36mmsieve (g)	1004. 1
wt. of aggregate passing 2.36mm sieve in g W2 =	67.704
Aggregate impact value (W2 / W1) X 100 =	**19.50 %**

Aggregate Crushing Value Test Results

Table 8: Crushing value test results

Description	Aggregates
W1, Total wt of dry sample in gm	2.840
W2, Wt of portion passing 4.75mm sieve in gm	0.56
Aggregate crushing value %=(W2/W1)100	**19.7%**

Combined Gradation for PQC Mix Design

Table 9: Gradation of Cement Concrete

Sieve size (mm)	33% of 20 mm	27% of 10 mm	40% of Sand	Combined Grading	Limits as per IS 383 Table 5
40	33	27	40	100	100
20	31.65	27	40	98.65	95-100
12.5	0	27	40	67.00	-
10	2.59	25.69	40	68.28	-
4.75	0.89	2.13	38.23	41.25	30-50
2.36	0	0.71	36.40	37.11	-
1.18	0	0	34.86	34.864	-
0.600	0	0	28.06	28.064	10-35
0.300	0	0	10.81	10.808	-
0.150	0	0	2.09	2.09	0-6

Table 10: Designation of concrete mix

Mix	Fiber (%)	Hypo sludge (%)	Cement (%)
S1	0	0	0
S2		5	95
S3		10	90
S4		15	85
S5		20	80
S6	0.25	0	0
S7		5	95
S8		10	90
S9		15	85
S10		20	80
S11	0.50	0	0
S12		5	95
S13		10	90
S14		15	85
S15		20	80
S16	0.75	0	0
S17		5	95
S18		10	90
S19		15	85
S20		20	80
S21	1.00	0	0
S22		5	95
S23		10	90
S24		15	85
S25		20	80

Table 11: Mix proportions of different concrete mixes

Mix	w/c Ratio	Hypo sludge %	Fiber %	Hypo sludge (kg/m^3)	Fiber (kg/m^3)	Cement (kg/m^3)	Fine Aggregates (kg/m^3)	Coarse Aggregates (kg/m^3)	Water (l/m^3)
S1	0.38	0	0	0	0	390	729	1226	148.2
S2	0.38	5	0	19.50	0	370.5	729	1226	148.2
S3	0.38	10	0	39.00	0	351	729	1226	148.2
S4	0.38	15	0	58.5	0	331.5	729	1226	148.2
S5	0.38	20	0	78	0	312	729	1226	148.2
S6	0.38	0	0.25	0	2.44	390	729	1226	148.2

S7	0.38	5	0.25	19.50	2.44	370.5	729	1226	148.2
S8	0.38	10	0.25	39.00	2.44	351	729	1226	148.2
S9	0.38	15	0.25	58.5	2.44	331.5	729	1226	148.2
S10	0.38	20	0.25	78	2.44	312	729	1226	148.2
S11	0.38	0	0.50	0	4.88	390	729	1226	148.2
S12	0.38	5	0.50	19.50	4.88	370.5	729	1226	148.2
S13	0.38	10	0.50	39.00	4.88	351	729	1226	148.2
S14	0.38	15	0.50	58.5	4.88	331.5	729	1226	148.2
S15	0.38	20	0.50	78	4.88	312	729	1226	148.2
S16	0.38	0	0.75	0	7.33	390	729	1226	148.2
S17	0.38	5	0.75	19.50	7.33	370.5	729	1226	148.2
S18	0.38	10	0.75	39.00	7.33	351	729	1226	148.2
S19	0.38	15	0.75	58.5	7.33	331.5	729	1226	148.2
S20	0.38	20	0.75	78	7.33	312	729	1226	148.2
S21	0.38	0	1.00	0	9.77	390	729	1226	148.2
S22	0.38	5	1.00	19.50	9.77	370.5	729	1226	148.2
S23	0.38	10	1.00	39.00	9.77	351	729	1226	148.2
S24	0.38	15	1.00	58.5	9.77	331.5	729	1226	148.2
S25	0.38	20	1.00	78	9.77	312	729	1226	148.2

Table 12: Gradation of Cement Concrete

Fraction	Sp.Gr SSD	Water absorption (%)	DRY Kg/Cum	SSD Kg/Cum	Absolute Vol.(Cum)
Cement	3.15	Nil	390	390	0.124
Water	1.00	Nil	170	148.2	0.148
CA 20 mm	2.834	1.16	671	679	0.240
CA 10 mm	2.790	1.48	539	547	0.196
River Sand	2.509	0.80	723	729	0.291
Admixture (%)	1.202	Nil	2.34	2.34	0.002
Total			**2495.5**	**2495.5**	**1.00**

Observation on Trial Mix

Observation on Trial Mix:

Grade of concrete	M40
Cement content per cum	390 Kg
Water cement ratio	0.38

Ingredients Mixed for trial .

a) Required quantity of concrete		0.050 Cum
b) Cement		19.50 Kg
c) 20mm aggregate	33.0%	33.95 Kg
d) 10mm aggregate	27.0 %	27.35 Kg
e) River sand	40.0 %	36.45 Kg
f) Admixture (% by wi. of cement)	0.6%	117.00 Grams

Compressive strength of concrete

For the different replacement amounts of hypo sludge with cement and the inclusion of polypropylene fibre, the compressive strength of each mix was assessed at 7, 14, and 28 days of age. Table 13 shows the average compressive strength values after varied curing times (7 days, 14 days, and 28 days) for various replacement amounts of hypo sludge (0%, 5%, 10%, 15%, and 20%) and the addition of polypropylene fibre (0%,.25%, 0.50%, 0.75%, and 1.00%). which illustrates the fluctuation in compressive strength caused by various concentrations of hypo sludge and polypropylene fibre, plot these data. Hypo sludge replacement levels with cement with 0% polypropylene fibre. It is evident that the presence of hypo sludge increases concrete's compressive strength by up to 10%. The compressive strength then starts to decline.

Table 13: Test results for compressive strength of concrete

Mix	Hypo sludge (%)	Fiber (%)	7 Days (N/mm^2)	14 Days (N/mm^2)	28Days (N/mm^2)
S1	0	0	29.10	43.65	48.50
S2	5		29.58	44.37	49.30
S3	10		30.06	45.09	50.10
S4	15		28.75	43.13	47.92
S5	20		27.72	41.58	46.20
S6	0	0.25	29.35	44.03	48.92
S7	5		29.76	44.64	49.60
S8	10		30.72	46.08	51.20
S9	15		28.34	42.51	47.23
S10	20		27.48	41.22	45.80
S11	0	0.50	30.16	45.23	50.26
S12	5		30.71	46.06	51.18
S13	10		31.89	47.84	**53.15**
S14	15		29.52	44.28	49.20
S15	20		27.82	41.72	46.36
S16	0	0.75	28.54	42.80	47.56
S17	5		29.52	44.28	49.20
S18	10		30.74	46.11	51.23
S19	15		28.33	42.49	47.21
S20	20		24.74	37.11	41.23
S21	0	1.00	28.02	42.03	46.70
S22	5		27.90	41.85	46.50
S23	10		26.74	40.10	44.56
S24	15		24.14	36.22	40.24
S25	20		23.14	34.70	38.56

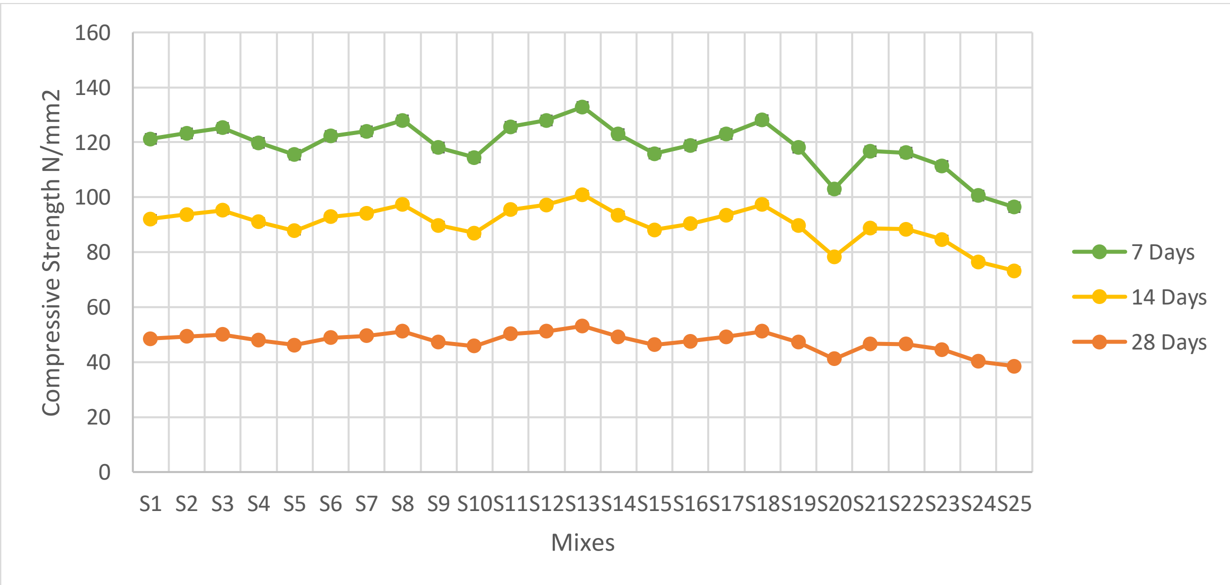

Fig 2: Compressive strength of various mixes at 28 Days Curing Period

Fig 3: Compressive strength Test

The similar pattern for 0.25%, 0.50%, 0.75%, and 1% is shown for polypropylene fibre in Figures 4.4, 4.6, 4.8, and 4.10. After 28 days of curing, the mixes with 5%, 10%, 15%, and 20% of hypo sludge showed compressive strength changes for 0% polypropylene fibre of 1.65, 3.30, -1.20, and -4.74, respectively. Compressive strength for 0.25% polypropylene fibre for 5%, 10%, 15%, and 20% hypo sludge decreased by a percentage of 1.39, 4.66, 3.45, and -6.38 after 28 days of curing. For 5%, 10%, 15%, and 20% of hypo sludge for 0.5% of polypropylene fibre after 28 days of curing, the corresponding percentage drop in compressive strength was 1.83, 5.75, -2.11, and -7.76. Compressive strength for 0.75% polypropylene fibre for 5%, 10%, 15%, and 20% hypo sludge decreased by 3.45, 7.72, -0.74, and -13.31 percents, respectively, after 28 days of curing. Compressive strength for 1% of polypropylene fibre decreased by -0.43, -4.58, -13.83, and -17.43 percentage points for 5%, 10%, 15%, and 20% of hypo sludge, respectively, after 28 days of curing. A negative indication shows a decline in fortitude. As can be seen, the compressive strength changed very little up to 10% of hypo sludge, but beyond that point, the compressive strength dramatically dropped because of the hypo sludge's tendency to absorb water, which changed the water-cement ratio. A decrease in cement concentration due to increased sludge dose results in poor bonding, especially surrounding sludge particles. As a consequence, early fracture development eventually materialized during the compressive test.

It was observed that adding polypropylene fiber up to 0.5% enhanced the compressive strength of the concrete. After then, the strength of polypropylene fibres with a 0.75% and 1% reduction. This is because polypropylene fibre helps to create a solid aggregate with good cohesion. The concrete stiffens and becomes more difficult to compact with higher fibre doses, which tends to reduce compressive strength. According to the discussion above, it is recommended to use a mixture of 10% hypo sludge (as a cement alternative) and 0.5% polypropylene fibre to get the best compressive strength.

Split tensile strength of concrete

The splitting tensile strength of each combination for the various replacement quantities of hypo sludge and polypropylene fibre was evaluated at 7, 14, and 28 days old. Table 4.6 shows the average strength values at the end of different curing durations (7 days, 14 days, and 28 days) for various hypo sludge replacement amounts with cement (0%, 5%, 10%, 15%, and 20%) and fibre (0%, 0.25%, 0.5%, 0.75%, and 1%). These findings are show how the amounts of hypo sludge and polypropylene fibre impact the splitting tensile strength.

Table 14: Test results for splitting tensile strength of concrete

Mix	Hypo sludge (%)	Fiber (%)	7 Days (N/mm^2)	14 Days (N/mm^2)	28Days (N/mm^2)
S1	0	0	**3.05**	**4.29**	**4.5**
S2	5		**3.11**	**4.46**	**4.9**
S3	10		**3.30**	**4.84**	**5.0**
S4	15		**2.70**	**3.69**	**4.2**
S5	20		**2.58**	**3.50**	**3.7**
S6	0	0.25	**3.04**	**4.24**	**4.6**
S7	5		**3.05**	**4.38**	**4.88**
S8	10		**3.78**	**4.98**	**5.23**
S9	15		**3.24**	**4.38**	**4.72**
S10	20		**2.83**	**3.76**	**4.06**
S11	0		**2.88**	**4.21**	**4.72**
S12	5		**3.16**	**4.45**	**5.05**

S13	10	0.50	**3.69**	**4.99**	**5.70**
S14	15		**3.29**	**4.23**	**4.56**
S15	20		**3.09**	**3.75**	**4.02**
S16	0	0.75	**3.61**	**4.21**	**4.65**
S17	5		**3.64**	**4.68**	**4.93**
S18	10		**3.96**	**4.97**	**5.22**
S19	15		**3.84**	**4.62**	**4.86**
S20	20		**3.47**	**3.69**	**4.22**
S21	0	1.00	**3.20**	**4.01**	**4.52**
S22	5		**3.25**	**4.01**	**4.32**
S23	10		**3.30**	**3.87**	**4.16**
S24	15		**2.88**	**3.41**	**3.75**
S25	20		**2.84**	**3.03**	**3.32**

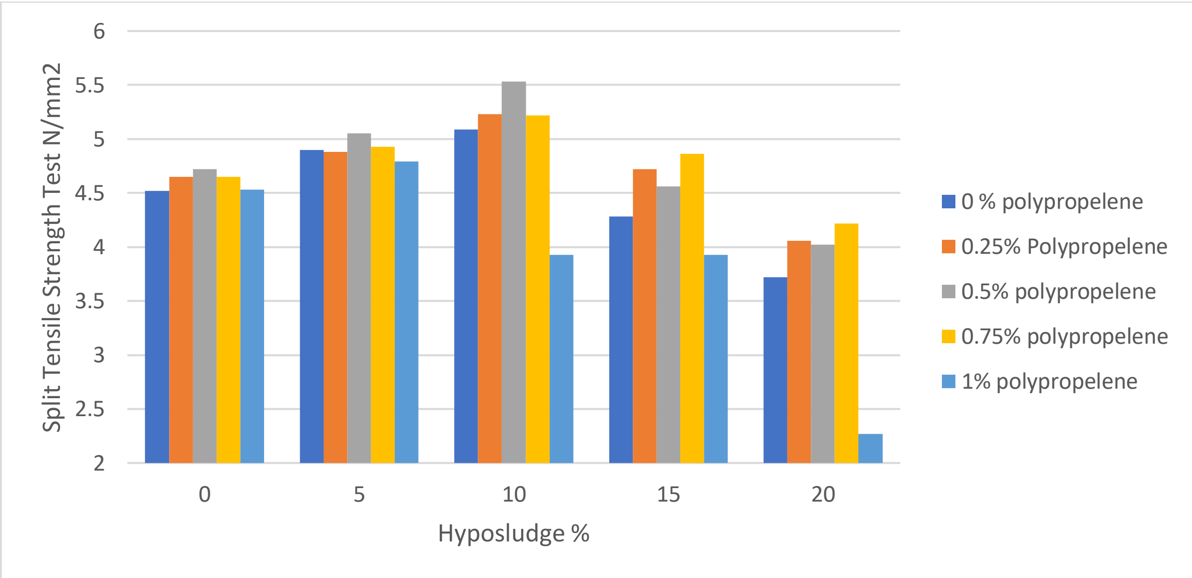

Fig 4: Effect of fiber on Split Tensile strength with variable % of hypo sludge atdifferent curing ages

Fig. 5: Split Tensile strength Test

The splitting tensile strength of all the mixtures with the various replacement quantities of fibres and hypo sludge with cement was evaluated at the ages of 7, 14, and 28 days. At the end of different curing durations (7 days, 14 days, and 28 days), Table14 shows the average strength values for various hypo sludge replacement levels with cement additions (0%, 5%, 10%, and 20%) and fibre additions (0%, 0.25%, 0.5%, 0.75%, and 1. Which show the variation in splitting tensile strength caused by different amounts of hypo sludge and polypropylene fibre, respectively. Figure6. shows the variation in splitting tensile strength of concrete with several percentages of hypo sludge replacement with cement for 0% of polypropylene fibre. Hypo sludge has been demonstrated to boost concrete's splitting tensile strength by up to 10%. The spitting tensile strength begins to deteriorate at this point. The polypropylene fibre seen in figures had a similar pattern at concentrations of 0.25%, 0.50%, 0.75%, and 1%. For mixes comprising 0% polypropylene fibre, the percentage change in splitting tensile strength after 28 days of curing was 8.41, 12.61, -5.31, and -17.70, respectively. For 0.25% polypropylene fibre, the percentage decrease in splitting tensile strength for 5%, 10%, 15%, and 20% hypo sludge after 28 days of curing was 4.95, 12.47, 1.51, and -12.69, respectively. For 0.50% of polypropylene fibre, the percentage decrease in splitting tensile strength for 5%, 10%, 15%, and 20% of hypo sludge after 28 days of curing was 6.99, 17.16, -3.39, and -14.83, respectively. For 5%, 10%, 15%, and 20% of hypo sludge, the percentage decrease in splitting tensile strength for 0.75 percent polypropylene fibre after 28 days of curing was 6.02, 12.26, 4.52, and -9.25, respectively. For 1% of polypropylene fibre, the percentage decrease in splitting tensile strength for 5%, 10%, 15%, and 20% of hypo sludge after 28 days of curing was 5.74, -13.25, -13.25, and -49.89, respectively. A negative indication shows a decline in fortitude. It is evident that the results line up with those of compressive strength. For all polypropylene fibre percentages, the concrete mix including 10% hypo sludge showed the greatest percentage increase in compressive strength. Observations show that adding polypropylene fibre up to 0.5% enhanced the concrete's splitting tensile strength. After then, the strength of polypropylene fibres with a 0.75% and 1% reduction. As can be seen from the discussion above, using a mixture of 10% hypo sludge (as a cement alternative) and 0.5% polypropylene fibre (as an additive) is recommended in order to attain the maximum splitting tensile strength.

Coefficient of brittleness

According to Altindag (2003), the coefficient of brittleness is calculated by dividing the concrete's compressive strength by its splitting tensile strength. Table 15 displays the coefficient of brittleness for various mixes after 28 days.

Table 15: Coefficient of brittleness for different mix at 28 days curing age

Mix	Hypo sludge (%)	Fiber (%)	Compressive strength (N/mm^2)	Tensile strength (N/mm^2)	Coefficient of brittleness
S1	0	0	48.5	4.52	10.73
S2	5		49.3	4.9	10.06
S3	10		50.1	5.09	9.84
S4	15		47.92	4.28	11.20
S5	20		46.2	3.72	12.42
S6	0	0.25	48.92	4.65	10.52
S7	5		49.6	4.88	10.16
S8	10		51.2	5.23	9.79
S9	15		47.23	4.72	10.01
S10	20		45.8	4.06	11.28
S11	0	0.50	50.26	4.72	10.65
S12	5		51.18	5.05	10.13
S13	10		53.15	5.70	**9.32**
S14	15		49.2	4.56	10.79
S15	20		46.36	4.02	11.53
S16	0	0.75	47.56	4.65	10.23
S17	5		49.2	4.93	9.98
S18	10		51.23	5.22	9.81
S19	15		47.21	4.86	9.71
S20	20		41.23	4.22	9.77
S21	0		46.7	4.53	10.31
S22	5		46.5	4.79	9.71
S23	10		44.56	3.93	11.34

S24	15	1.00	40.24	3.93	10.24
S25	20		38.56	2.27	16.99

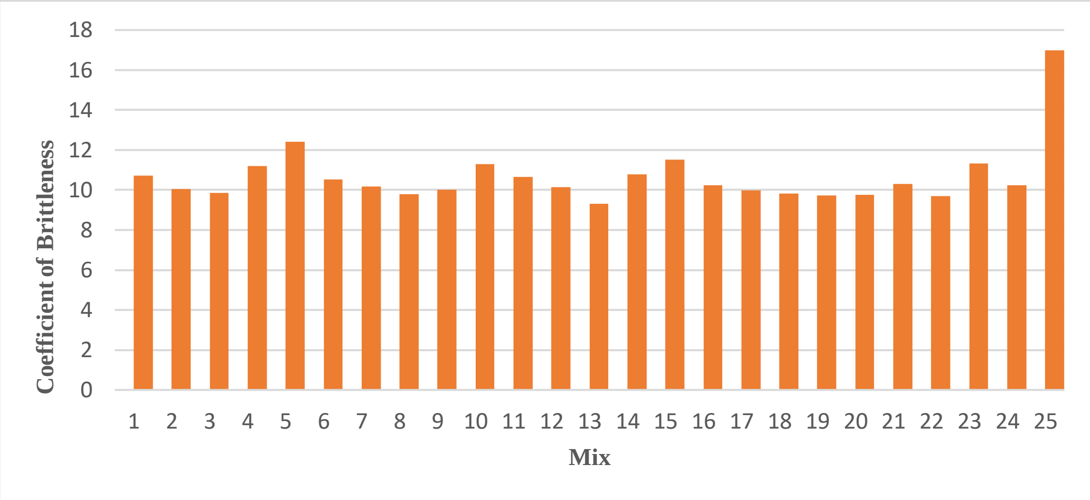

Fig 6: Coefficient of brittleness of variable mixes

Up to 10% more hypo sludge results in a decrease in the coefficient of brittleness; beyond that point, the coefficient of brittleness rises. This is due to a drop in cement concentration at larger sludge dosages, which causes weak bonding, particularly surrounding sludge particles. As a consequence, early fracture development eventually materialized during the compressive test. As the percentage of polypropylene fibre rises, the coefficient of brittleness falls up to 0.5%. It then resumes its growth after that.

This is because polypropylene fibre helps to create a solid aggregate with good cohesion. But a higher fibre dosage makes the concrete stiffer and harder to collapse, which results in the formation of air spaces. It is recommended that the S 13 (10% hypo sludge and 0.5% polypropylene fibre), which has the lowest coefficient of brittleness (9.32), be used. Additionally, S25 has a maximum coefficient of brittleness of 15.24. This is due to a higher concentration of hypo sludge and polypropylene fibre interfering with the concrete's proper adherence.

CONCLUSION

Examining the compressive strength and splitting tensile strength of concrete containing polypropylene fibre and hypo sludge was the aim of the present study. The study's objectives were to evaluate the outcomes of adding concrete and substituting part of the hypo sludge with cement and polypropylene fibres. 0% to 20% hypo sludge and 0% to 1% fibre made with polypropylene. A water-to-cement ratio of 0.38 was decided upon after many mix experiments, and it was maintained throughout each mix. Concrete underwent tests to ascertain its compressive strength and splitting tensile strength after 7, 14, and 28 days of curing. According to the findings of the experimental research, concrete mixed with 0% to 10% of hypo sludge concentration showed a constant increase in compressive strength and splitting tensile strength for all curing ages. Strength is greatly reduced after that. This is as a result of the water-to-cement ratio being altered by the hypo sludge's ability to absorb water. The compressive strength and splitting tensile strength of concrete mixed with 0% to 0.5% polypropylene fibre increased steadily for all curing ages. After that, the compressive strength is drastically reduced. Larger fibre doses result in air gaps that make concrete stiff and difficult to crush, which tends to lower strength. The use of hypo sludge and polypropylene fibre increases the strength of concrete for all curing ages up to a certain threshold. After then, the concrete's durability abruptly begins to deteriorate. because higher doses of concrete lead it to lose its ability to establish a good connection. Combinations of at least 0.75 percent polypropylene fibre and at least 15% hypo sludge have shown to lose strength. Therefore, using more hypo sludge and polypropylene fibre than required is not recommended. As a result of the concrete's inadequate adhesion at higher doses, cracks start to show up sooner. The greatest compressive and splitting tensile strengths were found in the M13 combination, which also included 0.5% polypropylene fibre and 10% hypo sludge. Thus, S13 is suggested for maximum strength. Mix S13 (10% hypo sludge, 0.5% polypropylene fibre) is the best option since it has the greatest coefficient of brittleness (11.49), has the lowest coefficient of brittleness (6.18) and the maximum dose of hypo sludge and polypropylene fibre. The cost-feasibility study reveals that incorporating hypo sludge into concrete decreases the cost of the substance while weakening it. Generally speaking, employing hypo sludge (waste material) in concrete might save disposal costs for the paper industry while producing strong concrete for construction. Additionally, it is feasible to concurrently lessen the damaging effects that cement manufacture has on the environment.

REFERENCES

1. Ahmadi B, Al-Khaja W. Utilization of paper waste sludge in the building construction industry. Resource Conservation Recycle. 2001;32(2):105-13. doi: 10.1016/S0921-3449(01)00051-9.
2. Ahmed S, Bukhari IA, Siddiqui JI, Qureshi SA. A study on properties of polypropylene fiber reinforced concrete. 31st Conference on Our World in Concrete and Structures. Singapore; 2006. p. 63-72.
3. Alam M, Berera V. An experimental study on use of hypo sludge in cement concrete. Int J Progr Civ Eng. 2015;2(1):1-23.
4. Altindag. Correlation of specific energy with rock brittleness concepts on rock cutting; 2003.
5. J South Afr Inst Min Metall:163-72.
6. Awang H, Mydin AO, Ahmad MH. Mechanical and durability properties of fiber lightweight foamed concrete. Aust J Basic Appl Sci. 2013;7(7):14-21.
7. Bagherzadeh R, Pkravan HR, sadeghi AH, Latifi M, Merati A. An investigation on adding polypropylene fibers to reinforce light weight concrete composites. J Eng Fabr Fibers. 2012;7(4):13-21.
8. Balamurugan R, Karthickraja R. An experimental investigation of partial replacement of cement by industrial waste (hypo sludge). J Eng Res App. 2014;4(4):430-35.
9. BIS. 10262-2009: recommended guidelines for concrete mix design. New Delhi: Bureau of Indian Standard; 2004.
10. BIS. 1199-1959 (reaffirmed 2004): methods of sampling and analysis of concrete. New Delhi: Bureau of Indian Standard; 1999.
11. BIS. 2386 (Part I). New Delhi: Methods of Test for Aggregates for Concrete, Bureau of Indian Standard; 1963 (Reaffirmed; 2002).
12. BIS. Specification for coarse and fine aggregates from natural sources for concrete. New Delhi: Bureau of Indian Standard-1997; 1970. p. 383 (Reaffirmed; 2002).
13. BIS. Methods of physical tests for hydraulic cement. New Delhi: Bureau of Indian Standard; 1988. p. 4031 (Part 4, 5&6)-1988.
14. BIS. Code of practice- plain and reinforced concrete. New Delhi: Bureau of Indian Standard; 2000. p. 456 (Reaffirmed; 2005).
15. BIS. Methods of tests for strength of concrete. New Delhi: Bureau of Indian Standard; 1959. p. 516 (Reaffirmed; 2004).
16. BIS. Splitting tensile strength of concrete-Method of test. Delhi: Bureau of Indian Standard; 2004. p. 5816-1999 (Reaffirmed; 2004).
17. BIS. Specification for 43 grade OPC. New Delhi: Bureau of Indian Standard; 2005. p. 8112-2013.
18. Broda J, Brachaczek W. Influence of polypropylene fiber geometry on the mechanical properties of cement mortars. Fibers Text East Eur. 2015;23(2):123-29.
19. Brown R, Shukla A, Natarajan KR. Fiber reinforcement of concrete structures. URITC Project no 536101. Kingston, RI: University of Rhode Island Transportation Center; 2002.
20. Garcia R, Vegas I, Frias M, Rojas MIS. The pozzolanic properties of paper sludge waste. Construction Build Mater. 2007;22:1484-90.
21. Gencel O, Ozel C, Brostow W, Martínez-Barrera GM. Mechanical properties of self- compacting concrete reinforced with polypropylene fibers. Mater Res Innov. 2011;15(3):216-25. doi: 10.1179/143307511X13018917925900.
22. Ismail M, Ismail MA, Lau SK, Muhammad B, Majid Z. Fabrication of bricks from paper sludge and palm oil fuel ash. Conc Res Lett. 2010;1(2):60-6.