

Experimental Investigation of M55-Grade High-Performance Concrete using Micro Silica

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Abstract - This study investigates the reported influence of micro silica on the mechanical performance of M55-grade high-performance concrete prepared with a superplasticizer. Five mixture contents—0%, 6%, 10%, 15%, and 20%—were compared using the experimental charts and observations supplied in the project report. Compressive strength was reported at 7, 14, and 28 days. The 15% mixture recorded the highest plotted compressive strengths of 59.60, 67.50, and 73.74 MPa, respectively, compared with 35.12, 42.80, and 47.50 MPa for the control mixture. The supplied report also includes flexural-strength and splitting-tensile-strength charts, a slump chart, and a graph captioned as a rebound-hammer test. The graph labelled as rebound hammer has a vertical axis in N/mm², so its values are reproduced as plotted source values and require verification before being interpreted as rebound numbers. The report describes UPV and rapid chloride penetration testing, but numerical UPV and RCPT results are not stated in the extracted report. The findings suggest that 15% micro silica is the most promising of the reported mixtures for strength, subject to confirmation of dosage basis, repeat testing, and complete durability data.

Keywords—M55 concrete, high-performance concrete, micro silica, silica fume, superplasticizer, compressive strength, flexural strength, splitting tensile strength, rebound hammer, UPV, RCPT.

I. INTRODUCTION

High-performance concrete is designed to provide enhanced strength, durability, and serviceability for demanding structural applications. M55-grade concrete requires a carefully controlled water-to-binder ratio, suitable aggregate grading, and effective admixture use. Micro silica (silica fume) is a finely divided silica-rich material that can improve particle packing and contribute to additional calcium-silicate-hydrate formation through pozzolanic reaction. Its high surface area can also increase water demand, making a compatible superplasticizer important for maintaining workability.

The supplied project report examines micro silica contents of 0%, 6%, 10%, 15%, and 20%, with strength comparisons at 7, 14, and 28 days. In addition to compressive strength, the report presents flexural and splitting tensile strength charts and discusses non-destructive testing and chloride penetration. The present paper reorganizes the supplied results into an IJERT-style technical paper while retaining the reported numerical values and clearly identifying results that are not numerically documented.

II. OBJECTIVES AND SCOPE

- To compare compressive strength at 7, 14, and 28 days for the five reported micro silica contents.
- To summarize the flexural-strength and splitting-tensile-strength values plotted in the supplied charts.
- To present the reported slump and rebound-hammer-related information without inventing missing readings.

- To document the stated mix-design basis and the described UPV and RCPT procedures.
- To identify the most promising dosage within the available dataset and indicate the data that require verification.

III. MATERIALS AND MIX-DESIGN BASIS

The source report specifies OPC 53-grade cement, micro silica, Zone II fine aggregate, and angular coarse aggregate comprising a 60% 20 mm and 40% 10 mm blend. The reported target slump is 125 mm, and the selected water-to-cement ratio is 0.29. A superplasticizer dosage of 0.6% by mass of cementitious material is stated. The source identifies severe exposure conditions and good supervision for the mix-design basis.

Parameter	Parameter / Value reported in supplied report
Concrete grade	Concrete grade — M55
Cement	Cement — OPC 53 grade
Specific gravity: cement	Specific gravity: cement — 3.10
Specific gravity: micro silica	Specific gravity: micro silica — 2.23
Specific gravity: coarse aggregate	Specific gravity: coarse aggregate — 2.84
Specific gravity: fine aggregate	Specific gravity: fine aggregate — 2.67
Coarse aggregate blend	Coarse aggregate blend — 60% 20 mm + 40% 10 mm
Fine aggregate grading	Fine aggregate grading — Zone II
Target mean compressive strength	Target mean compressive strength — 67.54 MPa
Water-to-cement ratio	Water-to-cement ratio — 0.29
Target slump	Target slump — 125 mm
Superplasticizer	Superplasticizer — Hindplast SUPER-SCA (1000), SG 1.04
Superplasticizer dosage	Superplasticizer dosage — 0.6% by mass of cementitious material

The source report's worked trial-mix calculation for the 15% mixture states cement = 446 kg/m³, micro silica = 66.9 kg/m³, water = 146.31 kg/m³ after aggregate absorption adjustment, fine aggregate = 629 kg/m³ (dry), and coarse aggregate = 1313 kg/m³ (dry). It gives 20 mm aggregate = 788 kg/m³ and 10 mm aggregate = 525 kg/m³. These are reproduced as reported; the original calculation contains differences between intermediate water values, so the batch sheet should be checked before field use.

Mix-design item	Mix-design item / Reported quantity
Cement	Cement — 446 kg/m ³
Micro silica at 15%	Micro silica at 15% — 66.9 kg/m ³
Water after absorption adjustment	Water after absorption adjustment — 146.31 kg/m ³

Fine aggregate (dry)	Fine aggregate (dry) — 629 kg/m ³
Coarse aggregate (dry)	Coarse aggregate (dry) — 1313 kg/m ³
20 mm coarse aggregate	20 mm coarse aggregate — 788 kg/m ³
10 mm coarse aggregate	10 mm coarse aggregate — 525 kg/m ³



Fig. 1. Micro silica product shown in the supplied project report.

IV. EXPERIMENTAL PROGRAMME

The supplied report describes cube specimens for compressive strength, prism specimens for flexural strength, and cylindrical specimens for splitting tensile strength. Specimens were demoulded after casting and immersed in water for curing. Strength charts are provided for 7, 14, and 28 days. The report also includes a rebound hammer photograph and a graph captioned as a rebound hammer test, and describes UPV and RCPT assessment.

The report's methods section refers to IS 516 for compressive and flexural testing and gives the splitting tensile expression $f_{ct,sp} = 2P/(\pi LD)$, where P is the failure load, L is cylinder length, and D is cylinder diameter. The source states that UPV is intended to assess internal uniformity and that RCPT was conducted after 28 days; however, no numerical UPV readings or RCPT charge-passed values are supplied in the extracted report. Therefore, no numerical UPV or RCPT result is inferred in this paper.



Fig. 2. Fresh concrete/slump observation photograph from the supplied report.

V. RESULTS AND DISCUSSION

A. Compressive strength

The supplied compressive-strength graph reports the following values for all five mixtures. The highest values at each curing age are associated with the 15% micro silica mixture. The 20% mixture is lower than the 15% mixture at 7, 14, and 28 days.

Micro silica content	Micro silica content / 7 days (MPa)	14 days (MPa)	28 days (MPa)
0%	0% — 35.12	42.80	47.50
6%	6% — 40.69	45.66	50.02
10%	10% — 42.76	51.20	55.24
15%	15% — 59.60	67.50	73.74
20%	20% — 57.50	59.20	61.21

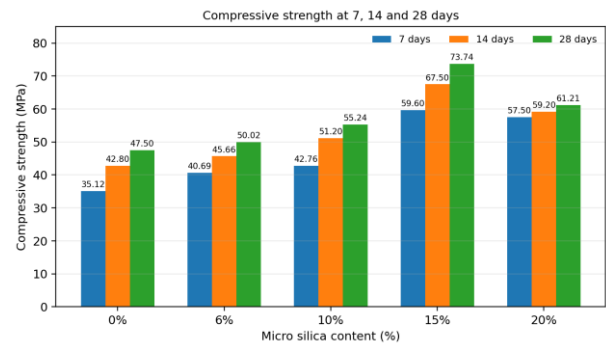


Fig. 4. Compressive strength for the five micro silica contents at 7, 14, and 28 days; values transcribed from the supplied Graph 6.

Relative to the control mix, the 15% mixture increases the plotted compressive strength from 35.12 to 59.60 MPa at 7 days, from 42.80 to 67.50 MPa at 14 days, and from 47.50 to 73.74 MPa at 28 days. The plotted results indicate a non-linear response: strength rises with dosage up to 15%, while the 20% mixture shows a reduction relative to 15%. This conclusion is limited to the supplied data and does not establish statistical significance because replicate counts and variation statistics are not stated.

B. Flexural strength

The values plotted in the source flexural-strength graph are transcribed in Table II. The 15% mixture gives the highest listed flexural strength at all three ages; the 20% mixture is lower than the 15% mixture.

Micro silica content	Micro silica content / 7 days (N/mm ²)	14 days (N/mm ²)	28 days (N/mm ²)
0%	0% — 3.32	3.66	3.86
6%	6% — 3.57	3.78	3.96
10%	10% — 3.66	4.01	4.16
15%	15% — 4.32	4.60	4.81
20%	20% — 4.25	4.31	4.38

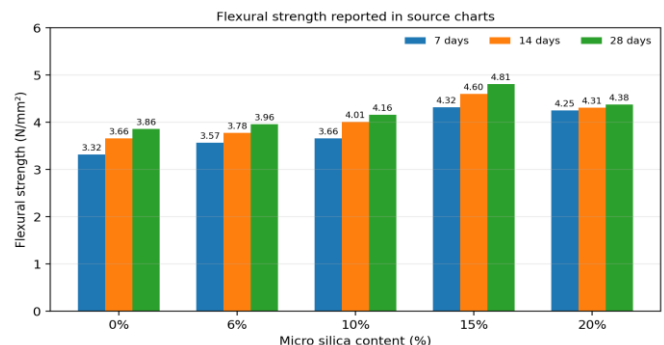


Fig. 5. Flexural-strength values transcribed from the supplied Graph 7.



Fig. 6. Flexural-strength test setup photograph supplied in the report.

C. Splitting tensile strength

The splitting-tensile-strength graph in the supplied report shows the following plotted values. Because several values in the chart are close to those in the flexural chart, the transcribed values below should be checked against the original laboratory records before publication.

Micro silica content	Micro silica content / 7 days (N/mm ²)	14 days (N/mm ²)	28 days (N/mm ²)
0%	0% — 3.32	3.66	3.86
6%	6% — 3.57	3.78	3.96
10%	10% — 3.96	4.01	4.32
15%	15% — 4.32	4.60	4.81
20%	20% — 4.25	4.31	4.38

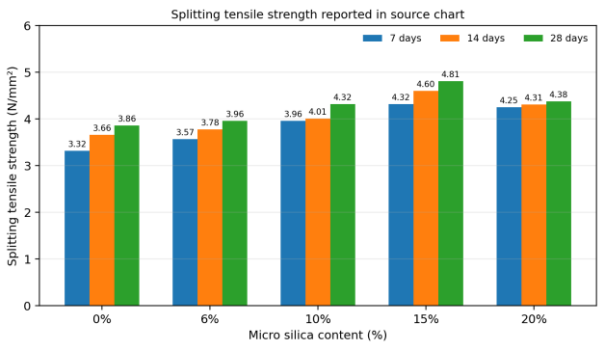


Fig. 7. Splitting-tensile-strength values transcribed from the supplied Graph 8; verify against original records.

D. Rebound hammer-related graph

The supplied report includes a graph captioned “Influence of Silica Fume Content on HPC Rebound Hammer Test”. The plotted vertical axis, however, is labelled “Compressive Strength N/mm²”, and the values range from 33.8 to 70.48. These are not presented as conventional rebound numbers in the graph. To preserve the supplied information without misclassification, Table IV and Fig. 8 reproduce the graph values exactly as plotted and flag their measurement identity for author verification.

Micro silica content	Micro silica content / Series 1	Series 2	Series 3
0%	0% — 33.80	41.20	45.80
6%	6% — 38.90	42.60	47.20
10%	10% — 40.90	48.30	51.20
15%	15% — 55.70	62.20	70.48
20%	20% — 56.40	57.30	58.20

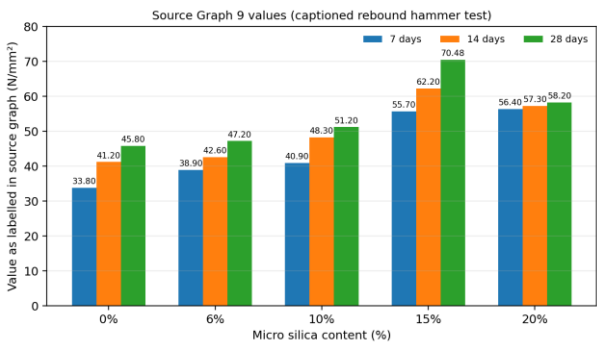


Fig. 8. Source Graph 9 values reproduced by age-series order; original axis says compressive strength while caption says rebound hammer test.



Fig. 9. Rebound hammer testing photograph supplied in the report.

The source also includes an indicative rebound-number interpretation table: below 20—poor or weak surface; 20–30—fair surface hardness; 30–40—good surface hardness; 40–50—very good surface hardness; above 50—very hard surface, requiring verification of readings and surface condition. Such interpretation is not a substitute for the applicable standard test procedure or a validated mix-specific correlation.

E. Slump and fresh-concrete workability

The source report specifies a target slump of 125 mm. Its slump graph visibly labels 120 mm and 115 mm for two of the plotted mixtures, but the remaining plotted values are not clearly labelled in the supplied figure. The original graph is retained in Fig. 3 rather than inventing values for unlabelled bars. The slump values and dosage labels should be checked against the laboratory observation sheet.

F. UPV and rapid chloride penetration test

The report describes UPV as a non-destructive method for examining internal uniformity and integrity, and describes RCPT after 28 days of curing. The supplied text includes the conventional charge-passed classification: greater than 4000 coulombs—high penetrability; 2000–4000—moderate; 1000–2000—low; 100–1000—very low; less than 100—negligible. These are classification bands, not experimental results for the present mixtures. Actual UPV velocities and RCPT coulomb readings were not numerically documented in the supplied text and must be inserted from laboratory records if available.

RCPT charge passed (coulombs)	RCPT charge passed (coulombs) / Classification stated in source
> 4000	> 4000 — High
2000–4000	2000–4000 — Moderate
1000–2000	1000–2000 — Low
100–1000	100–1000 — Very low
< 100	< 100 — Negligible



Fig. 10. RCPT apparatus shown in the supplied report.

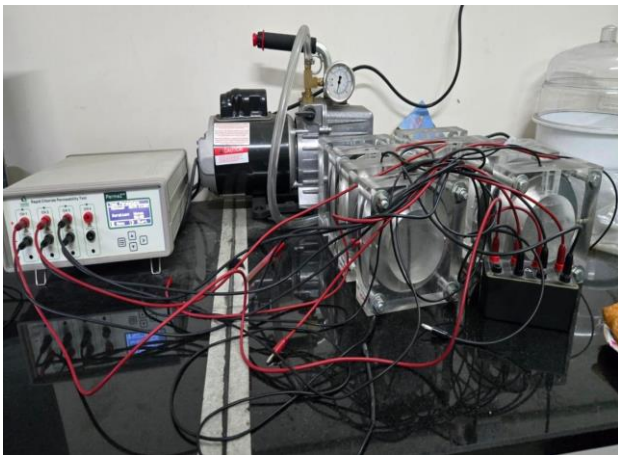


Fig. 11. RCPT test setup photograph shown in the supplied report.

VI. CONCLUSIONS

- Among the five mixtures plotted in the supplied report, 15% micro silica achieved the highest reported compressive strength at 7, 14, and 28 days: 59.60, 67.50, and 73.74 MPa, respectively.
- The control mixture recorded 35.12, 42.80, and 47.50 MPa at the corresponding ages.
- The plotted compressive strength for the 20% mixture was lower than that for 15% at each curing age, indicating that increasing dosage beyond the observed optimum did not further improve strength in this dataset.
- The supplied flexural-strength chart also reaches its maximum at 15% micro silica. The splitting-tensile chart shows a similar trend, but its values should be checked against the source laboratory sheets because the values overlap closely with the flexural chart.
- The source Graph 9 is captioned as a rebound hammer test but its y-axis is labelled compressive strength in N/mm². The measurement identity should be clarified before publication.
- Numerical UPV and RCPT results were not stated in the supplied report text. Their test methods and classification context are retained, but no missing test results have been fabricated.

VII. LIMITATIONS AND FUTURE SCOPE

- Confirm whether micro silica percentages represent addition or cement replacement, and ensure the same definition is used throughout the paper and mix-design calculations.
- Check all plotted values against signed laboratory observation sheets, particularly splitting tensile strength and the rebound-hammer-related graph.
- Provide replicate specimen counts, individual readings, mean values, standard deviation, and coefficient of variation for each mixture and curing age.
- Add the measured UPV values and RCPT charge passed for each mixture, along with test dates, specimen details, and applicable test standards.

- Report fresh-concrete workability for all five mixtures and clarify the unlabelled values in the supplied slump graph.
- Extend testing to 56 and 90 days, assess shrinkage and durability, and evaluate the cost and sustainability implications of the selected mixture.

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