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Utilization of Data Science to Investigate the Role of Nano Materials in Road Transportation Engineering

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Abstract- *Nanotechnology is the technology in which nanoscale material properties are utilized in construction or formulation of new composite materials. When the conventional materials interacts with nanoparticles their physical parameters change dramatically. The reason being that nanoparticles provide highly reactive sites on their surface[1] bringing in unusual physical, chemical, and biological properties at the nano scale, differing in important ways from properties of bulk materials. Some nanostructured materials are stronger or have different magnetic properties compared to other forms or sizes of the same material.*
Working at the nanoscale enables us to utilize the unique physical properties of the nanomaterials. Presently we have made a comparative study of various parameters obtained by previous workers to find out the economicviability of the nanomaterials.
Key Words- *Nanosilica (NS), Nanoclay (NC), Compressive Strength, Flexure Strength*

I. Introduction-

Use of nanomaterials in road transportation engineering is increasing day by day. Many nanomaterials are at research level. Experiments are being done using different types of nanomaterials. Data obtained from the experiment are further analyzed using different types of calculations to obtain many useful results for Road Transportation Engineering. The Data Science plays an important role to investigate various aspects and suggesting utilization of different nanomaterials for their use. Application of nanotechnology was initially done in the field of Physics, Chemistry, Electronics, Biomedical and Bioscience field. Civil Engineering is also not untouched from the wide spread of nanotechnology. In field of road construction nanomaterials are making their increasing importance. Nanomaterials e.g. carbon nanotubes, nanosilica[2], nanoclay, TiO_2 etc. are being used in different ways for providing strength,durability environmental friendly works in field of road transportation.With the development nanomaterials and onset of new aspects as Nano-Technology, it is now possible to develop nano composites with integration of nanomaterials with conventional road construction materials. The use of nano composites can create revolution in Road Transportation Engineering. Data Science can act a good tool in development of new road transportation materials.

II. Data Science Utilization for Improvement of Concrete Utility

Compressive strength and flexure (bending) strength of concrete can be improved by mixing of nanosilica or nano clay[3] in cement concrete in different proportions. For obtaining better strength of concrete hybrid of nanosilica and nanoclay can also be used. Best proportion of these materials taken independently or in hybrid form can be obtained by practical experiment and analysis of the obtained data using the data science.
The present calculations are based on the data obtained by previous researchers [4] to have an idea of economical proportion of nano materials serving the purpose. In the analysis of economical proportion of nanosilica and nanoclay only wet mixing and 90 days strength data of [4] have been taken.

Calculation of Cost Difference of Samples- The cost difference of samples from controlled sample is being calculated on the basis of average market rates of cement, nanosilica, and nanoclay which are as under-
(i) Cement- Rs.300.00 per bag of 50kg or Rs.0.006 per gm.
(ii) Nano silica- Rs.800per kg or Rs.0.8 per gm.
(iii) Nano clay Rs.40.0 per kg or Rs.0.04 per gm.
Since items other than cement, nanosilica and nanoclay are fixed in quantity in all the samples their cost will not affect the difference of cost from the cost of controlled sample the price difference of each sample over the controlled sample is calculated in table no- 1..

Table-1Cost Difference of Samples

SampleNo	Cement Wt.gm	Cost of cement	NS wt.gm	NS Cost	NCWt.gm	NCCost	TotalCost	Cost Diff.fromS1
S1	500	3.0	-	-	0	0	3.0	-
S2	497.5	2.985	2.5	2.0	0	0	4.985	1.985
S3	496.25	2.9775	3.75	3.0	0	0	5.9775	2.9775
S4	495	2.97	5.0	4	0	0	6.97	3.97
S5	493.75	2.9625	6.25	5	0	0	7.9625	4.9625
S6	492.5	2.955	7.5	6	0	0	8.955	5.955
S7	495	2.97	0	0	5.0	0.2	3.17	0.17
S8	495	2.97	1.25	1.0	3.75	0.15	4.12	1.12
S9	485	2.91	3.75	3.0	11.25	0.45	6.36	3.36
S10	475	2.85	6.25	5	18.75	0.75	8.6	5.6
S11	495	2.97	2.5	2.0	2.5	0.1	5.07	2.07
S12	485	2.91	7.5	6.0	7.5	0.3	9.21	6.21
S13	475	2.85	12.5	10	12.5	0.5	13.35	10.35
S14	495	2.97	3.75	3.0	1.25	0.05	6.02	3.02
S15	485	2.91	11.25	9.0	3.75	0.15	12.06	9.06
S16	475	2.85	18.75	15	6.25	0.25	18.10	15.10

Economy Ratio- The economy ratio for a sample is defined as

Strength gain of sample over control mix strength/Cost difference of sample from the cost of control mix The economy ratio of any sample is important in the sense because it gives idea about how economically nanomaterials can be used in improvement of concrete strength so as to get maximum strength benefit at the lowest cost.

The economy ratio calculation for each mix from S2 to S16 are given in the Table-2. Since S1 is control mix (having no nanomaterial) so all the differences of strength and cost are taken from S1 .

Table-2 Economy Ratio

Sample	Cost diff.from S1Rs	Compressive strength diff. from S1 MPa	Economy ratio for mix(comp strength)	Flexure strength diff. fromS1 MPa	Economy ratio for mix(flexure)
S2	1.985	7.83	3.94	0.23	0.1158
S3	2.9775	17.9	6.0117	0.49	0.1645
S4	3.97	-7.47	-1.88	-0.43	-0.1083
S5	4.9625	-8.64	-1.74	0.09	0.0181
S6	5.955	-12.4	-2.08	0.08	0.0134
S7	0.17	22.84	134.353	1.55	9.1176
S8	1.12	25.61	22.8660	1.60	1.4285
S9	3.36	28.47	8.4732	1.42	0.422
S10	5.6	15.28	2.7286	0.18	0.0321
S11	2.07	18.67	9.01	-0.52	-0.2512
S12	6.25	17.46	2.79360.	0.89	0.1424
S13	10.35	16.03	1.5488	1.02	0.001
S14	3.02	16.46	5.450	1.08	0.3576
S15	9.06	20.29	2.2395	0.98	0.1081
S16	15.10	21.08	1.396	-0.16	-0.0106

III. Results and Discussion-

(i)By adding nanosilica and nanoclay the compressive strength and flexure strength of concrete is improved in most of the cases but in some cases strength is decreased.

(ii) Sample S9 hybrid mix of 0.75% NS and 2.25% NC gave maximum compressive strength improvement over the control mix..

(iii) Sample S8 having 0.25% NS and 0.75% NC gave maximum flexure strength improvement over the control mix.

(iv)The compressive strength improvement over control mix ofS8 having 0.25%NS and 0.75% NCis at 2nd position.

(v) Flexure strength improvement over control mix of S7 having 0%NS and 1%NC is at 2nd position.

(vi) Economy ratio for compressive strength is maximum forS7 and economy ratio for flexure strength is also maximum for S7.

(vii) Mix S7 gives optimum result considering the economy as well as gain in compressive strength. Its compressive strength gain is good enough and is not much less than maximum strength gain.

(viii)Similarly mix S7 is optimum considering economy and flexure strength gain. Its flexure strength gain is slightly less than maximum strength gain.

IV. Conclusions

(i) Although hybrid mix gave maximum strength gain for compression(S9) and flexure(S8) yet mix S7 gave optimum result considering strength gain witheconomy for both compression and flexure..
(ii)Mix S7 can be used economically at both places where compression is important for cement concrete road (where road bed is hard)and can also be used at the places where flexure strength is required for concrete road (where road bed is not very hard and concrete can bend)

Recommendations

(i)Nano materials can give beneficial results in road construction.
(ii)Their correct ratio can be obtained by analyzing experimental data using data science.
(iii) Many conclusions can be drawn from a given set of data using Data Science.
(iv)Data Science can play vital role in Nanotechnology research work being carried out in the field of Road Transportation.

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