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Study of Concrete by Replacing Fine Aggregate by ETP Sludge of TiO_2

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ABSTRACT
The rapid increase in construction activities leads to scarcity of conventional construction materials such as cement, fine aggregate and coarse aggregate. Researches 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 final destination of effluent treatment plant sludge affects the environment. So alternative option is necessary for disposing effluent treatment sludge. In this study is subjected to the effective reuse of effluent treatment plant sludge of TiO_2 pigment generated from Kerala Minerals and Metals Ltd (KMML). The aim of the thesis is to determine the strength parameters of concrete with the partial replacement of fine aggregate by waste sludge from KMML. Reuse of ETP sludge in concrete is an effective option for the problem of ultimate disposal up to greater extent. In this study the fine aggregate is replaced by the ETP sludge of TiO_2 with different percentages such as 5%, 10%, 15%, 20%, and 25% in M35 concrete mix. The various tests such as compression, tensile and flexural strength are conducted.

Keywords- ETP Sludge, Effluent Treatment Plant, Partial Replacement

I. INTRODUCTION

The construction materials such as concrete, bricks, hollow blocks, solid blocks, pavement blocks and tiles are produced from various natural resources. Now a days construction activities increases all over the world. This sudden increase of these activities causes the shortage of conventional construction materials. It will mostly affect in the case of fine aggregate. River sand is the mostly used fine aggregate in the concrete for the construction purposes. The fine aggregate is used in the concrete for producing better workability and uniformity in concrete.The demand of concrete is increases day by day. It will cause the utilization of river sand in large volume. It will cause the exploitation of natural resources and affects the water table...etc. and also cost of river sand increased in last few years due to the administrative restrictions.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.

In this study focuses the replacement of fine aggregate by ETP sludge of TiO2in M35 mix. The fine aggregate is replaced by 5%, 10%, 15%, 20%, and 25% with waste sludge. The various tests such as compression, tensile and flexural strength are conducted.

1.1 ETP Sludge of TiO_2

Titanium dioxide (TiO2) 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. The chlorides of impurity metals are removed from Titanium Tetra Chloride (TiCl4) by various processes to complete the manufacture of TiCl4. It is further purified by distillation to obtain pure Titanium Tetra Chloride in the liquid form. Titanium Tetra Chloride is vaporized, pre heated and oxidized with oxygen in the Oxidation Plant to produce raw Titanium Dioxide at a high temperature. The raw Titanium Dioxide is then classified and surface treated with various chemicals, filtered and washed to remove the salts, sent to the dryer. The Titanium Dioxide pigment in powder form which is as an ingredients in the manufacture of paints. The effluents generated due to the production of TiO2 contain the various chemicals and it is leads to the problems of disposal and degrading the environment. The chemical composition of ETP sludge was tested at the research lab at KMML which is approved by pollution control board of Kerala. The chemicals contents of effluent treatment plant sludge of TiO2 are presented in table below.

Fig 1. ETP Sludge of TiO_2

Table 1.Chemical contents of ETP sludge of TiO_2

No.	Constituent	Concentration (%)
1	TiO_2	22.2
2	Carbon	33.5
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

II. OBJECTIVES OF WORK

The ETP sludge from various industries are used as the construction materials. The study is carried out for finding the mechanical properties of concrete which is replaced by the ETP sludge of TiO_2.

1) To study the material properties of the materials
2) To study the strength parameters of the concrete which is replaced the fine aggregate by the ETP sludge.

2.1 Methodology

The Study was conducted in following steps,

1) Literature review
2) Inventory Survey
3) Experimental Investigation
4) Conclusion

III. MATERIALS USED

3.1 Cement

Cement can be defined as the bonding material having cohesive & adhesive properties. Ordinary Portland cement (OPC) confirming to IS 12269 (53 Grade) was used for the experimental work. Laboratory tests were conducted on cement to determine specific gravity, fineness, standard consistency, initial setting time, final setting time and compressive strength. Test results are mentioned on table below.

Table 2. Properties of Cement

Particulars	Values
Grade	OPC 53
Specific gravity	3.15
Standard Consistency, %	31.25
Fineness, %	4
Initial setting time, min	90
Final setting time, min	270

3.2 Fine Aggregate

M sand was used as fine aggregate. Laboratory tests were conducted to determine the different physical properties as per IS 2386 (Part III)-1970.

Table 3.Properties of Fine aggregate

Sl. No.	Test conducted	Result
1	Specific gravity	2.61
2	Bulk density	1.836gm/cc
3	Void ratio	0.346
4	Porosity	0.257
5	Fineness modulus	4.949

3.3 Coarse Aggregate

The size of aggregate is 20mm is used for the preparation of specimens. Laboratory tests were conducted on coarse aggregates to determine the different physical properties as per IS 2386. The properties of coarse aggregate are shown in Table below

Table 4. Properties of Coarse aggregate

Sl. No.	Test conducted	Result
1	Specific gravity	2.641
2	Bulk density	3.873gm/cc
3	Void ratio	3.385
4	Porosity	0.772%
5	Apparent specific gravity	2.666
6	Percentage of water absorbed	0.356%
7	Fineness modulus	5.883

3.4 Super Plasticizer

The super plasticizer used was Ceraplast 300 M which is developed by Cere-chemPvt Ltd, Chennai. It is compacted for blended cements, especially with slag cement. Creaplast 300 is a new generation high grade and high performance retarding super plasticizers specially designed for concrete replacement of cement up to 70-80 percentages by slag.it provide the good workability and increase the strength characteristics up to 25 percentages for properly designed concrete mix.

3.5 Water

Generally portable water should be used for the construction purposes. This is to ensure that the water is free from impurities such as suspended solids, organic matter and dissolved salts, which may adversely affect the properties of the concrete.

IV. MIX PROPORTION

The mix proportion for the M35 grade of concrete was arrived through trial mixes. The mix proportion for M35 grade of concrete is shown below

Table 5. Mix design

Mix	Cement	Fine Aggregate	Coarse Aggregate	Water
1	395.25	697	1107	158.1

V. RESULTS AND DISCUSSIONS

The fine aggregate in the concrete is replaced up to a certain percentage by ETP sludge of Tio2 in the concrete. The material properties and strength parameters of replaced concrete is studied. Each test result plotted in the figures and in the tables is the mean value of results obtained by testing of three specimens.

5.1 Workability

Compaction factor test is conducted for finding the workability of the concrete. The workability of various mixes was assessed as per the IS 1199:1959 specification. The values of compacting factor are in Table and Figure given below. The workability of the concrete is decreased with increasing the replacement of fine aggregate. The water absorption rate of ETP sludge is higher than the fine aggregate. Water cement ratio is maintained and super plasticizer is added for improving workability.

Table 6. Compacting factor values for different mixes

Mix	**Compaction factor**
M35	0.88
M35 + 5%	0.87
M35 + 10%	0.85
M35 + 15%	0.83
M35 + 20%	0.80

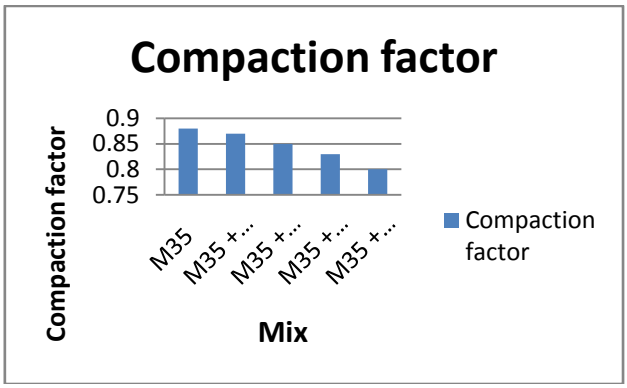

Fig 2.Variation of slump value

5.2 Compressive strength

The results showed that the compressive strength of the concrete is decreased when the addition of ETP sludge increases in the concrete. In 5% replaced mix, the compressive strength of the concrete is decreased by 0.85% of normal concrete. The strength parameter shows an inverse relation with the addition of replacement of fine aggregate. However, the target mean strength is achieved up to 10% of fine aggregate replacement in the concrete as per the Indian slandered code of mix design.

Fig 3. Compression testing

Table 7. Compressive strength for different mixes (N/mm^2)

Mix	**7 day**	**28 day**	**56 day**
M35	36.46	46.6	48.22
M35 + 5%	35.93	46.2	48.18
M35 + 10%	34.45	45.23	46.98
M35 + 15%	31.85	43.15	44.32
M35 + 20%	28.75	37.85	40.12

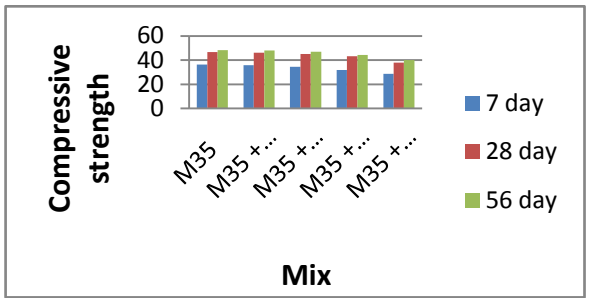

Fig 4. Variation of compressive strength for different mixes

5.3 Split tensile 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 below

Fig 5. Split tensile strength test on cylinder

Table 8. Split tensile strength for different mixes (N/mm^2)

Mix	28 day	56 day
M35	4.19	4.23
M35 + 5%	4.17	4.21
M35 + 10%	4.13	4.15
M35 + 15%	4.09	4.11
M35 + 20%	4.01	4.05

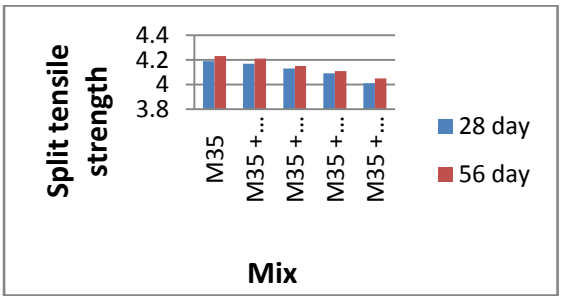

Fig 6. Variation of Split tensile strength for different mixes

5.4 Flexural strength

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. Flexural strength of various concrete mixes is tabulated below.

Fig 7. Flexural strength checking

Table 9. Flexural strength for different mixes (N/mm^2)

Mix	28 day	56 day
M35	5.52	5.71
M35 + 5%	5.49	5.60
M35 + 10%	5.41	5.56
M35 + 15%	4.30	4.31
M35 + 20%	3.19	3.24

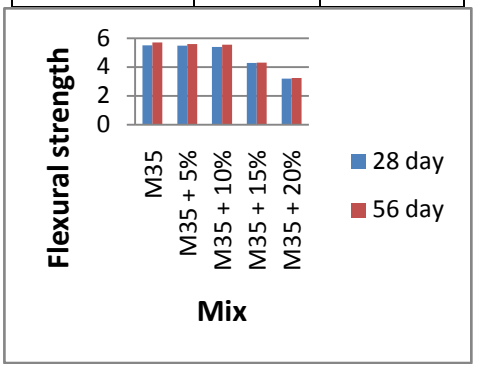

Fig 8. Variation of Split tensile strength for different mixes (N/mm^2)

VI. CONCLUSION

Experimental investigations are carried out to study the replacement of fine aggregate by ETP sludge of TiO2 in concrete. The mechanical properties such as compressive strength, flexural strength, split tensile strength, were examined. The major conclusions drawn from this research are presented below.

- The workability of the mix containing ETP sludge of TiO2 shows an inverse relation with the increase of replacement.
- The compressive strength of 5% replaced concrete has 99.14% of compressive strength of ordinary concrete and compressive strength of 10%, 15% replaced mix have attained 97.66% and 92.59% of strength of reference mix respectively.
- The split tensile and flexural strength of 5% replaced concrete are less but approximately similar to the ordinary M35 mix.
- The environmental degradation due to the effect of ETP sludge can be reduced up to certain limits by the partial replacement.

- The increased cost of construction due to the scarcity of fine aggregate can be reduced with the ETP sludge up to some extent.
- 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 slandered code of mix design. However 5% of ETP sludge replacement is recommended based on these studies for getting similar properties of normal concrete.

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