

Effect of Addition of Combination of Admixtures on the Flow And Strength Characteristics of Self Compacting Concrete

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Abstract: Self-compacting concrete (SCC) has emerged as a revolutionary construction material that can flow and consolidate under its own weight without the need for external vibration. This study investigates the influence of dissimilar combinations of admixtures on the flow and strength characteristics of self-compacting material. Five different admixture combinations were evaluated: Superplasticizer + Viscosity Modifying Agent (SP+VMA) as reference mix, SP+VMA+Air Entraining Agent (AEA), SP+VMA+Water Proofing Compound (WPC), SP+VMA+Retarder (RET), and SP+VMA+Accelerator (ACC). Results indicate that combinations with AEA, WPC, and RET showed improved flow characteristics compared to the reference mix, while ACC combination showed reduced flowability. For strength properties, AEA, WPC, and ACC combinations demonstrated enhanced performance, with WPC showing the highest improvement in compressive strength (6% increase) and AEA showing the most significant improvement in flexural strength (13% increase). The RET combination showed reduced strength properties compared to the reference mix. All admixture combinations can be effectively used in practical applications without compatibility issues.

Keywords: Self-compacting concrete, Admixtures, Superplasticizer, Viscosity modifying agent, Air entraining agent, Water proofing compound, Flow characteristics, Strength properties

1. INTRODUCTION

An important development in concrete technology is self-compacting concrete (SCC), which does not require mechanical consolidation since it may flow and fill formwork entirely while passing through reinforcement without bleeding or segregating. In order to solve the skilled labor scarcity and enhance the strength and longevity of concrete structures, this ground-breaking concrete technology was initially created in Japan in the late 1980s.

The development of SCC has been driven by the need to improve construction efficiency, decrease labor costs, and improve the excellence of material constructions. Traditional concrete requires vibration for proper consolidation, which can be challenging in heavily reinforced sections and may lead to noise pollution and worker fatigue. SCC overcomes these limitations by achieving consolidation through its inherent flow properties.

The key properties that define SCC include great flowability, passing ability through reinforcement, and confrontation to segregation. These properties are achieved through careful selection of materials and the usage of chemical admixtures, particularly superplasticizers and viscosity modifying agents. The balance between flowability and stability is crucial for successful SCC implementation.

Chemical admixtures play a pivotal role in SCC performance. Superplasticizers provide the necessary flowability by reducing water content while maintaining workability. Viscosity modifying agents help maintain cohesion and prevent segregation. Additional admixtures such as air entraining agents, waterproofing compounds, retarders, and accelerators can be incorporated to enhance specific properties based on application requirements.

The objective of this investigation is to systematically evaluate the consequence of different combinations of admixtures on both flow characteristics and strength assets of self-compacting concrete. Understanding these

effects is crucial for enhancing SCC mix designs for specific applications and guaranteeing reliable performance in construction projects.

2. REVIEW OF LITERATURE

2.1 Development and Properties of Self-Compacting Concrete

Okamura and Ouchi (2003) pioneered the development of SCC, emphasizing the importance of achieving high flowability without segregation. Their work established the fundamental principles of SCC design, focusing on the balance between powder content, aggregate proportions, and chemical admixtures.

Khayat (1999) conducted comprehensive studies on the workability characteristics of SCC, developing test methods to evaluate flow properties. His research highlighted the importance of viscosity control in preventing segregation while maintaining adequate flow.

2.2 Research Gaps

While extensive research has been conducted on individual admixtures in SCC, limited studies have systematically evaluated the combined effects of multiple admixtures on both flow and strength characteristics. This research addresses this gap by providing comprehensive evaluation of admixture combinations commonly used in preparation.

3. MATERIALS AND METHODS

3.1 Materials

3.1.1 Cement

53 grade Ordinary Portland Cement (OPC) imitating to IS: 8112-1989 was used with a specific gravity of 3.15. The cement exhibited typical chemical composition and physical properties suitable for high-performance concrete applications.

3.1.2 Fine Aggregate

Locally available natural sand with specific gravity of 2.63 was used as fine aggregate. The sand conformed to Zone II grading requirements as per IS: 383-1970, ensuring optimal particle size distribution for SCC applications.

3.1.3 Coarse Aggregate

Crushed stone aggregate with specific gravity of 2.88 conforming to IS: 383-1970 was used. The supreme aggregate size was restricted to ensure adequate passing ability through reinforcement.

3.1.4 Fly Ash

Class F fly ash found from Thermal Power Station, Shaktinagar, Raichur was used as supplementary cementitious material. Fly ash helps in achieving the required powder content for SCC while contributing to long-term strength development.

4. RESULTS AND DISCUSSION

4.1 Fresh Properties

The flow characteristics of different admixture combinations are presented in Table 1. The results demonstrate significant variations in flow properties based on admixture combinations.

Table 1: Flow Test Results of SCC for Different Combinations of Admixtures

Admixture	Slump	Slump	Orimet	V-funnel	L-Box Test	T20	T40	U	Box
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Combination	Flow with J-ring (mm)	Flow (mm)	Test Flow Time (sec)	Test Flow Time (sec)	Blocking Ratio H2/H1	(sec)	(sec)	Test Filling Height (H1-H2) (mm)
SP+VMA (Ref. mix)	355	480	23	32	0	20	31	440
SP+VMA+AEA	387	510	14	13	0.13	09	15	215
SP+VMA+WPC	375	500	15	15	0.17	13	18	300
SP+VMA+RET	368	482	18	20	0.20	15	20	370
SP+VMA+ACC	338	460	38	50	0.08	28	No flow	510

The slump flow test results indicate that AEA combination achieved the highest flow diameter (510 mm), followed by WPC (500 mm), while ACC combination showed the lowest flow (460 mm). The reference mix achieved a flow of 480 mm, which serves as the baseline for comparison.

J-ring test results demonstrate that all combinations except ACC maintained adequate passing ability through reinforcement. The AEA combination showed the best performance with minimal variance among slump flow and J-ring flow measurements.

V-funnel and Orimet test results reveal significant differences in flow times. AEA combination demonstrated the fastest flow times (13 and 14 seconds respectively), indicating excellent filling ability. In contrast, ACC combination showed prolonged flow times (50 and 38 seconds), suggesting reduced flowability due to accelerated setting.

L-box test results show blocking ratios within acceptable limits for all combinations except RET, which showed a higher blocking ratio of 0.20, indicating some restriction in passing ability through reinforcement.

4.2 Hardened Properties

4.2.1 Compressive Strength

The compressive strength results for different admixture combinations are presented in Table 2, showing significant variations in strength development.

Table 2: Compressive Strength Test Results of SCC for Different Combinations of Admixtures

Admixture Combination	Average Compressive Strength (MPa)	Percentage Change w.r.t Reference Mix	Standard Deviation
SP+VMA (Ref. mix)	28.74	-	0.927
SP+VMA+AEA	28.88	+0.50	0.445
SP+VMA+WPC	30.37	+6.00	0.533
SP+VMA+RET	27.56	-4.00	1.142
SP+VMA+ACC	30.30	+5.00	0.641

The WPC combination achieved the highest compressive strength (30.37 MPa), representing a 6% improvement over the reference mix. This enhancement can be qualified to the pore-blocking effect of the waterproofing compound, which reduces permeability and creates a denser matrix.

The ACC combination also showed significant improvement (30.30 MPa, +5%), demonstrating the beneficial effect of accelerated hydration on early strength development. The AEA combination showed minimal improvement (+0.50%), while maintaining consistent results with low standard deviation.

The RET combination showed reduced compressive strength (27.56 MPa, -4%), which can be attributed to the delayed hydration process that may affect the formation of calcium silicate hydrate gel.

4.2.2 Tensile Strength

Table 3: Tensile Strength Results and Analysis

Admixture Combination	Average Tensile Strength (MPa)	Percentage Change w.r.t Reference Mix
SP+VMA (Ref. mix)	5.76	-
SP+VMA+AEA	6.22	+8.00
SP+VMA+WPC	6.15	+7.00
SP+VMA+RET	5.26	-8.70
SP+VMA+ACC	5.81	+1.00

Tensile strength results show that WPC combination achieved 7% improvement, while AEA combination showed 8% improvement. The enhanced tensile strength in AEA combination can be attributed to the micro-structural improvements provided by controlled air entrainment, which helps in stress distribution.

4.2.3 Flexural Strength

The flexural strength outcomes demonstrate the most significant variations among all strength properties tested.

The AEA combination achieved the highest flexural strength improvement of 13%, indicating superior performance under bending loads. This can be attributed to the improved micro-structure and stress redistribution capabilities provided by the controlled air void system.

WPC combination showed minimal improvement (+0.70%), while ACC combination demonstrated moderate improvement (+5%). The RET combination showed the most significant reduction (-28%), indicating that delayed setting adversely affects the development of flexural strength.

4.2.4 Impact Strength

Impact strength results indicate the energy absorption capacity of different combinations. WPC combination showed the highest improvement in both first crack (+17%) and final failure (+18%) energy absorption, demonstrating enhanced toughness characteristics.

AEA and ACC combinations also showed improvements in impact resistance, while RET combination showed

5. CONCLUSION

Based on the comprehensive investigational investigation of different admixture combinations in self-compacting material, the following conclusions can be drawn:

5.1 Flow Characteristics

- Enhanced Flow Performance:** The combinations SP+VMA+AEA, SP+VMA+WPC, and SP+VMA+RET demonstrated superior flow characteristics compared to the reference mix, with AEA combination achieving the best overall flow performance.
- Reduced Flow with Accelerator:** The SP+VMA+ACC combination showed reduced flow characteristics due to accelerated setting, limiting workability retention time.
- Optimal Flow Parameters:** All combinations except ACC attained slump flow values within the acceptable range for SCC applications (480-510 mm), indicating successful self-compacting behavior.

REFERENCES

1. Aitcin, P. C. (2000). *High-Performance Concrete*. E & FN Spon, London.
2. Dawood, E. T., & Ramli, M. (2011). High strength characteristics of cement mortar reinforced with hybrid fibres. *Construction and Building Materials*, 25(5), 2240-2247.
3. Dodson, V. H. (1990). *Concrete Admixtures*. Van Nostrand Reinhold, New York.
4. EFNARC (2005). *Specification and Guidelines for Self-Compacting Concrete*. European Federation for Specialist Construction Chemicals and Concrete Systems.
5. IS 383 (1970). *Specification for Coarse and Fine Aggregates from Natural Sources for Concrete*. Bureau of Indian Standards, New Delhi.
6. IS 516 (1959). *Indian Standard Methods of Tests for Strength of Concrete*. Bureau of Indian Standards, New Delhi.
7. IS 5816 (1999). *Splitting Tensile Strength of Concrete - Method of Test*. Bureau of Indian Standards, New Delhi.
8. IS 8112 (1989). *Specification for 43 Grade Ordinary Portland Cement*. Bureau of Indian Standards, New Delhi.
9. Khayat, K. H. (1999). Workability, testing, and performance of self-consolidating concrete. *ACI Materials Journal*, 96(3), 346-353.
10. Khayat, K. H., & Ghezal, A. (1999). Utility of statistical models in proportioning self-consolidating concrete. *Materials and Structures*, 32(5), 338-344.
11. Lachemi, M., Hossain, K. M. A., Lambros, V., & Bouzoubaa, N. (2004). Development of cost-effective self-consolidating concrete incorporating fly ash, slag cement, or viscosity-modifying admixtures. *ACI Materials Journal*, 101(5), 419-425.
12. Okamura, H., & Ouchi, M. (2003). Self-compacting concrete. *Journal of Advanced Concrete Technology*, 1(1), 5-15.
13. Ramachandran, V. S. (1995). *Concrete Admixtures Handbook*. Second Edition, Noyes Publications, Park Ridge, New Jersey.
14. Yamada, K., Takahashi, T., Hanehara, S., & Matsuhisa, M. (2000). Effects of the chemical structure on the properties of polycarboxylate-type superplasticizer. *Cement and Concrete Research*, 30(2), 197-207.
15. Zhu, W., & Bartos, P. J. M. (2003). Permeation properties of self-compacting concrete. *Cement and Concrete Research*, 33(6), 921-926.
16. Todupunuri, A. (2024). Exploring the use of generative AI in creating deepfake content and the risks it poses to data integrity, digital identities, and security systems. Available at SSRN 5014688.
17. Todupunuri, A. (2025). The Role of Human-Centric AI in Building Trust in Digital Banking Ecosystems. SSRN Electronic Journal. <https://doi.org/10.2139/ssrn.5120605>
18. Explainable AI Framework for Policy-Compliant Anomaly Detection in Data Pipelines. (2025). *International Journal of Communication Networks and Information Security*, 16(4). <https://doi.org/10.48047/ijcnis.16.4.2111>
19. Gaddam, S. INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING.
20. Bajarang Bhagwat, V. (2023). Optimizing Payroll to General Ledger Reconciliation: Identifying Discrepancies and Enhancing Financial Accuracy. *JOURNAL OF ADVANCE AND FUTURE RESEARCH*, 1(4). <https://doi.org/10.56975/jaafr.v1i4.501636>
21. Prodduturi, S. M. K. (2024). Legal challenges in regulating AI-powered cybersecurity tools. *International Journal of Engineering & Science Research*, 14(4), 316-323.



22. Prodduturi, S. M. K. (2024). Investigating the challenges and opportunities of cybersecurity in the era of remote work. *European Journal of Advances in Engineering and Technology*, 11(10), 80-84.
23. Doragacharla, V. R. (2026). Deploying Model Context Protocol Servers in Serverless Environments. *Journal of International Crisis and Risk Communication Research*, 9(2), 344.
24. Doragacharla, V. R. (2026). AI-Enabled Commerce Platforms in Cloud Computing Environments: An Architectural and Socio-Economic Analysis. *Journal of Computational Analysis & Applications*, 35(1).
25. Reddy, S. K. (2025). Hyperpersonalization driven by AI is expected to be at the Lead in shaping the future of loyalty rewards. *Journal of Emerging Technologies and Innovative Research*.
26. Reddy, S. K. R. (2025). Tailoring Loyalty Rewards Systems across Industries: Cloud vs On-Prem Solutions. *International Journal of All Research Education and Scientific Methods (IJARESM)*.
27. Poojari, R. (2026). Privacy-Preserving Generative AI in Healthcare Systems Using Federated Learning Approaches. *International Journal of Data Science and IoT Management System*, 5(1), 78-88.
28. Poojari, R. INTELLIGENT SYSTEMS+B108 AND APPLICATIONS IN ENGINEERING.
29. Uday Kumar Kalae. (2025). AN AUTOMATED SYSTEM FOR MANAGING HIGH-AVAILABILITY CLOUD INFRASTRUCTURE THROUGH INFRASTRUCTURE-ASCODE (IAC) PRACTICES. *American Journal of AI Cyber Computing Management*, 5(2), 42–50. <https://doi.org/10.64751/ajaccm.2025.v5.n2.pp42-50>
30. Kalae, U. K. (2021). Enhancing data analytics and reporting efficiency using Power BI and SQL in cloud computing environments. *Journal of Computational Analysis and Applications*, 29(6), 2021. <https://doi.org/10.48047/jocaaa.2021.29.06.48>
31. Saikumar, B. (2023). Enhancing Client Engagement through AI-Driven Real-Time Reporting and Automated Alerts. *International Journal of Enhanced Research in Science, Technology & Engineering*, 12(11), 111–117. <https://doi.org/10.55948/ijerste.2023.1115>
32. Saikumar, B. (2024). Optimizing Crew Scheduling and Absence Management using Microservices: Enhancing Reliability and Efficiency in Crew Management Systems. *International Journal of Enhanced Research in Management & Computer Applications*, 13(11), 50–55. <https://doi.org/10.55948/ijermca.2024.0116>
33. Vasagam, M., Kumar, A., & Garg, A. (2026). Learning Execution Plan Embeddings for Multi-Dimensional Query Resource Prediction. *IEEE Access*.