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STRENGTH CHARACTERISTICS OF SOIL TREATED WITH NANO ZINC OXIDE FOR PAVEMENT APPLICATIONS

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Outline

- Objectives of the Present Study
- Selection of materials (soil -Nano material)
- Characterization of materials (soil , nano material)
- Test program
- Sample preparation
- Results and Discussions of Unconfined compression tests
- Conclusions

Objectives of present study

- To effectively establish the utilization of soils like silty sands clays in construction of subgrade / subbase in flexible pavements

- To understand the UCS behavior of soil reinforced with nano zinc oxide and optimize the dosage of nano material in stabilization process.

- To assess the stabilization process and ascertain the suitability of nano zinc oxide in construction of subgrades and sub bases in flexible pavements.

Material selection

- Silty sand (Powai soil) was obtained from IIT Bombay premises.

- Nano zinc oxide (nano ZnO) was synthesized in Material Science & Metallurgy Dept. of IIT, Bombay.

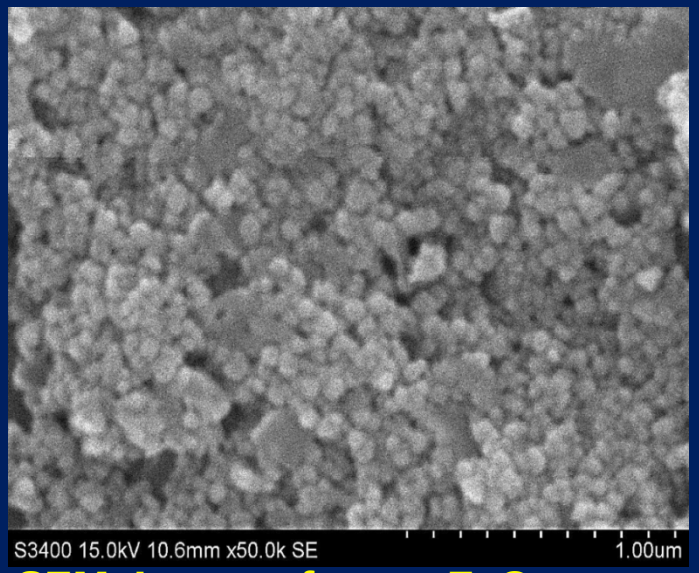
Characterization of Soil

Engineering properties

PROPERTIES	VALUES
Specific Gravity	2.63
Maximum dry density (gm/cm^3)	1.72
Optimum moisture content (%)	19
Gravel (%)	19
Sand size (%)	35.9
Silt size (%)	32.8
Clay size (%)	12.3
LL (%)	45.4
PL (%)	30.73
SL (%)	16.23
PI (%)	14.67
Group symbol (IS-1498:1970)	SM
Coefficient of Permeability 'k' (cm/sec)	3.457x 10^{-5}
Unsoaked CBR (%)	33.36
Soaked CBR (%)	14.07

Characterization of nano ZnO

PROPERTIES	VALUE
Average Particle size	35 nm
Specific surface area (m^2/g)	14.26
Purity (%)	99.9
Density (gm/cm^3)	5.6



SEM Image of nano ZnO (Rajagopalan and Khanna, 2013)

Characterization of OPC 53 grade…

PROPERTIES	VALUE
Soundness	5 mm
Specific surface area (cm^2/g)	2365
Initial setting time	36 minutes
Final setting tome	500 minutes
Compressive strength (7 days curing)	395 Mpa.

Sample preparation and test methodology

The oven dried soil sample were mixed with nano ZnO in increasing percentages by dry weight of soil by 1%, 1.5% and 2% . OPC was then mixed with each proportion by 2%, 4% and 6% by dry weight of soil.

- Modified proctor compaction tests were carried out to determine the MDD and OMC as per miniature compaction and CBR apparatus.

- UCS Samples of 38 mm x 76 mm were prepared and then kept for curing in a glass dessicator for 7, 14 and 28 days of curing.

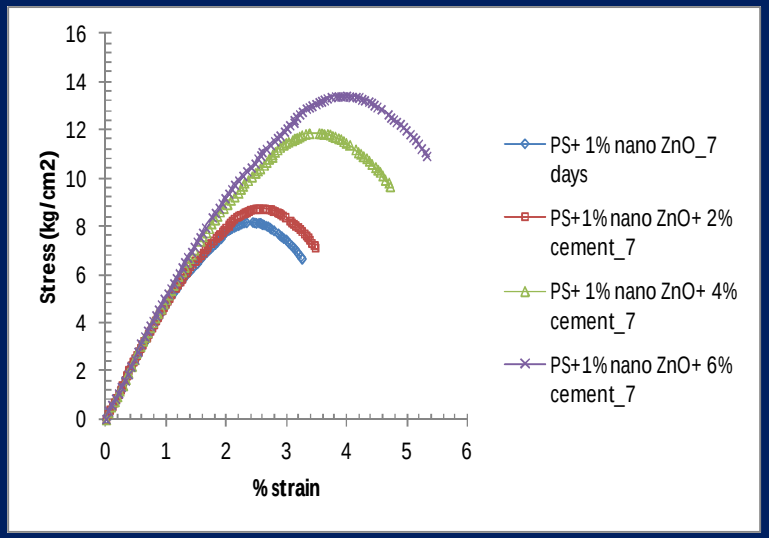
Miniature compaction and CBR mould, Patent file no. 201621013680 , Kulkarni, Dutta and Mandal (2016)

Curing of UCS samples in dessicator

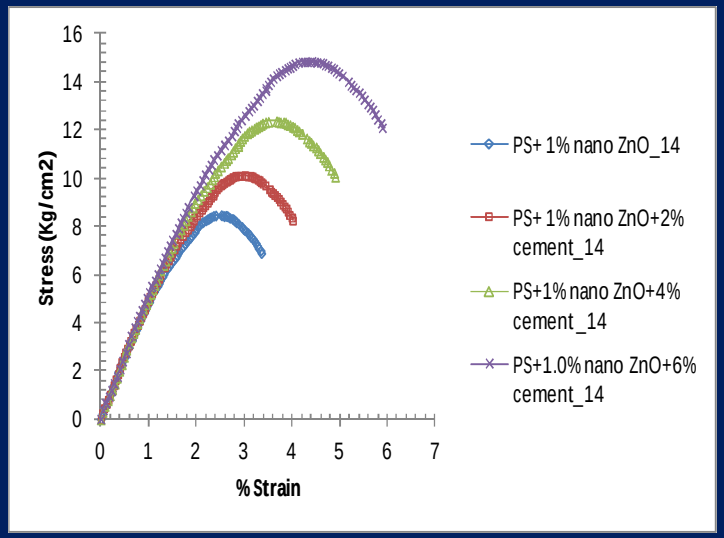
Results and Discussions – Modified compaction tests

Sample details	MDD (gm/cm^3)	OMC (%)
PS (neat soil)	1.72	19.0
PS + 1% nano ZnO	1.715	17.2
PS + 1% nano ZnO + 2% cement	1.72	17.4
PS + 1% nano ZnO +4% cement	1.74	17.5
PS + 1% nano ZnO + 6% cement	1.75	17.7
PS + 1.5 % nano ZnO	1.72	17.4
PS + 1.5 % nano ZnO + 2% cement	1.73	18.1
PS + 1.5 % nano ZnO + 4% cement	1.75	18.7
PS + 1.5 % nano ZnO + 6% cement	1.76	19.1
PS + 2 % nano ZnO	1.73	17.5
PS + 2 % nano ZnO + 2% cement	1.74	18.2
PS + 2 % nano ZnO + 4% cement	1.75	18.4
PS + 2 % nano ZnO + 6% cement	1.77	18.6

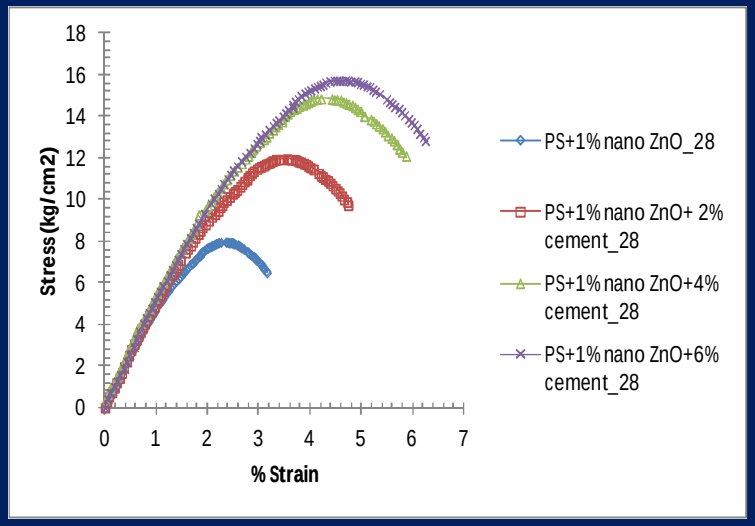
UCS Results with 1% nano ZnO for 7, 14 and 28 days of curing…..



Stress strain curves of soil mixed with 1% nano ZnO and varying percentages of cement for 7 days of curing.



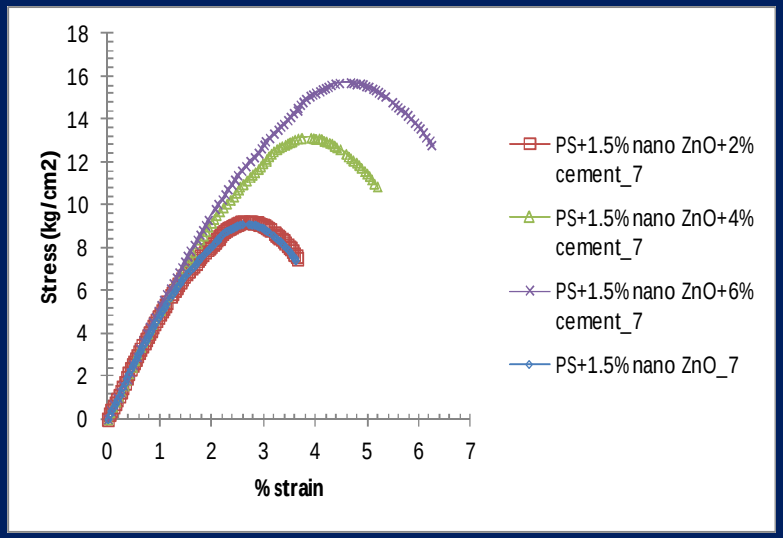
Stress strain curves of soil mixed with 1% nano ZnO and varying percentages of cement for 14 days of curing.



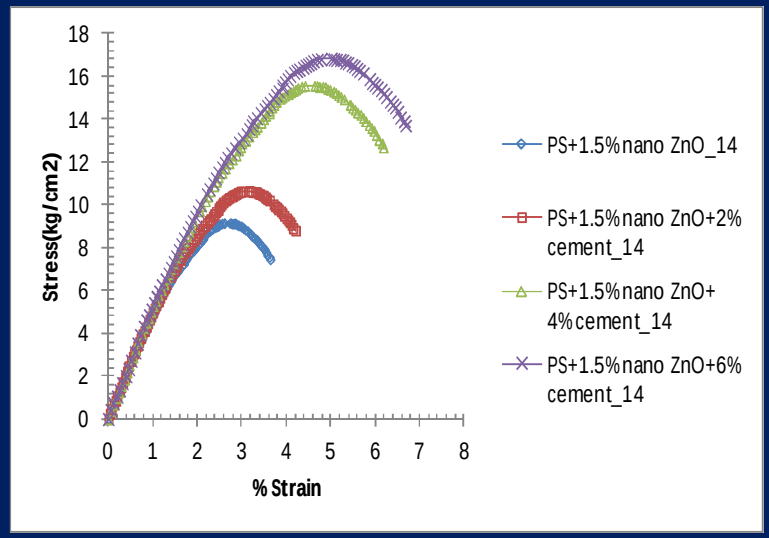
Stress strain curves of soil mixed with 1% nano ZnO an
percentages of cement for 28 days of curing.

Sample details	UCS (kg/cm²) 7 days	UCS (kg/cm²) 14 days	UCS (kg/cm²) 28 days
PS (neat soil)	6.345	6.221	5.65
PS + 1% nano ZnO	8.182	8.464	7.956
PS + 1% nano ZnO + 2% cement	8.745	10.12	11.945
PS + 1% nano ZnO + 4% cement	11.874	12.36	14.851
PS + 1% nano ZnO + 6% cement	13.415	14.851	15.732

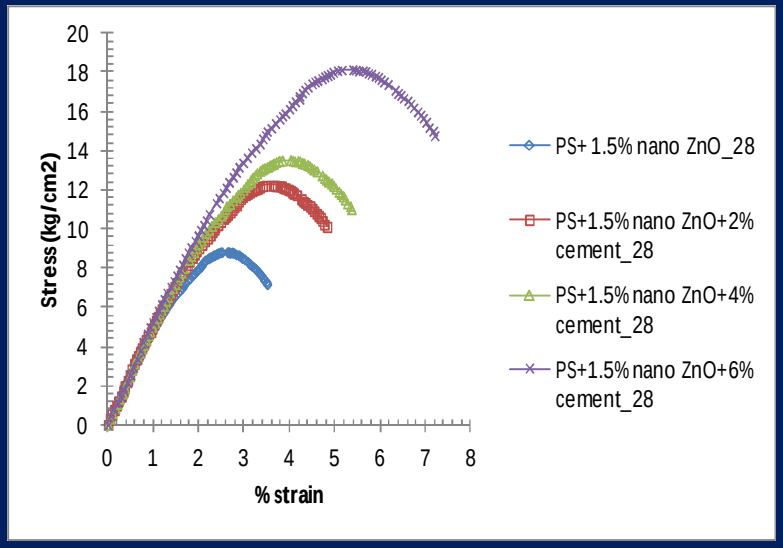
UCS Results with 1.5 % nano ZnO for 7, 14 and 28 days of curing…..



Stress strain curves of soil mixed with 1.5% nano ZnO and varying percentages of cement for 7 days of curing.



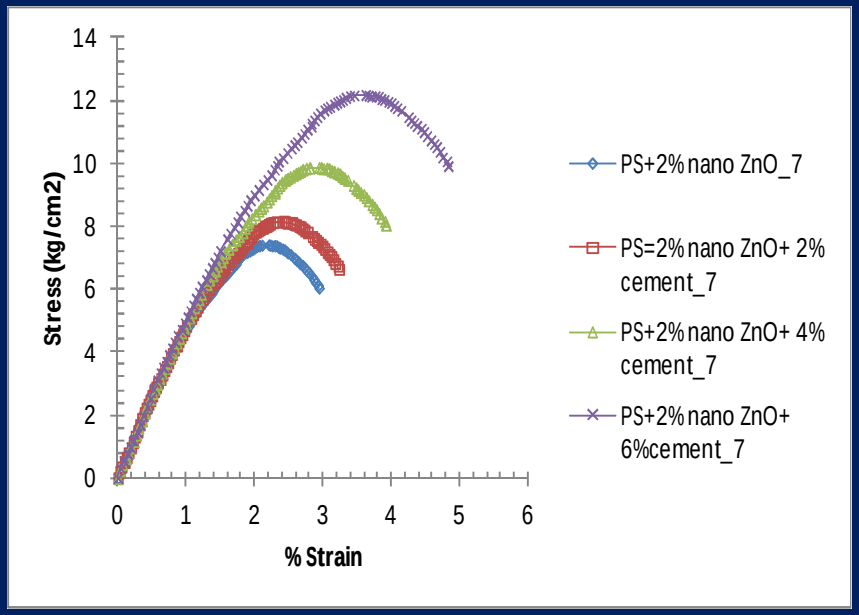
Stress strain curves of soil mixed with 1.5% nano ZnO and varying percentages of cement for 14 days of curing.



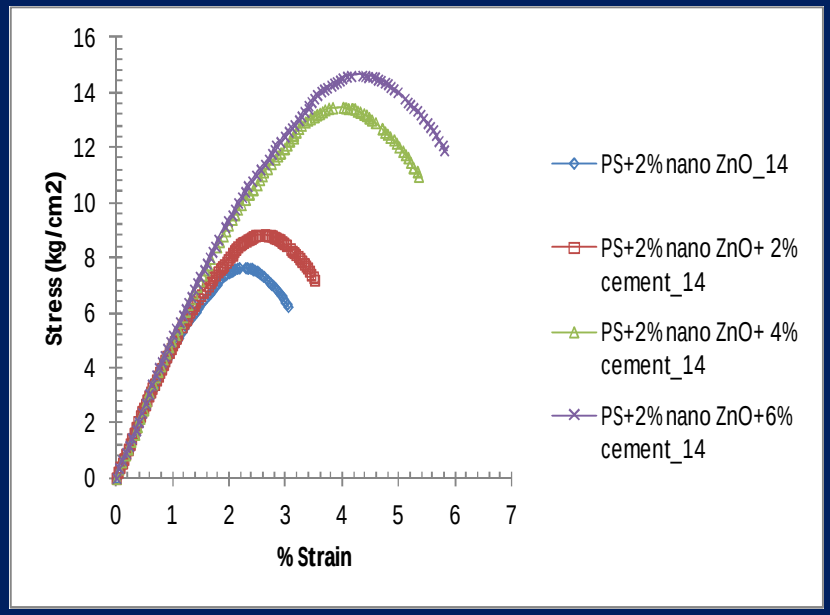
Stress strain curves of soil mixed with 1.5% nano ZnO and varying percentages of cement for 28 days of curing

Sample details	UCS (kg/cm^2) 7 days	UCS (kg/cm^2) 14 days	UCS (kg/cm^2) 28 days
PS + 1.5% nano ZnO	9.11	9.162	8.832
PS + 1.5% nano ZnO + 2% cement	9.212	10.647	12.23
PS + 1.5% nano ZnO + 4% cement	13.14	15.572	17.215
PS + 1.5% nano ZnO + 6% cement	15.71	16.832	18.14

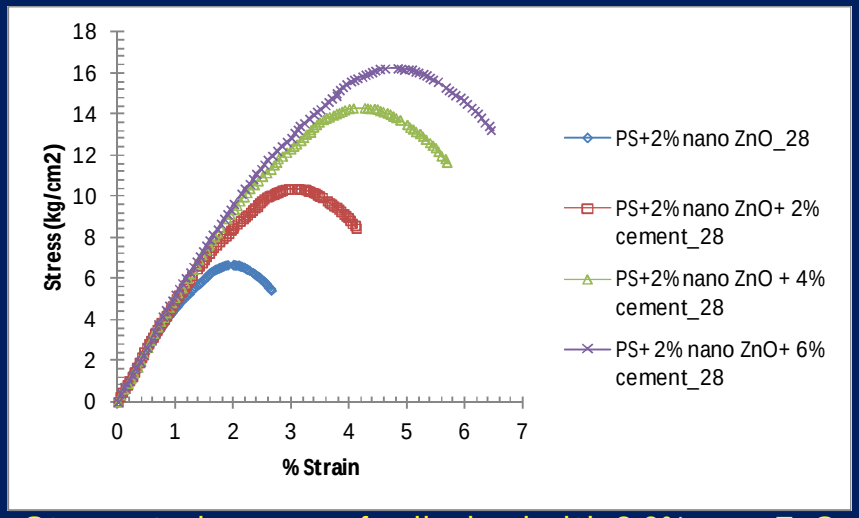
UCS Results with 2.0% nano ZnO for 7, 14 and 28 days of curing…..



Stress strain curves of soil mixed with 2.0% nano ZnO and varying percentages of cement for 7 days of curing



Stress strain curves of soil mixed with 2.0% nano ZnO and varying percentages of cement for 14 days of curing



Stress strain curves of soil mixed with 2.0% nano ZnO and varying percentages of cement for 28 days of curing

Sample details	UCS (kg/cm²) 7 days	UCS (kg/cm²) 14 days	UCS (kg/cm²) 28 days
PS + 2% nano ZnO	7.415	7.652	6.676
PS+2.0% nano ZnO + 2% cement	8.153	8.834	10.38
PS+ 2.0% nano ZnO + 4% cement	9.876	13.472	14.321
PS + 2.0% nano ZnO + 6% cement	12.176	14.625	16.245

Results of UCS values for 7, 14 and 28 days of curing…..

Sample details	UCS for 7 days of curing (Kg/cm^2)	UCS for 14 days of curing (Kg/cm^2)	UCS for 28 days of curing (Kg/cm^2)
PS	6.345	6.221	5.65
PS + 1% nano ZnO	8.182	8.464	7.956
PS+1% nano ZnO+2% cement	8.745	10.12	11.945
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PS+ 2% nano ZnO+4% cement	9.876	13.472	14.321
PS+ 2% nano ZnO+6% cement	12.176	14.625	16.245

Inferences / Major Findings

- The unconfined compressive strength of soil was observed to increase with increase in nano zinc oxide proportions. Addition of 1.5% of nano ZnO yielded optimum results.

- On addition of 2%, 4% and 6% cement to soil with 1.5% nano ZnO the 7 days unconfined compressive strengths were observed to be enhanced by 45.1%, 107.09% and 147.5% respectively when compared to neat soil.

- The soil samples treated with varying proportions of cement were observed to yield a higher strength and failed at slightly higher strains as compared to samples treated with only nano zinc oxide.

- Soil mixed with 1.5% nano ZnO with 4% cement well satisfies the 7 days UCS criteria for chemically stabilized soil for sub bases as per 'IRC:37-2012 – Tentative Guidelines for the design of flexible pavements' pertaining to the Indian sub continent

- The research is thus an attempt to stabilize the soil together with nano zinc oxide and cement which holds a very promising future for pavement infrastructural applications.

Thank you !!