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Sustainability meets performance: the game-changing MasterCO$_2$re technology

While the use of low-clinker cements holds the greatest potential for the reduction of the CO_2 emissions associated with concrete, it also poses major challenges for concrete producers. Loss in consistence, worsening of rheology, and reduction of mechanical strengths are the main, frequently occurring undesirable outcomes. The new range of superplasticisers developed by Master Builders Solutions addresses the performance gaps and limitations associated with challenging low-clinker cements. The data presented here show how the new superplasticiser MasterCO$_2$re, based on Intelligent Cluster System (ICS) technology, enables a smooth transition from CEM II/A and II/B to the new type CEM II/C, ensuring consistence retention, advanced rheology, excellent strength development properties and robustness.

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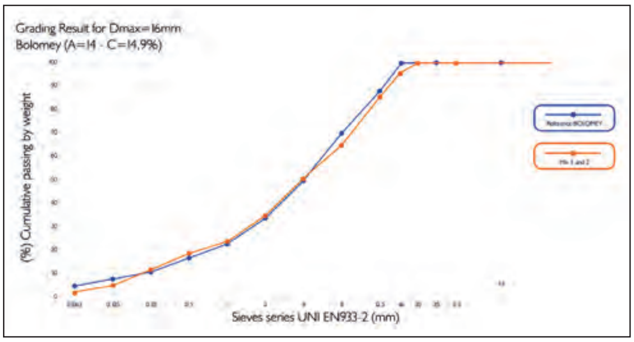
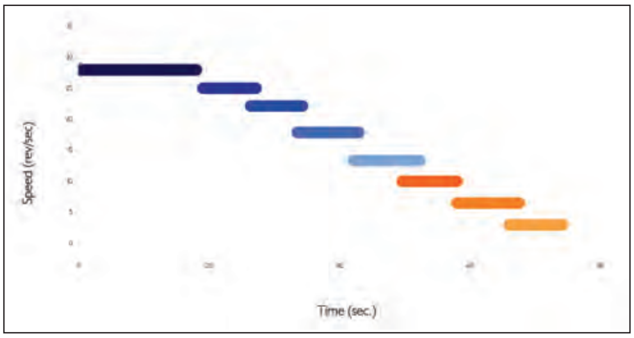
The rheology imparted by MasterCO$_2$re in comparison with conventional polycaboxylate (PCE) superplasticisers is the real driver of this current transformation, as it allows for the further reduction of water content in concrete without any negative impact on pumpability, placing and finishing. The reduction of CO_2 emissions and the savings of water that can be achieved are massive. This demonstrates that by using ICS technology, the transition to low-clinker cement is not only possible but also economically viable, without compromising on quality.

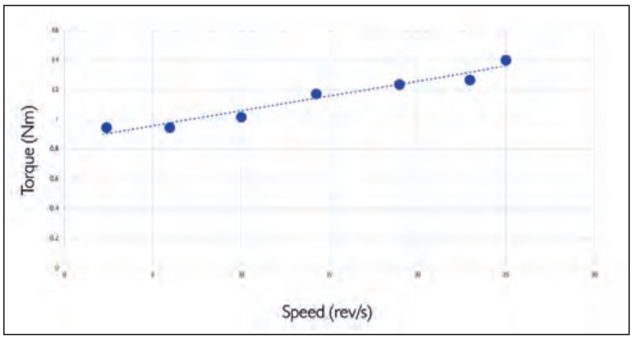
Experimental programme

Concrete tests have been performed on three different commercial II/C-M cements and the corresponding reference limestone-blended cements with the same clinker. The water:cement ratio (w/c) and initial slump have been kept constant among the three series of tests (Mix 1, w/c = 0.51). The mix design and grading curve are reported in Table 1 and Figure 1 respectively.

Plastic viscosity, yield value and thixotropy of concrete have been measured by using an eBT-V rheometer from Schleibinger Testing Systems using the conditions reported in Figure 2. The test consists of measuring the torque generated by a rotating vane in the concrete. The values recorded at the different speeds allow for the interpretation of rheological properties through the Reiner–Riwlin model.







All concretes have been prepared with a planetary mixer with a vertical shaft (P50 from OMG SICOMA, 65Hz, 1950rpm). Slump has been measured after 5, 30, 60, 90 and 120 minutes according to BS EN 12350-2[1]. Compressive strengths have been tested on 15 × 15 × 15cm cubic specimens according to BS EN 12390-2 and Part 3[2].

A second series of tests has been carried out with the same conditions but at a lower w/c ratio (Mix 2, w/c = 0.46). The water volume has been compensated as reported in Table 1.

Left: Figure 1 – grading curve of Mix 1 and 2.
Top: Figure 2 – eBT-V measurement conditions – step profile.
Above: Figure 3 – example of interpolation of torque vs speed data.

Results and discussion

Results from the first series of tests are reported in Table 2, while rheology parameters are shown in Figures 4, 5 and 6.

MasterCO$_2$re technology proves to be very robust against different types of clinker, limestone filler and SCMs, showing outstanding performance in terms of slump retention with all tested cements. The new admixture guarantees a slump retention up to two hours without retarding strength development, which is even increased with respect to reference standard admixture, as shown in Table 3.

Intelligent Cluster System is based on a unique technology that creates clusters of finely tuned chemical structures, thus ensuring the release of the chemicals as they are needed in the system: MasterCO$_2$re is in part composed of free polymer(s), specifically designed to meet the initial fluidity requirements, and the clusters, which are the key components of this technology. The matrix of the cluster is the core of the technology, enabling a controlled release of the polymers according to the properties of the cementitious system. In addition, the controlled release allows workability retention without any retardation, thus resulting in an excellent early strength development, since it allows a more orderly growth of hydration crystals and a lower porosity, resulting in an excellent early and long-term strength development.

Figures 4 and 5 show the yield stress and plastic viscosity

Component	Mix 1	Mix 2
Cement (kg/m^3)	330	330
Crushed sand 0–4 mm (kg/m^3)	969	991
Coarse aggregate 4–8 mm (kg/m^3)	208	213
Coarse aggregate 8–12 mm (kg/m^3)	286	292
Coarse aggregate 12–19 mm (kg/m^3)	437	448
Effective water (litres)	168	152
Water:cement	0.51	0.46
Paste volume (dm^3/m^3)	273	257

Table 1 – Mix designs used in the trials.

			Dosage (% bwc)	Slump	Slump @45 min	Slump @90 min	Slump @120 min
CEM A II/A-LL 42,5 N	w/c = 0.51	Standard admixture	0.9	210	70		
		MasterCO$_2$re	1	210	220	200	200
CEM A II/C-M (S-LL) 32,5 N	w/c = 0.51	Standard admixture	0.9	220	160	90	
		MasterCO$_2$re	1.1	220	230	220	220
	w/c = 0.46	Standard admixture	1.3	210	120		
		MasterCO$_2$re	1.4	210	220	220	220
CEM B II/A-LL 42,5 R	w/c = 0.51	Standard admixture	1	210	170	150	
		MasterCO$_2$re	1.1	220	220	220	220
CEM B II/C-M (S-LL) 42,5 N	w/c = 0.51	Standard admixture	1.1	200	190	180	180
		MasterCO$_2$re	0.8	220	220	220	220
	w/c = 0.46	Standard admixture	1.6	220	200	190	180
		MasterCO$_2$re	1.6	220	220	220	210
CEM C II/B-S 32,5 R	w/c = 0.51	Standard admixture	0.8	220	220	200	190
		MasterCO$_2$re	0.9	220	230	220	220
CEM C II/C-M (S-LL) 32,5 N	w/c = 0.51	Standard admixture	0.8	220	220	210	190
		MasterCO$_2$re	0.8	220	230	220	220
	w/c = 0.46	Standard admixture	1.2	220	220	200	190
		MasterCO$_2$re	1.2	220	230	230	210

Table 2 – Concrete test results (Mix 1 and 2).

			Compressive strengths @24 hrs, 10°C (MPa)	Compressive strengths @24 hrs, 20°C (MPa)	Compressive strengths @28 days, 20°C (MPa)
CEM A II/A-LL 42,5 N	w/c = 0.51	Standard admixture	4.3	12.2	39.4
		MasterCO$_2$re	6.7	16.4	40.1
CEM A II/C-M (S - LL) 32,5 N	w/c = 0.51	Standard admixture	3.3	8.9	38.6
		MasterCO$_2$re	4.5	12	42.8
	w/c = 0.46	Standard admixture	5.2	15	48.8
		MasterCO$_2$re	6.1	16.9	51.9
CEM B II/A-LL 42,5 R	w/c = 0.51	Standard admixture	19.6	28.7	51.4
		MasterCO$_2$re	24.6	32.9	55
CEM B II/C-M (S - LL) 42,5 N	w/c = 0.51	Standard admixture	3	13.3	43.9
		MasterCO$_2$re	9.5	20.8	48.8
	w/c = 0.46	Standard admixture	5.8	18.3	51.2
		MasterCO$_2$re	5.1	21.6	56.2
CEM C II/B-S 32,5 R	w/c = 0.51	Standard admixture	5.9	10.6	47.4
		MasterCO$_2$re	5.1	10.9	52.8
CEM C II/C-M (S - LL) 32,5 N	w/c = 0.51	Standard admixture	4.1	7.2	38.2
		MasterCO$_2$re	4.9	9.2	42.9
	w/c = 0.46	Standard admixture	5.6	10.2	48.5
		MasterCO$_2$re	5.9	11.2	51.9

Table 3 – Strength development (Mix 1 and 2).

of the mixes: at w/c = 0.51, with both CEM II/A-LL and CEM II/C-M (S-LL), yield stress and plastic viscosity of the concretes made with MasterCO$_2$re are lower, showing that this technology improves the rheology of both systems.

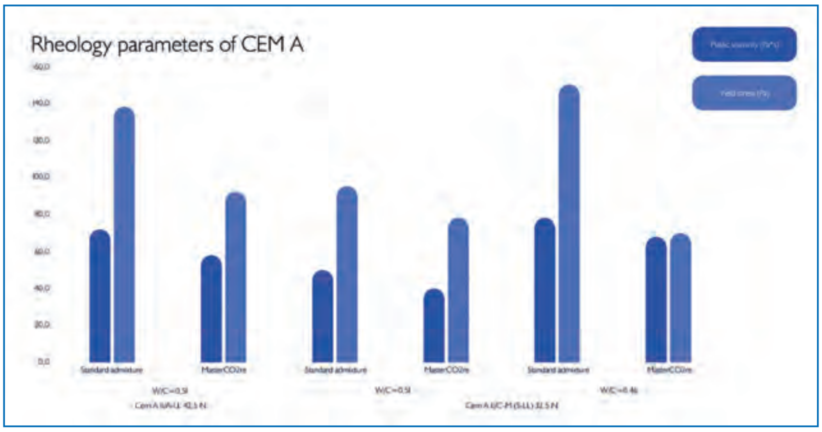
Robustness of the rheology can also be explained by the mechanism of the ICS: the clusters provide a tribological/lubrication effect between the concrete components and, especially at low w/c ratios, are able to reduce friction, thus ensuring better rheology of concrete.

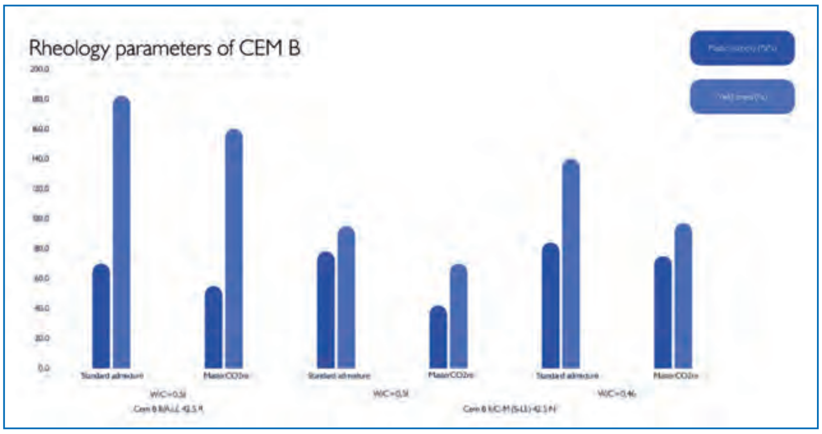
Concluding remarks

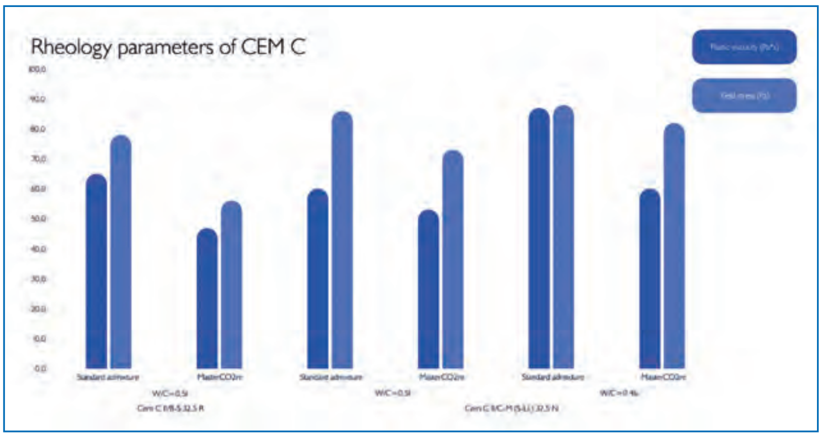
The following conclusions can be drawn from the data presented:

- MasterCO$_2$re improves the rheology of concrete, in comparison with standard PCE admixtures, with all types of cements tested.
- The plastic viscosity of concrete with CEM II/C-M and a w/c ratio of 0.46 is comparable with the plastic viscosity of concrete with CEM II/A or II/B and w/c ratio 0.51.
- Consistence retention over two hours is ensured with all cements.
- Mechanical strengths, at early and ultimate ages, are superior with MasterCO$_2$re compared with conventional PCEs.
- The gap in 28-day strengths brought about by the switch from CEM II/A or CEM II/B to CEM II/C can be filled in all cases thanks to the additional reduction of water made possible by MasterCO$_2$re without negative impact on the pumping and placing of concrete, as demonstrated by the rheological data.

The new superplasticisers based on ICS technology prove to be a solution for modern concrete using new cements with reduced clinker content and less water, therefore paving the way for a more sustainable future for the construction industry. ■







References:

1. BRITISH STANDARDS INSTITUTION, BS EN 12350-2. *Testing fresh concrete. Part 2 –Slump test*. BSI, London, 2019.
2. BRITISH STANDARDS INSTITUTION, BS EN 12390. *Testing hardened concrete. Part 2 – Making and curing specimens for strength tests. Part 3 – Compressive strength of test specimens*. BSI, London, 2019.

Top: Figure 4 – rheology parameters of CEM A.
Middle: Figure 5 - rheology parameters of CEM B.
Bottom: Figure 6 – rheology parameters of CEM C.

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Unveil the Power of MasterCO$_2$re™

Intelligent Cluster System Simplifies Low-clinker Concrete Production

Looking for an easy way to produce low-clinker concrete without sacrificing performance? MasterCO$_2$re™ is an intelligent cluster system to reduce imposing amounts of CO_2 while maintaining rheology, workability retention, and desired strength properties.

Learn more to achieve sustainable concrete performance