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Freezing-Thawing Resistance of Self-compacting Concrete with addition of Basalt Fibers

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Abstract: Frost resistance is an imperative parameter for cold areas that can affecting the durability and strength of structural concrete. In paper studies was conducted to investigate the effect of addition basalt fibres on fresh, mechanical and durability properties as measured by the rapid chloride penetration (RCPT) and frost resistance as measured freezing-thawing cycles of self-compacting concrete (SCC). Basalt fibres are included as SCCBF0%, SCCBF0.1%, SCCBF0.2%, and SCCBF0.3% of the concrete volume in the M30 grade of SCC mixes. The ASTM C666/C 666M–3 standard code was approved to conduct the 50 cycles freezing-thawing test on the specimens. After every 10 cycles of freezing-thawing, weight loss, density, and ultrasonic pulsevelocity, concrete specimens were tested for compressive strength. Dynamicmodulus elasticity, relative dynamic moduluselasticity, and durability factor were also measured. As a consequence of the testing, it was discovered that basalt fibre concrete outperformed control mixtures in terms of strength and resilience to repeated freezing-thawing cycles. Conferring to experiment results that carried out, using of basalt fiber 0.3% increased the frost durability of SCC mixtures.

Index Terms - Freezing-thawing, basalt fibers, self-compacting concrete, dynamic modulus of elasticity and durability factor.

I. INTRODUCTION

An ever-evolving world necessitates construction techniques that are constantly improved. Concrete is one of the building materials that is used most frequently today. For Indian circumstances, the lack of concrete durability caused by the freezing-thawing action of frost is not very significant. But in most of the world, it is the most important factor. But in other parts of India, the wintertime temperatures drop below zero. As a result of repeated cycles of freezing-thawing, concrete constructions [1], in especially those that are exposed to the atmosphere, are vulnerable to the destructive effects of frost. One of the weathering processes that has the greatest impact on the resilience of concrete is the frost effect. The lifespan of concrete can be drastically shortened to only a few years in harsh conditions. As a result of how frequently damage from freezing and thawing occurs, the USA, Russia, and North European nations have investigated this aspect of concrete weathering in great detail [3].

Although alternate wetting-drying, heating-cooling, salt penetration and deposition, calcium hydroxide leaching, the action of some acids, the alkali-aggregate reaction, mechanical wear and tear, abrasion, and cavitation all have an impact on the durability of concrete, the action of frost is one of the most significant factors in colder regions. Fresh concrete shouldn't be exposed to freezing temperatures, as is widely known. Significant amounts of free water are present in fresh concrete [1] when this free water is exposed to temperatures below freezing, discrete ice lenses are created. When water freezes, its volume increases by around 9%. Fresh concrete is disrupted by ice lenses that form in the concrete's body, nearly always resulting in permanent damage. If fresh concrete is exposed to freezing action and then permitted to harden at a temperature above freezing, it will lose its structural integrity. Therefore, the most important thing to remember when working with fresh concrete in cold weather is to keep the temperature above 0°C. Additionally, it is not advisable to expose the concrete that is hardening to a very low temperature. According to estimates, the pressure caused by water freezing inside of hardened concrete may reach 14 MPa. To withstand the harmful effect, concrete's strength must be greater than the tension it is under at any given time. Additionally, the fully hardened concrete is susceptible to frost damage, especially from the impact of repeated freezing-thawing cycles [10]. The worst conditions for frost action occur when concrete is in a position where it is always moist and has many faces exposed to the elements. via means of A high-tech fibre product without environmental pollution, basalt fibre is green, healthful, and environmentally beneficial. In comparison to other fibres, basalt fibre has great electrical qualities, high wave permeability, is non-conductive, and can withstand both high and low temperatures. It is also utilised to make materials for sound insulation and heat insulation in the industry [4]. Al + Ns performed significantly improved than conventional mixes in terms of strength and durability when unprotected to freezing-thawing cycles [2]. Self-compacting concrete mixtures' ability to withstand frost was boosted by up to 20% when coarse particles were substituted for basic pumice [5]. India has a variety of climates, with some sections having temperate climates and harsh winters, particularly those in the northernmost parts of the country like Ladakh and Jammu & Kashmir. These areas experience sub-zero temperatures, with some places, like Drass in the Ladakh region, reaching as low as -60 C. In most cold areas, the freezing-thawing cycle is a problem that needs to be taken into consideration during design. Freezing-thawing damage to assemblies can be minimised or completely avoided with correct details and specifications [9]. Concrete self-compacting with basalt fibre and carbon fibre has better mechanical qualities than basalt fibre [8].

By adding more basalt fibre to concrete, the freeze-thaw cycle can be improved. Additionally, basalt fibre and gel adhere to one another more strongly, and the hydration products that adhere to its surface gradually disappear. Concrete has the best frost resistance when basalt fibre concentration is 0.3%. By optimising the entire structure and lowering internal concrete faults, basalt fibre content of 0.3% increases concrete's durability [7]. Steel fibre reactive powder concrete was vulnerable to chloride salt corrosion, while basalt fibre significantly improved reactive powder concrete's freeze-thaw resilience as compared to steel fibre [3]. In self-compacting concrete that contains diverse mineral admixtures and nano-clay, 3% nano silica significantly increases the F-T resistance of SCC [16]. Steel fibre self-compacting concrete can considerably increase the frost resistance of SCC and can play a restricted role in quality loss, dynamic elastic modulus, and intensity. The higher the frost resistance, within a specific range, the more steel fibre is present [17]. If there is no freezing-thawing effect, the addition of 2.0% steel fibres to rubber concrete can raise the compressive strength by 26.6%. However, the strengthening effect is lost when rubber concrete is subjected to cyclic freezing-thawing. Although the relative dynamic elastic modulus is negatively impacted by steel fibres, the mass loss rate is positively impacted [18].

Due to the potential benefits of fibre, research on basalt fibre in self-compacting concrete has gained attention on a global scale in recent years. This study examines the effects of adding 6mm-long basalt fibre to four distinct mixtures using SCCBF0%, SCCBF0.1%, SCCBF0.2%, and SCCBF0.3%. determine the fresh for slump flow, T50cm flow, U-box, L-box, V-box test, mechanical properties and durability properties are Rapid chloride penetration test (RCPT), frost resistance for weight-loss, density, ultrasonic pulsevelocity, and dynamic moduluselasticity, relative dynamic moduluselasticity, durability factor and lastly, compressive strength of all SCC mixtures subjected to 50 freezing-thawing cycles and curing application were tested. To extend the durability and service life of concrete, numerous investigations on its frost qualities have been carried out worldwide; nevertheless, the addition of basalt fibre to self-compacting concrete has received relatively little attention.

II. RESEARCH SIGNIFICANCE

Common concrete has some flaws, including weak toughness, low tensile strength, and ease of cracking, which make it simple for dangerous substances to penetrate concrete through cracks, leading to a substantial loss in concrete durability and limiting the use of concrete in complicated contexts. Concrete's compactness, overall structure, and connectivity between holes have all been found to improve with the addition of fibre, which also increases frost resistance [3]. Basalt fibre has many benefits, including high strength, low temperature resistance, and corrosion resistance. In cold climates where de-icing salt has been used, the coupling of chloride corrosion and the freezing-thawing cycle results in significant concrete degradation [15]. The freezing and thawing of concrete buildings have caused a great deal of concern. The durability of concrete is significantly influenced by its pore structure. Low-porosity concrete constructions dramatically lower the amount of internal pore solution, which lowers internal water pressure brought on by pore solution freezing and increases the concrete's resistance to freeze-thaw.

Few studies have been conducted to describe the consequences of basalt fiber's freezing-thawing activity, particularly in the creation of self-compacting concrete, according to literature reviews. The primary goal of the study described here is to examine the effects of basalt fibre addition on the M30 self-compacting concrete grade's ability to withstand cold. Fresh properties are slump flow, T50cm flow time, V-box, U-box difference, L-box test. Mechanical (7, 28 days) are compressive, split, flexural strength test and durability properties are RCPT, mainly preform to frost resistance of 50 cycles freezing-thawing Concrete specimens were tested for every 10 cycles of compressive strength after Freezing-Thawing cycles, weight loss, density, and UPV, dynamic moduluselasticity, relative dynamic moduluselasticity, and durabilityfactor were calculated.

III. EXPERIMENTAL PROGRAME AND METHODOLOGY

3.1. Materials

Ordinary Portland Cement (OPC) of 53grade, compliant with IS:269-2015 [26], with a 3.15 specific gravity, the chemical parameters of which are shown in table 1, and a normal consistency of 33%. According to IS:456-2000 [27], potable water is utilised for mixing and curing. The ratio of water to cement is 0.47. As a coarse aggregate, crushed stone with a maximum size of 10 mm, a 2.8 specific gravity, and a 1.50g/cm3 bulk density in accordance with IS:383-2016 [28] was utilised. The river sand of grading zone II in accordance with IS:383-2016 [28] has a fineness modulus of 2.57, a specific gravity of 2.66, and a bulk density of 1.5 g/cm3. It uses the 1.10 specific gravity polycarboxylic-ether type superplasticizer [30] that is commercially available. 25% of cement can be replaced with GGBS, a highly cementitious material with a specific gravity of 2.9, high CSH content, and chemical parameters that are shown in the table. 2. Basalt fibre in the SCC 6 mm length as shown in Fig. 1 for the mechanical and physical qualities as table. 2 [4].

Table. 1. Chemical composition of cement and GGBS (values in percenters).

Chemical composition	SiO2	Fe2O3	CaO	Al2O3	MgO	SO3	Na2O+K2O
Cement	20.5	3.8	63.1	4.9	1.7	2	0.9
GGBS	31.79	0.48	38.77	17.08	6.25	0	0

Table. 2. Physical & Mechanical properties of basalt fibre.

Length (cm)	Density (g/cm3)	Density elastic modulus (G pa)	tensile strength (MPa)	heat conductivity coefficient (W/(m.k))	Fracture elongation (%)
1-1.4	2.63-2.65	91-110	3300-4800	0.03-0.04	2.4-3.2

Fig. 1. Basalt fibers

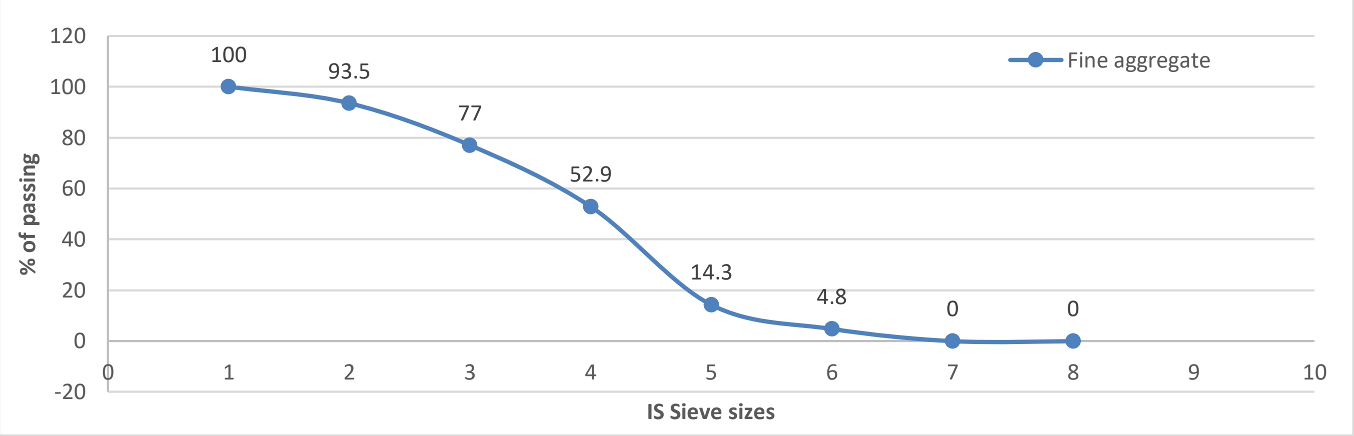

Fig. 2. Gradation curves of fine aggregate

3.2. Mix proportions, casting and curing of test specimens

Table 3 shows the mix proportions of SCC that were created using the IS 10262:2019 procedure. All of the constituent materials were weighed in accordance with the design, added to a mixer, and mixed for three to five minutes to create a total of four separate concrete composites that contain varying percentages of basalt fibre (0.1%, 0.2%, and 0.3%), as well as a control mix (0% fibre). The freshly mixed composites are examined for their fresh qualities and cast into 150x150x150 mm cubes for the measurement of compression strength, 100x100x500 mm beams for the examination of flexural strength, and 150x300 mm cylinder's that were cast in accordance with IS:516(Part I/Sec I):2019 [24].

To ascertain if concrete is resistant to the penetration of chloride ions, the RCPT is carried out in accordance with ASTM C1202 [25]. At 28 days, two samples from each concrete mix are analysed concurrently. After curing, 50 mm thick disc samples are taken from the centre of each 10 x 20 cm cylinder, and the moisture content is determined in accordance with ASTM C1202 standards [25]. The disc specimen's are then moved to the test chamber, where one face of each disc is in contact with a 0.30 N, NaOH solution and the other with a 3% NaCl solution. Across the faces, a direct voltage of 60 0.1 V is applied. Over the course of six hours, the data logger captured the current that flowed through the concrete specimen. After six hours of testing, each concrete's data on current(amperes) versus time(seconds) is plotted, and the area under the curve is combined to determine whether the test was successful(coulombs). Three samples from each combination were cast for each test, for a total of 108 samples.

Cast 100 mm cube-shaped specimens were left in the lab for 24 hours. The all-concrete examples were then removed from the mould and given a 28-day water cure. After that, the concrete samples underwent 50cycles of alternating freezing-thawing (Algin et al. 2018). The freezing-thawing phases of each cycle each require 2.5 hours freezing and 2 hours thawing. Weightloss, density, ultrasonic pulsevelocity, dynamic moduluselasticity, relative dynamicmodulus elasticity, and durabilityfactor were calculated for every 10 freezing-thawing cycles up to 50 cycles [2]. To get the dynamic modulus elasticity, relative dynamic modulus elasticity, and durability factor, utilise the formulae provided below (Salemi et al. 2014). A non-destructive ultrasonic pulsevelocity test was used to calculate the pulse velocity. Additionally, compressive strength was measured for 0, 10, 20, 30, 40&50 freezing-thawing cycles using compression testing equipment on the specimens. As seen in Fig. 3, the samples stayed placed in a freezer chamber that was set to freeze the samples at -10 0C.

Table 3. Mix proportions for Self-compacting concrete

Mix	Cement (kg /m^3)	GGBS (kg /m^3)	FA (kg/m^3)	CA (kg /m^3)	Water (kg /m^3)	W/C	SP (kg /m^3)
SCC	331.5	110.5	780	756	190	0.47	2.65

Percentage weight loss= $\frac{W1-W2}{W2}\times 100$

W_1 = Zero cycle weight of the specimens & W_2 = Weight of the specimens after'c' freezing–thawing cycles

Dynamicmoduluselasticity(DMD) = $V^2\rho\,\frac{(1+\mu)(1-2\mu)}{(1-\mu)}$

E = Dynamic modulus elasticity(N/m^2), V = Pulse velocity(m/sec), ρ=mass density (Kg/m3) and μ = Poisson's ratio(assumed as 0.2).

Relative dynamicmodulus elasticity (RDME) = $(E_c/E_0)\times 100$

E_c = DynamicModulus of elasticity at cycle'c', E_o = DynamicModulus of elasticity at '0' cycle Durability factor.

Durability factor = $[(RDME)_n \times n]/M$

$(RDME)_n$= Relative-Dynamic Modulus of Elasticity at 'n' Cycles, where 'n' is the minimum number of cycles at which RDM is more than60% and M is the maximum number of cycles at which testing is to be terminated. Due to the fact that the test was terminated after

50cycle's, before any elasticity modulus reached 60% of its initial value, the Durability-factor value in this study was equal to the RDME (n and M is 50).

Fig. 3. Freezing-thawing of concrete specimens in freezer

IV. RESULTS AND DISCUSSION

4.1. Fresh properties

All combinations are chosen to fall into the SF2 class of slump diameter [19]. Figure 1 illustrates this. 4. Depending on the amount of basalt fibre used, there can be a variance in the resultant slump flow diameter between 665 and 720 mm. Although the amount of included fibre directly affects the workability of basalt fibre reinforced SCC, it is largely regulated by the amount of additive employed, and the amount of superplasticizer needs to be increased in order to get the necessary slump flow diameter. The slump flow diameter of the SCC produced decreases as basalt fibre content increases, as seen in Table 4. The workability of previously finished concrete is typically made worse by the use of fibre [1]. The first is the mixing process increasing the coefficient of friction between the cement and fibre, and the second is the basalt fibre using a set quantity of moisture.

The difference in T500 flow time according to the amount of fibre added to the mixes created for this study is depicted in Fig. 5. Fresh SCC mixtures have a range of T500 flow times between 2.6 and 4.5 sec. The quantity of fibre augmentation increases the T500 flow time, as seen in Table 4. According to Fig. 5, which displays the results of the V-funnel tests carried out for this study, the ranging data are between 7.1 and 10.5 sec, which corresponds to the SCC class of VF2 according to EFNARC. The results of the V-funnel duration rise as basalt fibre amount increases, as shown in Table 4. Because of the high content added and the fibres' vast surface area, more cement paste is absorbed around the fibres, which causes the mixture's viscosity to rise [1].

U-box test is utilized to measure the filling capacity of SCC. Fig. 7 shows minimum value SCCBF0% is 10.5mm and maximum value 25mm for SCCBF0.3%. In presence of basalt fibers increases U-box values will be increases and Fig. 8 shows L-box test is passing ability ratio of SCC, it indicates the ranging data are between H2/H1 is 0.85 sec and 0.95 which refers to the SCC class of PA2 according to EFNARC. In presence of basalt fibers increases L-box values will be decrees as shown Table. 4. Finally all fresh properties of SCC to achieve guidelines of EFNARC.

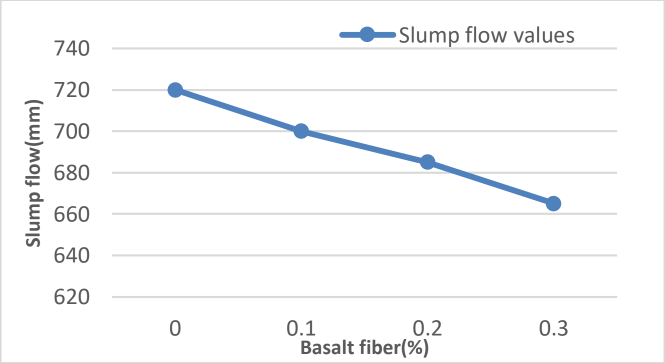

Fig. 4. Difference of the slump flow results

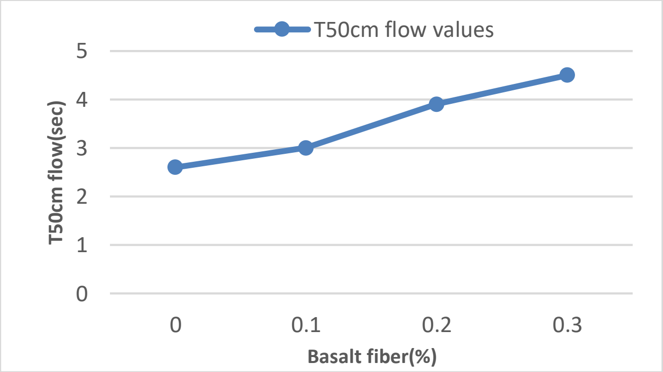

Fig. 5. Difference of the T500mm flow results

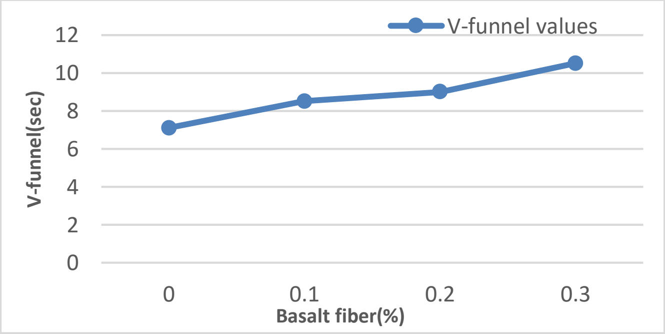

Fig. 6. Difference of the V-funnel time results

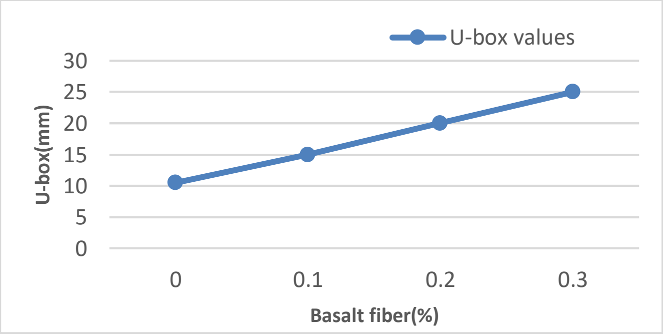

Fig. 7. Difference of the U-box results

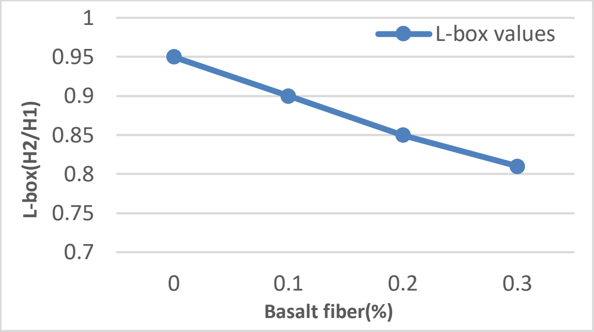

Fig. 8. Difference of the L-box H_2/H_1 results

Table 4. Physical properties of self-compacting concrete

S. No	Mix	Slump flow(mm)	T500mm flow	V-funnel (Sec)	U-box(mm)	L-box(H2/H1)
1	**SCCBF0%**	720	2.6	7.1	10.5	0.95
2	**SCCBF0.1%**	700	3	8.5	15	0.9
3	**SCCBF0.2%**	685	3.9	9	20	0.85
4	**SCCBF0.3%**	665	4.5	10.5	25	0.81

Fig. 9. Slump flow test.

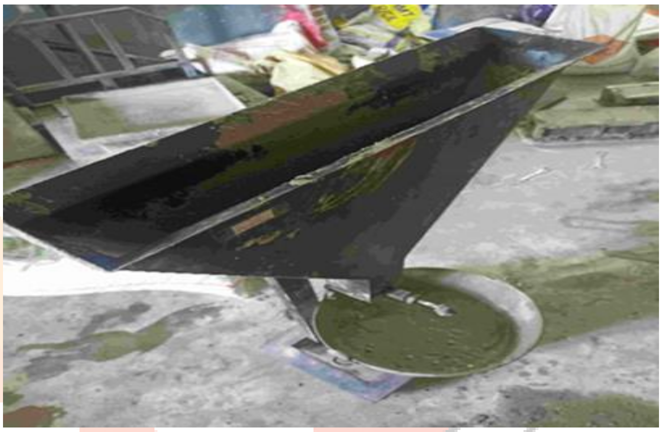

Fig. 10. V-Funnel test

Fig. 11. U-box test

Fig. 12. L-box test

4.2. Mechanical properties

The 28-day compressive strength test results for SCC mixes with and without basalt fibre incorporation are shown in Figure 14, with results ranging between 23 and 41 MPa. According to Table 5, adding basalt fibre to SCC mixes improves the results for compressive strength. The concrete mixes with the fibre volume fraction of SCCBF0.3% have the maximum compressive strength when basalt fibre is taken into account [1]. The compressive strength is somewhat higher for the concrete mixtures including SCCBF0%, SCCBF0.1%, SCCBF0.2%, and SCCBF0.3% fibre volume fractions than the combination containing SCCBF0%, although the findings are still higher than the control mixture. Comparing the basalt fibre reinforcement combination to the control mixture, there is an increase in compressive strength. However, the addition of fibre increases the cement matrix system's poor interface areas, which results in a reduction in the compressive strength of the concrete [21]. The comparison shows that these samples' compressive strengths are about greater than those of the control sample.

The results of the split tensile strength tests for the SCC mixtures made with and without fibres inclusion are presented in Fig. 15, which shows that the addition of fibres to the SCC mixtures also improves the outcomes for the split tensile strength tests. This shows that as more fibre is used, the split tensile strength increases as well. The concrete mixture containing 0.3% fibre had the greatest splitting tensile strength value, which shows an increase in the value of the splitting tensile strength when compared to the control concrete. Table 5. As a result, the stresses are transferred to the bridging fibres, delaying the emergence of macrocracks. A bridging effect is likely provided by the increase in fibre length. Therefore, using longer fibres in concrete improves strength since they have a bigger bridging effect and have a stronger pulling out resistance than shorter fibres [22].

The results of the flexural strength tests for the SCC mixes made with and without basalt fibre incorporation are shown in Fig. 16, which shows results in the range of 7.4 to 8.9 MPa. The fibres added to the SCC mixes boosts the flexural strength values, and Table 5 demonstrates that the conventional sample has the lowest bending strength. According to a comparison of the data, concrete mixtures with 0.3% fibre have the highest flexural strengths. The flexural strength data shown here are in quite good accord with earlier research on standard concrete, demonstrating that adding fibres to concrete can greatly improve bending behaviour. For instance, according to [22], adding basalt fibres at a rate of 0.1% to 0.3% results in an improvement in flexural strength. This research supports the idea that longer fibres offer stronger anchoring, bonding mechanisms, and bridging effects that improve the outcomes for flexural strength. Fig. 13 shows the experimental setup for compressive, split, flexural strength tests.

(a) (b) (c)

Fig. 13. a) Compressive b) Split tensile c) Flexural strength test

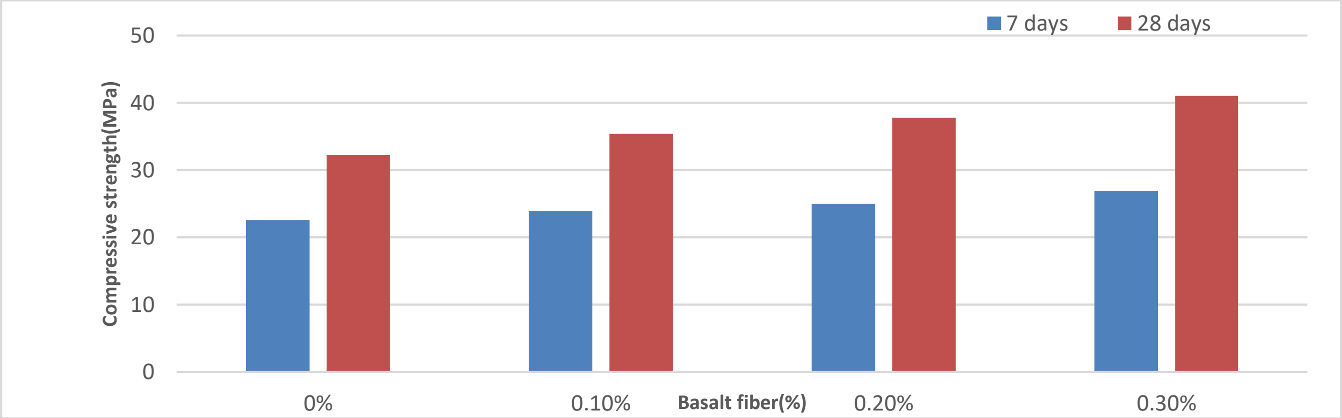

Fig. 14. Variation of the compressive strength with fibre content

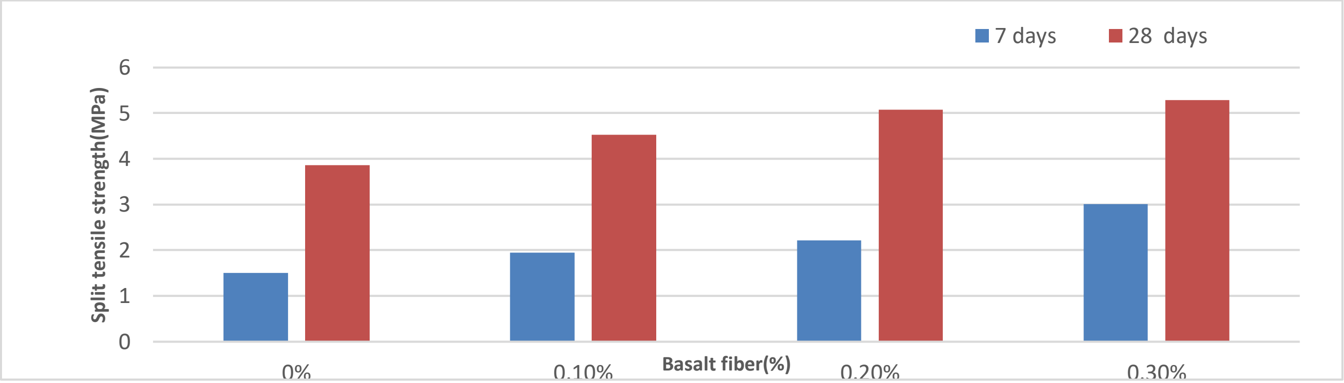

Fig. 16. Variation of the flexural strength with fibre content

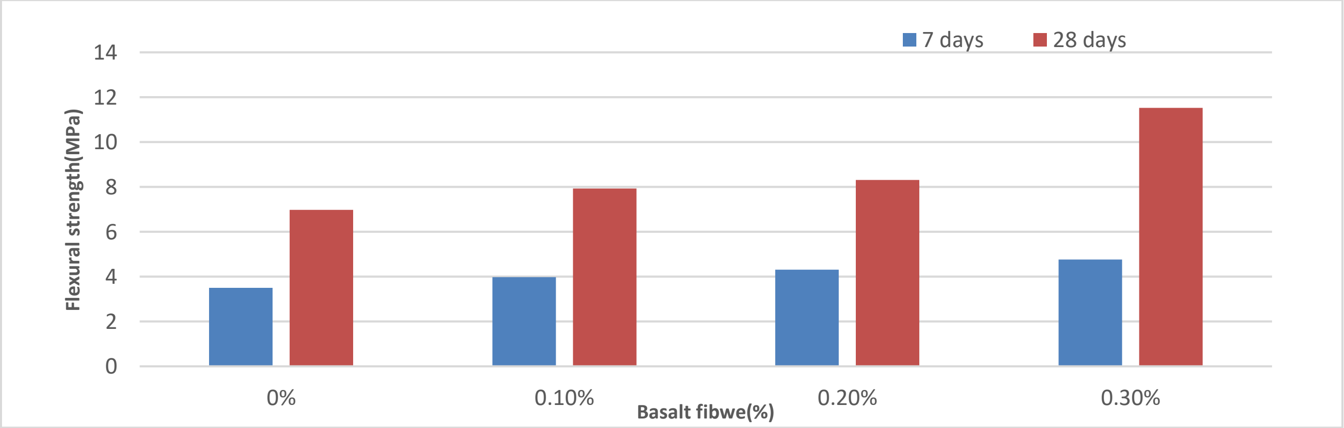

Fig. 16. Variation of the flexural strength with fibre content

Table 5. Mechanical properties of self-compacting concrete

S.N O	**Mix**	**Compressive strength (Mpa)**		**Split tensile strength (Mpa)**		**Flexural strength (Mpa)**	
		7 days	28 days	7 days	28 days	7 days	28 days
1	**SCCBF0%**	22.81	32.22	1.50	3.86	3.49	6.98

2	**SCCBF0.1%**	23.85	35.40	1.95	4.52	3.97	7.92
3	**SCCBF0.2%**	25.03	37.77	2.21	5.07	4.37	8.3
4	**SCCBF0.3%**	26.88	41.03	3.01	5.28	4.76	10.35

4.3. RCPT test

Due to its simplicity and speed, the rapid chloride permeability test(RCPT) measures the resistance of concrete to chloride ion infiltration as fig. 17. The results of the fast chloride permeability tests achieved on the SCC samples made with and without basalt fibre combination are revealed in Fig. 18. It shows that the fibre reduces the SCC's chloride permeability, which fluctuates between 1470 and 2093 Coulombs. Three mixtures, as shown in Table. 6, yield values below the 2000 Coulombs threshold level obtained for the concentration of 0.3% fibre usage having the less resistance of SCCBF0.3%. Because the remaining fast chloride permeability findings were obtained over this cutoff point, they were categorised as low class in ASTM C1202. Concrete's internal bleeding pathway and related pore channels in the cement paste are reduced by the use of fibre. As a result, the fibre lowers porosity and encourages improvement in concrete's compactness, considerably reducing the permeability of concrete.

Table 6. Rapid Chloride permeability test results

S. No	**Mix**	**RCPT value (Coulomb)**
1	SCCBF0%	2093
2	SCCBF0.1%	1804
3	SCCBF0.2%	1632
4	SCCBF0.3%	1470

Fig. 17. RCPT test.

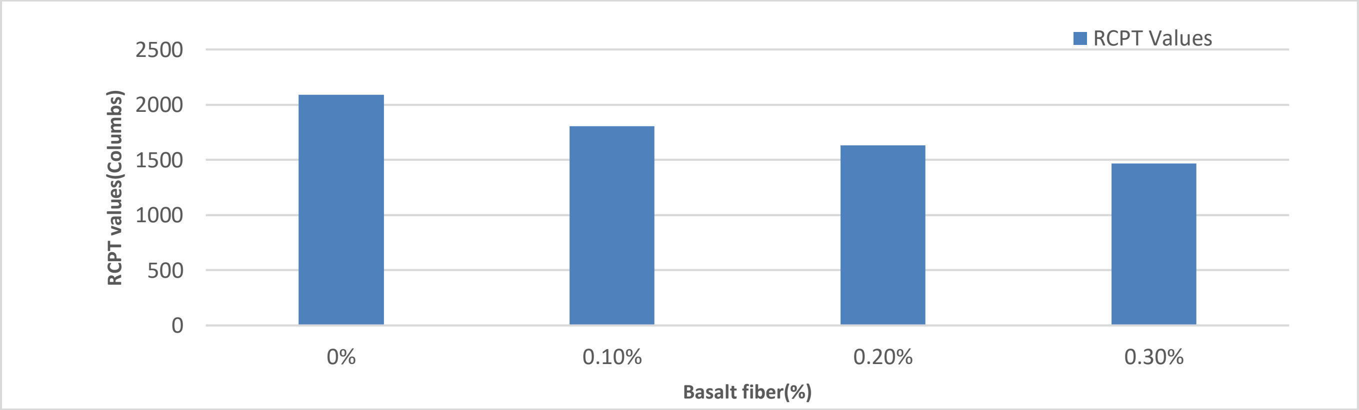

Fig. 18. Difference of the rapid chloride permeability with fibre content

4.4. Percentage weight loss

For each blend, three samples were used in the studies, and the averaged findings were presented. The basalt fibre mixes in Table. 7 as SCCBF0.1%, SCCBF0.2%, and SCCBF0.3% exhibit reduced weight loss than the conventional mixes SCCBF0% as the freezing-thawing cycle advances, as seen in Fig. 19. Additionally, it can be deduced that an improvement in pore structure reduces the percentage of weight loss as a result of an increase in concrete's compressive strength [2]. For all concrete mixtures, the % weight loss was zero up to the tenth freezing-thawing cycle. At the 10th and 20th freezing-thawing cycles, only the SCCBF0% mix displayed a weight loss. However, the weight of all the concrete mixes fell as the freezing-thawing cycle continued. The SCCBF0% mix had a weight loss percentage of 1.612, while the SCCBF0.3% mix had a weight loss percentage of 0.120. The % weight loss results for the basalt fibre self-compacting concrete mixes are less than the control mixes at the conclusion of the freezing-thawing cycles.

Table 7. Fraction weight loss at the end of sequence freezing–thawing cycles

		No of cycles					
S. No	**Mix**	**0**	**10**	**20**	**30**	**40**	**50**
1	**SCCBF0%**	0	0.120434	0.51161	0.918836	1.427989	1.612253
2	**SCCBF0.1%**	0	0.07776	0.39032	0.642312	0.863487	0.995223
3	**SCCBF0.2%**	0	0.040112	0.248859	0.4329	0.552704	0.704809
4	**SCCBF0.3%**	0	0.040453	0.078709	0.39185	0.427019	0.566343

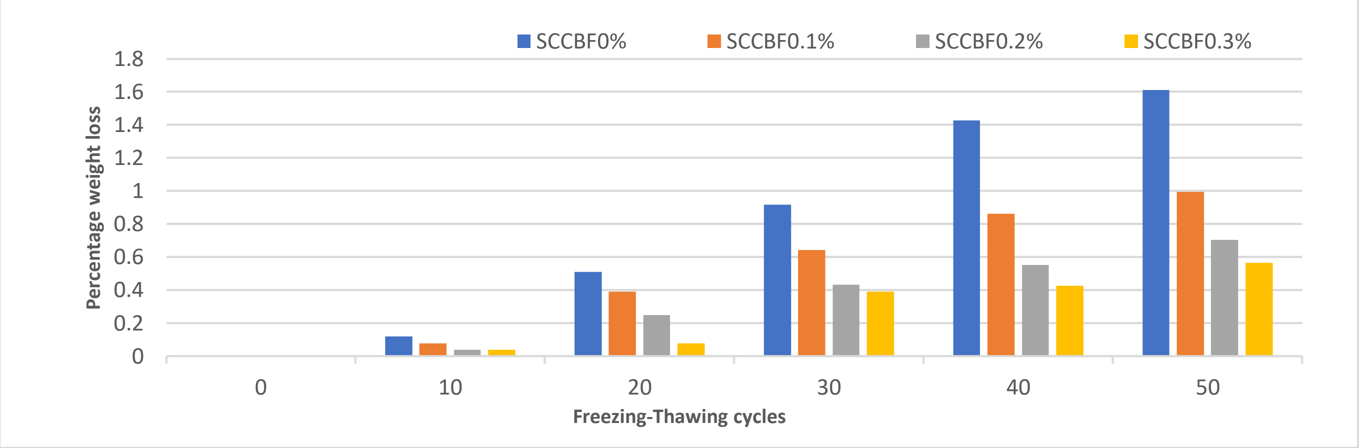

Fig. 19. Fraction weight loss at the end of sequence freezing–thawing cycles

4.5. Compressive strength after Freezing-Thawing.

Compressive strength tests were performed on SCC mixtures at 0, 10, 20, 30, 40, and 50 freezing-thawing cycles. As the number of freezing-thawing cycles increases, as indicated in Fig. 21, the strength of all concrete mixtures with and without basalt fibre mix (SCCBF0.1%) gradually decreases. SCCBF0.3% had a compressive strength value of 41 MPa, which was the highest among all the freezing-thawing cycles. Fig 20 the results show that the conventional mix SCCBF0% has extreme strength about 32.15 MPa for zero cycle and after 50th cycle value 31 MPa, so number of cycles increases (every 10 cycles up to 50) compressive strength also decreases as similarly SCCBF0.1%, SCCBF0.2% and SCCBF0.3, fig. 21 test setup for compression machine, addition of basalt fibre mixes presented less decrease in compressive strength because of the more responsiveness of basalt fibre Li et al. 2020, decrease the total porosity and average pore size of concrete and optimizes the pore-structure. The use of basalt fibre decreases the overall porosity of concrete. The average pore size of concrete steadily decreases as the amount of basalt fibres increases. Compressive strength is increased by concrete's minimum total porosity (SCCBF0.3%). Additionally, Table. 8 found that basalt fibre caused a lower percentage loss of compressive strength than control mixes.

Table 8. Compressive strength (Mpa) values of after freezing–thawing cycles

No of Cycles	SCCBF0%	SCCBF0.1%	SCCBF0.2%	SCC0.3%
0	32.15	35.4	37.6	41
10	32	35.3	37.5	40.8
20	31.5	35.2	37.4	40.75
30	31.4	35.1	37.3	40.6
40	31.35	35	37.1	40.4
50	31	34.5	36	40.1

Fig. 21. Compressive strength test

4.6. Density

Fig. 22. Shows maximum density of SCC is zero cycle freezing-thawing and minimum density for 50 cycles concrete specimens. Increasing number of freeze-thaw cycles to decreases density (SCCBF0%> SCCBF0.1%> SCCBF0.2%> SCCBF0.3). because as the number of freezing-thawing cycles rises, all concrete mixtures have porous structures. Even while basalt fibre mixtures have densities that are lower than conventional mixes', the percentage of densities that decreased as a result of freezing-thawing cycles was higher for conventional mixes. reflect the number of cycles and mixes for SCC in table 9. Denser mix is the control.

Table. 9. Density of freezing-thawing cycles values.

S.No	Mix	No of cycles					
		0	10	20	30	40	50
1	SCCBF0%	2.48	2.488	2.528	2.588	2.416	2.441
2	SCCBF0.1%	2.498	2.57	2.552	2.475	2.411	2.487

3	**SCCBF0.2%**	2.51	2.492	2.405	2.53	2.519	2.395
4	**SCCBF0.3%**	2.56	2.471	2.539	2.542	2.565	2.458

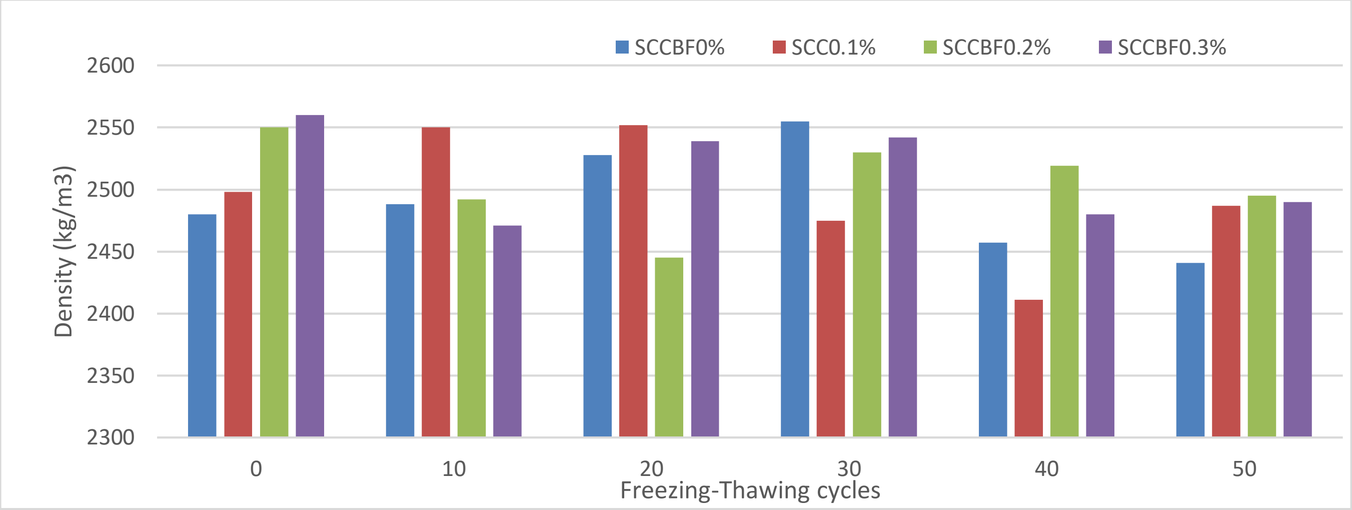

Fig. 22. Density at the end of series freezing–thawing cycles

4.7. Ultrasonic Pulse Velocity (UPV)

Table 10 displays the UPV values for control concrete and SCCBFs every ten freeze-thaw cycles. Additionally, Fig. 24 shows the % change in UPV values after ten freezing-thawing cycles. The best result was obtained for SCCBF0% when taking into account the findings measured after 50 freeze-thaw cycles. In terms of the first reading, the UPV values specified after 50 freezing-thawing cycles decreased in the SCCBF0.1%, SCCBF0.2%, and SCCBF0.3% groups, respectively. The percentage decrease in UPV with freezing-thawing cycles was greater for SCCBF0.3% after 50 cycles and before zero cycle as almost the same value [2], but the addition of basalt fibre 0.3% as more than control mix is necessary because of the small change in the porous structure of all concrete mixes as the number of freezing-thawing cycles advances. Figure 23 shows testing for UPV values. According to IS13311 (Part1):1992 for all SCC mixes, UPV value is excellent for more than 4.5 km/sec since basalt SCCBF0.3% holding and bonding after 50 cycles of freezing-thawing and pores are decreased in this way.

Fig. 23. UPV testing

Table. 10. Ultrasonic pulse velocity Values(km/sec).

S.No	**Mix**	**No of cycles**					
		0	**10**	**20**	**30**	**40**	**50**
1	**SCCBF0%**	5.94884	5.405405	4.894763	4.962779	4.889976	4.591368
2	**SCCBF0.1%**	5.714286	5.122951	4.914005	4.889976	4.842615	4.854369
3	**SCCBF0.2%**	5.552471	5.230126	4.938272	4.764173	4.914005	4.878049
4	**SCCBF0.3%**	5.230126	5.030181	5.012531	4.796163	4.938272	5.012531

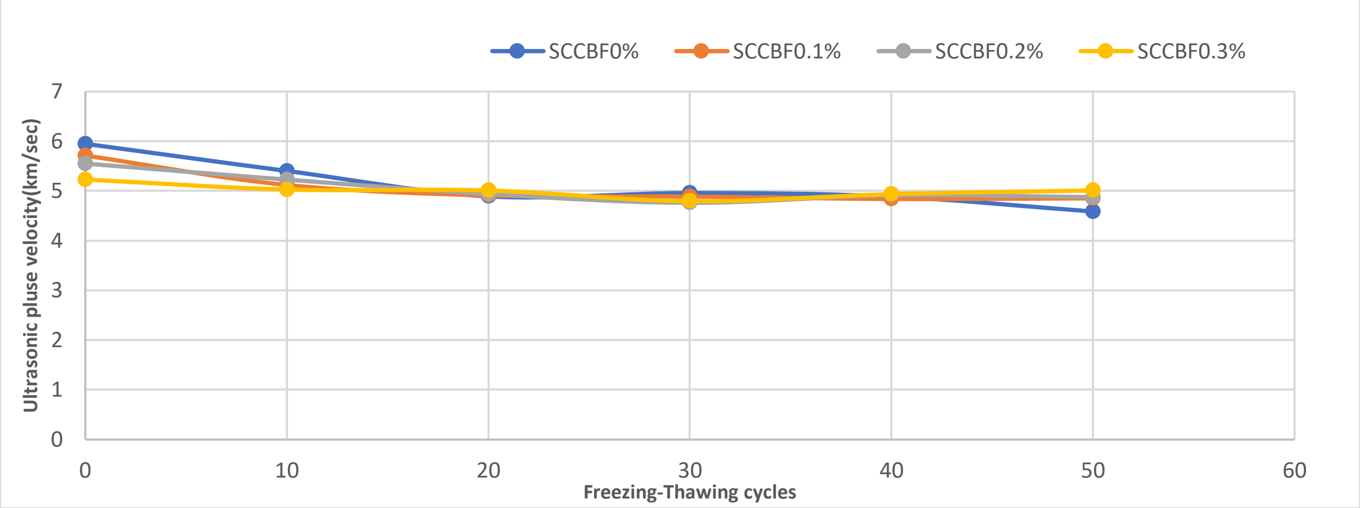

Fig. 24. Ultrasonic pulse velocity at the end of sequence freezing–thawing cycles.

4.8. Dynamic modulus of elasticity (DME)& relative dynamic modulus of elasticity (RDME)

The DMD and RDME values computed using the data gathered at the conclusion of every succeeding 10 freezing-thawing cycles are displayed in Fig. 25. As shown in fig. 26, control mixes had a higher percentage decrease in DMD with freezing-thawing cycles even though basalt fibre addition mixes (SCCBF0.1%, SCCBF0.2%, and SCCBF0.3%) had lower dynamic modulus of elasticity values than conventional mixes (SCCBF0%). RDME, which was still more than 60% at the conclusion of the cycles for all the concrete mixes but significantly lower than conventional mixes as the number of freezing-thawing cycles increased [5], declined as the cycles increased. Table. 11 and 12 as different mixes SCC presence of best percentages as 0.3% than control mix.

Table. 11. Freezing-Thawing of Dynamic modulus of elasticity (DME) values.

S.No	Mix	No of cycles					
		0	**10**	**20**	**30**	**40**	**50**
1	**SCCBF0%**	78.98	65.42	54.511	56.63	52.87	46.31
2	**SCCBF0.1%**	73.41	60.23	55.46	53.26	51.51	52.74
3	**SCCBF0.2%**	70.755	61.34	53.66	51.68	54.74	53.43
4	**SCCBF0.3%**	63.02	56.27	57.41	52.62	54.41	56.3

Table. 12. Freezing-Thawing of Relative dynamic modulus of elasticity(RDME) values.

S.No	Mix	No of cycles					
		0	**10**	**20**	**30**	**40**	**50**
1	**0**	100	82.8311	69.01874	71.7017	66.941	61.9772
2	**SCCBF0.1%**	100	82.04604	75.54829	72.55142	70.16755	71.84307
3	**SCCBF0.2%**	100	86.69352	75.83916	73.04077	77.36556	75.5141
4	**SCCBF0.3%**	100	89.28911	91.09806	83.4973	86.33767	89.33672

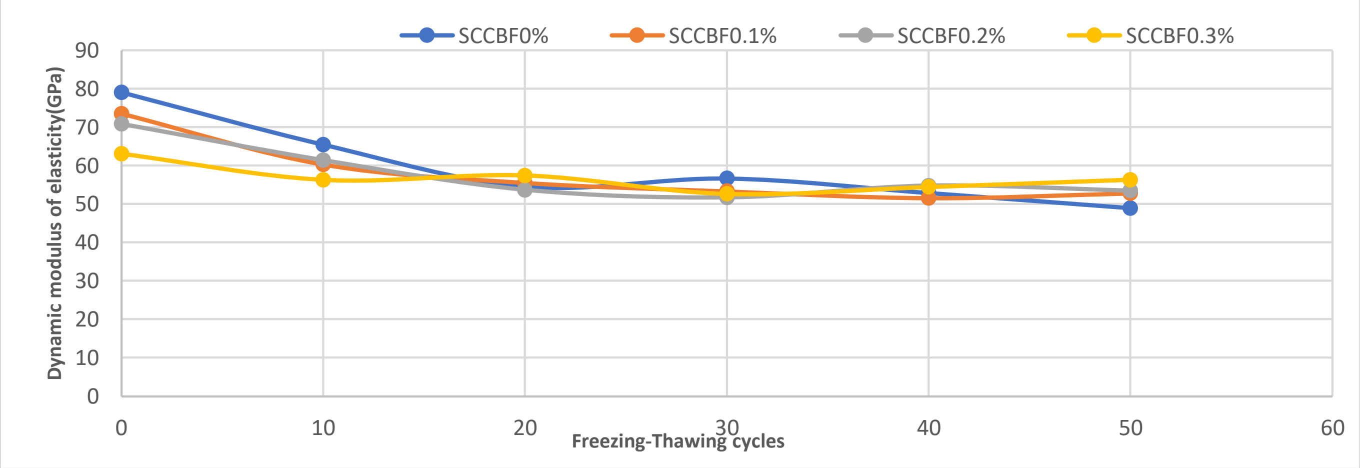

Fig. 25. DME values at the end of sequence freezing–thawing cycles

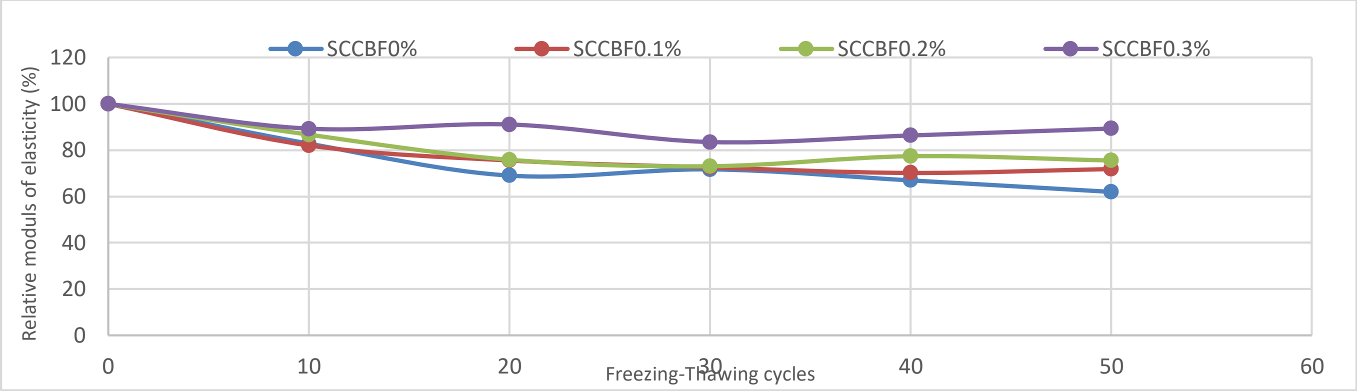

Fig. 26. RDME values at end of sequence freezing–thawing cycles

4.9. Durability factor

The durability factor deviation is depicted in Fig. 28 after each set of ten subsequent freezing-thawing cycles. According to the criteria used in this investigation, all of the concrete mixes exhibited durability factors of at least 60%. [2]. Table 10 shows that although all concrete mixes durability factors fell throughout the course of the freezing-thawing cycles, the fraction reduction values for the conventional mix, SCCBF0%, and the addition of basalt fibre mixtures, SCCBF0.1%, SCCBF0.2%, and SCCBF0.3% were in the range of 100-90 as table.13 as per similar as [5].

Table. 13. Freezing-Thawing of Durability factor Values

S.No	Mix	No of cycles					
		0	10	20	30	40	50
1	**SCCBF0%**	100	82.83	69.01	71.7	66.94	61.97
2	**SCC 0.1%**	100	82.04	75.54	72.55	70.16	71.83
3	**SCC 0.2%**	100	86.69	75.83	73.04	77.36	75.51
4	**SCC 0.3%**	100	89.28	91.09	83.49	86.33	89.33

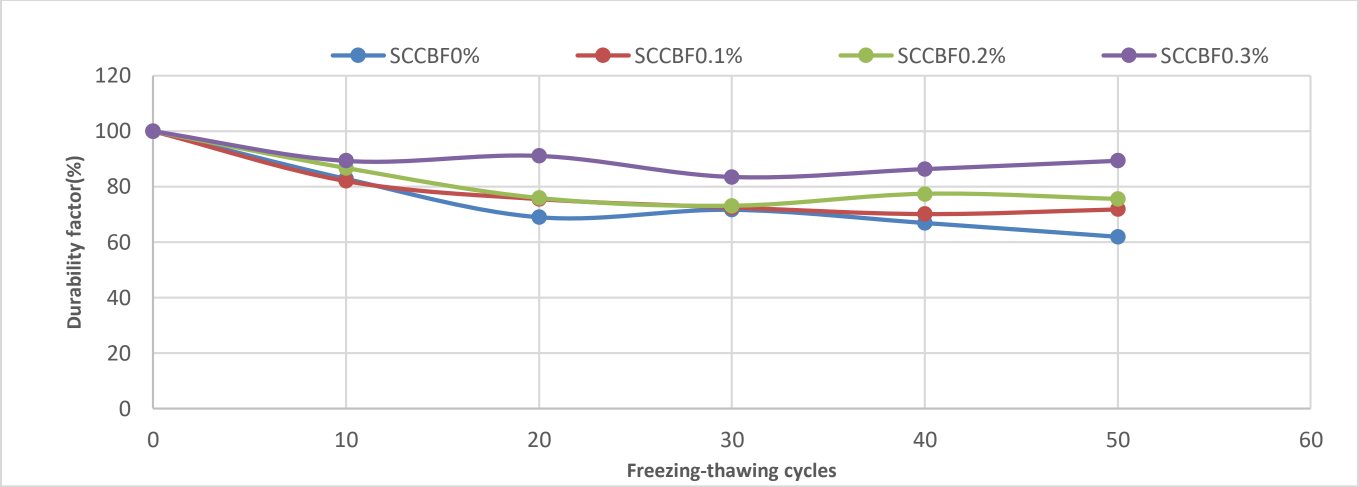

Fig. 27. Durability factor at the end of sequence freezing–thawing cycles.

V.CONCLUSIONS

The outcomes of the parametric experimental study that was presented allow for the following deductions:

- While generated from some of the mixes exceeded the maximum limit recommended by EFNARC, all mixes showed satisfactory flowability and self-compaction characteristics. Adding basalt fibre content improves slump flow, T50 flow time, V-box flow time, U-box and L-box deference will be lowered.
- From samples with SCCBF0.3% fibre content for 28 days, the mechanical parameters with the maximum compressive strength (41.03 MPa) were obtained. These samples' compressive strength as a result is roughly 8.8% more than the conventional sample. The concrete mixes mixed with the content of SCCBF0.3% yielded the maximum flexural strength (10.35 MPa) and the highest splitting tensile strength (5.28 MPa), both of which show a rise in splitting tensile strength of approximately 1.42% when compared to control concrete.
- Increases in basalt fiber percentage cause a rise in the depth of rapid chloride penetration, and the concrete mixture with SCCBF0.3% has the greatest value as compare conventional mix.
- Basalt fibres in concrete reduce moisture penetration and capillary water uptake, the percentage weight loss findings for the BFSCC mixes are lower than those for the conventional mix. Additionally, due to better pore structure, weight loss percentage drops as the percentage of fibres increases.
- The compressive strength of freezing-thawing BFSCC mixes increases but number of cycles increases strength will lightly dresses.
- Basalt fibre mixtures have densities that are lower than control mixes, while control mixes experienced a greater percentage of densification loss due to freezing-thawing cycles.
- Basalt fibre mixtures have lower values for UPV and dynamic modulus of elasticity than control mixes, although conventional mixes had a higher percentage of these values that decreased with freezing-thawing cycles.

- The relativedynamic modulus of elasticity(RDME), which was still greater than 60 percent at the conclusion of the cycle's as the number of freezing-thawing cycles increased, decreased as well. However, addition basalt fibre performed noticeably improved than conventional mixtures.
- All of the concrete mixtures have durability factors above 60%, indicating that their freeze-thaw resistance is adequate, however the addition of basalt fibres greatly outperformed the control mixtures.

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