



Effect of Expanplast SP100 on the Workability of Concrete at Low Water Cement Ratio

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Abstract

Workability is one of the most critical properties of fresh concrete, particularly when low water–cement ratios are adopted to achieve high strength and durability. However, reducing the water content often results in poor flowability, segregation issues, and difficulties in placement and compaction. This study investigates the effect of a polycarboxylate ether (PCE) based water-reducing admixture, Expanplast SP100, on the workability of concrete at a low water–cement ratio. Concrete mixes were prepared at a constant water–cement ratio of 0.41, with varying dosages of Expanplast SP100 ranging from 0.5% to 3% by weight of cement. Slump test results were used to evaluate workability performance and retention. The results demonstrate a significant improvement in workability with increasing admixture dosage, without the addition of extra mixing water. Optimal workability was achieved at dosages between 2% and 2.5%, beyond which only marginal improvements were observed. The findings confirm that Expanplast SP100 is highly effective in enhancing workability at low water–cement ratios, making it suitable for high-performance and pumpable concrete applications.

Keywords: Workability, Superplasticizer, Expanplast SP100, Slump Test, Low Water–Cement Ratio, Fresh Concrete

1. Introduction

Concrete workability is a critical property of fresh concrete that governs its ease of mixing, transportation, placement, compaction, and finishing, directly influencing the quality and durability of hardened concrete (Neville, A.M., 2012). In modern construction, the demand for high-strength and durable concrete has increased significantly, leading to the widespread adoption of low water–cement (w/c) ratios, which enhance strength, reduce porosity, and improve resistance to permeability and aggressive environmental conditions (Taylor & Francis, 2025). However, reducing the w/c ratio adversely affects workability, resulting in stiff mixes that are difficult to place and compact (Huang 2024), especially in heavily reinforced sections and pumped concrete applications. To address this challenge, high-range water-reducing admixtures, commonly known as superplasticizers, are extensively used to improve workability without increasing water content. Among these, polycarboxylate ether (PCE) based superplasticizers have proven to be the most effective due to their combined electrostatic repulsion and steric hindrance mechanisms, which disperse cement particles efficiently and provide superior slump retention compared to conventional admixtures. Recent

studies have shown that PCE-based admixtures can significantly increase initial slump and maintain workability over extended periods, making them suitable for ready-mix concrete, long-distance transportation, and hot-weather concreting. Expanplast SP100 is a modern PCE-based superplasticizer designed to enhance workability and workability retention at low w/c ratios; however, limited published experimental data is available on its performance under controlled laboratory conditions (Alsadey, 2016). Therefore, this study investigates the effect of Expanplast SP100 on the workability and workability retention of concrete at a constant low water–cement ratio, with the aim of identifying an optimum dosage for practical engineering applications. Workability the ease with which fresh concrete can be mixed, transported, placed and compacted is a central property that directly affects durability, homogeneity, and the ultimate structural performance of concrete. Contemporary demands for sustainability and high performance have driven designers toward lower water–cement (w/c) ratios to reduce porosity and increase strength and service life. However, low w/c ratios make fresh concrete stiff and difficult to place, increasing labor, vibration, and risk of poor compaction. High-range water-reducing admixtures (superplasticizers) (Yamada et al. 2011), especially polycarboxylate ether (PCE) based products, have become the go-to solution because they can dramatically increase flowability without extra water by dispersing cement particles through electrostatic and steric mechanisms. Recent reviews and experimental studies confirm that PCE chemistry (side-chain length, backbone, molecular weight) strongly influences both immediate flow and slump retention (Ramachandran, V.S.2013), making selection and dosage optimization critical for industrial practice. Modern commercially available formulations (e.g., Expanplast SP100) are explicitly tailored for slump retention and pumpability in ready-mix and large pours, enabling extended handling times while preserving mix stability and minimizing bleeding.

2. Literature Review

The use of superplasticizers has become essential in modern concrete technology, particularly for improving workability at low water–cement ratios. Recent systematic reviews confirm that high-range water-reducing admixtures significantly enhance fresh concrete properties, especially flowability and slump retention, without compromising mix stability (Abril-Fernández et al., 2025). Polycarboxylate ether (PCE)–based superplasticizers are currently the most advanced class of admixtures due to their superior dispersing efficiency and adaptability to different cement systems.

Several studies have focused on the molecular structure and performance mechanisms of PCE superplasticizers. Peng et al. (2025) reported that the chemical architecture of PCEs plays a crucial role in determining workability and water reduction efficiency. Similarly various other studies demonstrated that side-chain length and backbone structure directly influence cement particle dispersion, resulting in improved initial slump and enhanced workability retention and design improves slump retention and clay tolerance, making these admixtures suitable for complex field conditions.

The effectiveness of PCE-based superplasticizers in improving workability has been validated through experimental investigations. Liseth (2025) highlighted that modern PCEs can significantly increase slump while maintaining cohesion, even at very low water–cement ratios. Cano and Chávez (2025) observed that the incorporation of superplasticizers and workability retention admixtures improved both initial flow and time-dependent workability, which is particularly beneficial for ready-mix concrete applications. Tajasosi et al. (2025) also reported improved fresh concrete properties with increasing superplasticizer dosage, although excessive dosages led to marginal gains.

Compatibility and dosage optimization have been identified as critical factors affecting superplasticizer performance. Studies have shown that improper dosage or incompatibility with cement or supplementary cementitious materials may reduce efficiency or cause undesirable effects such as delayed setting (Conf. Ser., 2020). Research on specialized PCE formulations has indicated that tailored superplasticizers can significantly enhance slump retention for specific aggregate or binder systems.

The influence of superplasticizers on workability has also been explored in sustainable and alternative concrete systems. Experimental studies involving recycled aggregates demonstrated that PCE-based superplasticizers effectively compensate for reduced workability caused by higher water absorption of recycled materials. Bhandari (2023) reported that PCEs play a vital role in maintaining workability in low-carbon cement systems, supporting sustainability objectives without sacrificing performance.

Despite extensive research on PCE superplasticizers, limited published data is available on the performance of specific commercial products such as Expanplast SP100. Manufacturer technical data sheets indicate that Expanplast SP100 is designed to provide high initial workability and excellent slump retention; however, independent laboratory-based validation is scarce (Expanplast SP100 TDS, 2024) Conferences, 2018). Therefore, further experimental

investigation is required to evaluate its effectiveness at a constant low water–cement ratio and to establish optimal dosage levels for practical engineering applications.

3. Materials and Methodology

3.1 Materials

- **Cement:** Ordinary Portland Cement (OPC) conforming to ASTM C150.
- **Fine Aggregate:** Natural river sand with appropriate grading.
- **Coarse Aggregate:** Crushed stone with nominal maximum size of 20 mm.
- **Water:** Potable water suitable for concrete mixing.
- **Chemical Admixture:** Expanplast SP100 (PCE-based superplasticizer).

3.2 Mix Proportions

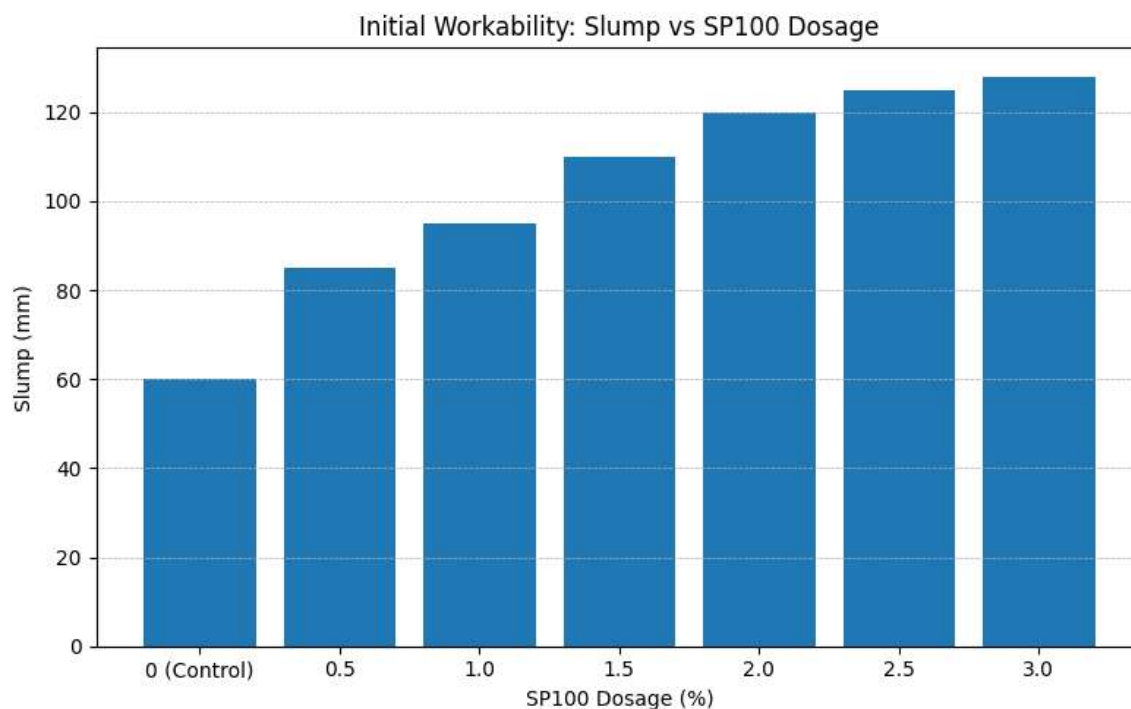
- **Mix ratio:** 1 : 2 : 4 (cement : fine aggregate : coarse aggregate)
- **Water–cement ratio:** Constant at 0.41
- **Expanplast SP100 dosages:** 0.5%, 1%, 1.5%, 2%, 2.5%, and 3% by weight of cement
- **Control mix:** Concrete without admixture

3.3 Workability Test

Workability was evaluated using the **slump test** in accordance with **ASTM C143**. Fresh concrete was placed in the slump cone in three layers, each compacted with 25 strokes. The vertical settlement of concrete after lifting the cone was measured as the slump value. The results of workability are given in below table 1 and graph 1.

Table 1: Slump Test Results

SP100 Dosage (%)	0 (Control)	0.5	1.0	1.5	2.0	2.5	3.0
Slump (mm)	60	85	95	110	120	125	128



Graph:1 Concrete workability (Slump vs SP100 Dosage)

The results clearly indicate that the addition of Expanplast SP100 significantly improves the workability of concrete at a low water–cement ratio. The control mix, prepared without admixture, exhibited a slump of only 60 mm, indicating stiff and less workable concrete. This behavior is typical for mixes with low water content, where cement particles tend to flocculate, trapping water and reducing flow.

With the introduction of Expanplast SP100 at a dosage of 0.5%, the slump increased to 85 mm, representing a substantial improvement in workability. Further increases in dosage resulted in a continuous rise in slump values, reaching 120 mm at 2% dosage. This improvement can be attributed to the effective dispersion of cement particles by the PCE-based admixture, which releases trapped water and reduces internal friction.

At dosages beyond 2.5%, the increase in slump became marginal, suggesting that most cement particles were already well dispersed. Excessive admixture did not result in segregation or bleeding, indicating good mix stability. The results suggest that an optimum dosage range of 2–2.5% provides excellent workability while maintaining mix cohesion.

4. Workability Retention (Slump vs Time)

Workability retention was evaluated by measuring slump at regular time intervals after mixing. Slump values were recorded at **0, 30, 60, and 90 minutes** for the control mix and

selected Expanplast SP100 dosages, while maintaining a constant water–cement ratio of 0.41. The test was conducted in accordance with **ASTM C143**. All results are represented in table 2 and graph 2.

Table: 2 Slump Retention with Time

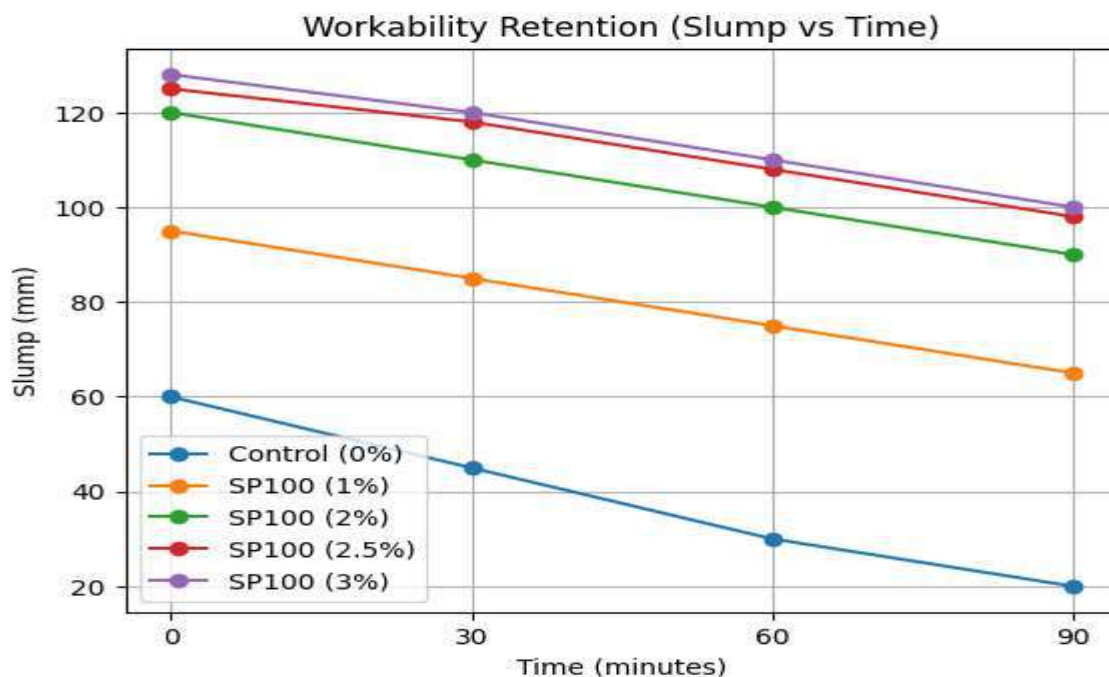
Time (min)	Control (0%)	SP100 (1%)	SP100 (2%)	SP100 (2.5%)	SP100 (3%)
0	60	95	120	125	128
30	45	85	110	118	120
60	30	75	100	108	110
90	20	65	90	98	100

The control mix exhibited a rapid loss of workability with time, as indicated by a reduction in slump from 60 mm at initial mixing to only 20 mm after 90 minutes. This sharp slump loss is attributed to the low water–cement ratio and rapid flocculation of cement particles, which restricts the free movement of water within the mix.

Concrete mixes containing Expanplast SP100 showed significantly improved workability retention. At a dosage of 1%, the slump remained at 65 mm after 90 minutes, indicating moderate retention compared to the control mix. Higher dosages of 2% and 2.5% demonstrated superior performance, maintaining slump values of 90 mm and 98 mm respectively after 90 minutes.

The improved slump retention can be attributed to the polycarboxylate ether (PCE) chemistry of Expanplast SP100, which provides both electrostatic repulsion and steric hindrance between cement particles. This mechanism delays re-flocculation and reduces early stiffening of the concrete mix, thereby maintaining flowability over time.

Among the tested mixes, the **2–3% dosage range** showed the most stable workability retention without signs of segregation or bleeding. This indicates that Expanplast SP100 not only improves initial workability but also ensures adequate slump retention, which is crucial for transportation, pumping, and placement in large-scale construction projects.



Graph 2. Workability Retention (Slump vs Time)

The figure 2 illustrates the variation of slump with time for concrete mixes containing different dosages of Expanplast SP100 compared with the control mix (0% admixture). Slump measurements were recorded at 0, 30, 60, and 90 minutes to evaluate workability retention at a constant low water–cement ratio.

The **control mix (0%)** shows a rapid loss of workability, with slump decreasing sharply from about 60 mm at initial mixing to nearly 20 mm after 90 minutes. This steep decline indicates poor workability retention, which is typical of low water–cement ratio concrete without chemical admixtures due to rapid flocculation of cement particles and early stiffening.

In contrast, concrete mixes containing **Expanplast SP100** exhibit significantly improved workability retention. The mix with **1% SP100** demonstrates a moderate reduction in slump over time, retaining approximately 65 mm after 90 minutes, which is substantially higher than the control mix. This indicates that even a low dosage of SP100 effectively delays slump loss. The mixes with **2% and 3% SP100** show the best performance in terms of workability retention. Although a gradual decrease in slump is observed with time, these mixes maintain high slump values throughout the 90-minute period. At 90 minutes, the 2% and 2.5% mixes retain approximately 90 mm and 98 mm slump, respectively, indicating stable and sustained workability. The relatively flatter slopes of these curves reflect slower re-flocculation of cement particles.

Overall, the figure clearly demonstrates that increasing the dosage of Expanplast SP100 enhances both initial workability and workability retention. The improved retention is attributed to the polycarboxylate ether (PCE) mechanism, which provides electrostatic repulsion and steric hindrance between cement particles, thereby reducing early stiffening. Based on the trends observed, a dosage range of 2–3% appears to be optimal for achieving adequate workability retention in low water–cement ratio concrete, making it suitable for practical applications such as ready-mix concrete, pumping, and hot-weather concreting

5. Conclusion

- The control concrete mix exhibited low initial workability and rapid slump loss due to the low water–cement ratio.
- Addition of Expanplast SP100 significantly improved the initial workability of concrete at all dosage levels.
- Slump values increased progressively with increasing SP100 dosage, confirming effective dispersion of cement particles.
- Concrete mixes containing SP100 showed superior workability retention compared to the control mix.
- Slump retention improved markedly with time, especially for mixes containing 2%, 2.5%, and 3% SP100.
- The 3% SP100 dosage produced the highest initial slump; however, the improvement over 2.5% was marginal.
- An optimum dosage range of 2–2.5% **Expanplast SP100** was identified for achieving stable and adequate workability.
- Expanplast SP100 effectively delayed slump loss up to 90 minutes, making the concrete suitable for extended handling.
- The admixture enhanced pumpability and ease of placement without increasing water content.
- Overall, Expanplast SP100 proved to be highly effective in producing workable and stable concrete at a low water–cement ratio for practical construction applications.

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