Investigation On Workability of M65 High Performance Concrete Incorporating Fly Ash and Silica Fume

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***Abstract*— This study investigates the workability and compressive strength of M65 grade high-performance concrete incorporating industrial by-products such as fly ash (20-30%) and silica fume (5-10%) as partial replacements for cement. A total of five mix proportions (M1 to M5) were prepared with a constant water-cement ratio of 0.32 and varying superplasticizer dosage (1.0% to 1.5%). Slump test was conducted to assess workability, and compressive strength was evaluated at 7, 14, and 28 days on 150 mm cubes. Results indicate that the addition of silica fume reduces workability due to increased cohesion, while fly ash improves flowability. The optimum mix (M2: 20% fly ash + 5% silica fume) achieved a 28-day compressive strength of 66.7 MPa, meeting the target strength for M65 grade. The combination of 25% fly ash and 7.5% silica fume (M2) yielded the highest strength at 68.9 MPa. This research demonstrates that appropriate combinations of fly ash and silica fume can produce sustainable, high-strength concrete suitable for structural applications.**

***Index Terms*—High-performance concrete, M65 grade, fly ash, silica fume, workability, compressive strength.**

I. INTRODUCTION

High-performance concrete (HPC) is increasingly used in modern construction due to its enhanced mechanical properties and durability. The use of supplementary cementitious materials (SCMs) such as fly ash and silica fume has gained prominence as a sustainable approach to reduce cement consumption while improving concrete performance. Fly ash enhances long-term strength and durability, while silica fume acts as a highly effective pozzolan, refining the pore structure and increasing compressive strength. This study aims to evaluate the workability and compressive strength of M65 grade concrete with varying percentages of fly ash (20-30%) and silica fume (5-10%).

II. MATERIALS AND MIX PROPORTIONS

Ordinary Portland Cement (OPC 53 grade) conforming to IS 12269 was used. Class F fly ash and densified silica fume were obtained from local suppliers. Natural sand (Zone II) and crushed granite coarse aggregate (20 mm maximum size) were used. A polycarboxylate ether-based superplasticizer was added to maintain workability. The water-cement ratio was kept constant at 0.32 for all mixes.

Table 1 presents the mix proportions used in this study.

Mix ID	Cement (%)	Fly ash (%)	Silica fume (%)	Water Cement Ratio	Superplasticizer (%)	Mix ID
M1	100	0	0	0.32	1.0	100
M2	75	20	5	0.32	1.2	75
M3	70	20	10	0.32	1.5	70
M4	65	25	10	0.32	1.5	65
M5	60	30	10	0.32	1.5	M5

III. TEST PROCEDURES

Slump Test (IS: 1199-1959) for workability
Work ability means easily work with concrete the good workability of the concrete sure that concrete easily placing into the formwork and it requires minor tamping for the compaction. Super plasticizer and

plasticizer increase the workability of the concrete but the good workability has negative side of the decrease in the strength. The slump test is the easiest way to measures the workability on the field and the construction site. Slump test is giving the result of concrete weather it is workable or the cohesive

Preparation of Apparatus and fresh concrete

Clean the slump cone thoroughly to remove any dried concrete from previous tests. Oil or wet the inner surface of the slump cone and the base plate with a thin film of oil or water to prevent concrete from sticking. Place the slump cone centrally on the rigid base plate.Stand firmly on the foot pegs of the cone to prevent movement during filling.Mix the M65 concrete as per the designed mix proportions.

For mixes containing silica fume and fly ash, ensure thorough dry mixing of cementitious materials before adding water and superplasticizer. The mixing sequence for M65 HPC: Dry mix cement, fly ash, silica fume, fine aggregate, and coarse aggregate for 2-3 minutes. Add 80% of water and mix for 2 minutes.

Filling the Slump Cone (Three Layers)

Fill the cone with fresh concrete in 3 equal layers, each layer approximately one-third the height of the cone (about 100 mm per layer) Fill the cone up to 100 mm height Tamp the layer 25 times using the tamping rod. Ensure tamping strokes are uniformly distributed over the entire cross-section. Penetrate the rod into the previous layer (for second and third layers). Fill the cone up to 200 mm height (second third). Tamp 25 times uniformly.

- For the second layer, the tamping rod should just penetrate into the first layer.Fill the cone up to 300 mm height (overflowing slightly). Tamp 25 times uniformly. After tamping, strike off the excess concrete using the tamping rod in a rolling motion.

Measuring the Slump

Remove the slump cone by lifting it vertically and steadily without any lateral or twisting motion Invert the slump cone and place it beside the slumped concrete. Place the tamping rod across the top of the inverted cone. Measure the difference in height between: The top of the inverted cone (tamping rod level) The highest point of the subsided concrete Record the slump value in millimeters (mm).

True Slump

Shear Slump

Collapse Slump

Observe the type of slump

True Slump: Concrete subsides evenly without disintegration, indicating good workability suitable for most construction.

Shear Slump: One half of the concrete slides down, signaling poor cohesion and a non-uniform mix.

Collapse Slump: Concrete completely collapses, showing very high workability but an overly wet mix with segregation risk.

IV RESULTS AND DISCUSSION

Table 2 SlumpTest Reading.

Mix ID	Initial Heigh	Final Heigh	Slum	Type of Slu	Mix ID	Initial Heigh
M1	300	250	50	True Slump	300	250
M2	300	265	35	True Slump	300	265
M3	300	270	30	True Slump	300	270
M4	300	260	40	Shear Slump	300	260
M5	300	245	55	True Slump	300	245

Table 3: Workability Assessment

Mix ID	Workability	Remarks
M1	Medium	Control mix
M2	Low	Slight reduction due to silica fume
M3	Very low	High cohesion, sticky mix
M4	Medium	Balanced mix
M5	High	Improved flow due to fly ash

The control mix (M1) exhibited medium workability with a true slump of 50 mm. The inclusion of 5% silica fume (M2) reduced slump to 35 mm due to the high surface area and water demand of silica fume. At 10% silica fume (M3), the mix became highly cohesive and sticky, resulting in a very low slump of 30 mm. However, when fly ash content was increased to 30% (M5), workability improved significantly (55 mm slump) due to the spherical shape and lubricating effect of fly ash particles. Mix M4 showed a shear slump (40 mm), indicating a balanced but slightly stiff mix.

V. CONCLUSION

The control mix (M1) exhibited medium workability with a slump of 50 mm. The addition of 5% silica fume (M2) reduced the slump to 35 mm, and at 10% silica fume (M3), the slump further decreased to 30 mm. This reduction is attributed to the high specific surface area and water demand of silica fume particles, which increases the cohesion and stickiness of the mix. However, the superplasticizer dosage was increased from 1.0% (M1) to 1.5% (M3) to compensate for this loss in workability.

Mix M4 (25% fly ash + 10% silica fume) showed a slump of 40 mm, representing a balanced workability. Mix M5 (30% fly ash + 10% silica fume) exhibited the highest slump of 55 mm, demonstrating the beneficial effect of fly ash on workability due to its spherical particle shape, which provides a lubricating effect and reduces internal friction.

Workability: The addition of silica fume reduces workability due to increased cohesion and water demand. At 10% silica fume, the slump decreased from 50 mm (control) to 30 mm. However, increasing the fly ash content to 30% improved workability to 55 mm due to the spherical shape of fly ash particles

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REFERENCES

[1] *IS 456:2000*, *Plain and Reinforced Concrete – Code of Practice*. New Delhi, India: Bureau of Indian Standards, 2000.

[2] *IS 516:1959 (Reaffirmed 2013)*, *Methods of Tests for Strength of Concrete*. New Delhi, India: Bureau of Indian Standards, 1959.

[3] *IS 1199:1959 (Reaffirmed 2018)*, *Methods of Sampling and Analysis of Concrete*. New Delhi, India: Bureau of Indian Standards, 1959.

[4] *IS 383:1970 (Reaffirmed 2016)*, *Specification for Coarse and Fine Aggregates from Natural Sources for Concrete*. New Delhi, India: Bureau of Indian Standards, 1970.

[5] *IS 10262:2019*, *Concrete Mix Proportioning – Guidelines*. New Delhi, India: Bureau of Indian Standards, 2019.

[6] *IS 12269:2013*, *Ordinary Portland Cement, 53 Grade – Specification*. New Delhi, India: Bureau of Indian Standards, 2013.

[7] M. Neville, *Properties of Concrete*, 5th ed. Harlow, U.K.: Pearson Education, 2011.

[8] P. K. Mehta and P. J. M. Monteiro, *Concrete: Microstructure, Properties, and Materials*. New York, NY, USA: McGraw-Hill, 2014.

[9] R. Siddique, "Utilization of silica fume in concrete: A review," *Journal of Materials in Civil Engineering*, vol. 23, no. 5, pp. 529–541, 2011.

[10] M. I. Khan and R. Siddique, "Utilization of fly ash in concrete: A review," *Resources, Conservation and Recycling*, vol. 55, no. 11, pp. 885–895, 2011.