CONCERA™ CP Series

Rheology-modifying water reducer

Introduction

The CONCERA™ CP Series is a patent-pending, rheology-modifying, polycarboxylate-based (PC) ASTM C494 Type A water reducer that enables the production of Control Flow Concrete, a highly flowable concrete with minimal or no segregation using unmodified conventional mix designs. Control Flow Concrete typically have slump flow values in the 400 to 650mm range and may require minimal external energy to properly consolidate. CONCERA CP Series is a component of GCP Applied Technologies' Control Flow Concrete System and is typically used in mix designs that also contain a PC-based mid- or high range water reducer. CONCERA CP Series imparts many desirable properties to Control Flow Concrete including segregation resistance, stability, improved passing and filling ability, excellent tolerance to moisture variation and extended slump life. CONCERA CP Series also produces concrete with consistent, predictable slump flow and air control properties and readily enables jobsite concrete to be retempered with water to restore slump lost during transit. CONCERA CP Series has minimal impact on other concrete properties including early and later age compressive strength and drying shrinkage, while initial time of set and total bleed may slightly increase.

ASTM C 1611-Standard Test Method for Slump Flow of Self-Compacting Concrete (SCC) details a qualitative visual test procedure for measuring rheology, stability and segregation resistance properties of highly flowable concrete and SCC. The test procedure includes a visual inspection of the concrete spread after the slump flow test is completed. This inspection includes observing the distribution of coarse aggregate within the concrete spread and mortar fraction and bleeding characteristics around the perimeter of the spread. Finally, a Visual Stability Index (VSI) value is assigned to the concrete spread using 0-3 criteria as detailed to the right.

Visual Stability Index Values

- **0 = HIGHLY STABLE -** No evidence of segregation or bleeding.
- **1 = STABLE -** No evidence of segregation and slight bleeding observed as a sheen on the concrete mass.
- **2 = UNSTABLE -** A slight mortar halo ≤ 10mm and/or aggregate pile in the center of the concrete mass.
- **3 = HIGHLY UNSTABLE -** Clearly segregating by evidence of a large mortar halo ≥ 10mm and/or a large aggregate pile in the centre of the concrete mass.

A CONCERA CP1028 field test evaluation program using an array of 24.2-44.8 Mpa (3500-6500 psi) mix designs containing different types and quantities of cements, pozzolans and fine and coarse aggregates was conducted at several test sites in North America. The mix design and admixture test matrix included:

- Conventional 200mm slump using polycarboxylate-based high range water reducer (HRWR).
- Highly flowable 400 to 650mm slump flow using polycarboxylate-based HRWR.
- Control Flow Concrete 400 to 650mm slump flow using CONCERA CP1028 rheology-modifying water reducer and polycarboxylate-based HRWR.

TABLE 1 - CONCERA™ CP1028 Field Test Results

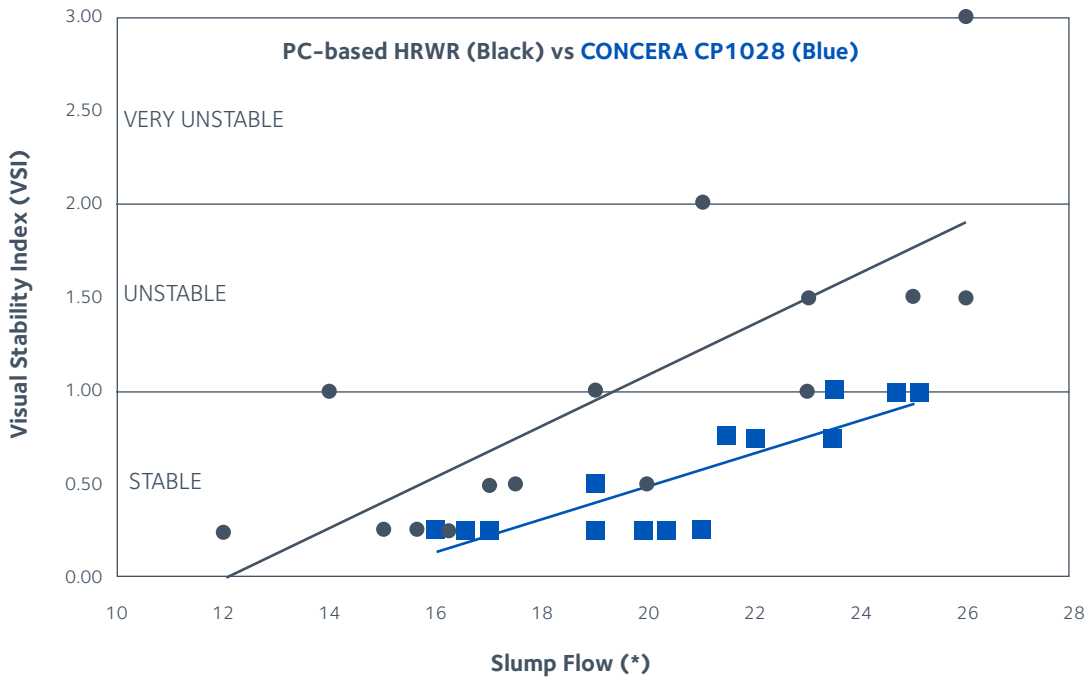
(Results below represent averages from 6 tests)

	Units	Conventional HRWR 200mm slump mix design	Conventional HRWR highly flowable 400-650mm mix design	CONCERA CP1028 +PC-based HRWR highly flowable 400-650mm mix design
Conventional HRWR dosage rate	mL / 100kg	326	567	326
CONCERA CP1028 dosage rate	mL / 100kg	-	-	652
Initial slump/slump flow	mm	slump-206	597	561
Initial VSI (ranked 0-3)	0-3	(not applicable)	1.7	0.75
Initial VSI description	-	-	unstable	stable
60 minute slump flow	mm	(not tested)	376	470
60 minute VSI (ranked 0-3)	0-3	(not applicable)	0.45	0.35
60 minute VSI description	-	-	highly stable	highly stable
Initial plastic air	%	1.8	0.9	1.1
Initial time of set	(hr:min)	5:28	6:30	6:20
2/3 day comprehensive strength	Mpa (psi)	22.7 (3287)	23.6 (3428)	22.9 (3324)
7 day compressive strength	Mpa (psi)	30.9 (4475)	31.7 (4592)	31.7 (4597)
28 day compressive strength	Mpa (psi)	37.5 (5436)	37.3 (5410)	37.4 (5430)

Table 1 above details summary of test results including initial slump flow, VSI, plastic air, initial time of set, early, 7, 28 day compressive strength along with 60 minute slump flow and VSI. Field test results clearly show CONCERA CP1028 produces highly flowable, stable, segregation-resistant concrete with excellent slump retention properties over 60 minutes and minimal impact on other pertinent plastic and hardened concrete properties.

Figure 1 below further details polycarboxylate-based HRWR (black) and CONCERA CP1028 (blue) concretes VSI values over a range of slump flows. CONCERA CP1028 concretes also typically contain a PC-based MRWR or HRWR. CONCERA CP1028 concretes consistently show better (lower) VSI values when compared to highly flowable PC-based HRWR concrete with all VSI's < 1. **Note:** *ACI 237-Self-Compacting Concrete* document states – A VSI rating <1 is an indication that the highly flowable concrete is stable. ACI 237 further states that VSI ratings are subjective and should be used primarily as a quality control tool, rather than as a acceptance/rejection criteria for a specific mix design.

Figure 1 - Slump Flow (") vs Visual Stability Index (0-3)



When CONCERA™ CP1028 is incorporated into a conventional off-the-shelf mix design, and additional incremental improvements to the overall rheology, segregation resistance, stability or other properties are desired, relatively minor and inexpensive mix design modifications can be made. First, most conventional MRWR/HRWR mix designs are designed in the 130-200mm slump range and CONCERA CP1028 has built-in water reducer capability to increase 130mm slump concretes up to the highly flowable 400 to 650mm range. Therefore, since most CONCERA CP1028 mix designs already contain a PC-based MRWR or HRWR, rheology improvements can be realised by slightly reducing the PC-based MRWR or HRWR dosage rate and increasing the CONCERA CP1028 dosage rate. This adjustment will increase the total amount of rheology modifier in the concrete. Several other mix design adjustments are detailed below, with implications related to making a specific adjustment detailed in parentheses. It is highly recommended CONCERA CP1028 Control Flow Concrete be tested prior to job startup using applicable mix designs and materials.

- Adjust MRWR/HRWR – CONCERA CP1028 ratio
- Reduce total coarse aggregate content (increases drying shrinkage)
- Reduce nominal coarse aggregate size (increases drying shrinkage)
- Optimise coarse aggregate particle shape/angularity
- Optimise coarse aggregate gradation, avoid severely gap graded coarse aggregate
- Increase fine aggregate, reduce coarse aggregate content (water demand and shrinkage impact)
- Increase mortar and/or paste fraction (water demand and shrinkage impact)
- Slightly increase total cementitious content (cost increase)
- Incorporate or increase the percentage of fly ash in the mix design
- Reduce slump flow to low end of 400 to 650mm range (workability impact)
- Slightly increase plastic air content (strength impact)
- Slightly reduce water content, increase CONCERA CP1028 dosage rate

In summary, a widespread North America-based field test program confirmed CONCERA CP1028 enables the production of 400 to 650mm Control Flow Concrete with minimal or no segregation using typically unmodified conventional mix designs. CONCERA CP1028 imparts many other desirable properties to Control Flow Concrete including improved passing and filling ability, tolerance to moisture variation, consistent slump flow and slump flow retention properties and minimal impact on compressive strength and set time. Several minor mix design modifications can also be tested and implemented if additional improvements to overall rheology, stability and segregation resistance properties are desired.

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