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Effect on the Addition of Nano Silica Particles and Peg on the Rheological, Strength and Durability Properties of High Strength Self Curing Self Compacting Concrete

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ABSTRACT

In the new era, development of high strength concrete demands good amount of cement content which is very exorbitant. Increase in grade of concrete results in escalating the amount of cement quantity. Therefore, by adding small amount of mineral admixtures to the concrete mix can boost the strength of concrete effectively. Focus of this research work is to develop the high strength self compacting concrete which can be self cured. The size of nano silica particles has a great influence on concrete characteristics while comparing it with other nano materials at suitable proportion. The combination of PEG and NS demands an extensive analysis as their contribution towards hydration process is significant. In the present study, Nano silica (NS) was used as mineral admixture, Polyethylene glycol (PEG) was used as self curing agent. Initially optimum content of NS was determined in order to attain the high strength self compacting concrete. Nano silica replaced with cement with the mass of cement and Polyethylene glycol replaced with water by different proportions to the mass of cement. The fresh properties of prescribed mixes satisfies the EFNARC guidelines. Permeability of concrete can be lowered by adopting mineral admixture like NS which helps to overcome chloride ion entry. For which, Durability tests like Rapid Chloride Permeability Test (RCPT) and water absorption and desorption tests were initiated to know the performance of Nano Silica in Self Compacting Concrete. The improved results I,e, optimum content was observed at 2% addition of NS and 3% addition of PEG.

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1. Introduction

In traditional concrete, general defects like honeycombs and air bubbles were observed due to improper compaction [1]. Self-compacting concrete (SCC) is a sort of concrete which can flow through confined zones without any external vibration. It can flow by its own heaviness. Poor compaction leads to reduction in durability properties. SCC was developed in 1988 and is characterized by its fresh properties like its filling and flow ability and defiance to segregation [2–4]. Also, it possesses high deformability, aversion to segregation and less yield stress.

Concrete is a porous material which can make water and other liquids as easy target for entrance into concrete and cause decay in durability properties [5]. Structural degradation may occur if durability properties are not concerned. Concrete is made up of amorphous phase with different materials of sizes which have particle sizes from 300nm to 32mm. By improving particle packing leads to revamp the properties of concrete mix. Improved particle packing can be achieved by adding materials which having sizes smaller than 300nm. Compatible materials that can add to concrete mix smaller than 300nm are micro silica, silica fume and nano silica [6]. The best material to be added is nano silica [1,2,6–11]. Generally, size of NS ranges from 10nm to 50nm.Inclusion of NS to the high performance concrete works as anti-bleeding agent [1,3]. NS can also reduce the segregation tendency and improves cohesiveness of concrete. Due to its nano particle distribution nature, NS can fill very tiny voids in concrete mix, which can improve durability properties [1,7,10].

Generally, conventional concrete specimens will be cured for a period of 28 days to attain its target strength. Curing of concrete is not possible in water scarcity areas and structures which are not accessible for curing hence, internal curing is the only way to overcome this complication [2]. Reliable quantity of strength that can be attained by means of typical curing, can be accomplished by including self-curing agent to concrete mix. Polyethylene glycol is chemical that can be used as self-curing agent [6,12,13]. PEG is harmless, inodorous, neutral, lubricating, non-volatile and clear [12,13]. Due to its water retention capacity moisture in concrete, lasts for longer period and which can improve the heat of hydration process. When PEG is added to water it forms hydrogen bonds with water molecules which can deduce the chemical potential of water molecules which in turn reduces the vapor pressure and decreases the surface evaporation of water. The current research work come up with a novelty approach about influence of NS and PEG on SCC characteristics under water exposure conditions by optimum dosages.

2. Literature review

Hongjian Du (2019): In his research work, author experimented in briefing the ascendency of Nano Silica on the performance of ultra-light weight cement composites. Expanded glass particles and Cenospheres were used as a replacement to fine aggregate. Also observed how far colloidal nano-silica dosage make an impact on durability characteristics [2].

Seyed Alireza Zareei (2019): The author made a novel approach by making nano silica and basic oxygen steel slag as a substitute to cement and fine aggregate respectively. It was clear that, incorporation of steel slag reduced the workability of mix. By the experimental investigation, it is that water absorption, Crack width has a significant impact by the alteration of substitute proportions [12].

Nadine Hani (2018): Inclusion of nano silica as a partial substitute to cement is observed by verifying the water binder ratio of 0.41; 0.45; 0.5. SEM analysis was performed and in addition to that author defined the segregation resistance, Viscous nature of nano silica in this case. Decline in strength characteristics at higher water binder ratio can be overcome by nano silica [3].

Magadha I Mousa (2015): In this novel research work, author adopted pre-soaked light weight aggregate and PEG as self-curing agents. Brief comparative analysis was made with two agents and concluded that PEG shown a better performance in terms of mechanical properties. Also effect of silica fume was determined [14].

3. Research significance

The current research work involves computation of output data obtained after certain period is considered to be experimental data for which analysis of modelling can be done and also the experimental programme contributes immense vision in developing material science. High performance concrete is subjugated to an extreme outlook in the research industry. Many tasks are explored on evaluating the performance of concrete. To overcome the challenges faced by traditional concrete like creep; shrinkage, high performance concrete come into picture. Here, mineral admixture called NS which is one among the carbon footprint reducing material. However, to meet the demands of durability standards, self-curing technique plays a crucial role on performance criteria. In that aspect, research on it makes a greater repercussion on concrete performance. The proposed mix design in the current research work attained the good rheological and durability characteristics by satisfying the workability considerations. Whereas in the mentioned literature works did not meet the criteria.

4. Research gap

The touch on literature review to the concerned topic given me a healthier idea to develop a bridge on the gaps formed on the existed research works. Major gaps that come to notice as per the literature review is as follows:

A) The earlier research works focused merely on rheological & microstructure of concrete when NS used as a substitute to cement. Extensive research work need to be carried out on densifying the concrete by using NS as substitute.

B) Analyzing the Interfacial Transition Zone is précised for various substitutes. Briefing the C-S-H gel formation as a motivation requirement such that its potential applications have made more familiar.

C) Demands further research for a fruitful application of NS to know concrete mysteries and this work led to add meaningful concrete behavior in terms of performance criteria to the previous works.

5. Applications

The present investigation carried out for extensive application of NS as the construction material. However, well known burning issue is greenhouse effect which can retard the emission of carbon dioxide by using substitutes like NS.

a) The stressed point is NS is finer than the cement particle which helps to overcome in filling voids which in turn adopted where permeability is foremost criteria.
b) Applied where hydration process needs to be retarded, since high surface area of NS functions as a nucleation site for precipitation of C-S-H gel.
c) Suitably adopted for various concretes like Eco-Concrete; Self Compacting Concrete due to its economy in lifetime cycle cost.

6. Experimental program

6.1. Materials

Ordinary Portland cement of 53 grade with specific gravity 3.02 was adopted in the proposed work. Class F fly ash was used and obtained from industrial plant. Specific gravity of fly ash is 2.02. Nano silica was used as mineral admixture and replaced with cement in different proportions [1,2,4,6,7]. Polyethylene glycol was used as self-curing agent and replaced with water content [12,14]. Both NS and PEG were acquired from local commercial supplier [12,14]. River sand of zone-II and passing from 2.36mm was considered as fine aggregate and coarse aggregate passing through 12.5mm was used. Master glenium sky 8233 was used as super plasticizer. The percentage of constituents of cement and nano silica was shown in table 1.

Table 1
Chemical compositions of Cement and Nano silica.

Chemical Analysis	% In Cement	% In Nano Silica
SIO_2	22.74	99.80
AL_2O_3	3.22	0.056
Fe_2O_3	3.72	0.016
CaO	63.1	-
MgO	1.56	-
K_2O	0.62	0.007
Na_2O	0.39	0.005
SO_3	0.37	-

6.2. Mix design

Mix design was obtained by several trial and error mixes. In this proportion, water binder ratio and super plasticizer named master glenium sky 8233 was kept constant for all mixes [11]. Water binder ratio is 0.34 and super plasticizer is 0.6% of cement content [3,15]. The dosage of varied amounts of nano silica [6], PEG 400 and materials used in concrete mix were shown in table 2.

Fig. 1. Pan mixer Used for concrete Blending.

Table 2
Mix designation.

Mix Designation	Cement(kg/m^3)	Fly Ash (kg/m^3)	Nano Silica (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	PEG 400 (kg/m^3)
NSSCC 1	500	110	0	850	795	0
NSSCC 2	495	110	5	850	795	0
NSSCC 3	490	110	10	850	795	0
NSSCC 4	485	110	15	850	795	0
SCSCC 1	490	110	10	850	795	0
SCSCC 2	490	110	10	850	795	2.5
SCSCC 3	490	110	10	850	795	5
SCSCC 4	490	110	10	850	795	10
SCSCC 5	490	110	10	850	795	15
SCSCC 6	490	110	10	850	795	20

6.3. Workability tests

a) Slump Flow: The horizontal flow characteristics of concrete is determined by performing slump flow test as per EFNARC (European Federation of National Associations Representing for Concrete) guidelines as shown in fig 2. The appropriate check can be made on behalf of filling ability of concrete.

Fig. 2. Slump Flow.

b) V Funnel Test: The other type of workability test performed in the laboratory to determine the filling ability and this test possess a condition that aggregate size should be less than 20mm. It is conducted as per guidelines prescribed by EFNARC as shown in fig 3.

Fig. 3. V Funnel.

c) L Box Test: This test developed for underwater concreting for defining passing ability. Executed the test by satisfying EFNARC guidelines as shown in fig 4. The test involves in allowing the passage of concrete from vertical to horizontal chamber.

Fig. 4. L Box.

6.4 Experimental procedure

In this experimental programme, an electrical pan mixer with 80liter capacity as shown in figure 1 was used for blending of materials. All the materials were estimated in mass proportions. Theme of the mixing is to attain uniform and homogeneous mix which covers every single aggregate with binding material. Consistency and flow properties must not be disturbed throughout the mixing and placing of concrete into moulds. A cylindrical concrete specimen of 100mm diameter and 50mm length was placed and fixed air-tight in the diffusion cell [16]. The diffusion cell contains two chambers, concrete specimen was sandwiched between these two chambers [4,17,18]. One chamber is filled with NaCl solution with concentration of 0.3M and other chamber is filled with NaOH solution with concentration of 2.4M. Under the DC voltage of 60 volts, chloride ions are forced to move from one chamber to other through concrete specimen as shown in fig 5. The test was conducted for six hours, for every half an hour time interval the values of current passing in amperes were taken. By interpreting the values that taken for every half an hour, total charge passing through the concrete can be determined. Test procedure conducted according to ASTM C1202 [19].

$$Q = 900 \text{ X } (I_0+2I_{30}+2I_{60}+2I_{90}+\ldots+2I_{330}+I_{360}) \quad (1)$$

Where, Q = Total charge in coulombs

I_0 = Current reading in amperes immediately after voltage is applied,

I_t = Current reading in amperes at **t** minutes after voltage is applied.

Fig. 5. RCPT test setup.

Water absorption and desorption tests were performed to know the permeability of concrete [5]. This test was performed according to ASTM C642 [18,20]. For water desorption test, concrete specimens were placed in oven at 105^0C for 72 hrs. Weight of each concrete specimen was recorded for 0, 1, 3, 6, 12, 24, 36, 48, 60 and 72 hours. The results of percentage of desorption will show evaporation characteristics of concrete mix.

Concrete specimens after oven dried at 105^0C they were allowed to cool up to room temperature and immersed in water for water absorption test. For water absorption test weight of each concrete specimen was recorded for 0, 0.5, 1, 5, 3, 5, 6, 8, 10, 12, 24, 30, 36, 48, 60 and 72 hours.

The results of percentage of absorption will show permeability characteristics of concrete mix. Water Accessible porosity was determined According to ASTM C 642.

% of water accessible porosity= $\frac{Ww-Wo}{Ww-Wa}$ x 100

Where, W_w= Mass in air after immersion in water, W_o= Mass in after oven dry, W_a= Apparent mass in water.

7. Results and discussion

7.1. Fresh properties of concrete

The fresh characteristics of concrete were found by preforming tests like slump and V funnel and L-Box test as shown in fig 2, fig 3, fig 4 respectively. Due to more specific surface area of NS, the results were declined. By this we can conclude that NS has negative effect on fresh properties. To overcome this, PEG which plays vital role to overcome the incomplete hydration process on behalf of for self-compacting concrete. Figure 6 & 7 & 8 & 9 & 12 & 13 explains about slump flow, V funnel and L-Box test results of NS and PEG at chosen percentages. Similarly, Figure 10 & 11 depicts V funnel T5 results and regression analysis is made for the conducted fresh property tests as shown in fig 14 & 15. Table 3 and Table 4 conveys the information related to fresh property test results for NS and PEG.

Table 3
Fresh Properties of Nano Silica.

Mix Designation	V Funnel (Sec)	V Funnel T5 (Sec)	L Box (H_2/H_1)
Conventional Mix	9	11.7	0.95
NSSCC 1%	10.6	12.8	0.91
NSSCC 2%	11.4	14.5	0.87
NSSCC 3%	14.9	17.6	0.84

Table 4
Fresh Properties of PEG400.

Mix Designation	V Funnel (Sec)	V Funnel T5 (Sec)	L Box (H_2/H_1)
SCSCC 0%	11.5	14.3	0.84
SCSCC 0.5%	11.6	13.7	0.88
SCSCC 1%	10.8	13.1	0.91
SCSCC 2%	9.9	11.2	0.93
SCSCC 3%	8.7	10.4	0.96
SCSCC 4%	8.1	9.5	0.98

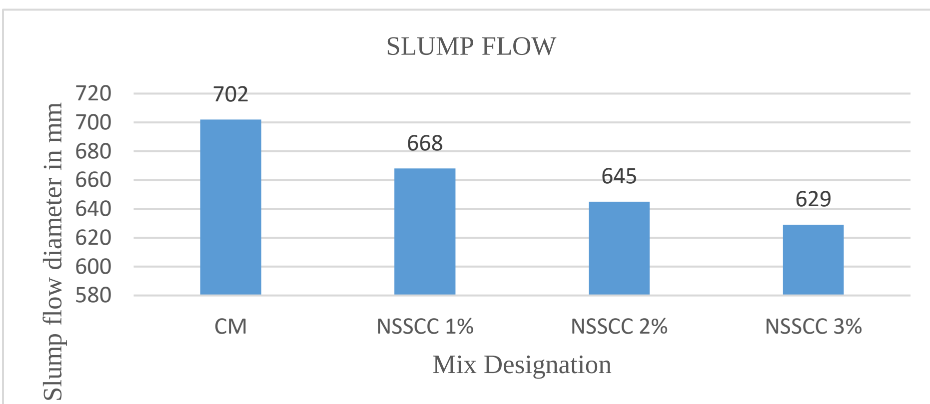

Fig. 6. Slump Flow Results of NS.

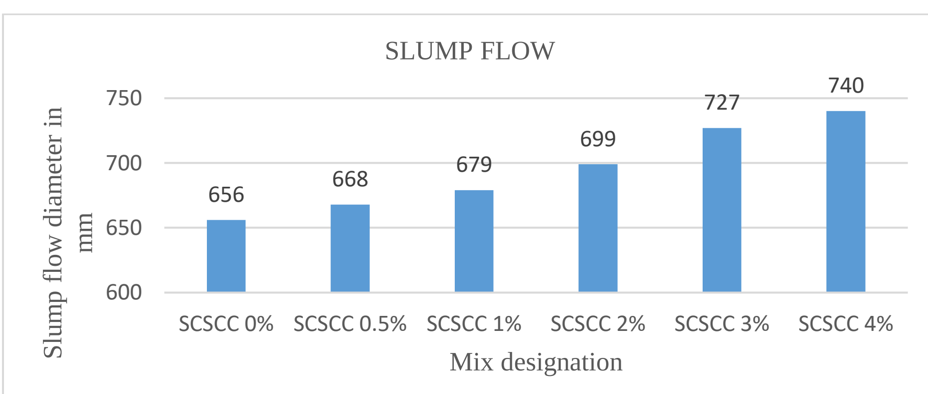

Fig. 7. Slump Flow Results of PEG 400.

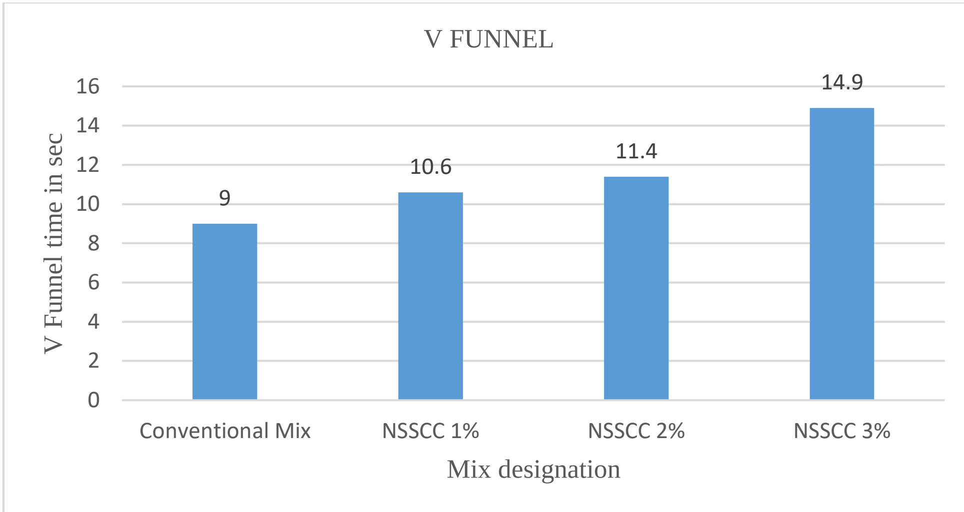

Fig. 8. Results of V Funnel of Nano Silica.

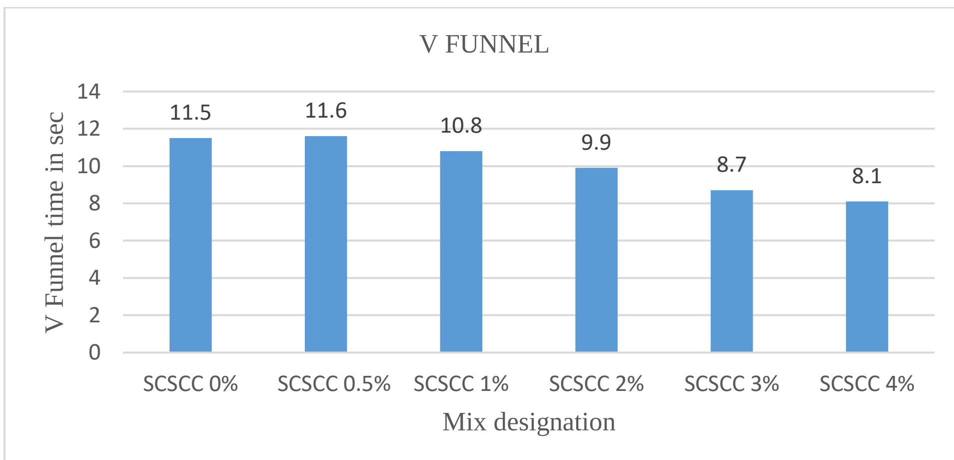

Fig. 9. Results of V Funnel of PEG 400.

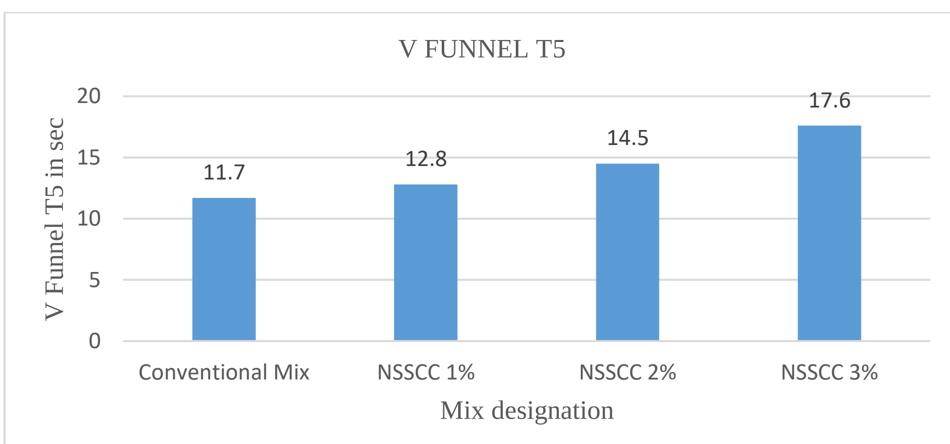

Fig. 10. Results of V Funnel T5 of Nano Silica.

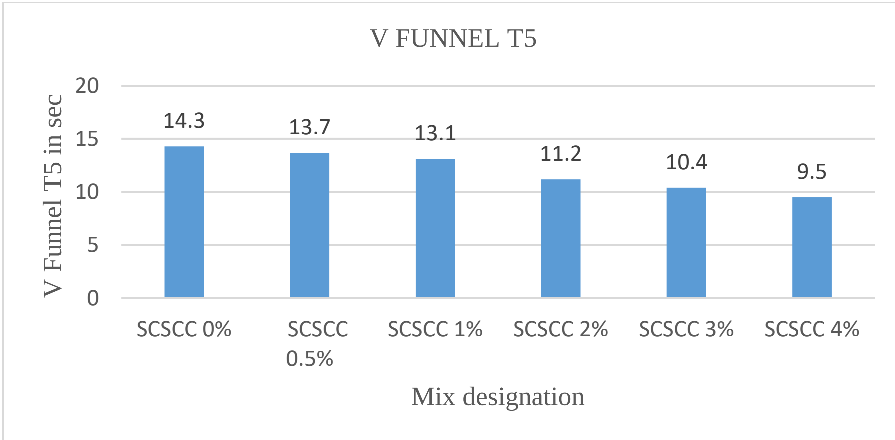

Fig. 11. Results of V Funnel T5 of PEG 400.

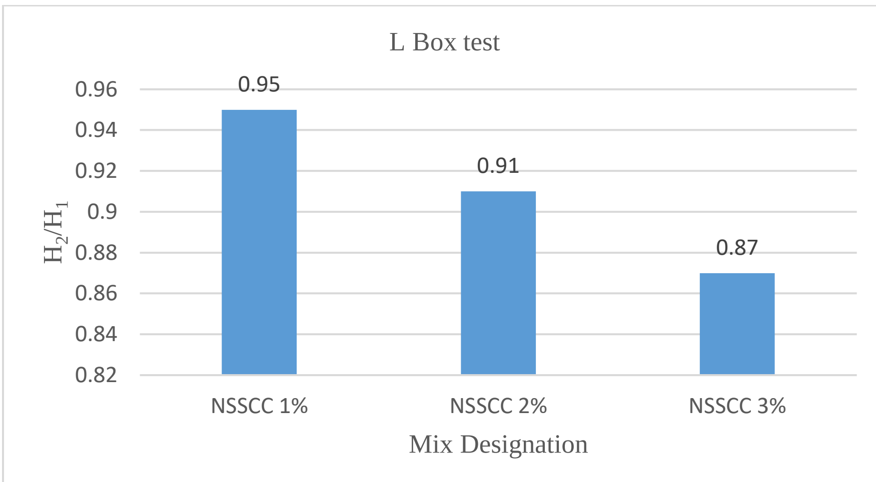

Fig. 12. Results of L Box test for Nano Silica.

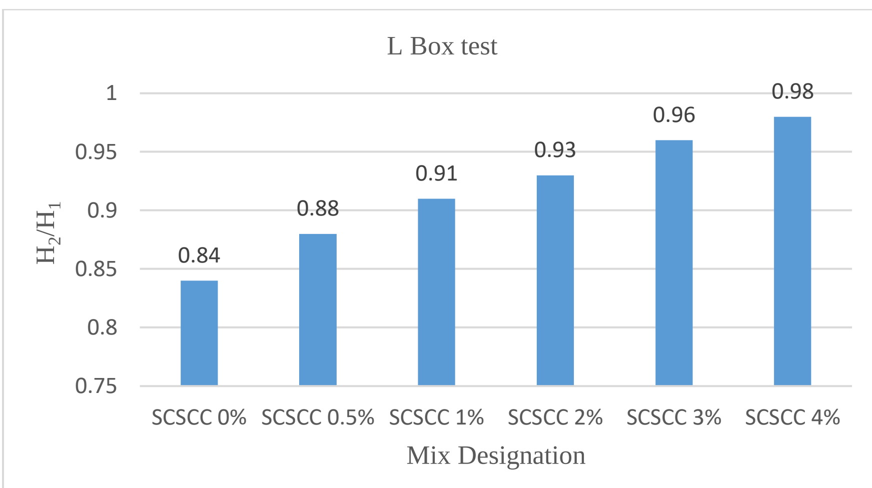

Fig. 13. Results of L Box test for PEG400.

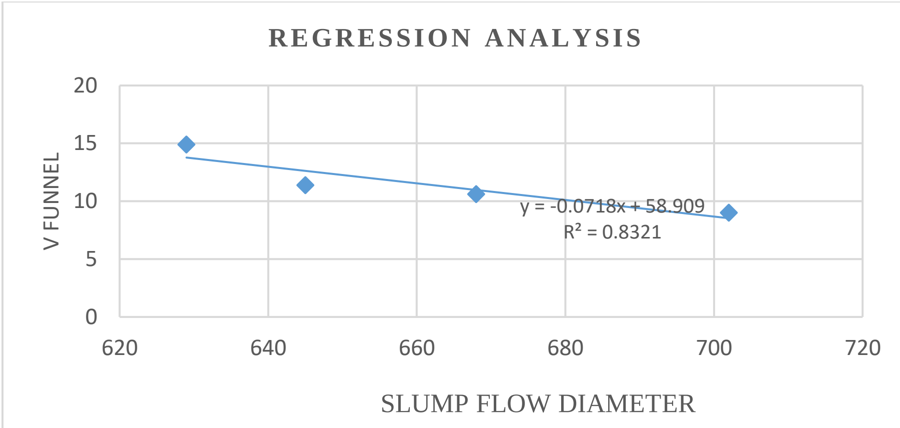

Fig. 14. Regression Analysis Slump Flow vs V funnel.

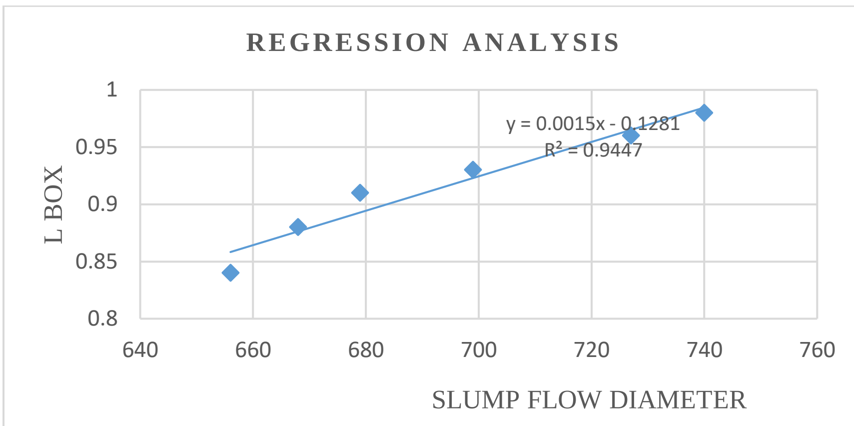

Fig. 15. Regression Analysis Slump Flow vs L Box.

7.2. Mechanical properties of concrete

Table 5
Mechanical Properties of Nano Silica.

Mix Designation	Compressive Strength (Mpa)	Split Tensile Strength (Mpa)	Flexural Strength (Mpa)
NSSCC 1	65.03	5.85	7.804
NSSCC 2	73.6	5.88	8.096
NSSCC 3	82.3	10.699	10.699
NSSCC 4	78.2	7.03	10.166

Table 6
Mechanical Properties of PEG 400.

Mix Designation	Compressive Strength (Mpa)	Split Tensile Strength (Mpa)	Flexural Strength (Mpa)
SCSCC 1	56.6	4.528	6.226
SCSCC 2	59.3	4.744	6.523
SCSCC 3	63.56	5.720	7.630
SCSCC 4	78.3	7.047	8.613
SCSCC 5	80.3	9.636	10.439
SCSCC 6	77.6	6.208	9.312

A) Compressive strength

Standard cube specimens were casted and tested for ascertaining the compressive strength. The adopted mould size is about 150*150*150mm. Compressive strength results at 4 weeks strength was shown in figure 17&18. Tests were accomplished as per IS 516-1959 [21]. From the results, compressive strength was intensified by adding NS. NS improves the microstructure and densify the concrete by filling tiny voids which resulted in tight packing of constituents [1,2]. Strength of concrete was increased as by increasing the dosage of NS up to 2% dosage, after 2% dosage there was a decrease in strength value [1,2]. As we know that silicondioxide plays the secondary prime constituent in cement constituents and hereby the inclusion of nano silica made the paste thicker which as a result raised the hydration process to a considerable extent. The specimen undergone a gradual rate of application of load and it is observed that NSSCC samples took more time to first crack appearance while comparing it with SCSCC samples.

The percentage of increase in strength compared to conventional mix for 1%, 2% and 3% was 13.18%, 26.56% and 20.25% respectively. The utmost strength was obtained at 2% dosage. The limit of absorption was listed in table 8 According to CEB 1989 [22]. As the dosage of PEG increasing there was an increase in the strength values. Table 5 and 6 represents the results. The percentage of increase in strength contrasted to conventional mix for 0%, 0.5%, 1%, 2%, 3% and 4% was -12.96%, -8.81%, -2.26%, 20.41%, 23.48%, 19.32% respectively. Polyethylene glycol dosage up to 2% has negative effect on concrete. Maximum strength value was achieved at 3% dosage. The compressive strength test equipment setup is as shown in figure 16 and the attained results of prescribed specimen samples are displayed in figure 17 & 18. Simultaneously, regression analysis is performed between compressive and flexural strength results as shown in fig 24.

Fig. 16. Compressive strength test.

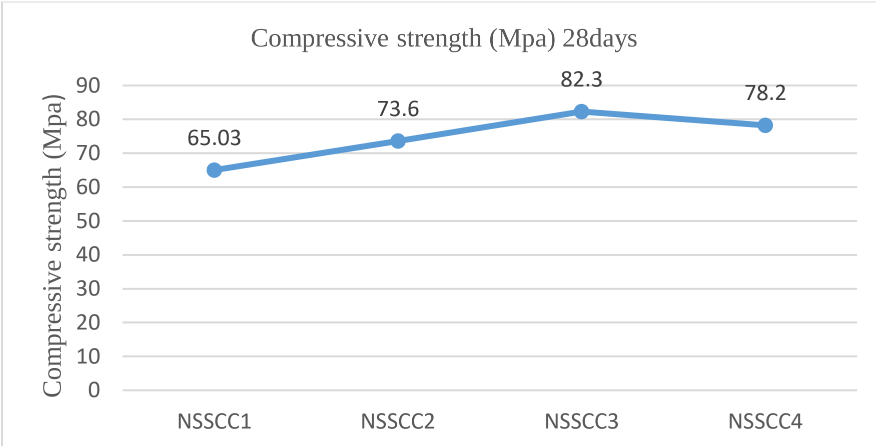

Fig. 17. Compressive strength of NSSCC mixes @28 days.

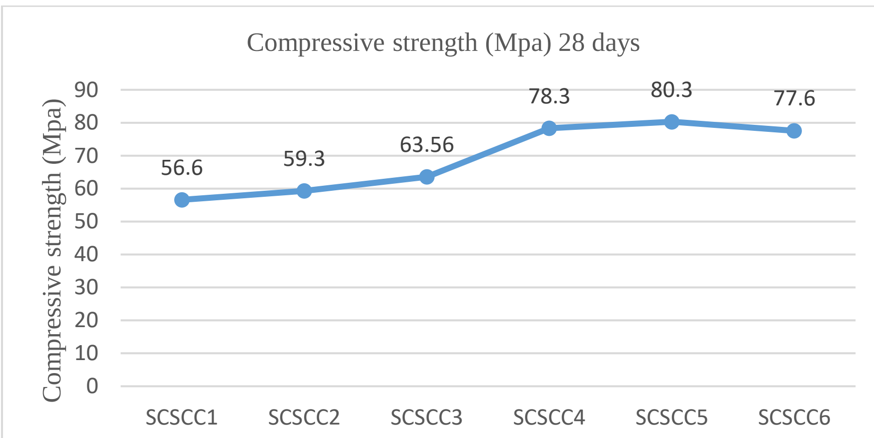

Fig. 18. Compressive strength of SCSCC mixes @28 days.

B) Flexural strength

The flexural strength is a mechanical property of concrete which is expressed as modulus of rupture performed as per ASTM C78 [23]. Turned on compressive strength of concrete, it is 10% to 15%, simultaneously judged by type, size and volume of metal used. The specimen of size 100*100*500 mm cured for a period of 28days and obtained the results for all mixes as shown in fig 19. Well known point from the experimental work is that NS improves the microstructural nature of concrete. The strength was developed enormously due to good

hydration process and the results were shown in figure 20&21.

Fig. 19. Flexural Strength test.

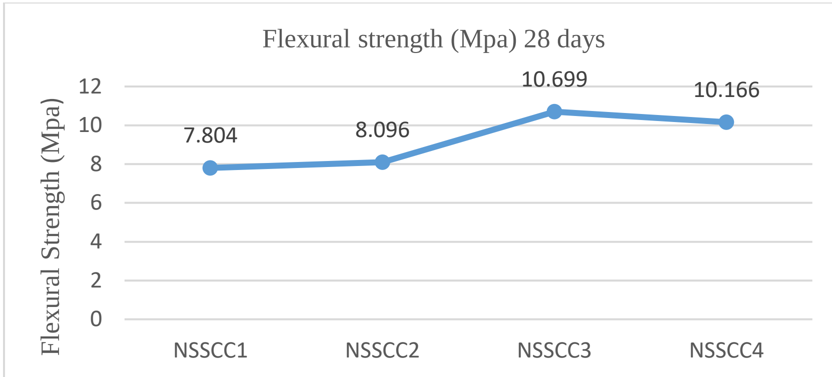

Fig. 20. Flexural Strength of NSSCC @ 28 days.

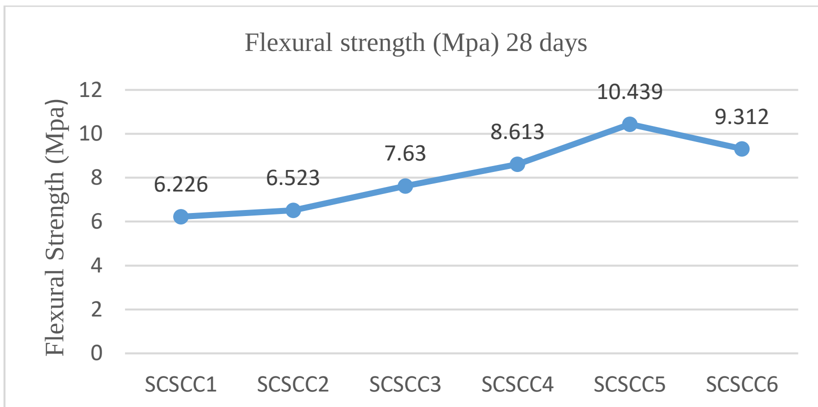

Fig. 21. Flexural Strength of SCSCC @ 28 days.

C) Split tensile strength

The concrete which is extensively adopted performs well with compressive stress whereas lacks with tensile stress. Hence, need to focus on developing or minimizing those losses is significant. In this work, NS incorporated at 0%, 1%, 2%, 3% and the test conducted on 100mm diameter and 200mm height cylindrical cubes and evaluated by following IS 5816-1999 [24]. The cylinder samples exhibited a severe crack at an instance before the failure occurs and this is due to the bond emerged between the cement constituents with the help of NS and PEG. The test results as shown in figure 22&23 in which NSSCC3 shown a good result. The good results achieved at 2% dosage.

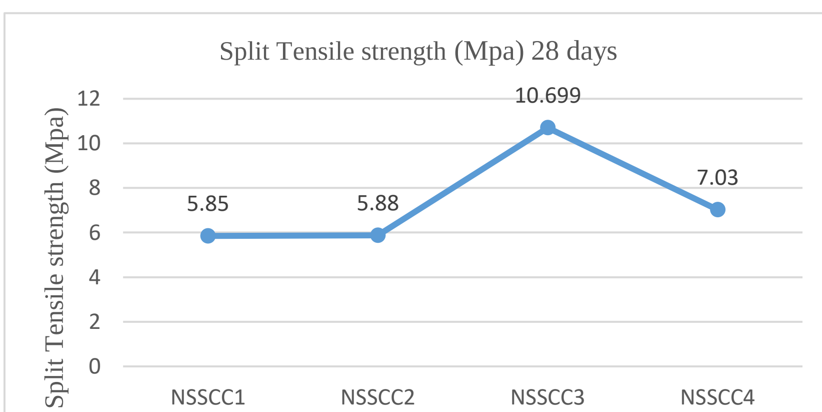

Fig. 22. Split Tensile Strength of NSSCC @ 28 days.

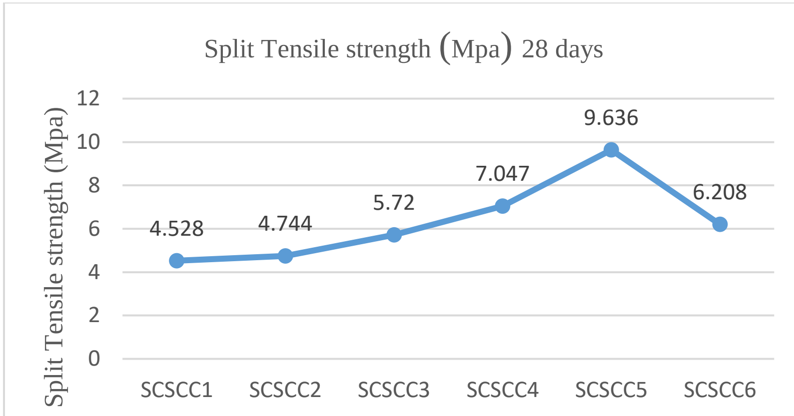

Fig. 23. Split Tensile strength of SCSCC @ 28 days.

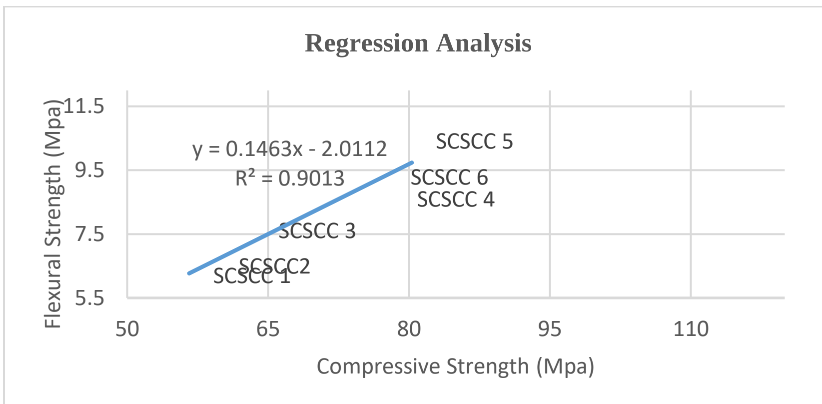

Fig. 24. Regression Analysis on Compressive vs Flexural.

7.3. Durability properties of concrete

A) Rapid chloride permeability test

Figure 25 represents the total charge progressed through the concrete specimens [9,13,18]. The study involves in knowing the aversion to intrusion of chloride ions. The conductance for the different mixes enable us to get an idea about the reluctance to chloride ions. Referring the Figure 25&26, less charge passed through NS at 2% dosage and PEG at 3% dosage were observed. Since, due to the improved resistance to chloride ion penetration for minimized micro-cracks and lower permeability. The chloride diffusion assessment criteria were referred from ASTM were shown in table.7.

Table 7
Chloride diffusion assessment criteria (ASTM).

Serial Number	Chloride permeability	Charge passed in coulombs
1	High	>4000
2	Moderate	2000-4000
3	Low	1000-2000
4	Very low	100-1000
5	Negligible	<100

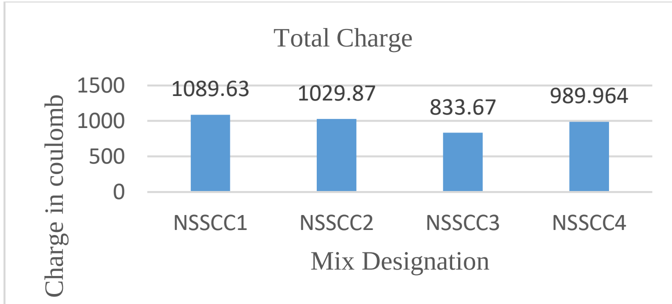

Fig. 25. RCPT Results for NSSCC.

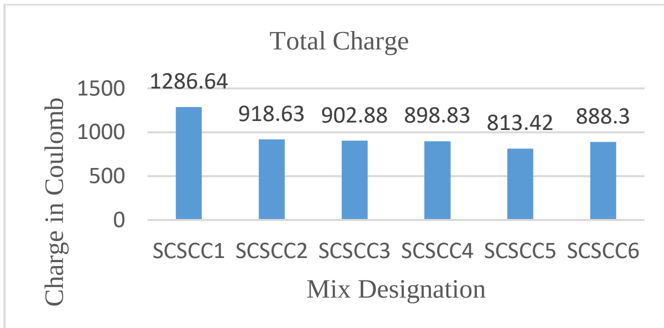

Fig. 26. RCPT Results for SCSCC.

B) Water absorption and desorption

This test is to examine the freezing and thawing durability of concrete. It helps us to make a note on porosity nature of concrete. Main criteria for the efflorescence formation on the concrete surface is due to entry of moisture. So, it is prioritized in terms of durability consideration. According to CEB 1989, the values for absorption were obtained good for all the concrete mixes. Best values were obtained for mix containing 2% Nano silica and 3% polyethylene glycol [8,25]. The specimens were oven dried at a considerable temperature as shown in figure 27. Results of percentage absorption and desorption was shown in below figures 28 & 29 & 30 & 31 respectively. However, table 9 and table 10 conveys the attained absorption values of NS and PEG respectively and table 11 and table 12 coveys the desorption values NS and PEG respectively of the concrete specimens.

Fig. 27. Cubes placed in oven for desorption test.

Table 8
Limits of absorption according to CEB 1989.

Percentage of absorption at 30min	Absorption rate	Quality of concrete
<3	Low	Good
3-5	Average	Average
>5	High	Poor

Table 9
Percentage of Absorption values of Nano Silica.

TIME (HOURS)	CONVENTIONAL MIX	NSSCC 1%	NSSCC 2%	NSSCC 3%
0	0	0	0	0
0.5	1.21	0.9	0.6	1.04
1.5	1.56	1.3	0.84	1.35
3	1.78	1.39	1.05	1.57
5	2.24	1.76	1.34	1.85
6	2.4	1.85	1.36	2.04
8	2.52	1.86	1.44	2.09
10	2.57	1.94	1.48	2.12
12	2.65	1.99	1.58	2.18
24	2.93	2.18	1.94	2.48
30	3.35	2.28	2.06	2.61
36	3.42	2.28	2.09	2.61
48	3.48	2.28	2.18	2.66
60	3.55	2.28	2.23	2.73
72	3.36	2.30	2.26	2.78

Table 10
Percentage of Absorption values of PEG 400.

TIME (HOURS)	SCSCC 0%	SCSCC 0.5%	SCSCC 1%	SCSCC 2%	SCSCC 3%	SCSCC 4%
0	0	0	0	0	0	0
0.5	1.4	1.35	1.45	1.42	1.17	1.23
1.5	1.9	1.65	1.75	1.85	1.39	1.75
3	2.23	2.1	2.12	2.25	1.74	2.09
5	2.95	2.43	2.65	2.55	1.85	2.45
6	3.18	2.65	2.7	2.66	2.04	2.55
8	3.28	2.73	2.79	2.78	2.16	2.72
10	3.39	2.85	2.87	2.89	2.21	2.85
12	3.56	2.99	2.9	2.95	2.26	2.85
24	3.95	3.35	3.25	3.25	2.62	2.9
30	4	3.55	3.45	3.36	2.76	3.25
36	4.05	3.6	3.5	3.36	2.76	3.35
48	4.05	3.62	3.55	3.36	2.85	3.35
60	4.12	3.71	3.55	3.52	2.99	3.45
72	4.14	3.8	3.68	3.67	3.1	3.59

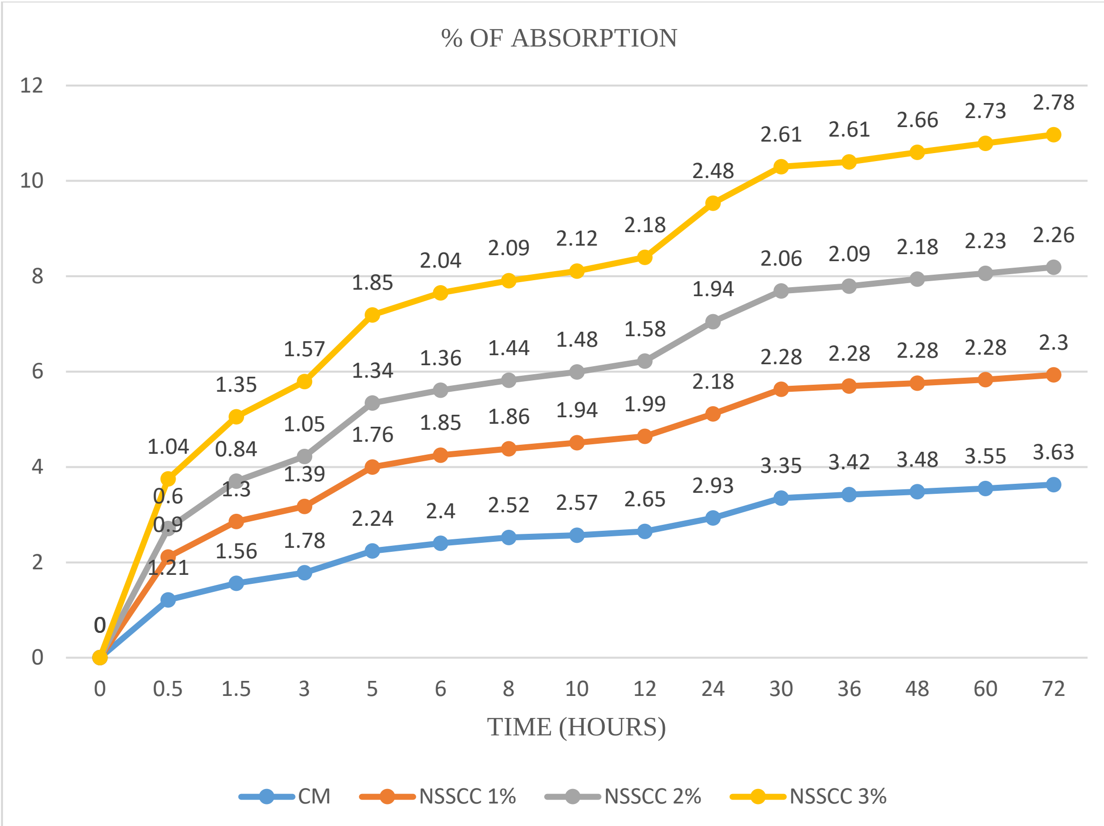

Fig. 28. Results of % of Absorption for NSSCC mixes.

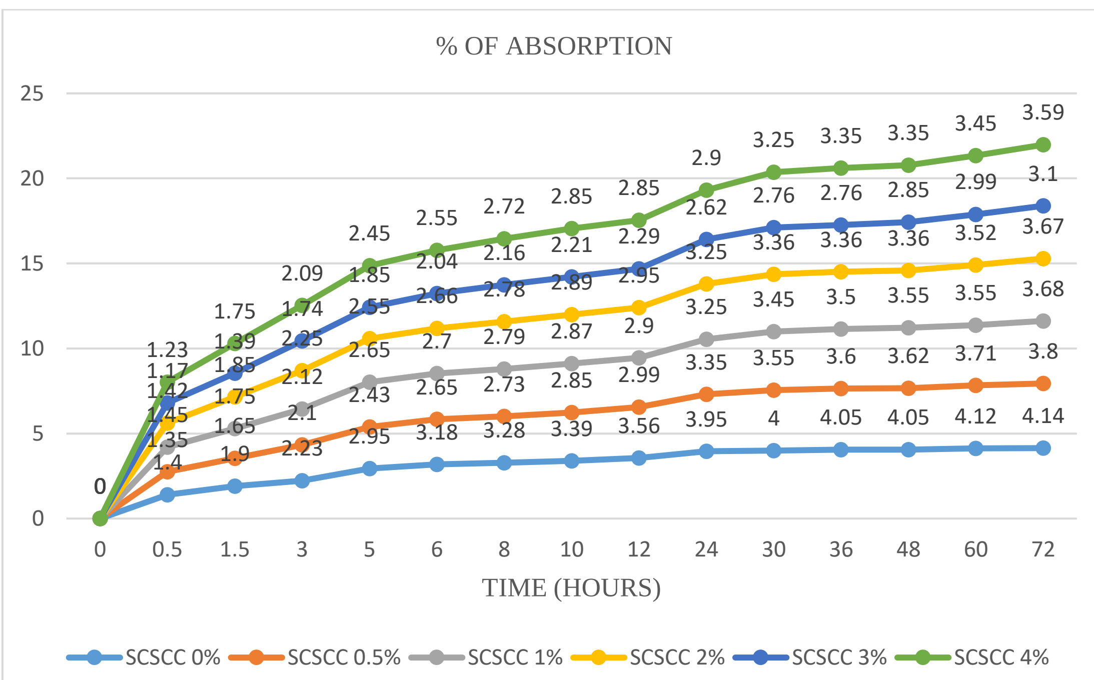

Fig. 29. Results of % of Absorption for SCSCC mixes.

Table 11
Percentage of Desorption values of Nano Silica.

TIME (HOURS)	CONVENTIONAL MIX	NSSCC 1%	NSSCC 2%	NSSCC 3%
0	0	0	0	0
1	0.1	0.05	0.06	0.07
3	0.35	0.31	0.25	0.2
6	0.9	0.8	0.85	0.66
12	1.35	1.25	1.27	1.25
24	1.65	1.55	1.5	1.75
36	2.35	1.79	1.85	2.1
48	2.85	2	2.02	2.49
60	3.08	2.45	2.34	2.9
72	3.12	2.85	2.6	3.02

Table 12
Percentage of Desorption values of PEG 400.

TIME (HOURS)	SCSCC 0%	SCSCC 0.5%	SCSCC 1%	SCSCC 2%	SCSCC 3%	SCSCC 4%
0	0	0	0	0	0	0
1	0.02	0.05	0.03	0.05	0.04	0.08
3	0.35	0.35	0.32	0.2	0.15	0.18
6	1.12	0.85	0.56	0.35	0.45	0.45
12	1.65	1.2	1.5	0.5	1.12	1.00
24	2.45	1.65	2.35	1.15	1.72	1.42
36	3.10	2.24	2.54	1.6	1.95	1.8
48	3.20	2.7	2.68	2.45	2.1	2.20
60	3.32	2.85	2.7	2.6	2.20	2.40
72	3.34	2.96	2.7	2.62	2.32	2.50

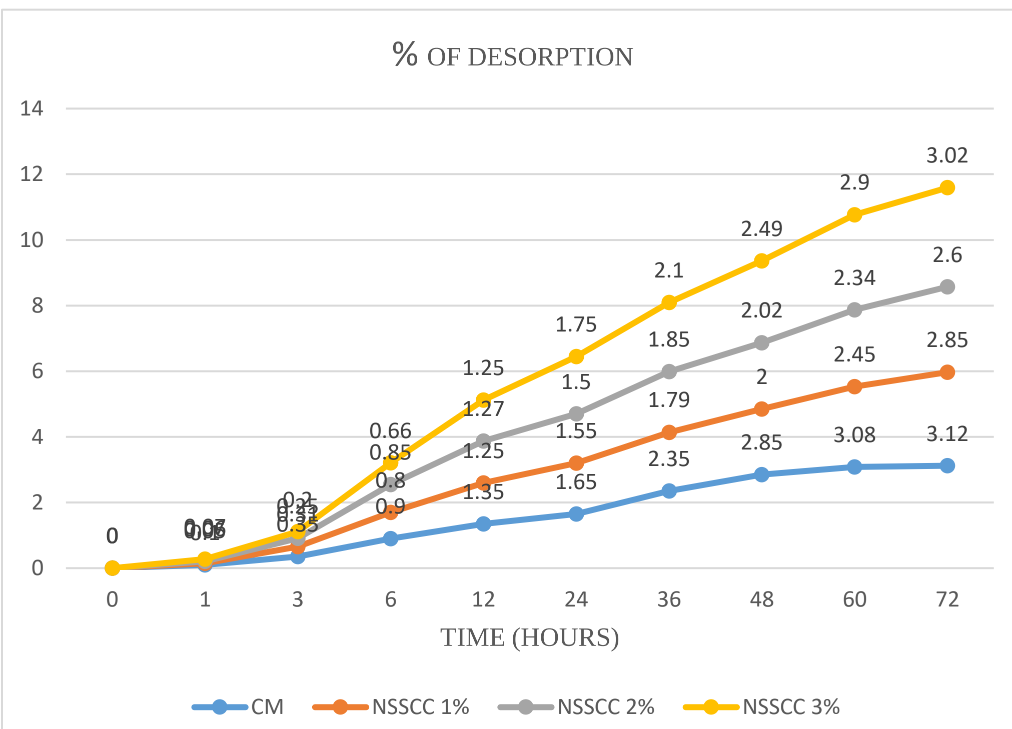

Fig. 30. Results of % of Desorption for NSSCC mixes.

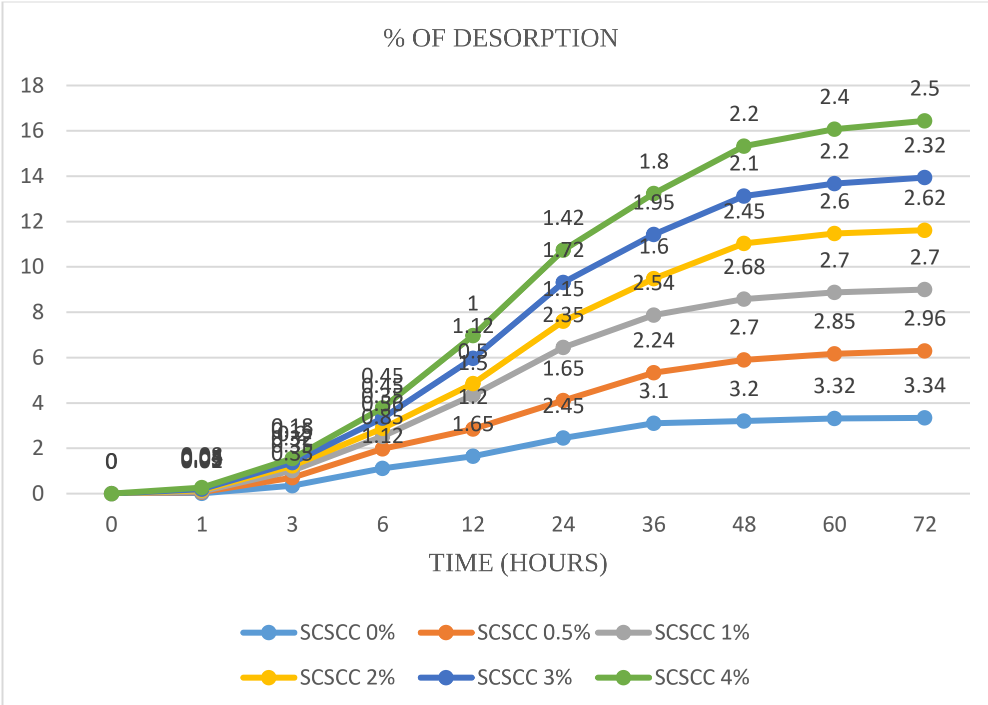

Fig. 31. Results of % of Desorption for SCSCC mixes.

7.4. Water accessible permeability

The entry of external or environmental agents into the microstructure zone of concrete leads to unknowing complications. So, in due course it is inevitable to conduct durability tests like water accessible permeability as per IS 3085-1965 [26]. The percentage of water accessible permeability was shown in the Figure 32. Minimum value of permeability was observed at 2% addition of NS and for self-curing concrete mix minimum value was observed at 3% PEG [13] due to adding NS beyond 2% lead to irregular distribution nano particles which results in decaying the strength. Figure 32 represents the percentage of water accessibility under various mix proportions [25].

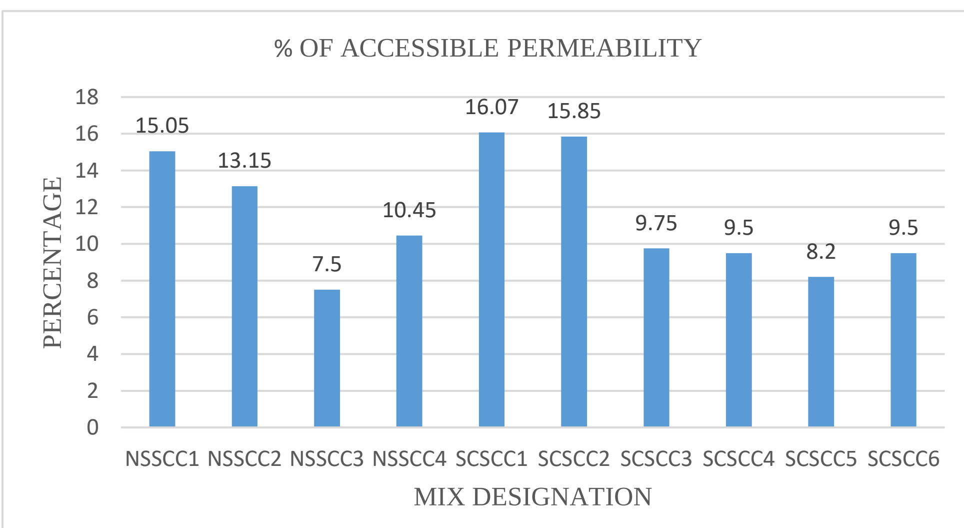

Fig. 32. Percentage of water accessible permeability.

8. conclusion

- From the work, it can be culminated that the flow properties of concrete were declining due to high specific surface area of NS which leads to less workability and in the same line better results were obtained by using PEG.
- The NSSCC 3 and SCSCC 5 shown an utmost result in terms of compressive strength of about 82.3 Mpa & 80.3 Mpa respectively. This is due to high densifying nature of concrete under the influence of nano silica and PEG.
- From the RCPT results, the permeability of all concrete mixes was low. At 2% dose of NS and 3% dose of PEG of concrete the charge passed was very low. This is due to less passage of charge into the mix.
- Addition of NS to concrete mix reduces the porosity of concrete up to 2% dosage, Addition of NS beyond 2% dosage causes irregular dispersion of nano particles and increases the porosity of concrete. Polyethylene glycol improves the heat of hydration process internally.

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