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Development of Concrete by Utilizing Toothpaste Industry Sludge Containing $CACO_3$ as Partial Replacement of Cement and Fine Aggregate

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***Abstract*— Concrete is the one of the major building construction materials and is widely used around the world. Cement and Sand are the main component of Concrete. Cement as mentioned above one of the basic major gluing materials used by construction industry mainly for concrete in large volumes. Its production leads to significant emission of carbon-dioxide; production of one ton of cement emits approximately one ton of carbon-dioxide. CO_2 is major contributor to the green house effect and the global warming of the planet, which is a major global environmental issue currently the planet is encountering. The sand; another raw materials of concrete, is also struggling to cope with the rapidly growing demand in many areas around the globe. The sources of good quality river sand is also depleting very fast. Sand is now being extracted at a rate far greater than their renewal. Tooth Paste manufacturing industries generate sludge (TPIS) in large quantity. Despite having high amount of calcium carbonate, as per present practices, such sludge are being used for filling low-lying areas or being burnt in cement kiln along with other toxic sludge. This paper presents an experimental investigation carried out to analyze the feasibility of using TPIS in partial replacement of cement & sand. From experimentation, it is observed that TPIS can be used in replacement of sand upto 15% to meet compressive strength requirements for M20 grade.**

***Keywords*: *Concretes, green house* effect *, global warming Toothpaste industrial sludge (TPIS), compressive strength*.**

I. INTRODUCTION

India is the world's fastest developing country with high economic growth rate targeting to become 5 trillion economy in coming years and further due to exponential growth of population in recent years we are currently on the verge of large-scale urbanisation creating hence a huge demand for physical infrastructure & building houses; thus for the materials to build them. The Indian economy has been growing at an average annual rate of 5-8% since 2001.For the 12th five year plan (2012-13 to 2016-17), the target has been set to achieve an average annual growth rate of 9%. The rate of urbanization in India has also been rapid with a decadal growth rate of 31.3% between 1991 and 2001 and 31.8% between 2001 and 2011. The overall urban population has increased from 217.17 million to 377.10 million during 1991 to 2011. The numbers of towns and cities have also increased from 3,768 to 7,951 during this period .The growth in the economy and population coupled with urbanization has resulted in an increasing demand for residential, commercial, industrial and public buildings as well as other physical infrastructure. Various studies indicate that, out of the total constructed area existing in India in 2030, about 70% would have been constructed between 2010 and 2030. Building construction in India is estimated to grow at a rate of 6.6% per year during the period 2005 to 2030. The building stock is expected to multiply five times during this period **(Figure-1.1)**, resulting in a continuous increase in demand for building materials. To cope up with this infrastructure & housing necessity, the country needs to build thousands of units of houses at least for the next 10 years. Housing is the primary need of every human being. As for the human body, carbons are the building block, cement concrete & bricks are the building blocks of a house. There is great demand for construction and thus increasing pressure for use of natural resources causing their acute shortage.

This rapid industrialisation and urbanisation which is always associated with the problem of environmental degradation. With the advent of pollution control technologies, the industries are able to combat air and water pollution.

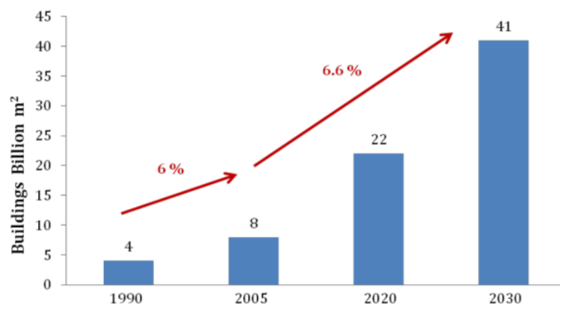

Figure-1.1: Projected Increase in Building Area in India [3]

However, the treatment of industrial effluents invariably results in the generation of large volume of the sludge transferring pollutants from liquid phase to solid phase. The indiscriminate disposal of the sludge from effluent treatment plants deteriorate surface soil and contaminate ground and surface water, which become an important environmental and

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public health issue. Considering the seriousness of the same, the Ministry of Environment and Forests (MoEF), Government of India, listed chemical sludge from wastewater treatment as hazardous waste (MoEF 2008). Under the guidelines for Management and Handling of hazardous wastes, land fill disposal is recommended for inorganic sludge from wastewater treatment plants (MoEF, 1991). Besides collection, transport and storage of wastes, construction of secured land fill sites pose problems of land acquisition, high land and construction cost, closure of site, environmental monitoring etc. Therefore, it is now a global concern to find a socio, techno-economic and eco-friendly solution to dispose industrial solid wastes. The recycling of industrial solid wastes as substitute for building materials is not only environment friendly but also cost effective alternative way to sustain a cleaner and greener environment. Nevertheless, the manufacture of these building materials emits gaseous pollutants which are well known for its ill-effects towards global warming. Hence the usage of industrial solid wastes as building materials will exhibit environmental benefits such as conservation of natural resources/raw materials, decrease landfill capacity , reduce mining activity, minimize global warming. Considering the environmental concern, the use of industrial solid wastes, especially, use of effluent treatment plants (ETP) sludge as a partial supplement to building materials plays an important role and it is gaining a great momentum.

Concrete, the single most widely used building material around the globe is a heterogeneous composite that consists of combination of readily available basic building materials including cement, water, coarse aggregate, fine aggregate. The reason behind the enormous use of concrete in the construction sector lies in its versatile, reliable and sustainable nature, because of its strength, rigidity, durability, mouldability, efficiency and economy. Humans have been using concrete in their pioneering architectural feats for millennia.

The raw materials of concrete i.e. river sand and gravel, are also struggling to cope with the rapidly growing demand in many areas around the globe. The sources of good quality river sand and gravel are depleting very fast. According to United Nations Environment Program (UNEP-GEAS) report, “Sand-rarer than one thinks”, published in March,2014[7] , sand and gravel has now become the most widely used natural resource on the planet after water. These are now being extracted at a rate far greater than their renewal. Globally, between 47 to 59 billion tonnes of material mined every year, of which sand and gravel account for the largest share from 68% to 85%. The use of aggregates for concrete all over the world can be estimated at 25.9 billion to 29.6 billion tons a year for 2012 alone.

This problem natural materials can be tackled by using some waste material to replace some part of the primary component which in turn can also solves the disposal problem of the waste material. This will also help in economizing the resources. It will help in conservation of resources and reducing pollution. Also, there will be reduction in construction cost. One such material is toothpaste industry sludge. Huge amount of dry toothpaste sludge is produced on daily basis. There are two ways to solve the problem.

Few studies have been performed on utilizing sludge materials in the process of concrete making. *Pitroda et. al (2013)* [3] conducted an experimental study for the innovative use of hypo sludge in concrete formulations as a supplementary cementitious material was tested as an alternative to traditional concrete. The cement has been replaced by waste paper sludge accordingly in the range of 0% (without hypo sludge), 10%, 20%, 30% & 40% by weight for M-25 & M-40 mix. *Ms. Monica C. Dhoka (2013)* [4] studied application of industrial waste such as marble powder, quarry dust, wood ash, paper pulp, etc. to reduce consumption of natural resource and energy and pollution of the environment. Use of such waste material saves 14%-20% amount of cement.

Abhishek Jain et al., (2013), [1] has proposed that the experimental studies on mortar containing flyash as a partial replacement of sand by weight as well as by volume were carried out to quantify its utilization. So, we decided to replace dry toothpaste sludge as soil. Experiments have been performed to study the effect of 10-50% clay replacement with toothpaste sludge. The flyash mortar mix 1:1:5 (cement:flyash:sand) by weight consumes about 20% less quantity of cement and overall consumption of flyash is also less. Further *Akshay C. Sankh et al. (2014)* [2], states in his paper foundry sand which is very high in silica is regularly discarded by the metal industry. Currently, there is no mechanism for its disposal, but international studies say that up to 50 percent foundry sand can be utilized for economical and sustainable development of concrete.

So, we decided to use dry toothpaste sludge as partial replacement of cement and sand. Experiments have been performed to study the effect of 10-50% cement and sand replacement with toothpaste sludge (TPIS).

II. MATERIALS AND PROPERTIES

A. Materials Used

Materials used in the study i.e. TPIS, Cement, Sand and Coarse aggregates, were locally procured. The toothpaste sludge was taken from a local toothpaste making factory. The sludge was kept in containers. It was available in powdered form **Figure- 2.1**. The physical properties of sludge were as per **Table-2.1**. The chemical composition was calculated from XRF/XRD tests. The composition of TPIS is described as below in **Figure- 2.2** and **Table 2.2(a&b).** The physical properties of cement, sandand coarse aggregate are given below in **Table-2.3,2.4(2&b) & 2.5** respectively.

Figure- 2.1: Lime sludge from the toothpaste industry(TPIS)

Table-2.1: Physical Properties of Material Used

Material	Specific Gravity	Fineness Modulus
Toothpaste Sludge	2.38	1.51

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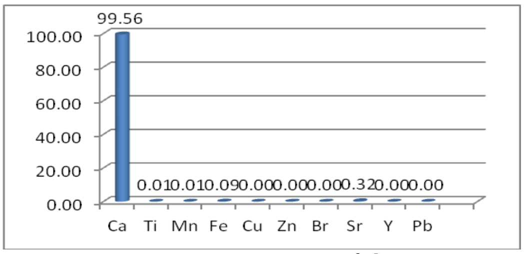

Figure- 2.2: Percentage concentration of elements present in the toothpaste sludge(XRF studies)

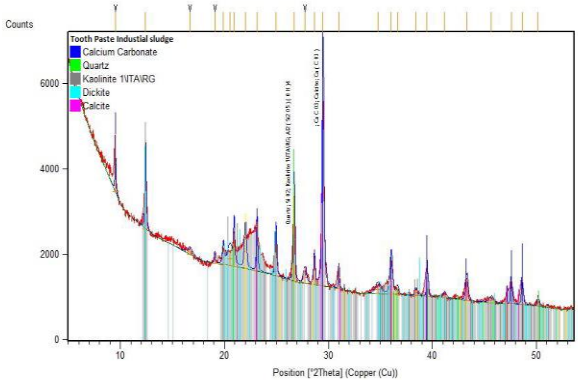

Figure-3.10 : XRD pattern of Toothpaste Waste

Table-2.2a: Chemical composition of toothpaste sludge

Composition	Percentage
O	50.15%
Ca	20.61%
Si	20.55%
C	7.23%
Na	0.64%
S	0.39%
Mg	0.26%
Al	0.07%
Cl	0.03%
P	0.03%
Fe	0.02%
Sr	0.01%
K	53ppm
Cu	14ppm
Zr	5ppm

Table-2.2b: XRD analysis for Compound study in toothpaste samples

Sr.no.	Element Oxides	Toothpaste Samples Mass (%)
1.	SiO_2	28.9
2.	Al_2O_3	0.962
3.	Fe_2O_3	0.116
4.	TiO_2	2.16
5.	CaO	59.3
6.	MgO	0.476
7.	Na_2O	0.34
8.	K_2O	0.839
9.	SO_3	3
10.	P_2O_5	3.68
11.	MnO	0.0138
12.	PbO	0
13.	ZnO	2.71
14.	S_2O_2	0.123

Table-2.3: Oxide analysis of cement using XRF

Sr.No.	Element Oxides	Cement(C) mass %
1.	SiO_2	20.19
2.	Al_2O_3	4.99
3.	Fe_2O_3	2.95
4.	TiO_2	0.44
5.	CaO	58
6.	MgO	3.73
7.	Na_2O	0.34
8.	K_2O	1.03
9.	SO_3	4.3
10.	P_2O_5	0.08
11.	MnO	0.06
12.	LOI	3.1
13.	IR	2.52

Table-2.4a: Physical Properties of Material Used

Material	Specific Gravity	Fineness Modulus
Sand	2.67	2.65

Table-2.4b: Chemical composition of River Sand

Sr.No.	Elements Present	River Sand
1	Aluminium (%)	3.96
2	Silicon (%)	37.88
3	Potassium (%)	1.20
4	Calcium (%)	0.87
5	Titanium (%)	0.20
6	Iron (%)	1.29
7	Vanadium (ppm)	49.6
8	Chromium (ppm)	69.1
9	Manganese (ppm)	246.8
10	Cobalt (ppm)	4.4
11	Nickel (ppm)	27.0
12	Zinc (ppm)	27.6

Table-2.5: Physical Properties of Coarse Aggregate

Physical Properties	Test Result	
	20mm Nominal Size	10mm Nominal Size
Specific Gravity	2.68	2.67
Water Absorption (%)	0.53	0.64
Bulk Density (kg/m^3)	1640	1590
Moisture Content	Nil	Nil

B. Mixing and Proportions

In this study, 11 mixes (including different Cement and Sand replacement mixes) were evaluated to study their engineering properties and to find out their behavior. Crushed & powdered TPIS was partially replaced for the Cement and fine aggregate (sand) in different replacements. The materials, work designs, and all tests are explained in this chapter.

Table: 2.6- Mix Proportion Quantities M20 concrete

Mix Constituents	For one cum of concrete (Kg)
Cement	348.33
Water	191.58

Fine aggregate	651.24 at 1.8% moisture (i.e. SSD condition)
Coarse aggregate	1201.10 kg-SSD condition i.e. 0.8% moisture 20mm = 600.55 kg 10mm = 600.55 kg
Admixture	3.4
Water cement ratio	0.54
Workability in mm after 45 min	85
3days average compressive strength (N/mm^2)	9.3
7days average compressive strength (N/mm^2)	14.3
28days average compressive strength (N/mm^2)	29.0 N/mm^2

Finally a mix of concrete of proportion M20 (1:1.85:3.50) was adopted for the present study **(Table 2.6 , 2.7 & 2.9).** The first mix MC is control mix having only cement as binder. The second mix MCTPSC series had toothpaste waste (powder-TPIS) as replacement of cement. The Third mix MCTPSS series had toothpaste waste (powder-TPIS) as replacement of Sand. The compressive strength tests were conducted to monitor the strength development of concrete containing upto 20% of this pozzolana as cement and Sand replacement.

Table 2.7- Description of Mixes

Set No.	Designations	Mix Description
1	MC	Mix with Cement and natural aggregates (Control Mix)
2	MCTPSC-1	Mix with Cement and natural Aggregates with 5% partial replacement of **Cement** with TPIS
	MCTPSC-2	Mix with Cement and natural Aggregates with 10% partial replacement of **Cement** with TPIS
	MCTPSC-3	Mix with Cement and natural Aggregates with 15% partial replacement of **Cement** with TPIS
	MCTPSC-4	Mix with Cement and natural Aggregates with 20% partial replacement of **Cement** with TPIS
	MCTPSC-5	Mix with Cement and natural Aggregates with 25% partial replacement of **Cement** with TPIS
3	MCTPSS-1	Mix with Cement and natural Aggregates with 5% partial replacement of **Sand** with TPIS
	MCTPSS-2	Mix with Cement and natural Aggregates with 10% partial replacement of **Sand** with TPIS
	MCTPSS-3	Mix with Cement and natural Aggregates with 15% partial replacement of **Sand** with TPIS
	MCTPSS-4	Mix with Cement and natural Aggregates with 20% partial replacement of **Sand** with TPIS
	MCTPSS-5	Mix with Cement and natural Aggregates with 25% partial replacement of **Sand** with TPIS

C. Preparation, Procedure of Mixing and Curing

The proportioning of quantity of both cement and aggregate is done by weight as per the concrete mix design. The water and the admixture are measured by volume. All measuring equipments were maintained in clean serviceable condition with their accuracy periodically checked. The workability tests are carried out immediately after mixing of concrete using the slump cone test. The specimens are used according to the

Table 2.8-The Details of Mixes used throughout the Investigation

Set No.	Designation	Cementitious Material (Kg)		Fine Aggregates (Kg)		Coarse aggregate (Kg)	Water (lts)	W/C Ratio	Super –Plasticizer (lts)
		Cement	TPIS	Sand	TPIS				
1	MC	15.00	--	27.50	--	52.50	8.10	0.54	0.015
2	MCTPSC-1	14.25	0.75	27.50	--	52.50	8.10	0.54	0.015
	MCTPSC-2	13.50	1.50	27.50	--	52.50	8.10	0.54	0.015
	MCTPSC-3	12.75	2.25	27.50	--	52.50	8.10	0.54	0.015
	MCTPSC-4	12.00	3.00	27.50	--	52.50	8.10	0.54	0.015
	MCTPSC-5	11.75	3.25	27.50	--	52.50	8.10	0.54	0.015
3	MCTPSS-1	15.00	--	26.13	1.37	52.50	8.10	0.54	0.015
	MCTPSS-2	15.00	--	24.75	2.75	52.50	8.10	0.54	0.015
	MCTPSS-3	15.00	--	23.36	4.14	52.50	8.10	0.54	0.015

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	MCTPSS-4	15.00	--	22.00	5.50	52.50	8.10	0.54	0.015
	MCTPSS-5	15.00	--	20.63	6.87	52.50	8.10	0.54	0.015

specification laid down in IS 516:1959. Standard cast iron cube moulds of size 150x150x150mm are used in the preparation of test specimens. The moulds have been cleaned to remove dust particles and applied with mineral oil on all sides before the concrete is poured into the mould. The admixture is mixed with the constituents of concrete at the time of adding water.

Thoroughly mixed concrete is filled into the mould and compacted in three equal layers and each layer was compacted 25 times with 5/8 inch diameter steel rod with a rounded end. Excess concrete is removed with trowel after proper compaction and top surface is smoothened. After casting, the specimens are stored in the laboratory with room temperature for 24 hours from the time of addition of water to the ingredients. After 24±2 hours period, the specimens are removed from the moulds and immediately submerged in the clean and fresh water tank. The specimens are cured for 28 days marked then completely immersed in city water until the time of testing.

III. RESULTS AND DISCUSSIONS

The experimental results of this study concerned with concrete properties are presented and discussed for the fresh properties, unit weight tests were conducted, while for the hardened properties, compressive strength.

The results and properties of various mixes tested are shown below.

A. Unit Weight

The fresh unit weight for all concrete mixes was determined, listed in **Table- 3.1** and plotted in **Figure- 3.1(a), (b) & (c).**

Table-3.1 Fresh unit weight for all mixes

Set No.	Details	Designation	Weight of Cube (avg) (Kg)	Unit Weight (Kg/m^3)
1	Mix with Cement and aggregates (Control Mix)	MC	8.103	2400.80
2	Mix with Cement and Aggregates with partial replacement of **Cement** with TPIS	MCTPSC-1	7.891	2338.07
		MCTPSC-2	7.297	2162.07
		MCTPSC-3	6.910	2047.40
		MCTPSC-4	6.432	1905.77
		MCTPSC-5	6.012	1781.33
3	Mix with Cement and Aggregates with partial replacement of **Sand** with TPIS	MCTPSS-1	7.992	2368.00
		MCTPSS-2	7.321	2169.18
		MCTPSS-3	7.121	2109.92
		MCTPSS-4	6.892	2042.07
		MCTPSS-5	6.531	1935.11

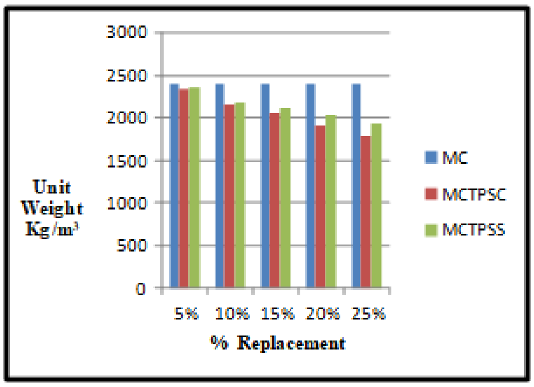

Figure- 3.1(a)

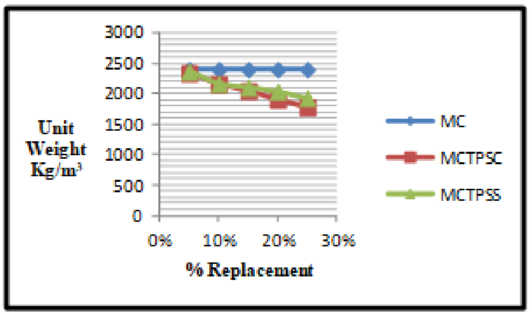

Figure- 3.1(b)

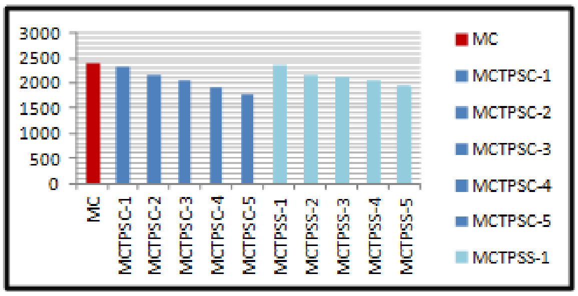

Figure- 3.1(c)

Figure- 3.1(a),(b) & (c) Graphs showing trends f reduction in Unit Weight w.r.t %age Replacement

The results indicate that the using of TPIS led to the density of the concrete mixes decreasing as compared with the control mix. This is because of the lower specific gravity of the TPIS as compared with Cement and Sand. The Mixes with Cement and natural Aggregates with partial replacement of Cement with TPIS indicated lower densities relative to Mixes with partial replacement of Sand with TPIS. This decrease is due to the lower specific gravity of sand compared to cement. However, densities as compared with control mix, as shown in **figure 3.1(a), (b) & (c)**. This behavior may be exhibited to the advantage of the reduction of weight in concrete mix due to the using of TPIS.

B. Compressive Strength Test

Compressive strength is generally the main property value used to investigate the concrete quality in the codes. That is why, it is very important to evaluate whether changes

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in the mixture composition will affect the early and later compressive strength of concrete. The compressive strength results (IS: 516-1959 (RA 2013)) for all mixes at ages of 3, 7, 14 and 21days are shown in **table 3.2**.

Table 3.2- Compressive Strength for all mixes at different age of curing

Set No	Details	Designation	Compressive Strength (N/mm^2) at the age of 3 Days	7 Days	14 Days	28 Days
1	Mix with Cement and natural aggregates (Control Mix)	MC	11.1	18.1	25.0	28.0
2	Mix with Cement and natural Aggregates with partial replacement of **Cement** with TPIS	MCTPSC-1	10.1	16.1	22.8	25.3
		MCTPSC-2	8.8	14.5	20.2	22.6
		MCTPSC-3	8.0	12.7	18.1	20.1
		MCTPSC-4	5.8	9.2	12.9	14.1
		MCTPSC-5	4.3	6.8	9.5	10.9
3	Mix with Cement and natural Aggregates with partial replacement of **Sand** with TPIS	MCTPSS-1	11.0	18.3	25.0	27.7
		MCTPSS-2	10.5	18.4	25.0	27.7
		MCTPSS-3	10.2	18.0	24.6	27.4
		MCTPSS-4	9.6	15.9	21.6	24.1
		MCTPSS-5	8.4	13.5	18.5	20.7

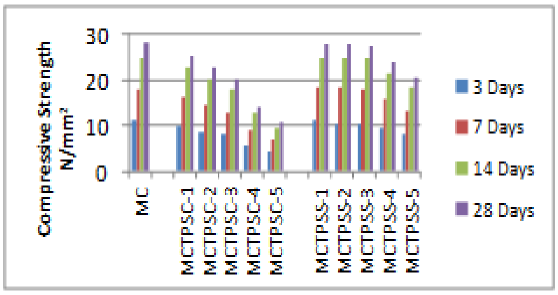

Figure-3.2: Compressive strength development for control mix and all mixes in sets 2 and 3

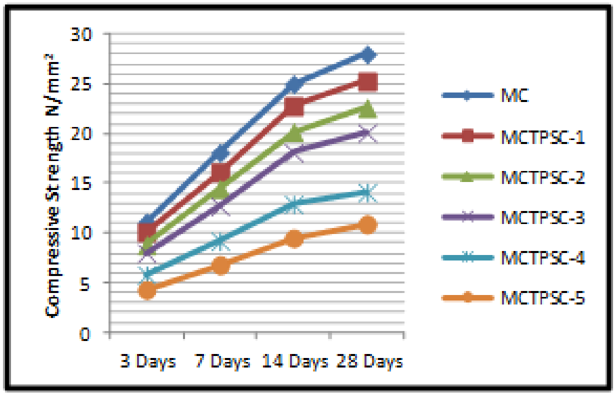

Figure 3.3: Compressive strength development for control mix and all mixes in set 2

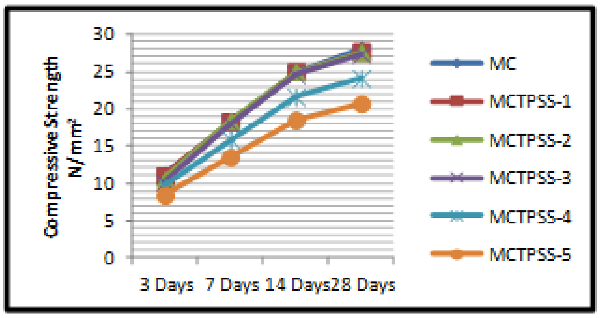

Figure 3.4: Compressive strength development for control mix and all mixes in set 3

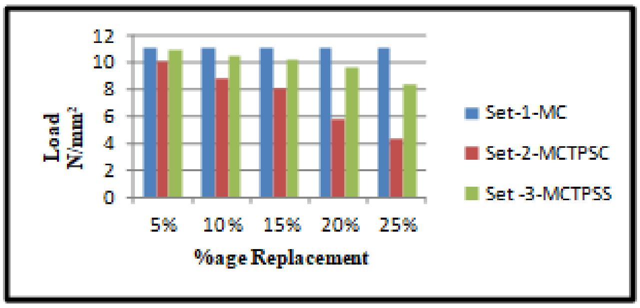

Figure- 3.5(a)

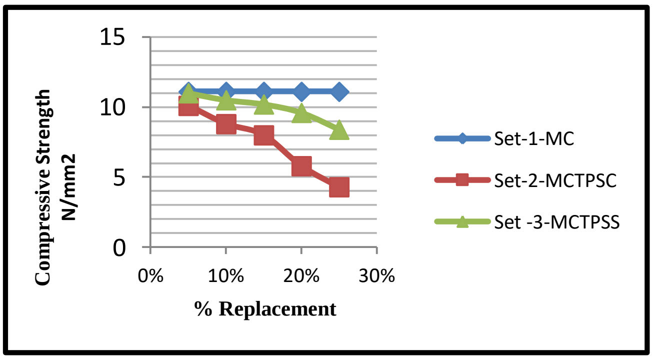

Figure- 3.5(b)

Figure- 3.5(a) & (b): Graphs showing compressive strength at the age of 3 Days

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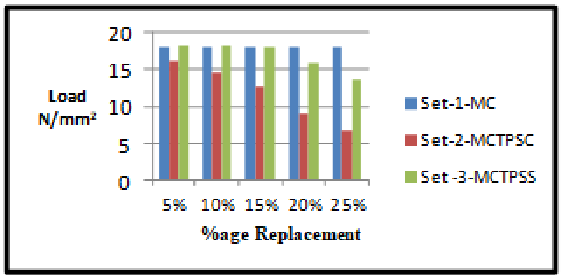

Figure- 3.6(a)

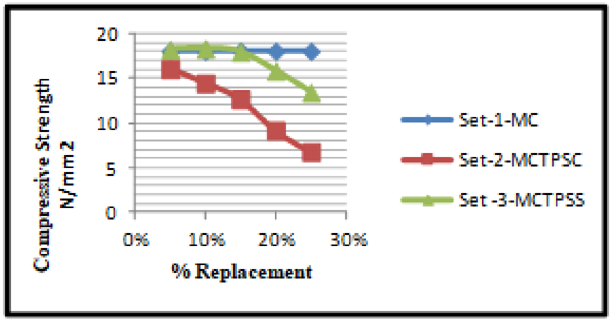

Figure- 3.6(b)

Figure- 3.6(a) & (b): Graphs showing compressive strength at the age of 7 Days

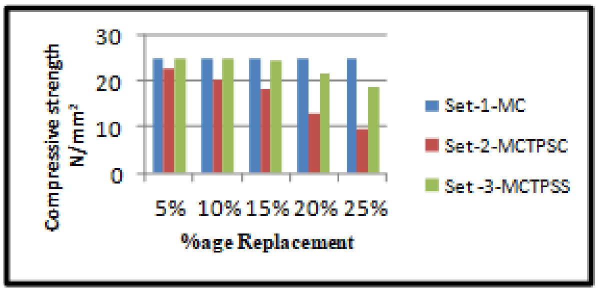

Figure- 3.7(a)

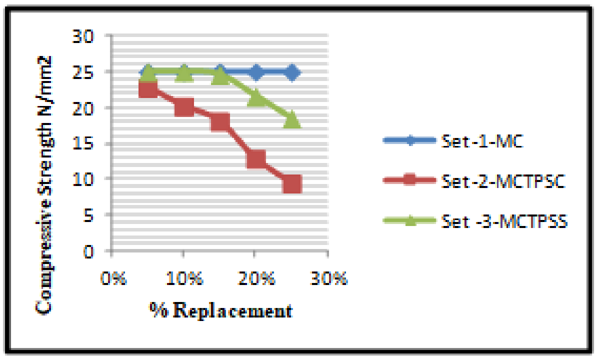

Figure-3.7 (b)

Figure- 3.7(a) & (b): Graphs showing compressive strength at the age of 14 Days

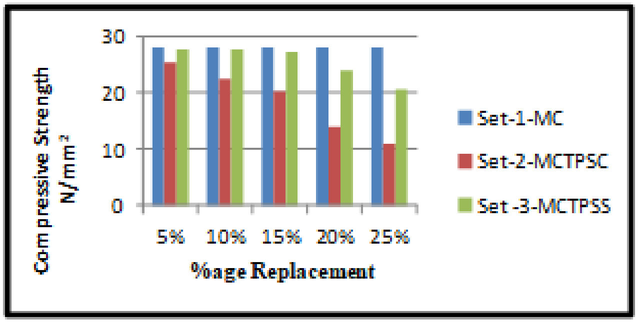

Figure- 3.8(a)

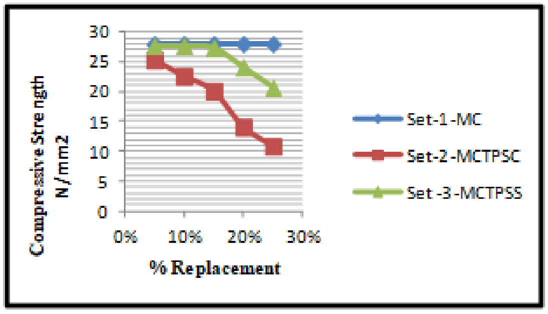

Figure- 3.8(b)

Figure- 3.8(a) & (b): Graphs showing compressive strength at the age of 28 Days

The compressive strength with age for the control mix and mixes containing 5, 10,15,20 and 25% of TPIS as partial replacements of Cement & sand and the comparison between the values of the compressive strength for the same mixes are plotted and show in **figures-3.2 to 3.8** respectively.

C. Discussion

The following observations can be drawn from these figures of test results:

1. The using of TPIS has a highly negative effect and reduction on the compressive strength at all ages of the test in set no.2 mixes (MCTPSC) i.e. partial replacement of cement with different % of TPIS. This effect increases relatively with the increase of TPIS replacement. This behavior may be because of lower or inert behaviour or non-cementitious properties between the TPIS and cement paste, mainly attributed to the non-reaction of TPIS. At initial replacement of 5 to 10% there has been decrease in strength with in permissible limits but on higher replacement it had been substantially high (**Figures- 3.3, 3.5 to 3.8**). An exception to this trend at initial replacement, which shows compressive strength with in lesser than those for mixes MCTPSC -3 to MCTPSC -5, may be that this increment is due to the effect of pozzolanic activity (very fine TPIS particles) prevailing over the inert effect of TPIS. **Figure-3.3** clearly indicates the continuous fall in strength with increase in replacement percentage in comparison to the strength of control mix.

2. MCTPSS (Set No.-3) mixes show a significant maintenance in strength with age. It can be observed that the percentage of compressive strength with age relatively maintained with the increment of TPIS replacements of sand with the strength of Control Mix (**Figures-3.4 to 3.8**) for MCTPSS upto replacement of sand by 15% i.e. MCTPSS-3. For example, compared with compressive strength of control mix average percentage compressive strength for mixes MCTPSS-1, MCTPSS-2 and MCTPSS-3 are 99.79, 98.80 & 96.90% i.e. very negligible fall in strength i.e. -0.22, -1.20 & -3.10 % respectively. This behavior refers to the pozzolanic activity as well as filler attribute of TPIS with very fine sand particles, as previously mentioned in the literature section. **Figure-6.4** clearly indicates the overlapping of graph lines of compressive strength with increase in replacement percentage upto 15% in comparison to the strength of control mix graph lines.

3. But for mix MCTPSS-4 & 5 i.e. replacement of sand by 20 % & 25% of TPIS there has been substantial decrease in strength in comparison to results of control mix (**Figures-3.3to 3.8**) i.e. -13.31% & -25.45%. Figure-6.4 indicated the segregation of graph lines of 20% & 25% from control mix & replacement of sand upto 15% which clearly indicates the continuous fall in strength with replacement percentage beyond 15% in comparison to the strength of control mix and replacement of sand below 15%.

IV. CONCLUSION

After the experimental investigation of use of toothpaste sludge in following conclusions were made: According to the obtained test results & specific findings with respect to concrete and fired clay bricks developed in this study lead to the following final conclusions:

- Compressive strength of concrete developed by with increasing percentage of replacement of cement with TPIS found decreasing to the extent that it started disintegrating or crumbling. The compressive strength of ‘cement-TPIS’ system reduces by more than 50% for 25% replacement of cement with TPIS from the Control Mix. There is an increase of 28.5% water absorption in the reference mix compared to the base mix. Though the addition of TPIS instead of cement makes the concrete lighter compared to the base mix. These results can be explained as TPIS is light weight and increases the initial porosity of the system and has a porous structure and cement has finer particle size compared to TPIS, which is a heavy material and improves packing of the matrix through interlocking on reaction. The loss in strength is mainly due to non-reactivity of TPIS and it acted as inert material on normal temperature. So it is concluded that TPIS is not useful as replacement of cement.
- In second system when sand is partially replaced with TPIS the Compressive strength is almost maintained with increasing percentage replacement upto 15% from the Control Mix. ‘Sand-TPIS’ system has no compressive strength reduction compared to Control Mix. This can be because of pozzolanic & granular structure of TPIS closer to sand properties. Further addition of TPIS to 20 to 25% instead of sand results in decrease of 13% to 25% respectively compared to the Control Mix. Further the mi so produces lighter concrete due to less specific gravity of the TPIS to sand. Thus, the performance of concrete on the parameter of compressive strength and weight so produced is better as a replacement of sand upto 15% with TPIS.

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