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Strengthening of Concrete by Incorporation of Nano-Silica and Dolomite Powder

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***Abstract*:- Nano technology is an emerging field of science with wide applicability. Nano technology has opened new areas for research in the almost all fields. Matter exhibits different physical, chemical, biological properties at nano-scale. The use of nano-particles in concrete will be beneficial to overcome its various drawbacks. Much research has been already done in the arena of civil engineering encompassing various topics like strength, durability, performance etc. Incorporation of nano-particles in concrete for strength enhancement has also been done by the previous researchers. Nano-particles have been combined with fibres also to know the combined effect of two on the strength. It is found that nano-particles has never been used in combination with dolomite powder and can be used as cement's replacement .In following study strengthening of concrete was done by the incorporation of nano-silica and dolomite powder. Three levels (values) of the above two parameters i.e. percentage replacement cement with dolomite powder and nano-silica were taken. Test results indicated that the combination of nano silica and dolomite powder did not satisfy requirement of desired strength in concrete. The concrete lost its strength significantly by using nano silica and dolomite powder.**

INTRODUCTION

Concrete being a composite material made by the mixture of coarse and fine aggregates with cement. With the increasing use of cement in building material different types of cements are used according their uses. These coarse and fine aggregates bonded together with cement which hardens with time. Cement reacts along with water and fine aggregate, coarse aggregates to make a mixtures which binds the materials together. Physical properties of wet slurry can be improved by additives such pozzolans or super-plasticizer. Frequently concrete poured along with the reinforcing materials which resulted higher strength in tensile, yielding reinforced concrete. The one type of cement which is now increasingly used is nano-concrete. Nano concrete generally made up of nano-particles. In nano-concrete nano-particles plays very important role. Concrete being composite material inherits a lot of drawbacks which reduces its strength and its life. To overcome these drawbacks which are associated with concrete and to increase its strength, nano particles are increasingly used in concrete. These nano particles can fill the small voids which ultimately increases strength of concrete.

Silicon dioxide's nano particles which is known as nano silica inhabits a wide applicability in different areas like in field of biomedical research because of their stability, also contains less amount in toxicity and holds ability to function along with a range of molecules and polymers. Silica in nano form is now widely used as an admixture in concrete because of its various application and endurance to overcome the inherit drawbacks associated with it. Up to the certain extent when nano-silica is applied in concrete, it increases its strength and improves various other mechanical properties. Dolomite in its natural form known as Calcium Magnesium Carbonate which contains a good amount of purity and white colour. Dolomite being a rock mineral known for wettability, dispersibility and absorption of plasticizer. Dolomite has application for ornamental purpose and gardening work. In India Chhattisgarh is the leading state in the production of dolomite which accounts total production of 28%. Andhra Pradesh, Odisha, Karnataka and Madhya Pradesh are other leading states in production of dolomite materials. Dolomite is one of the mineral of limestone. Rich constituents in dolomite are magnesium and calcium. It also contain other minerals in smaller amounts. It is also applied as supplement of calcium and magnesium. Various research studied found out that fine dolomite powder in fact can be applied as cementitious materials to produce cement by adding dolomite limestone.

3.0 MATERIALS AND EXPERIMENTAL PROGRAM

Different class of materials and experiments conducted in the project. Cement, fine, coarse aggregate are the main materials which we used in the experiment. The different tests like fineness test, sieve analysis, consistency test conducted to know the values of specific gravity pertaining to fine, coarse aggregates that are crucial for getting quantity of fine, coarse aggregates during project.

3.0 MATERIALS USED

The properties and specification of materials which were applied in present study are as follow:

3.1.1 Cement

In present study particularly Ambuja Cement was applied. Various tests were conducted on cement samples. These test were fineness test, initial and final setting time test, soundness test, and compressive strength test. Tests were performed according IS code procedures. Ambuja cement's was obtained as specific gravity 3.15 and cement's density was 1400 kg/m^3**.**

3.1.2 Coarse Aggregates

Aggregates having coarse nature plays decisive role in making concrete. In present study 20mm size of locally available coarse aggregates were used. The obtained value

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of specific gravity of coarse aggregate was 2.89 and bulk density was 1108.3 kg/m3.

3.1.3 Fine Aggregates

Locally available fine sand was incorporated in the present work. Sieve analysis and other tests were conducted to get properties of sand like specific gravity, water absorption and bulk density. After performing the pycnometer test on the sand specific gravity came 2.16. Bulk density of sand was 1457.3 kg/m^3.

Table 3.1 Test conducted on dry cement, cement mortar and their results

Tests	Apparatus used	Testing procedure as per	Values for PPC acc. IS 1489(Part 1) :1999	Results
Fineness	IS 10mm sieve	IS 4031 (Part 1) : 1996	Should not be more than 10%	4%
Standard consistency	Vicat Apparatus(conforming IS 5513 : 1976)	IS 4031 (Part 4) : 1998	-	32.5%
Initial Setting Time	Vicat Apparatus (conforming IS 5513:1973)	IS 4031 (Part 5) : 1998	Min. 30 min	32 min
Final setting Time	Vicat Apparatus (conforming IS 5513:1973)	IS 4031(Part 5) : 1998	Max. 600 min	300 min
Soundness	Le- Chatelier's Apparatus (conforming IS 5514: 1969)	IS 4031(Part 3) : 1998	Should not be less than 10 mm	8mm
Compressive Strength	Cube mould of 70.6 mm (conforming IS 10080: 1962)	IS 4031 (Part 6) : 1998	-	at 7days-20.1MPa at 28 days-37.80MPa

3.2 Experimental Program/ Research Model

In following study cement, coarse aggregate, fine aggregates, nano-silica and dolomite are important factors. In present study various amount containing dolomite, silica in nano form were taken.

3.2.1 Factors and their levels

In existing work, there main important factors which entangled in the study to enhance the cement's strength are nano silica, dolomite and ratio of water binder. Nano silica being in small size helps in to occupy voids in concrete and further promote strength of concrete. Dolomite helps in addition of strength in concrete. The substance of nano silica and dolomites and water binder ratios are used at different levels in the study. The table showing silica in nano form and dolomite's different levels and water binder ratio is as follow:

Table 3.2 Factors and their percentage at different levels

Factors	Level 1	Level 2	Level 2
Nano silica	2%	3%	4%
Dolomite	15%	20%	25%
Water binder ratio	0.40	0.40	0.40

3.2.2Proportioning Mix

In mix proportioning various combinations were made with the help of percentage of nano silica and dolomite powder. In this study the percentage of nano silica were taken as 2%, 3% and 4% by weight of cement. The substance of dolomite was used in 15%, 20% and 25 % by weight of cement. With help of these percentage amounts of nano silica, dolomite nine combinations were made. Entire number of cubes from these nine combinations came 54. The various combinations, no of cubes to be cast and test to be performed are mentioned in following table:

Table 3.3 Combinations and number of cubes

Serial No.	Percentage Nano silica	Percentage of Dolomite Powder	Cubes to be cast	
			7 Days	28 Days
1	2%	15%	3	3
2	2%	20%	3	3
3	2%	25%	3	3
4	3%	15%	3	3
5	3%	20%	3	3
6	3%	25%	3	3
7	4%	15%	3	3
8	4%	20%	3	3
9	4%	25%	3	3
			Total cubes 27	Total cubes27

3.2.3 Experimental setup

Experimental set up includes different experiment procedure and materials which are applied in the programme. In current study the materials cement, sand, coarse aggregate, nano silica, dolomite powder used. To perform compressive strength and workability of concrete compression testing machine (CTM) and slump cone are used. The mould of 150X150X150mm is used for casting of cubes.

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Table 3.4 Total volume of cubes and test to be performed

Specimen	Specimen size	Test to be performed	No of mixes	No of specimen for each mix		Total specimen to be performed
Cubes	150mmX150mm X150mm	Compressive strength and workability test.	9	3	3	54

Figure 3.1: Preparation of mixture

3.2.4 Preparation of specimens

Preparation of specimen is important step in casting of cubes. Following steps are applied in the making of specimen.

Preparation of Materials: All materials are brought at room temperature, which is 27 ± 3 C before starting the test. The cement samples must be fully dry mixed either by applying hand or in a proper mixer in a way to ensure the blending and equal uniformity in desired material, proper care and precautions must be applied to avoid intrusion of undesirable matter. Cement should then store in a dry place, most preferably in air tight metal container. Samples aggregates for every batch concrete must be of the required grading and ought to be and fully air dried condition. The aggregate must be separated into coarse fine aggregates and combined each concrete batch in such way so that we get the desired grading. Sieve 480 can normally applied for separating coarse, fine aggregates, but special grading required both coarse, fine aggregates ought to further separated in different sizes.

*Proportioning***:** The proportion of material contain water, in making concrete mixes used for calculating suitability of materials available, must similar in respect of those which are employed in work.

*Weighing***:** The cement's quantity , every aggregate's size and required water for every batch must calculated by weight up to accuracy of 0.1 % of whole weight of required batch. Mixing concrete: The concrete can mixed either with hand or preferably in batch mixer such way so that loss in water and material can be avoided.

We use in present study the hand mixing Hand Mixing: In case of hand mixing, the batch must be mixed in water tight and a platform which is a non-absorbent, with trowel and shovel and other suitable implement. a) The fine aggregate, cement must be mixed in dry condition fully until we get uniform colour. b) coarse aggregates then added with the fine aggregates and cement and mixed properly until they are distributed wholly c) Then water is applied to the entire batch until we get desired consistency.

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Figure 3.2 Casting of cubes

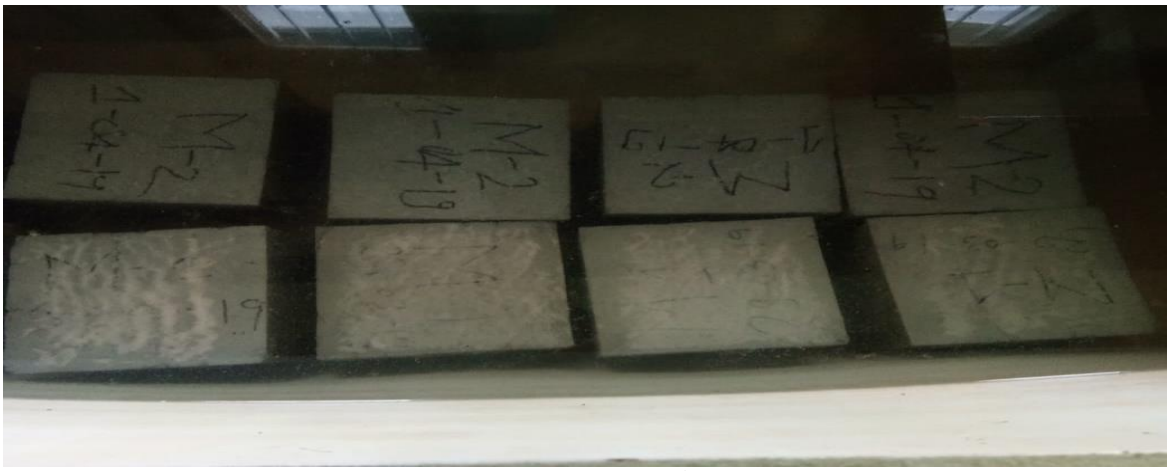

Figure 3.3 Casted cubes placed for curing

Figure 3.4 Cube during compressive strength test

4.0 RESULT AND DISCUSSION

The two tests compressive strength and workability were performed on the cubes. The percentage of nano silica were taken as 2%, 3% and 4% by weight of cement. The amount of dolomite taken in casting of concrete cubes were 15%, 20% and 25% by weight of cement. Total 54 concrete cubes of size 150mm x 150mm x 150mm were cast and were tested at 7 and 28 days the results of which are given and have been discussed in this chapter.

4.1 Workability

Slump cone test was performed on the concrete prior to casting of cubes in order to assess the workability; the results of which are shown below in the table.

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Table 4.1 results of slump cone test on concrete

S.No.	Mix	Percentage of Nano-silica	Percentage of Dolomite Powder	Water-powder ratio	Slump Value
1	M1	2	15	0.4	0
2	M2	3	15	0.4	0
3	M3	4	15	0.4	0
4	M4	2	20	0.4	0
5	M5	3	20	0.4	60
6	M6	4	20	0.4	40
7	M7	2	25	0.4	60
8	M8	3	25	0.4	150
9	M9	4	25	0.4	200

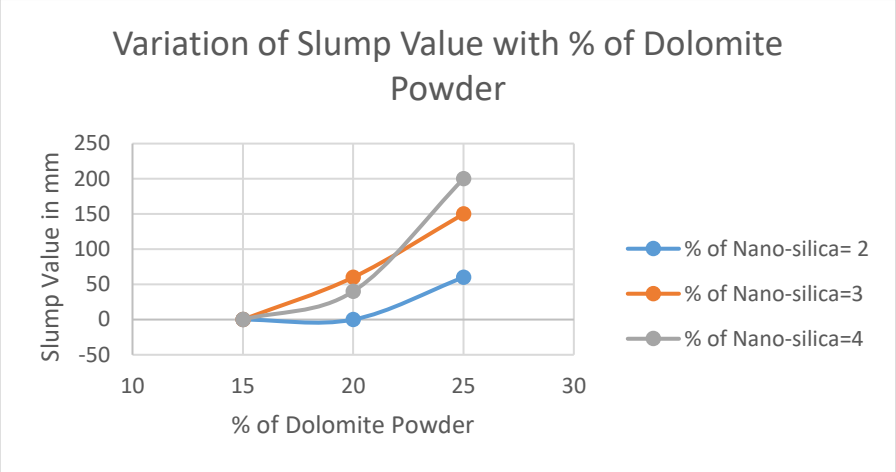

Fig. 4.1 Variation of slump value with varying % of dolomite powder

From fig. 4.1 it is clear that we got zero workability at the initial phases. From Mix M1 to Mix M4, the mixture showed zero workability. When we used 15% of dolomite powder by weight of cement with the corresponding increase in the percentage of nano silica 2%, 3%, and 4%, it showed zero workability. But as we increased the percentage of dolomite 20% and 25% by weight of cement, it increased the workability of concrete. At the amount of 25% by weight of cement, it showed highest slump value of 200mm in Mix 9. In Mix M 9, Mix M8 and Mix 7, we found the workability increased consecutively. So Higher amount of dolomite powder plays very important role in increasing the workability of concrete.

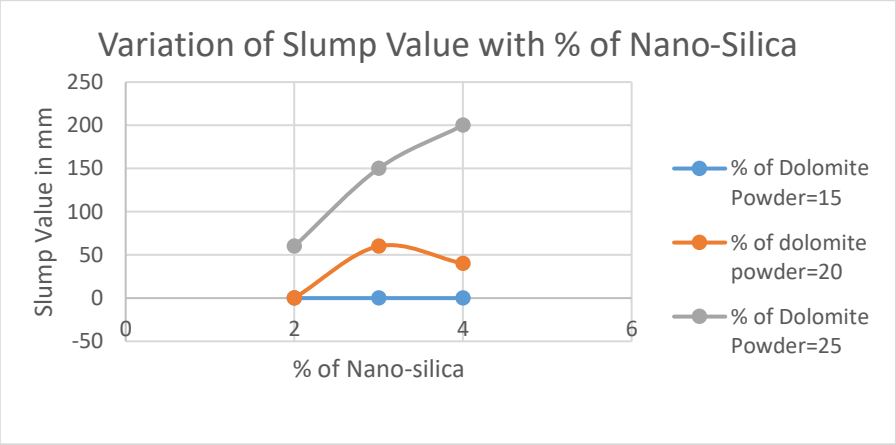

Fig. 4.2 Variation of slump with varying % of nano silica

The above graph showed the variation of slump values with varying percentages of nano silica. At the initial stages we got zero workability at the percentage amount of nano silica 2%, 3% and 4% by weight of cement, up to Mix M4. This is because nano silica greatly increases the water demand of mixture. It decreases the amount of water which is necessary for lubricating mechanism. It reduces the water between voids which leads to increase in the viscosity of mixture. But as we increases the percentage of dolomite, it increases the workability of concrete. AT Mix M9 gave us highest value of slump of 200mm, at 25% of dolomite. In concrete dolomite very crucial role for increasing the workability of mixture.

4.2 Compressive Strength

The result of compressive strength of the cubes and their graphs are as follows:

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Table 4.2 Results of compressive strength test

S.No.	Mix	% of Nano-Silica	% of Dolomite Powder	w/c ratio	7 Days Strength			Standard Deviation	Average Compressive Load	7-Days Compressive Strength	28 Days Strength			Standard Deviation	Average Compressive Load	28-Days Compressive Strength
1	M1	2	15	0.4	370	400	390	15.28	386.67	17.19	375	330	310	33.292	338.33	15.04
2	M2	3	15	0.4	345	345	330	8.66	340.00	15.11	385	375	350	18.028	370.00	16.44
3	M3	4	15	0.4	315	355	365	26.46	345.00	15.33	375	405	390	15.000	390.00	17.33
4	M4	2	20	0.4	325	328	345	10.79	332.67	14.79	385	350	365	17.559	366.67	16.30
5	M5	3	20	0.4	310	300	325	12.58	311.67	13.85	335	360	360	14.434	351.67	15.63
6	M6	4	20	0.4	295	295	245	28.87	278.33	12.37	365	355	360	5.000	360.00	16.00
7	M7	2	25	0.4	245	325	245	46.19	271.67	12.07	315	335	340	13.229	330.00	14.67
8	M8	3	25	0.4	300	250	225	38.19	258.33	11.48	330	345	340	7.638	338.33	15.04
9	M9	4	25	0.4	285	245	225	30.55	251.67	11.19	360	365	335	16.073	353.33	15.70

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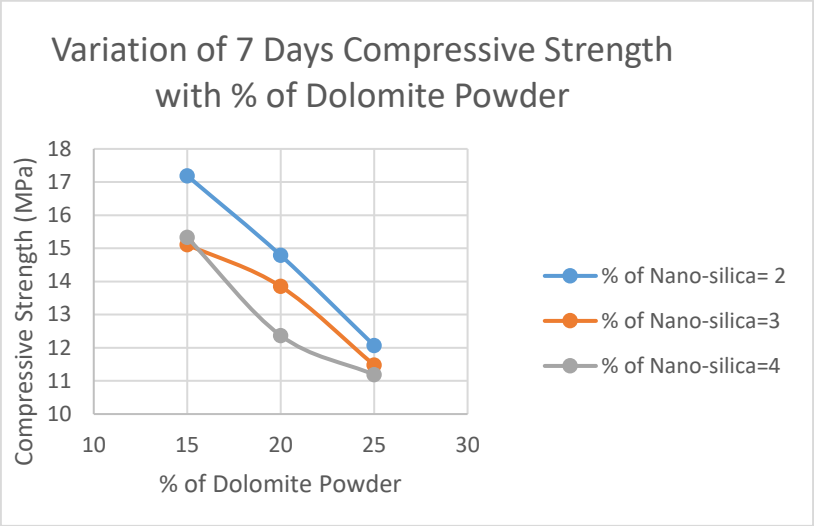

Fig. 4.3 Variation of 7 days compressive strength with % of dolomite powder

The designed mixes showed the variation of compressive strength with the varying percentages of dolomite powder and nano silica. The compressive strength varied in between 17.19 MPa to 11.19 MPa. The value of highest compressive strength 17.19 MPa was obtained at 15% dolomite, when the 2% of nano silica was added to the Mix M1 in 7 days. As the amount of dolomite increases in the mixture, the compressive strength decreases. The minimum amount of the compressive strength 11.19 MPa was gained when 25% dolomite powder was used in the mix 9. This showed that the compressive strength of concrete decreases as we increases the percentage of dolomite powder and nano silica.

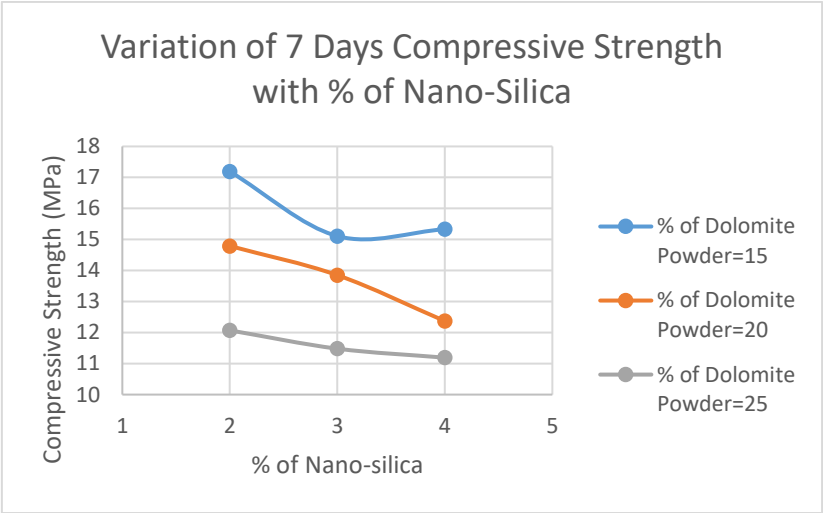

Fig. 4.4 Variation of 7 days compressive strength with varying % of nano silica

From Fig. 4.4 it is clear that the compressive strength of design mixes varies when the percentage of the nano silica changes 2%, 3% and 4%. When we used nano silica 2% by weight of cement, the maximum compressive strength was obtained 17.19 MPa in 7 days was gained in design mix M1. As we increased the percentage of nano silica in the design mix with the corresponding increase in dolomite percentage, the compressive strength of design mixes also decreases in 7 days.

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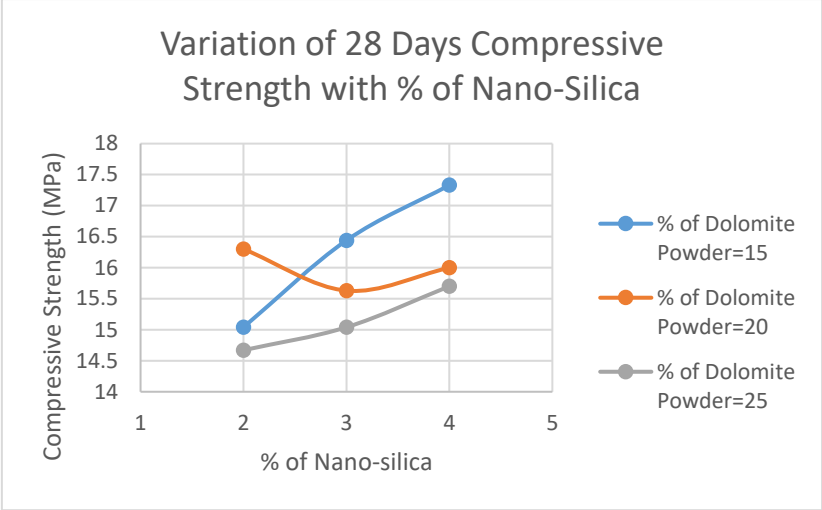

Fig 4.5 Variation of 28 Days compressive strength with % of dolomite powder.

When the design mixes were tested at 28 days it did not showed sufficient increase in strength of cubes. The highest value 17.33 MPa we got at 15% of the dolomite powder at 4% nano silica. The compressive strength varied in between 17.33MPa to 14.67 MPa. The minimum compressive strength 14.67 MPa, we get in design Mix 7 when we used 25% dolomite powder and 2% nano silica by weight of cement.

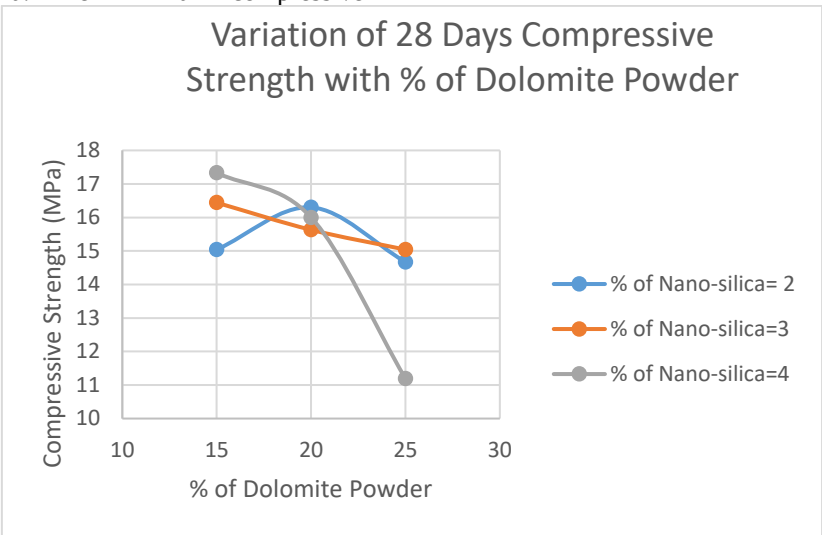

Fig. 4.6 Variation of 28 days compressive strength with varying % of Nano Silica

The above graph showed variation of compressive strength with the increase in percentage of the nano silica. The highest value of the compressive strength, we got at 2% of nano silica. As we increased the percentage of nano silica in the mixes up to 4%, the compressive strength of mixes reduced considerably.

The compressive strength of mixes decreases as we increases the amount of nano silica and dolomite powder. Nano silica and dolomite powder reduced the compressive strength by half of the mixes. The compressive strength of cubes decreases after an increase in percentage of dolomite powder because dolomite is a non pozzolanic material and does not form C-S-H (Calcium Silicate Hydrate) gel as other pozzolanic material forms. Whereas, when we use nano silica in desired amount it shows good impact on the mechanical property because of its high reactivity. But the combine use of nano silica and dolomite reduces the compressive strength of concrete significantly.

SUMMARY AND CONCLUSION

5.0 SUMMARY

In present work we studied the behavior of concrete as we incorporated dolomite powder, nano silica in casted cubes. Nano silica was applied in amount of 2%, 3% and 4% by weight of cement whereas the dolomite powder's amount was applied 15%, 20%, 25% by weight of cement. Total nine mixes were created. Total cubes 54 were casted period in between 7, 28 days. Two tests, first Workability, second compressive strength were performed in cubes. The maximum slump obtained at designed Mix 9 at 2% nano silica and 25% dolomite and minimum slump obtained in design Mix M1 to M4. The value of highest compressive strength 17.19 MPa was obtained at 15% dolomite, when the 2% of nano silica was added to the Mix M1 in 7 days. The highest value 17.33 MPa we got at 15% of the dolomite powder at 4% nano silica in Design Mix 3.

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5.1 CONCLUSIONS

We can withdraw, following conclusion from above study have been drawn:

a) Design Mix M1 to Mix M4 gave us minimum slump value 85mm at 2% percent nano silica, 15% dolomite powder. Whereas, Mix M9 gave maximum slump value 200mm, when nano silica amount 4% and 25% dolomite is added to mix.

b) We get the maximum value compressive strength in design Mix M1 17.19 MPa in 7 days and 17.33MPa 28 days. Whereas, Mix 9 gave us the minimum value compressive strength 11.19 MPa in 7 days and 14.67 MPa, 28 days.

c) For 25% dolomite containing mix with amount increase in nano silica strength decreases.

d) For nano silica amount 4% containing mix with amount increase in dolomite strength of mix decreases.

5.2 SCOPE FOR FURTHER STUDY

Nano Silica is rapidly emerging field in the arena of civil engineering. It can open various new directions for further study. As we studied about dolomite powder, nano silica, their effect on the mechanical behavior in concrete. We can promote further research work in this arena of civil engineering. Some of areas where we can research are as follow:

We can study behavior of concrete by incorporating other nano particles of titanium, zinc, and iron with dolomite powder.

a) By mixing nano silica with any other powder, we can research on concrete and its properties.

b) Further research can be done in by mixing nano silica with any other pozzolanic material fly ash, rice husk ash, silica fume, powdered brick, and burnt oil shale.

c) We can study the changes in characteristic of concrete like workability, compressive strength to increase higher percentages of dolomite powder and nano silica.

d) We can also perform split tensile and flexural tests on mixes containing dolomite powder and nano silica.

e) We can use other workability methods such as tests like compaction factor, vee bee and flow test to compare the values, so that we will have better results.

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