International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

PERFORMANCE OF STRUCTURAL CONCRETE MIXED AND CURED WITH SEAWATER

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ABSTRACT:

The scarcity of potable water for construction-related processes like mixing and curing is a problem for coastal engineering. In terms of how concrete constructions set and acquire strength, water quality is a key factor. The study's overarching goal was to find a way to cure and mix concrete using saltwater. The primary objective of this experiment is to determine the maximum allowable concentration of silica fume as a partial cement replacement and sea water as a water replacement in concrete. A combination of 5% sea water and 10%, 15%, 20%, or 25% silica fume may partially substitute cement in concrete at percentages of10%,20%,30%, 40%, or 50%. The compressive strength, split tensile, and flexural tests were carried out using grade concrete cubes of 150x150x150mm, cylinders measuring 150x300mm, and beams measuring 50x10x10cm. The concrete was cast in M35.

Keywords:- : Sea Water, Silica Fume, compressive strength, split tensile strength, flexural strength.

INTRODUCTION

When using seawater for concrete mixing and curing, the early-age strength may be increased because the salt content accelerates the hydration process. However, the long-term structural strength is significantly decreased because chloride ions penetrate the concrete and corrode the reinforcing steel. This makes the concrete less durable and more prone to cracking, so it's not a good choice for reinforced concrete structures. So, while plain concrete may have some early strength gains, the negative effects on durability are still more significant.

LITERATURE REVIEW

METHODOLOGY

Reviewing the impact of using silica fume in lieu of some of the cement in concrete on its characteristics, KUMAR and DHAKA (2016) write on the topic. This research primarily focused on one parameter: M-35 concrete mix with silica fume as a partial replacement, with percentages of 0, 5, 9, 12, and 15% by weight of cement. The report provides an in-depth analysis of experimental data on compressive strength, flexural strength, and split tensile strength over a period of 7 and 28 days individually. Experimental research has shown that adding silica fume to concrete improves its strength and endurance over time compared to regular concrete.

The effect of silica fume on concrete is investigated by GHUTKE and BHANDARI (2014). The results shown that silica fume may effectively substitute cement. Silica fume concrete has a rapid increase in strength. Adding more silica fume to concrete reduces its workability. Using 10% silica fume as a substitute yields the best compressive strength rating. Because regular concrete loses strength when cement is replaced with silica fume at a rate of 15%. Somewhere between 10% and 15% replacement of silica fume is ideal.

In 2013, PRADHAN and Dutta studied how silica fume affected regular concrete. At24,7, and 28 days, a cement replacement of 20% with silica fume produced the best compressive strength. The increased compressive strength of the silica fume-infused concrete gives the impression that it is high-strength concrete.

1. MICRO SILICA (SILICA FUME)

By substituting silica fume for cement in an experiment, the behavior of concrete may be studied. To determine if the addition of silica fume to concrete improves its quality, a specific test is required.

Another substance that is used as an additive to synthetic minerals is silica fume, which is also known as micro silica or condensed silica flume. With the introduction of silica fume as an additive, a new era in concrete technology has begun. The foundation of contemporary high-performance concrete has been the use of super plasticizer in conjunction with silica fume. Keep in mind that silica fume isn't a strength enhancer on its own.

2. 2. SEA WATER

One of the key components of concrete is water. Only around 2.5% of the Earth's water is fresh, with the rest being saltwater. Five billion people will be without water to drink, according to the United Nations. As a result of excessive consumption and other environmental factors, water levels are steadily declining.

The presence of hazardous salts in seawater makes it unsuitable for use in mixing or curing concrete, as stated in IS 456:2000. In plain concrete without embedded steel, sea water may be used for mixing or curing in an inescapable circumstance, provided that all potential drawbacks and safeguards, such as the use of an adequate cement system, have been carefully considered.

3. 3.CEMENT

Concrete, stucco, mortar, and the majority of non-specialty grouts all employ ordinary Portland cement as a fundamental component. This form of cement is widely used globally. Producing concrete requires cement as its primary component. If you change the cement content in concrete, it will change its features drastically. Ordinary Portland Cement of 53 Grade, which confirms to IS 12269 - 2013, is used in this project.

- Cement

OXIDE	COMMON NAME	ABSERVATION	AP. AMOUNT %
CaO	LIME	C	60.0-67.0
SiO_2	SILICA	S	14.0-25.0
Al_2O_3	ALUMINA	A	3.0-8.0
Fe_2O_3	IRON-OXIDE	F	0.1-5.0
Mgo	MAGNESIA	M	0.1-4.0
Na_2O	SODA	N	0.1-1.3
K_2O	POTASSA	K	0.1-1.3
SO_3	SULFURIC ANHYDRIDE	S	0.5-3.0

Table 3.1 Chemical composition of Ordinary Portland cement -53 Grade

Table 3.2 physical properties of Ordinary Portland cement -53 Grade

4. 4.FINE AGGREGATE

The distribution of aggregate particle sizes is called gradation. Because the packing of particles in aggregate causes a decrease of voids, grading is a crucial quality of aggregate used to make concrete. Because of this, the amount of water and cement needed to make concrete are affected.To illustrate grading, consider the total percentage of weights that pass through a certain IS sieve. According to IS 383-1970, there are four distinct zones for the grading of fine aggregate. For each zone, the table shows the range of passing percentages.

The sand in Zones I and IV are the roughest and smoothest, respectively, while the sand in Zones II and III are in the middle. For reinforced concrete, it is best to utilize fine particles that fall under either Zone II or Zone III grading.

Table 3.3 Physical properties of fine aggregates

Fig No. 3.2 – Fine Aggregate

5. 5.COARSE AGGREGATE

Coarse aggregate is the material that passes through an IS Sieve with a size of 4.75 mm. Particles in Self Compacting Concrete may typically be no larger than 10–20 mm, however sizes of 40 mm and more have been used. Compared to continuously graded aggregates, which may cause grader internal friction and poor flow, gap graded aggregates are usually superior. In terms of the features of various aggregates, this study made use of crushed, locally accessible coarse aggregate with a maximum size of 20 mm and a minimum size of 12.5 mm. After being rinsed to remove any debris, the aggregates were dried until they reached a surface dry state. According to IS: 383-1970, the aggregates underwent testing.

S.No	Property	Result
1	Fineness Modulus	8.1
2	Specific Gravity	2.74
3	Bulk Density	
	Loose State	2.136gm/cc
	Compacted State	2.301 gm/cc

Table 3.4 Physical properties of coarse aggregates

Fig No. 3.3 – Coarse Aggregate

6. 6. WATER

In most cases, concrete may be mixed with water that is safe to drink. Streams and lakes that are home to aquatic life are also often acceptable. Water from the aforementioned sources does not need sample. You shouldn't use water in concrete if you have any reason to believe it contains sewage, mining water, or industrial plant or cannery waste—until testing prove otherwise. Since the quality of the water might fluctuate owing to low water or intermittent tap water being used for casting, it is best to avoid using water from such sources. The concrete may be mixed and cured using the drinkable water without any problems.

MIX DESIGN

TEST DATA FOR MATERIAL

TARGET MEAN STRENGTH

Target strength for mix proportion

$f`_{ck} = fck + 1.65s$

$= 35 + 1.65 \times 5$

$= 43.25$ N/mm^2

SELECTION OF WATER – CONTENT RATIO

Grade designation	:	M35
Type of cement	:	OPC 53 grade
Mineral admixture	:	silica fume, metakaolin.
Maximum nominal size aggregate	:	20 mm
Maximum water content	:	0.45
Workability	:	100mm (slump)
Exposure condition	:	Extreme (reinforced concrete)
Degree of supervision	:	Good
Type of aggregate	:	Crushed angular aggregate

From table 5 of Is 456 -2000 maximum w/c 0.45
= 0.45
Adopt = 0.40

SELECTION OF WATER CONTENT

Maximum water content for 20 mm aggregate

= 186 lit

Estimate water content for 100 mm slump = 186 + X

= 197.16 lit/m^3 **CALCULATION OF CEMENT CONTENT**

= 492.9 kg/m3

MIX CALCULATION

a. Volume of concrete = 1m^3

b. Volume of cement $= \frac{\textit{Mass of cement}}{\textit{Specific gravity of cement}} \times \frac{1}{1000}$ = (492.9/3.12)x(1/1000) = 0.157m^3

c. Volume of water = (maa of water/specific gravity of water)x(1/1000)

= (197.16/1) x (1/1000) = 0.197 m3

d, Volume of all in aggregate

= a – (b + c)
= 1- 0.354

Mass of coarse aggregate

= dxvolume of coarse aggregate x S.Gx x1000

= 0.646 × 0.594 × 2.74 ×1000
= 1051.40 Kg/m3

Mass of fine aggregate

Water cement ratio = 0.40

Cement material content = 197.16/ 0.4

= d x volume of fine aggregate x S,G x 1000

= 0.646 x 0.406 x 2.69 x 1000
= 705.52 Kg/m3

MIX PROPORTION

Cement = 492.9 kg/m
Water = 197.16 kg/m^3
Fine aggregate = 705.52 kg/ m_3
Coarse aggregate = 1050.4 kg/m_3
Water cement ratio = 0.4

Cement	Fine aggregate	Coarse aggregate	Water
492.9	705.52	1051.40	197.16
1	1.18	1.83	0.4

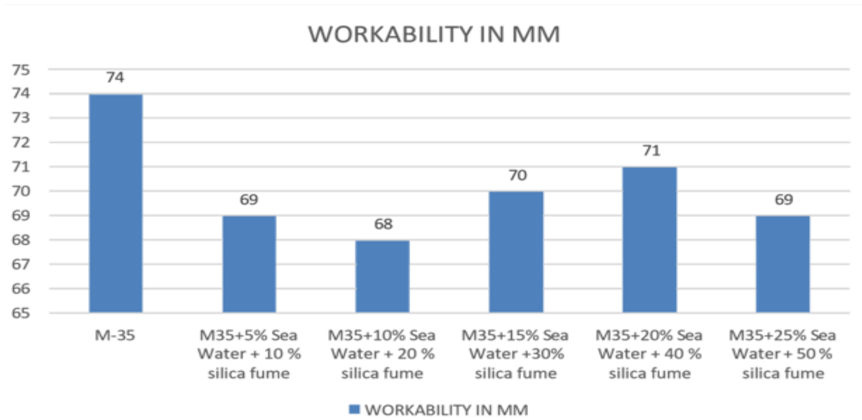
Table 4.1 Mix Proportion for M35 Concrete

SLUMP CONE TEST

The level of compaction has a significant impact on the strength of concrete for a certain mix fraction. Because of this, the mix's uniformity is crucial for the concrete's ease of transportation, placement, and finishing without segregation. It is claimed that a concrete is workable if it meets these characteristics. The workability of concrete is influenced by the friction inside the concrete matrix, which is caused by the aggregate's size and shape, and by the surface it comes into touch with, which is caused by the external friction. Another measure of workability that is more limited to water content factors is the consistency of concrete. As a result, even concrete with the same consistency might have different workability. In order to determine how consistent concrete is, one might do the slump test. While it can't tell you how workable concrete is, it's great for finding out if a mixture of nominal proportions isn't perfectly homogeneous.

MIX PROPORTIONS	Slump values
M-35	74
M35+5% Sea Water + 10 % silica fume	69
M35+10% Sea Water + 20 % silica fume	68
M35+15% Sea Water +30% silica fume	70
M35+20% Sea Water + 40 % silica fume	71
M35+25% Sea Water + 50 % silica fume	69

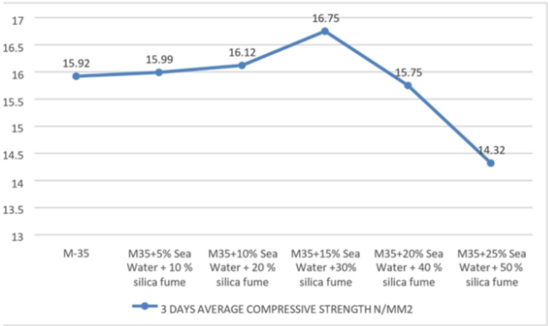
Table No. 5.1 Workability Results



COMPRESSION TEST ON CONCRETE CUBES

Because it is the quality metric, the compressive strength is a crucial property to measure when evaluating concrete. Compressive strength is the standard unit of measurement for other strengths. Because it is the quality metric, the compressive strength is a crucial property to measure when evaluating concrete. Compressive strength is the standard unit of measurement for other strengths. A cylinder's minimum compressive strength is equal to 0.8 times the cube of its compressive strength (10 cm x 10 cm). Common testing intervals for concrete specimens are 14 and 28 days after placement. In most cases, the cubes are tested at 14 and 28 days. However, there are situations when early testing is necessary, such as when removing a concrete shutter securely before 14 days. Typically, one cube is evaluated after 28 days, and two cubes after that; however, this may change based on

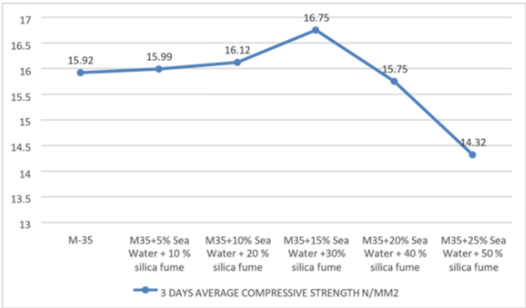
Graph No.5.3 Compressive Strength Results for 3 days



MIX NO.	% of S.W AND S. F%	3 DAYS AVERAGE COMPRESSIVE STRENGTH
1.	M-35	15.92
2.	M35+5% Sea Water + 10 % silica fume	15.99
3.	M35+10% Sea Water + 20 silica fume	16.12
4.	M35+15% Sea Water +30% silica fume	16.75
5	M35+20% Sea Water + 40 % silica fume	15.75
6	M35+25% Sea Water + 50 % silica fume	14.32

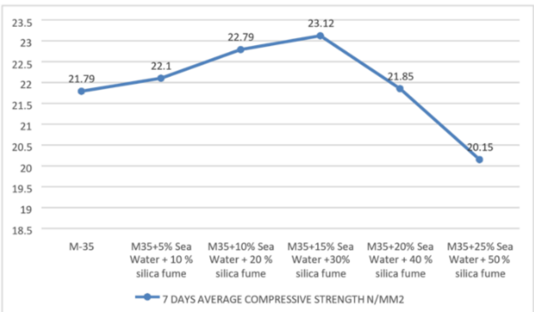
Table No.5.3 Compressive Strength Results for 3 days

Graph No.5.3 Compressive Strength Results for 3 days



MIX NO.	% of S.W AND S. F	7 DAYS AVERAGE COMPRESSIVE STRENGTH
1.	M-35	21.79
2.	M35+5% Sea Water + 10 % silica fume	22.10
3.	M35+10% Sea Water + 20 % silica fume	22.79
4.	M35+15% Sea Water +30% silica fume	23.12
5	M35+20% Sea Water + 40 % silica fume	21.85
6	M35+25% Sea Water + 50 % silica fume	20.15

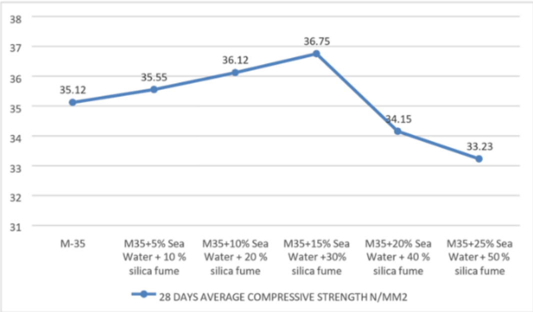
Table No.5.4 Compressive Strength Results for 7 days



Graph No.5.4 Compressive Strength Results for 7 days

MIX NO.	% of S.W AND S. F	28 DAYS AVERAGE COMPRESSIVE STRENGTH
1.	M-35	35.32
2.	M35+5% Sea Water + 10 % silica fume	35.55
3.	M35+10% Sea Water + 20 % silica fume	36.12
4.	M35+15% Sea Water +30% silica fume	36.75
5	M35+20% Sea Water + 40 % silica fume	34.15
6	M35+25% Sea Water + 50 % silica fume	33.23

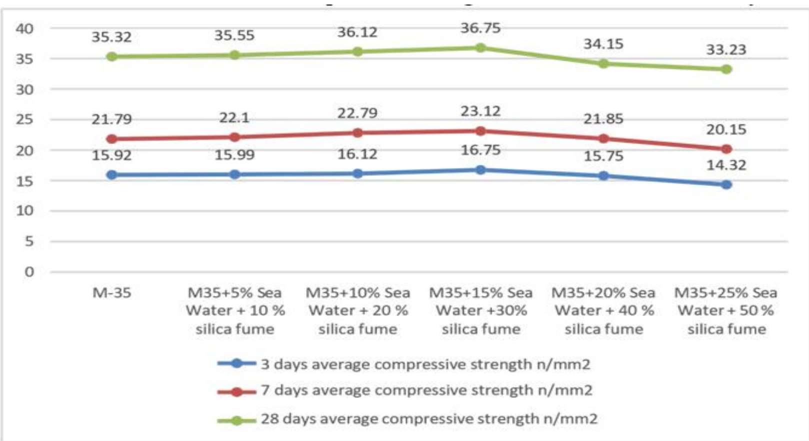
Table No.5.5 Compressive Strength Results for 28 days



Graph No.5.5 Compressive Strength Results for 28 days

MIX NO.	3 DAYS AVERAGE COMPRESSIVE STRENGTH	7 DAYS AVERAGE COMPRESSIVE STRENGTH	28 DAYS AVERAGE COMPRESSIVE STRENGTH
1.	15.92	21.79	35.32
2.	15.99	22.10	35.55
3.	16.12	22.79	36.12
4.	16.75	23.12	36.75
5	15.75	21.85	34.15
6	14.32	20.15	33.23

Table No.5.6 Compressive Strength Results for 3, 7 and 28 days



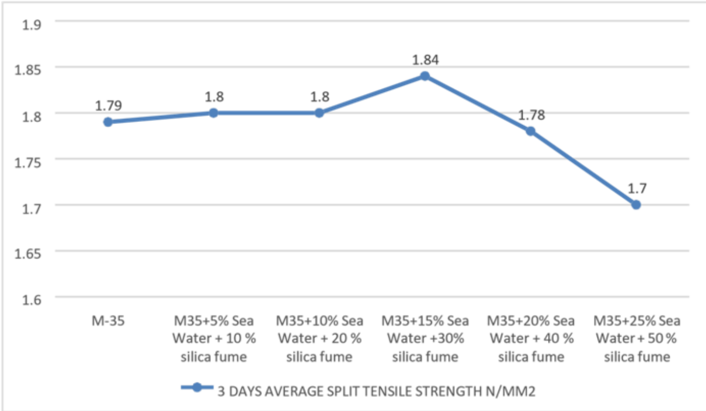
Graph No.5.6 Compressive Strength Results for 3, 7 and 28 days

SPLIT TENSILE STREGTH TEST

For an indirect measure of concrete's tensile strength, this is the gold standard test. According to IS: 5816-1970, this test might be carried out. In Figure 4, the loading surfaces of the Compression Testing Machine are positioned horizontally in relation to a conventional test cylinder of concrete specimen with dimensions 300 mm X 150 mm diameter. Once the cylinder fails along its vertical diameter, the compression stress is delivered diametrically and equally throughout its length. Strips of plywood are sandwiched between the specimen and the loading platens of the testing machine to distribute the applied load more evenly and to mitigate the high compressive stresses close to the load application locations. The poison's indirect tensile tension causes concrete cylinders to break in half along this vertical axis.

MIX NO.	% of S.W AND S. F		3 DAYS AVERAGE SPLIT TENSILE STRENGTH
1.	M-35		1.79
2.	M35+5% Sea Water + 10 % silica fume		1.8
3.	M35+10% Sea Water + 20 % silica fume		1.8
4.	M35+15% Sea Water +30% silica fume		1.84
5	M35+20% Sea Water + 40 % silica fume		1.78
6	M35+25% Sea Water + 50 % silica fume		1.70

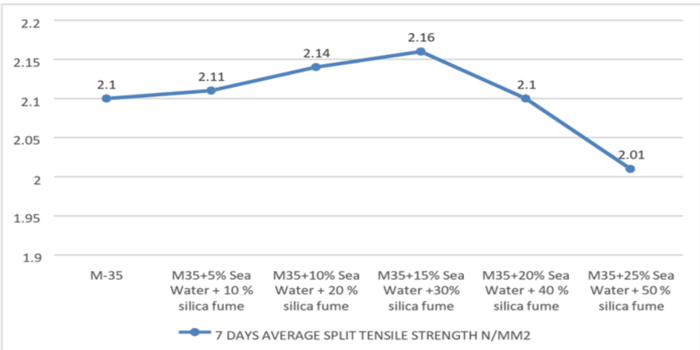
Table No.5.7 Split Tensile Strength Results for 3 days



Graph No.5.7 Split Tensile Strength Results for 3 days

MIX NO.	% of S.W AND S. F	7 DAYS AVERAGE SPLIT TENSILE STRENGTH
1.	M-35	2.1
2.	M35+5% Sea Water + 10 % silica fume	2.11
3.	M35+10% Sea Water + 20 % silica fume	2.14
4.	M35+15% Sea Water +30% silica fume	2.16
5	M35+20% Sea Water + 40 % silica fume	2.10
6	M35+25% Sea Water + 50 % silica fume	2.01

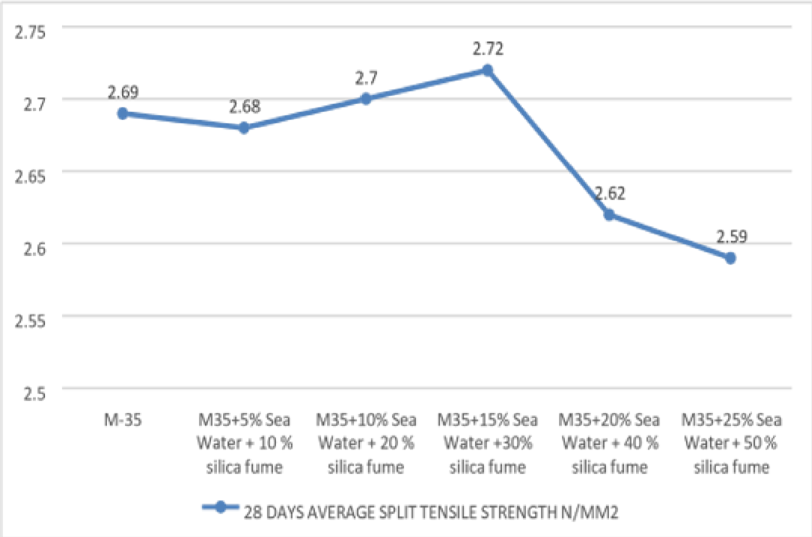
Table No.5.8 Split Tensile Strength Results for 7 days



Graph No.5.8 Split Tensile Strength Results for 7 days

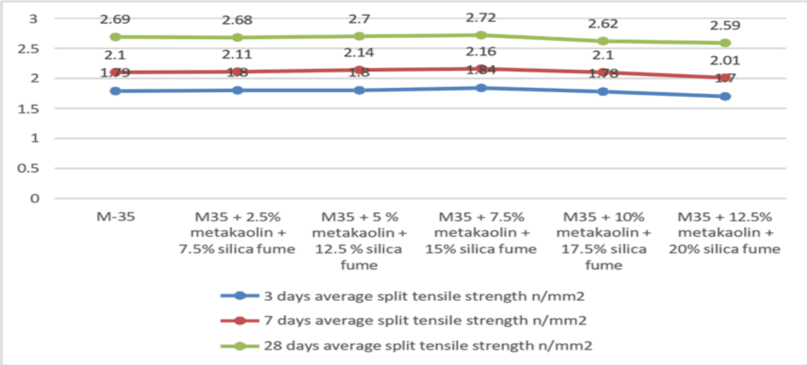
MIX NO.	% of S.W AND S. F	28 DAYS AVERAGE SPLIT TENSILE STRENGTH
1.	M-35	2.67
2.	M35+5% Sea Water + 10 % silica fume	2.68
3.	M35+10% Sea Water + 20 % silica fume	2.70
4.	M35+15% Sea Water +30% silica fume	2.72
5	M35+20% Sea Water + 40 % silica fume	2.62
6	M35+25% Sea Water + 50 % silica fume	2.59

Table No.5.9 Split Tensile Strength Results for 28 days



MIX NO.	3 DAYS AVERAGESPLIT TENSILE STRENGTH	7 DAYS AVERAGESPLIT TENSILE STRENGTH	28 DAYS AVERAGESPLIT TENSILE STRENGTH
1.	1.79	2.1	2.67
2.	1.8	2.11	2.68
3.	1.8	2.14	2.70
4.	1.84	2.16	2.72
5	1.78	2.10	2.62
6	1.70	2.01	2.59

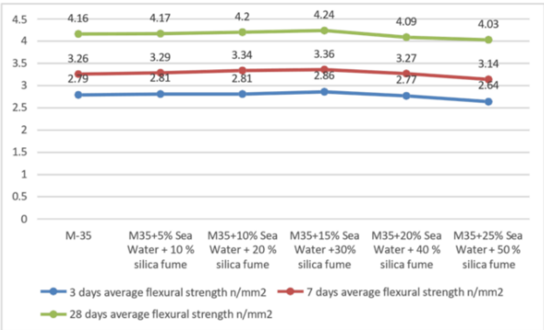
Table No.5.10 Split Tensile Strength Results for 3, 7 and 28 days



Graph No.5.10 Split Tensile Strength Results for 3, 7 and 28 day

FLEXURAL STRENGTH OF CONCRETE

In a perfectly homogenous material, the flexural strength and tensile strength would be identical. As a matter of fact, the majority of materials include flaws, whether little or huge, that serve to concentrate pressures in one area, resulting in a localized weakness. The flexural strength is determined by the strength of the intact "fibres" since, when a material is bent, only the extreme fibers experience the most stress. In contrast, if the same material were to undergo just tensile pressures, then failure would start as soon as the weakest fibers hit their limiting tensile stress since all of the fibers in the material would be under the same amount of stress. For the same material, flexural strengths are often greater than tensile strengths. On the other hand, tensile strength may be greater than flexural strength for a homogenous material whose imperfections are limited to its surface, such as scratches.



MIX NO.	3 DAYS AVERAGE FLEXURAL STRENGTH	7 DAYS AVERAGE FLEXURAL STRENGTH	28 DAYS AVERAGE FLEXURAL STRENGTH
1.	2.79	3.26	4.16
2.	2.8	3.29	4.17
3.	2.81	3.34	4.20
4.	2.86	3.36	4.24
5	2.77	3.27	4.09
6	2.64	3.14	4.03

RESULTS

concrete cubes

CTM

Slump cone test

CTM

Slump cone test

FLEXURAL SET-UP

CONCLUSION

At the ratio of various additives added to M-35 grade concrete—M35+15% sea water + 30% silica fume—we get the greatest compressive strength of 36.75 N/mm2.

At the amount of various admixtures applied to M-35 grade concrete—M35+15% sea water + 30% silica fume—we get the maximum split tensile strength — 2.72 N/mm2.

The M-35 grade concrete with the greatest flexural strength was made with the following proportions of additives: M35, 15% sea water, and 30% silica fume, yielding 4.24 N/mm2.

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[5] Bentz, D.P. (2010). Engineering the Properties of Cement-Based Materials via the Blending of Cements of Varying Finenesses, in the Magazine of Concrete Research, volume 62, issue 5, pages 327-338.

6. In a Review article on the impact of partially replacing cement with silica fume on the characteristics of concrete, Kumar & Dhaka (2016) discuss this topic.

7. In his 2016 research paper, Alok explores the use of silica fume and metakaolin as partial cement replacements in M-30 concrete.

8. [8] As a partial cement replacement, Sasikumar and Tamilvanan (2016) conducted an experimental investigation on the properties of silica fumes. The effects of silica fume on the characteristics of high-strength concrete were studied by mark hail in 2015.

Jain and Pawade (2015) investigated silica fume concrete properties. Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement [11] as observed by Hanumesh, Varun & Harish (2015).