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Feasibility Study On Compressive Strength Of Roller Compacted Concrete Pavement Using Nano Silica And Natural Fibre

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Abstract
Roller compacted concrete is similar to conventional concrete but it is having zero slump. The major advantage of Roller Compacted Concrete Pavement (RCCP) is it is more economical than the conventional concrete. In this research banana fibre is taken as the natural fibre. In this paper feasibility study of the composition for the RCCP with Nano Silica and Banana fibre has been specifically studied. Compressive tests according to IS 519 are conducted on RCCP using various compositions of Nano Silica such as 0%, 0.25% , 0.5% , 0.75% , 1.0% , 1.25% , 1.50% , 1.75% , 2.0% , 2.25% , 2.50%, 2.75% & 3.0% and also Banana Fibre of compositions 0.5%, 1.0% , 1.5% , 2.0% 2.5%, 3.0%. The results states that the feasible composition of Nano Silica isupto 2% and Banana fibre is upto 1.5%. Using the above conclusion further research can be carried out.

Keywords. RCCP, Banana fibre, Nano Silica, Compressive strength.

1. Introduction

Roller compacted concrete (RCC) is similar to conventional concrete but it is having zero slump[1]. RCC is transported, placed and then compacted with the earth and rock fill equipment's[2]. The ingredients of RCC is similar to conventional concrete which are cement, fine aggregate, coarse aggregate and water[3].RCC is mainly used as the pavement and it is sustainable and economical[4]. The cost of RCC pavement construction is 15%-30% lower than the cost of construction of conventional concrete pavement. Cost reduction is the main advantage of RCC[5]. Cement and water contents of RCC are comparatively lesser than the contents of the conventional concrete[6]. The compressive strength of RCC pavement is mainly depends upon the cement hydration and compaction[7]. The split tensile strength of RCC was lower than that of conventional concrete due to the no reinforcement used[8]. Roller compacted concrete is not appropriate when the materials like coarse and fine aggregate are of poor quality and not reasonably available, this is the main disadvantage of RCC[3]. The Mechanical performance of RCC is mainly depends upon the aggregate size. The compressive strength of RCC pavement is decreases with the increasing the aggregate size[9].

As RCC pavement is not having any reinforcement bars, all the applied loads on RCC pavement are transferred through the aggregates to lower courses and which results in the formation of the of tensile cracks, thermal and shrinkage cracks[10]. In order to improve ductility and bending resistance of RCC

pavement, materials such as fibres, polymers can be added[11]. Fibres are mainly classified into two categories, they are natural fibres and synthetic fibres[12].Natural fibres are more advantageous than the synthetic fibres in terms of availability and cost effectiveness[13]. Several studies have been carried out on utilizing the natural fibers as the additional material in producing the concrete[14].Cellulose fibre-reinforced concrete has been observed to improve mechanical properties [15]. On the other hand studies relating top coconut fibre has also shown good improvement for the mechanical properties [16]. In the research where banana fibre was incorporated in the self-compacting concrete, it has given positive results by improving mechanical properties [17] .

Nano silica have been used in the RCC addition to cement to reduce the loss in strengths of RCC when natural fibre is added to improve the ductility performance by minimizing the tensile cracks[18].Nano silica can improve partial losses occurred due to incorporation of fibre[10]. It is observed that the Nano Silica would be very useful in improving the mechanical properties. However the content of nano silica used for the improvement is up to 3%[19].Researchers found that Nano silica is a high purity amorphous silica powder, if when added may certainly increase the properties such as mechanical[20]. Nano silica has also being used to develop early strength, early age hydration and proved to be advantageous[21].In cases where nano silica was used upto 3 % with nano carbon black, it improved both flexural and mechanical properties[22].

In this research the compressive tests are conducted to find out the optimum requirement of nano silica and fibre content.

2. Materials

Recently world is mainly focusing on environmental sustainability by reducing the CO_2 gas emission. Approximately 10% of CO_2 emission is from the cement production.In this experimental work ordinary Portland cement of 53 grade with chemical composition shown in Table 1 was used throughout the entire work. The physical properties of cement such as specific gravity 3.15 and initial setting time of 46mins and final setting time of 135mins.Fly ash of class F with specific gravity of 2.20 is used as the filler material.The river sand of specific gravity 2.6 is used as the fine aggregate material.The coarse aggregate of sizes 6.35mm and 19mm of specific gravity 2.64 is used.Nano silica of mean size 5-20nm is used.Banana fibre of density 1.35g/cc is used as the natural fibre with tensile strength of 720Mpa.

Table 1 : Cement and Flyash Properties

Oxides composition (%)	Cement	Flyash
SiO_2	20.76	51.06
Al_2O_3	5.54	21.76
Fe_2O_3	3.35	3.15
MnO	-	0.028
CaO	61.4	8.54
MgO	2.48	1.45
Na_2O	0.19	2.03
K_2O	0.78	1.23
TiO_2	-	0.68
Loss of Ignition	2.2	1.20
Specific Gravity	3.15	2.3
Blaine Fineness (m^2/Kg)	325	291

Table 2 : Nano Silica Properties

Properties	Unit	Typical Value
Specific surface area	m^2/g	200±25
Average primary particle size	nm	12
Tamped density	g/l	approx. 50
Moisture	wt.%	<= 1.5
Ignition loss	wt.%	<=1.0
Ph		3.7-4.7
SiO2-content	wt.%	>=99.8

Table 3 : Banana Fibre Properties

Properties	Unit
Physical Properties	
Appearance	Gold brown fibre
Length(mm)	30-40mm
Diameter(mm)	1-3 mm
Density(g/cm^3)	1.3
Tensile strength	650-780 MPa
Chemical Properties	
Tenacity	29.98g/denier
Fineness	17.15
Moisture Regain	13.00%
Elongation	4%
Alco-ben extractives	1.70%
Total cellulose	65.00%
Alpha cellulose	61.50%
Residual gum	41.90%
Lignin	21.00%

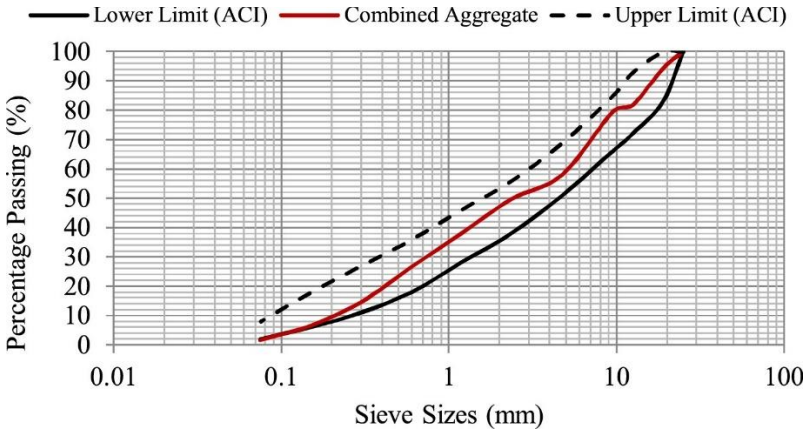


Figure 1: Combined Gradation curve of Aggregates

3. Methodology

3.1. Mix Proportion

As per ACI 327R-14 and ACI 211 design mix has been prepared for OPC 53 grade which is having a compressive strength of 25Mpa at 28 days[23]. Nano silica is taken as percentage of weight of cement. The mix proportion for Nano silica is shown in Table 4. Banana fibre is taken as the percentage of volume of concrete and its mix proportion is shown in Table 5.[24]

Table 4: Mix proportion for Nano silica

Mix	Nano silica (%)	Cement (kg/m^3)	Nano silica (kg/m^3)	Filler (kg/m^3)	FA (kg/m^3)	CA 6.35mm (kg/m^3)	CA 19mm (kg/m^3)	Water (kg/m^3)
N Ctrl	0	268.69	0.00	103.76	1148.05	415.03	416.85	98.24
N1	0.25	268.69	0.67	103.76	1148.05	415.03	416.85	98.24
N2	0.50	268.69	1.34	103.76	1148.05	415.03	416.85	98.24
N3	0.75	268.69	2.02	103.76	1148.05	415.03	416.85	98.24
N4	1.00	268.69	2.69	103.76	1148.05	415.03	416.85	98.24
N5	1.25	268.69	3.36	103.76	1148.05	415.03	416.85	98.24
N6	1.50	268.69	4.03	103.76	1148.05	415.03	416.85	98.24
N7	1.75	268.69	4.70	103.76	1148.05	415.03	416.85	98.24
N8	2.00	268.69	5.37	103.76	1148.05	415.03	416.85	98.24
N9	2.25	268.69	6.05	103.76	1148.05	415.03	416.85	98.24
N10	2.50	268.69	6.72	103.76	1148.05	415.03	416.85	98.24
N11	2.75	268.69	7.39	103.76	1148.05	415.03	416.85	98.24
N12	3.00	268.69	8.06	103.76	1148.05	415.03	416.85	98.24

Table 5: Mix proportion for Banana fibre

Mix	Banana fibre (%)	Cement (kg/m^3)	Banana fibre (kg/m^3)	Filler (kg/m^3)	FA (kg/m^3)	CA 6.35mm (kg/m^3)	CA 19mm (kg/m^3)	Water (kg/m^3)
F Ctrl	0	268.69	0	103.76	1148.05	415.03	416.85	98.24
F1	0.50	268.69	6.50	103.76	1141.55	415.03	416.85	98.24
F2	1.00	268.69	13.00	103.76	1135.05	415.03	416.85	98.24
F3	1.50	268.69	19.50	103.76	1128.55	415.03	416.85	98.24
F4	2.00	268.69	26.00	103.76	1122.05	415.03	416.85	98.24
F5	2.50	268.69	32.50	103.76	1115.55	415.03	416.85	98.24
F6	3.00	268.69	39.00	103.76	1109.05	415.03	416.85	98.24

3.2. Compressive Test Procedure

To evaluate the compressive strength the cube specimens of size 15x15x15 cm were prepared according to the IS: 516-1959 and tested by the compressive testing machine[25]. The results are tabulated in the table 6 and table 7.

Table 6: Compressive test results for Nano silica

Mix type	Compressive strength in Mpa
N Ctrl	30.05
N1	31.20
N2	31.50
N3	31.80
N4	31.95
N5	32.40
N6	32.50
N7	32.90
N8	33.20
N9	33.40
N10	30.00
N11	29.00
N12	27.60

Table 7: Compressive test results for Banana fibre

Mix type	Compressive strength in Mpa
F Ctrl	30.05
F1	30.20
F2	30.45
F3	31.20
F4	30.60
F5	30.10
F6	24.50

4. Conclusion

This study concludes that

1. The optimum content of Banana fibre is 1.5 % as there has been a slight decrease in the strength of the roller compacted concrete. At 1.5% of banana fibre maximum compressive strength is observed.

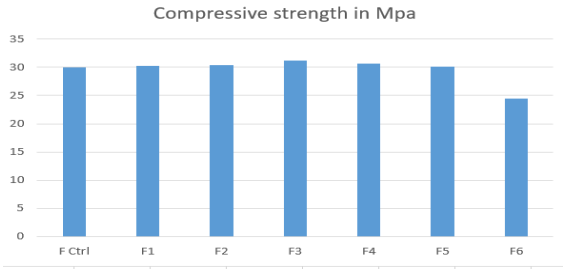


Figure 1:Compressive Strength for Banana Fibre

2. It is observed that the optimum condition for Nano Silica is upto 2%. It is found that there is gradual decrease in the compressive strength of RCC pavement with the addition of more than 2% of nano silica.

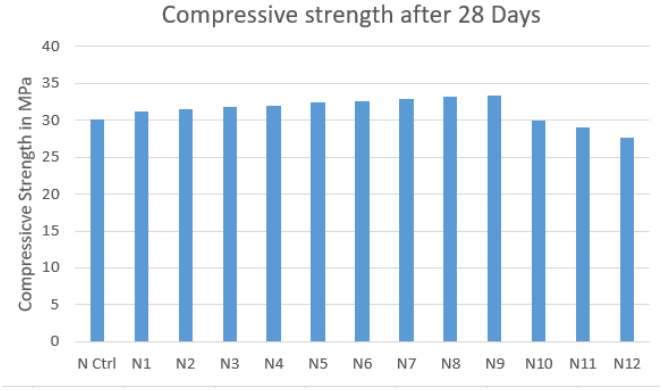
3. 

Figure 2:Compressive Strength for Nano Silica

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