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STUDY ON EFFECT OF LATHE WASTE METAL FIBERS IN TITANIUM DIOXIDE ETP SLUDGE CONCRETE

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Abstract- *Concrete is the most important construction material, which is manufactured at site. Concrete required for extensive construction activity can always be made available since all the ingredients of concrete are materials of geological origin. The rapid increase in construction activities leads to scarcity to conventional construction materials such as cement, fine aggregate and coarse aggregate. Researchers are being conducted for finding cheaper materials. In India, there are many industries producing large amount of effluent treatment plant waste sludge which leads in problems of disposal. The effective reuse of effluent treatment plant sludge of* TiO_2 *pigment generated from Kerala Minerals and Metals Ltd (KMML). Reuse of ETP sludge in concrete is an effective option for the problem of ultimate disposal up to greater extent.Steel scraps as a waste products used by innovative construction industry and also in transportation and highway industry. In addition to get sustainable progress and environmental remuneration, lathe scrap as worn-recycle fibbers with concrete are likely to be used. Compressive strength, flexural strength, impact strength, fatigue strength and split tensile strength were increased but up to 0.5-2% scrap content. In this study the fine aggregate will be replaced by ETP sludge of* TiO_2 *and lathe machine waste steels fibers will be added by weight of cement with different percentage increasing structural properties. The various tests such as compression, tensile, and flexural strength will be conducted and results will be compared with specimen without replacement.*

Keywords*: ETP Sludge and Lathe Waste Steel Fibers.*

1. INTRODUCTION

Concrete is a construction material which consists of the mixture of fine, coarse aggregate, cement which proportionally mixed with certain percentage of water. The importance of concrete as construction material is increasing every day. Surfaces of sawdust concrete hollow bricks have outstanding adhesion which guarantees a successful coating with various paints and varnishes, or other finishing materials. Sand as a primary fine aggregate possesses superior adhesion of components in concrete. It provides strength by serving as small fillers in a mixture. Cement binds sand particles together forming one solid sand mix.

Effluent Treatment Plant (ETP) sludge of Titanium dioxide (TiO_2) is also called Titania, which is a substance manufactured from selected sand. KMML is India's first and only manufacturer of Rutile Grade Titanium dioxide by chloride process. Effluent treatment plant sludge can be effectively used for replacement for fine aggregate. In India there are many industries which produce large amount of effluent treatment plant sludge in every year which leads to increasing problems in disposal and environmental degradation due to continuous exploration and depletion of natural resources. Since the land is limited, another method should be used for the disposal of industrial waste sludge. The pollution control board and also various researchers are trying to reduce the environmental degradation of the industrial wastes by various researches including in the field of concrete. This ETP sludge can be used as replacement of fine aggregate.

Steel scrap fiber reinforced concrete (SSFRC) defined as composite materials made with OPC, aggregates and reinforced with steel scrap randomly distributed fibers or discrete discontinuous fibers. Steel fibers balance the forces by transmitting tensile forces to the steel fibers which run along the cracks, as the result flexural toughness and flexural strength increases to great amount. Fibers are used broadly in two types of concrete structure i.e. Reinforced concrete structure using steel bars and non-reinforced structure. Addition of lathe scrap instead of steel fibers in plain cement concrete improves it flexural, compressive and impact strength. As the SFRC, the Lathe Scrap Reinforced Concrete (LSRC) also reduces the crack width when subjected to flexural load. In general, the mechanical properties of the concrete are increased by increasing the proportion of the lathe scrap up to 1.5%.The thickness of concrete pavement can be reduced to nearly 40%, when mixed with lathe scrap up to 1.5% by volume, which is economical when compared to plain cement concrete slab .The energy absorption capacity was increased almost linearly with the fiber content. Concretes containing lathe scrap have been shown to have substantially improved resistance to impact and greater ductility of failure in compression, flexure and torsion and can be effectively used in pavementThe present study deals with replace fine aggregate with ETP sludge of TiO_2 and lathe machine waste steels fibers and optimizes the percentages. Further, comparison of specimen with or without replacement by conducting tests such as compression, tensile and flexural strength. The cement used was of OPC 53 grade.

2. EXPERIMENTAL DETAILS

2.1 Materials

The cementations materials used in this study were ordinary Portland cement 53 grade, ETP sludge from KMML Pvt Ltd. Lathe waste metal fibres from mechanical workshops. The properties of cement is shown in Table 1. The chemical composition of ETP sludge and Lathe waste metal fibers are shown in Table 2 and Table 3. Table 4 shows the properties of admixture used. The ETP sludge used obtained from KMML India Ltd. and its properties are shown in Table 4. The coarse aggregate used was crushed stone of 20mm nominal size with specific gravity 2.65. The fine aggregate used was M sand with afineness modulus of 2.722.

Table-1 Properties of cement

SL. NO.	PARTICULARS	VALUES
1	Fineness of cement	6%
2	Specific gravity of cement	3.13
3	Consistency of standard cement paste	30.75%
4	Initial setting time	92min
5	Final setting time	267min
6	3^{rd} day compressive strength (N/mm^2)	28
7	7^{th} day compressive strength (N/mm^2)	32

Table-2 Chemical Contents of ETP Sludge of TiO_2

SL NO	CONSTITUENT	CONCENTRATION (%)
1	TiO_2	22.22
2	Carbon	35.5
3	Fe_2O_3	38.3
4	SiO_2	0.87
5	Al_2O_3	1.6
6	V_2O_5	0.13
7	Cr_2O_3	0.1
8	Others	3.3

Table-3 Properties Lathe Scrap

SL NO.	PROPERTIES	VALUES
1	Cross-section	Straight and deformed
2	Diameter(mm)	.33-.77
3	Length(mm)	25 -40
4	Density(kg/m^3)	7850
5	Young's modulus(N/mm^2)	$2x10^5$
6	Tensile Strength(N/mm^2)	500-3000
7	Specific gravity	7.85
8	Aspect Ratio	45-100
9	Elongation (%)	5-35

Table -4 Properties of Ceraplast-300

SUPPLY FORM	Liquid
COLOUR	Brown
CHEMICAL NATURE	Naphthalene formaldehyde based
SPECIFIC GRAVITY	1.24
SOLID CONTENT	40%
RECOMMENDED DOSAGE	0.3% to 1.2% by weight of cement

2.2 Mix proportioning

This study limited to the preparation of 10 different types of mixes. The first mix is a control mix and the next 5 mixes prepared by replacing fine aggregate by weight with ETP sludge in 5%,10%,15%,20% and 25%.After that at optimum percentage of replacement fine aggregate is added with 0.5%,1%,1.5% and 2% of lathe metal scrap by weight. For all 10 mixes the grade of cement used was M30.The various mix designation are shown in Table 5. At optimum percentage of replacement fine aggregate that is 15%, then added with 0.5%,1%,1.5% and 2% of lathe metal scrap by weight as shown in Table 6. The mix proportion for M30 grade of concrete is shown in Table 7.

Table-5 Mix designation for ETP sludge

MIX	FINE AGGREGATE PERCENTAGE	ETP SLUDGE PERCENTAGE
M30	100	0
M30+S5%	95	5
M30+S10%	90	10
M30+S15%	85	15
M30+S20%	80	20
M30+S25%	75	25

Table -6 Mix designation lathe waste addition

MIX	FINE AGGREGATE PERCENTAGE	ETP SLUDGE PERCENTAGE	LATHE WASTE METAL PERCENTAGE
M30+S15%+0.5%	85	15	0.5%
M30+S15%+1.0%	85	15	1.0%
M30+S15%+1.5%	85	15	1.5%
M30+S15%+2.0%	85	15	2.0%

Table-7Quantity of materials per cubic meter of concrete

SL NO	MATERIALS	QUANTITY
1	Cement	394 kg/m^3
2	Fine Aggregate	670.660kg/m^3
3	Coarse Aggregate	1215.184 kg/m^3
4	Water	157 kg/m^3
5	W/C ratios	0.39

2.3 Specimen preparation and test

Mixing was done in a laboratory type pan mixer. Pan mixers with revolving star of blades were used. While preparation of concrete specimens, aggregates, cement and mineral admixtures were mixed in the revolving pan. After proper mixing, mixture of water and plasticizer were added. The mixing was continued until a uniform mix was obtained. The concrete was then placed into the moulds which were properly oiled. After placing of concrete in moulds proper compaction was given using the table vibrator. Specimens were demoulded after 24 hours of casting and were kept in a curing tank for curing till the age of test.Cube specimens of dimensions 15 x 15 x 15 cm and 10 x 10 x 10 cm, cylindrical specimens of dimensions 15 x 30 cm and 10 x 20 cm and beam specimens of dimension 50 x 10 x10 cm were casted for different tests. The first session involved only the cube compression test for finding the optimum amount of ETP sludge. It conforms to IS 516-1959. Nine cubes were casted for each mix for finding the compressive strength after 3, 7 and 28 days. The test was conducted in a compression testing machine of capacity 2000kN, at a loading rate of 14N/mm^2 per minute. The compressive strength was calculated from the failure load divided by the cross sectional area of the resisting loads. The specimen used was of dimension 15 x 15 x 15 cm. The obtained results of compressive strength test for the first session are shown in Table 8. From which the optimum amount of ETP sludge was found as 10% based on the mean target strength. The results obtained for the second session for finding the optimum percentage lathe waste in optimum percentage of ETP sludge waste shown in Table 8.

Table-8 Compressive strength for different percentages of ETP Sludge (Mpa)

MIX	STRENGTH OF 3DAY	STRENGTH OF 7DAY	STRENGTH OF 28DAY
M30	20.26	25.55	36.50
M30+5%	18.25	23.55	35.90
M30+10%	17.73	22.10	35.06
M30+15%	18.04	27.44	33.84
M30+20%	15.45	20.11	29.55
M30+25%	12.34	18.62	24.88

Table-9 Compressive strength for different percentage of lathe waste(Mpa)

Mix	3day	7day	28day
A	18.04	27.44	33.84
A+0.5%	30.23	30.23	34.86
A+1.0%	31.66	31.26	35.90
A+1.5%	36.23	36.23	36.20
A+2%	32.36	32.36	35.26

Figure-1 Compressivee Strength Test

The flexural strength characteristics have similar tendency of compressive and the split tensile strength. The addition of ETP sludge instead of fine aggregate leads decrease in flexural strength of concrete. The flexural strength of 5% replaced concrete shows the similar characteristics with the normal concrete.

Table -9 Flexural strength value for for different percentages of ETP Sludge (Mpa)

Mix	**28 Day**
M30	4.19
M30+5%	4.17
M30+10%	4.13
M30+15%	4.09
M30+20%	4.01
M30+25%	4.00

Table-10 Flexural strength value for for different percentages of lathe Waste (Mpa)

Mix	**28 Day**
A	4.09
A+0.5%	4.38
A+1.0%	4.57
A+1.5%	4.98
A+2.0%	4.52

Figure-2 Flexural strength Test

The split tensile strength decreases with increase in the addition of ETP sludge. Split tensile strength of 5% replaced concrete is less than, the normal concrete. And the strength reduces with the increase of replacement. The split tensile value of different mixes are given in the Table 11 and table 12 shows split tensile value for different mixes.

Table-11 Split tensile value for different mixes

Mix	**28 Day**
M30 M30	3.60
M30+5%	3.58
M30+10%	3.50
M30+15%	3.48
M30+20%	3.42
M30+25%	3.40

Table-12 Split tensile value for different mixes

Mix	**28day**
A	40.30
A+0.5%	38.26
A+1.0%	42.30
A+1.5%	40.98
A+2.0%	37.86

Figure-3Splite TensileTest

The Young's modulus values are obtained from stress-strain diagram obtained by carrying out the test on 150mm × 300mm cylinders. Table 13and table14 shows the Modulus of elasticity for the 28day mixes.The modulus of elasticity decreases when replacement increases. The workability should be less when ETP content increases so the compaction is not effective thus there is more voids in the concrete. Therefore increase in the strain occurs and thus modulus of elasticity decreases. Modulus elasticity at lathe scrap addition showa increasing decreasing profile.

Table-13 Modulus of Elasticity value for for different percentages of ETP Sludge (Mpa)

Mix	**28 Days**
M30	46.30
M30+5%	36.20
M30+10%	46.28
M30+15%	40.30
M30+20%	44.30
M30+25%	38.46

Table -14 Modulus of Elasticity value for different percentages of ETP Sludge (Mpa)

Mix	**28day**
A	40.30
A+0.5%	38.26
A+1.0%	42.30
A+1.5%	40.98
A+2.0%	37.86

Figure-4 Modulus of ElasticityTest

Carbonation depth first just increases then decreases as the increase in replacement of fine aggregate. This may be due any chemical reaction occurs. The variation carbonation depth for different mixes for 56 day and 90 day are shown in the Table 15

Table-15 Depth of carbonation value for different mixes

Mix	Carbonation Depth	
	56day	**90 day**
A	5	7
A+0.5%	4	6
A+1.0%	3	5
A+1.5%	2	4
A+2.0%	2	3

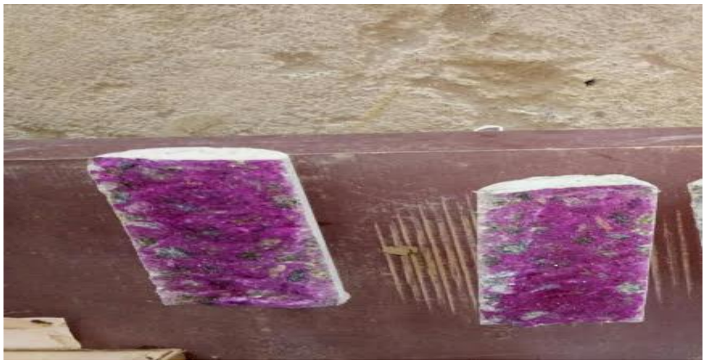

Figure-5CarbonationTest

Chloride induced reinforcement corrosion is the main durability problem for concrete structures in marine environment.If the chlorides reach the reinforcement steel, it will depassivate and start to corrode in presence of air and water. Since the corrosion products have a larger volume than the initial components, stresses are induced in concrete, leading to spalling and degradation of the concrete structures. By measuring the depth of penetration of chloride ions we can determine the resistance of concrete to chloride attack. The obtained depth of penetration of chloride ions for various mixes are presented in the Table16

Table-16 Depth of penetration of chloride ions

Mix	**Depth of penetration of chloride ions (mm)**	
	56 days of chloride exposure	**90 days of chloride exposure**
A	1	2
A+0.5%	2	3
A+1.0%	4	5
A+1.5%	6	7
A+2.0%	4	5

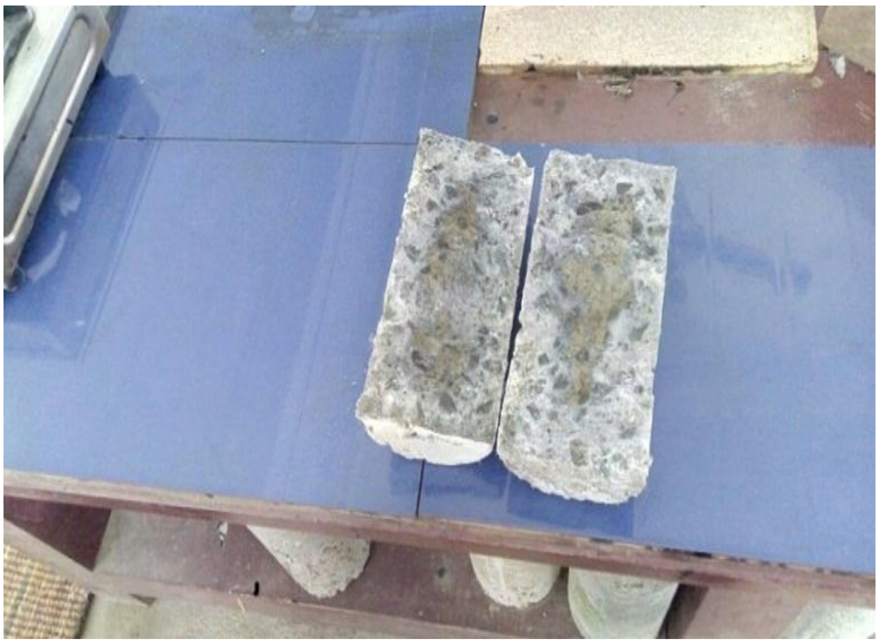

Figure-6 Chloride penetetionTest

The concrete specimens were kept submerged in normal water for first 3 days after casting and then in magnesium sulphate solution of 20,000 ppm for next 56 and 90 days. There were no significant changes on the surface of any of the specimens exposed to sulphate environment. The compressive strength of 10 cm cube specimens was determined and the values obtained for cubes with and without exposure to sulphate attack were compared. The percentage weight loss of samples exposed to sulphate environment was calculated and it was compared with that of the water cured specimens. This test was conducted for both 56 and 90 days. The test results are presented separately in table17.

Table -17 Strength variation at 56 days for specimens exposed to sulphate environment

Mix	**Water cured Strength (MPa)**	**Sulphate cured Strength (MPa)**
A	38	35
A+0.5%	30	26
A+1.0%	28	23
A+1.5%	30	26
A+2.0%	28	24

CONCLUSIONS

Experimental investigations are carried out to study the replacement of fine aggregate by ETP sludge of TiO_2 in concrete and lathe scrap metal fibres are added in at optimum percentage of replacement of fine aggregate to improve its mechanical properties .The properties such as compressive strength, flexural strength, split tensile strength ,modulus of elasticity, impact resistance and durability properties such as carbonation and chloride penetration were examined. The major conclusions drawn from this research are presented below.

1. The workability of the mix containing ETP sludge of TiO_2 shows an inverse relation with the increase of replacement.
2. The compressive strength of 5% replaced concrete has 98.35% of compressive strength of ordinary concrete and compressive strength of 10%, 15% replaced mix have attained 96.06% and 92.71% of strength of reference mix respectively.
3. The split tensile and flexural strength of 5% replaced concrete are less but approximately similar to the ordinary M30 mix.
4. The environmental degradation due to the effect of ETP sludge can be reduced up to certain limits by the partial replacement.
5. The increased cost of construction due to the scarcity of fine aggregate can be reduced with the ETP sludge up to some extent.
6. Based on these studies, up to 15% replacement of ETP sludge is possible in the concrete for achieving the target mean strength as per Indian standered code of mix design.
7. At 5% of ETP sludge replacement is recommended based on these studies for getting similar properties of normal concrete.
8. An optimum of 1% of lathe scrap as an addition can be used to improve the strength of fiber reinforced concrete.
9. At 1% of addition of lathe scrap addition the compressive strength increases up to 20.10% at 3day when compared to specimen with optimum percentage of percentage of replacement with ETP sludge.
10. 13.39% increase in compressive strength at 7days when compared to specimen with optimum percentage of percentage of replacement of ETP sludge and 17.12 % increase in 28 day strength.
11. The waste steel scrap material which is available from the lathe can be used as steel fibres for innovative construction industry.

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