Sustainability And Cost Analysis, And Scope Of Shredded Rubber Tyres With Nano Silica

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Abstract- *The importance of creating infrastructure using processes which are environmentally responsible and sustainable and that can help make full use of available resources throughout that project's life-cycle is of great essence in today's times. It's estimated that millions of rubber tyres are discarded which acts as a landfill and takes up acres of useful land in the process. Here we aimed to tackle this problem and find an alternative which is eco-friendly and which can be used in any con- struction activity by coming up with an idea to use shredded rubber tyres in a mix of concrete with addition of 0.5-1% of nano-silica to enhance the strength of the mix leading to be a cost-effective material.*

The Slump Test for workability and a Compression Test was performed on the innovative mix of shredded rubber, nano-silica crystals, cement (M20) and other cementitious material.

Various combinations such as 5%, 10%,15% and 20% of the shredded rubber tyres were mixed with 25% of cementitious material and 0.5% of nano-silica in batches over a span of 7,14,28 days and their strengths were analyzed.

The various percentages of shredded rubber tyre used in the mix had different results. The trails of 5% and 10% of shredded rubber tyre were used to yield enough strength to be at par with the stand- ard requirement while the 15% replacement yielded the same strength as that of conventional concrete.

The cost estimation analysis of this experiment makes the alternative mix viable if purchased in a bulk quantity. The amalgamation of two highly different materials such as nano-silica and shredded rubber tyres can create a sustainable and environmentally responsible alternative which can bring in many such more innovative and eco-friendly replacements in the construction industry.

Keywords- Shredded rubber tyres, Sustainable, nano-silica.

I. INTRODUCTION

The quantity of natural resources is depleting day by day, material like river sand used for construction purposes are available in very less amount and therefore the price of this material increases the cost of construction. To reduce the cost of construction and preserve natural resources an alternate material is being used as tyres. The alternative material should be available in large amount in market and should be cheaper in price, by seeing the amount of shredded rubber tyres going as a waste in Maharashtra, Tyres is considered as an alternative to the river sand because of availability and for environmental purposes. These tyres will be used as a replacement of cement starting from 20% and increase by an interval of 5% until target strength achieved. The tyres used in concrete mixture reduces the strength of concrete, to enhance the bonding between tyres and other mixtures and to gain strength, there will be introduction of a material called Nano-silica. This nano material helps to reduce the carbon footprints from the concrete.

Application of nano technology in concrete is as a supplementary material which improves the durability, decreasing permeability, and overall hardened the properties of concrete. The small quantity of non-silica is enough to enhance the properties of concrete, i.e., 1% to 3% of the volume of concrete mix. Various other alternative materials such as GBBS, PP, waste papers and Ferro cement were also researched but due to reason such as Research gap not found and availability in markets is very less, these materials were rejected.

To check that the both the materials are having some effects on the concrete mix or not, test such as Workability test, soundness test, consistency test and compression test were done on the various cubes of the selected materials and their composition as per the concrete mix design been achieved thus far.

II. OBJECTIVES

- To identify and check feasibility of innovative and economical material in concrete mix design.
- To check optimum quantity of replacement.
- To analyze technical and market feasibility of Shredded rubber tires and Nano silica.

III. RESEARCH GAP

The study on nano silica and shredded rubber tyre has always been done separately. The nano silica has the property of enhancing strength in a material whereas rubber material has the property of durability. Hence, the combination of these two materials can lead to an innovative and zero wastage product. This can help in the sustainability of materials and provide a good environmental alterna- tive. The use of cheap discarded rubber tyres can help in reducing waste and also dropping the cost of materials if purchased in bulk. It also gives rise to various innovative ideas and concepts in the construction industry.

IV. METHOD/THE ORETICAL DEVELOPMENT

3.1Material Selection and Procurement

1. Nano Silica (nS): It is a nano size material which is used as a replacement of fly ash. The addi- tion of this material (1% to 3%) reduces the quantity of cement required for the concrete, due to which the nano silica reduces the carbon footprint from the concrete. This material increases the strength and improves the ductility of material. Nano Silica also helps to quickly repair cracks (used in self-compacting concrete). The only limitation of this material is availability of nS and it is expensive material.

•Quantity procured :2 kg (to be used 1kg only)
•Procurement location: Gandhinagar Gujarat
•Cost:1000/kg

Figure 1: Nano Silica

2. Waste Shredded rubber Tyres: Waste rubber tyres are waste available in a large amount and nearly 275000 tyres are discarded every day. So, to reduce the waste tyres are used to replace of cement. These waste tyres are shredded into smaller pieces of around 1 to 10 mm in size. The tyres initially reduce the strength of concrete, but with the help of nano technology (nS) that problem can be rectified.
Quantity procured: 80kg
Specific properties: size 4-5 mm
Procurement location: Gujarat
Cost:8/kg

Figure 2: Waste Shredded Rubber Tyres

Why did we use Shredded rubber tyres?

- Shredded rubber tyres constitute almost 12% of global waste.
- Being a member of Paris Climate pact India has to work towards its goal to reduce carbon footprints.
- Construction industry contributes heavily to usage of natural resources.
- •The usage of waste rubbertyres can reduce the load of recycling.
- •The rubber tyres can be used in place of fine as well as coarse aggregates in concrete.
- It enhances the workability of concrete and reduces the crack development.

Why did we use Nano Silica?

- Nano silica helps improve the strength, ductility and almost every factor.
- Helps repair cracks quicker
- High porosity
- Must be used as a very small % 1-3 and has greater impact
- The only negative point in using it is the cost involved. It's quite expensive, up to 1200 per kg.

Nano-silica modified coating is applied on the surface of concrete, which can prevent the degree of carbonization of concrete. The reason is that the nano-SiO2

particles reduce the microscopic defects in the concrete and the damage to the polymer molecules caused by ultraviolet rays foundthat within a certain dose range, the mass of hydrated calcium silicate gels (C-S-H) and ettringite crystal (AFt) gradually increased with the increase of nano-SiO2 content. The incorporation of Nano- SiO2 can optimize the pore structure of recycled aggregate concrete and limit the diffusion capacity- ty of chloride ions. Adding nano-SiO2 to the cementing system can accelerate the early hydration of concrete, which is very beneficial for strengthening the early strength of concrete.

V. LABORATORY TESTS

Tests Performed on Coastal Road Laboratory:

Slump test 180: Workability test (Slump test): Concrete Slump Test is a measurement of concrete's workability, or fluidity. It's an indirect measurement of concrete consistency or stiffness. A slump test is a method used to determine the consistency of concrete. Generally concrete mix with Nano Silica comes around 80 mm to 100 mm. We will be proceeding with this step as soon as the materialswill get delivered.

Compression Test: Compression test is a measurement of concrete's strength or compression the concrete can bear. As the grade of our concrete is M20 and generally this grade of concrete results with the compressive value between 13 to 20 MPa.

VI. CONCRETE MIX DESIGN

In order to study such kind of mix between shredded rubber tyres, Nano silica and other materials used in concrete, we started with M20 grade of concrete and in order to learn its effectiveness in concrete we have decided to check various combinations of shredded rubber tyres such as 5%, 10%, 15%, 20% and 25% of cementitious material and keep Nano Silica constant with 0.5% of cementitious material. The combination which will achieve the target strength will be considered the most effective concrete mix.

For M20 grade of concrete, the target strength which we need achieve is 26.6 Mpa. And the maximum water cement ratio is 0.55, and we have considered it as 0.4. and the other details are mentioned in the table below.

VII. RESULTS AND DISCUSSION

1.Casting

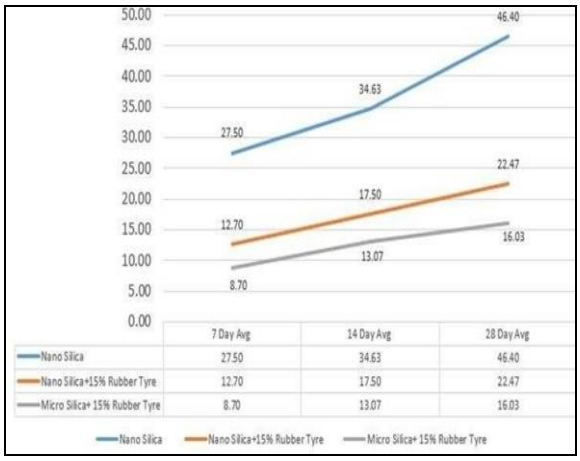
Casted 9 cubes of Nano-silica concrete cubes and more 9 cubes with the mix of Nano-silica and 15% Waste Shredded rubber tyres. Similarly, 9 cubes with the mix of Micro-silica and 15% Waste Shredded rubber tyres.

Table 2: Compression Test Results

		Nano Silica	Nano Silica+15% Rubber Tyre	Micro Silica+ 15% Rubber Tyre
7 DAYS	CUBE 1	27.1	12.9	8.9
	CUBE 2	27.8	13.2	8.4
	CUBE 3	27.6	12.2	8.9
	7 Day Avg	**27.5**	**12.7**	**8.7**
14 DAYS	CUBE 1	36.3	18.5	13.1
	CUBE 2	33.2	17.2	12.5
	CUBE 3	34.4	16.8	13.6
	14 Day Avg	**34.6**	**17.5**	**13.1**
28 DAYS	CUBE 1	45.2	19.9	14.6
	CUBE 2	46.2	23.6	17.1
	CUBE 3	47.8	23.9	16.4
	28 Day Avg	**46.4**	**22.5**	**16.0**

The results of Nano-silica were way beyond our target in 28 days, and in Nano-silica + 15% rubber tyre,, due to rubber the strength de- creased and reached very close to our target strength. And in micro-silica + 15% rubber tyre has showed the lowest strength among these mixes.

Comparison and observation the behavior of strength in 28 days.



Reason for failure:

1. It became very light weight by replacement with rubber tyres
2. The strength replacement was not up to the mark even after addition of nano silica.
3. Could not increase content more of nano silica so we replaced it with micro silica (90% purity) at a higher percent still could not compensate strength

So, moved on to a final solution of decreasing rubber content from 15 to 10 and 5 %respectively.

Casting 2

Table3: Strengths of cubes of three mix designs

		Nano Silica+5% Rubber Tyre	Nano Silica+10% Rubber Tyre	Nano Silica+15% Rubber Tyre
7 DAYS	CUBE 1	15.8	13.3	12.9
	CUBE 2	15.1	12.4	13.2
	CUBE 3	15	13.8	12.2
	7 Day Avg	**15.3**	**13.2**	**12.8**
14 DAYS	CUBE 1	21.8	18	18.5
	CUBE 2	21.1	18.7	17.2
	CUBE 3	22.5	19.1	16.8
	14 Day Avg	**21.8**	**18.6**	**17.5**
28 DAYS	CUBE 1	27..9	25.8	19.9
	CUBE 2	27	24.6	23.6
	CUBE 3	28.5	25.1	23.9
	28 Day Avg	**27.8**	**25.2**	**22.5**

Here, we have tested 3 cube mixes of different percentage of waste shredded tyre i.e., 5%, 10% and 15% as concluded above. From here we can see that, 28 days strength of Nano-silica with 5% has given the required strength.

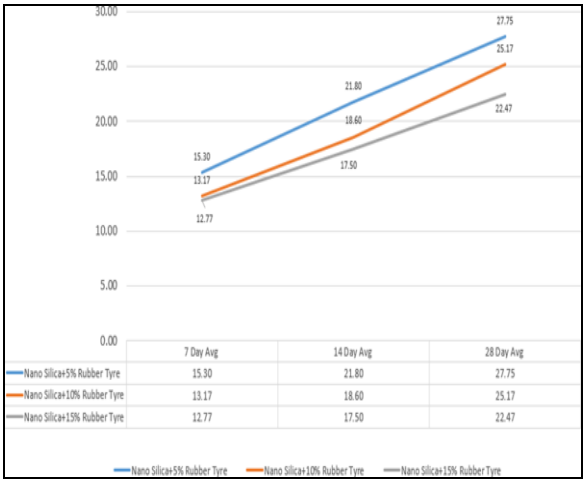


Figure5:Graph comparing all three mix designs

Discussion: Initially started with a combination of 15% rubber tyres with nano silica and we're also performed 20, 30 ,40% replacements with rubber tyres, but while performing we realized the strength was compromised due to loss in weight due to rubber replacements.

We also experimented by replacing nano-silica with micro silica and com- pared the strengths, but micro failed so we continued with nano silica only with 15%, 10%, 5% replacements and completed the project and checked if that would provide a sustainable and cost effective fit

VIII. CONCLUSION

a. The designed concrete which consists of rubber material and Nanosilica attains the goals of or sustainability and strength.

b. It replaces cementitious material which saves a huge amount of natural resources and gives the strength with lightweight product.

c. The chemical composition of the concrete is moreover same to the conventional concrete as nano-silica increases the binding between aggregates and rubber

d. The trails of 5% and 10% replacements gave results more than expected value .

e. The trail of 15% replacement gave same strength as of the conventional concrete

f. The cost of designed concrete includes processing of rubber which is slightly higher than the conventional concrete

g. This newly developed concrete perfectly obtains all the Sustainable developments Goals

h. It reduces the wastage of natural resources and increases the efficient reuse of waste rubber material.

i. The cost analysis conducted for the experimental outcomes design depict 20-25% increase compared to the conventional design

j. This estimate determines the retail prices of the components used for concrete design.

k. The cost is expected to reduce by a significant number when produced in mass quantum..

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