# Daracem® Superplasticizers

## Freeze-Thaw Durability of High Slump, Superplasticized Concrete

Tests were run in the GCP Advanced Technologies Construction Products laboratory to evaluate the freeze-thaw durability of air-entrained Daracem® 100 concrete with three different Type I cements. Three freeze-thaw beams were prepared for each mix. In two cements, the ASTM standard C494 procedure was followed, that is, both test and reference concrete were prepared at the same slump. In the third cement, all mixes were made at equal water/cement ratios with the slump falling where it would, to determine the effect of air on superplasticized concrete and durability. Daracem 100 was tested at 326, 652 and 978 mL/100 kg cement (5, 10 and 15 oz/100 lbs) respectively, along with Daracem 19 dosed at 652 mL/100 kg (10 oz/100 lbs), and a non-superplasticized reference mix. All mixes contained Daravair® AEA to obtain 5% to 7% entrained air content. Freeze-thaw beams were tested according to ASTM C666, Procedure A, Rapid Freezing and Thawing in Water. In addition, a 25 mm (1 in.) section was cut from the center of one cylinder from each mix. This was then polished and a hardened air analysis (ASTM C457, Linear Traverse Method) was performed on each specimen.

Table 1 contains the average relative durability factors for each mix at the completion of 300 cycles of freeze-thaw testing. ASTM C494 requires a minimum relative durability factor of 80. All samples passed with no visible signs of physical deterioration.

Table 2 contains the results of the hardened air analysis. Air void systems are considered to be of good quality when the spacing factor for all voids is 0.20 mm (0.008 in.) or less. Spacing factors for the Daracem 100 range from good to marginal, which is typical of superplasticized concrete. Whether the mixes were fabricated according to ASTM C494 procedures (water reduced to maintain a constant slump), or with a constant water/cement ratio, all air void systems were of the same quality.

**Table 1: ASTM C666, Durability Factors (%)**

| | ASTM C494 Standard Procedure | | | Constant W/C Ratio |
|---|---|---|---|---|
| Cement Sample | X | Y | Average | Z |
| Reference (control) | 100 | 97 | 98.5 | 100 |
| Daracem 19 @ 652 mL/100 kg (10 oz/100 lbs) | 100 | 98 | 99 | 100 |
| Daracem 100 @ 326 mL/100 kg (5 oz/100 lbs) | 100 | 98 | 99 | 100 |
| Daracem 100 @ 652 mL/100 kg (10 oz/100 lbs) | 99 | 100 | 99.5 | 100 |
| Daracem 100 @ 978 mL/100 kg (15 oz/100 lbs) | — | 98 | 98 | 98 |

**Notes:**
- Durability factors which exceeded 100% are reported here as 100%.
- All mixes contained Daravair M necessary to obtain 5–7% plastic air.
- One non-air-entrained control mix was run in cement X and failed at 42 cycles.

**Table 2: ASTM C457, Air Void Analysis by the Linear Traverse Method**

| Product and Dosage | Reference Mix | Daracem 19 @ 652 mL/100 kg (10 oz/100 lbs) | Daracem 100 @ 326 mL/100 kg (5 oz/100 lbs) | Daracem 100 @ 652 mL/100 kg (10 oz/100 lbs) | Daracem 100 @ 978 mL/100 kg 15 oz/100 lbs |
|---|---|---|---|---|---|
| **Cement X – ASTM C494** Plastic air, % | 5.80 | 5.00 | 5.00 | 5.50 | N/T |
| Total air voids Hardened air, % | 4.25 | 3.35 | 4.14 | 3.32 | N/T |
| Avg. chord length, mm (in.) | 0.16 (0.0064) | 0.19 (0.0076) | 0.19 (0.0076) | 0.19 (0.0076) | N/T |
| Spacing factor, mm (in.) | 0.20 (0.0079) | 0.26 (0.0102) | 0.24 (0.0096) | 0.26 (0.0102) | N/T |
| Air voids less than 0.5 mm (0.0197 in.) Hardened air, % | 2.71 | 1.98 | 2.19 | 2.59 | N/T |
| Avg. chord length, mm (in.) | 0.11 (0.0043) | 0.13 (0.0050) | 0.19 (0.0074) | 0.23 (0.0091) | N/T |
| Spacing factor, mm (in.) | 0.17 (0.0066) | 0.22 (0.0085) | 0.19 (0.0074) | 0.23 (0.0091) | N/T |
| **Cement Y – ASTM C494** Plastic air, % | 5.50 | 5.80 | 5.60 | 5.80 | 5.50 |
| Total air voids Hardened air, % | 5.32 | 5.31 | 4.37 | 5.19 | 4.68 |
| Avg. chord length, mm (in.) | 0.16 (0.0063) | 0.18 (0.0070) | 0.13 (0.0051) | 0.14 (0.0056) | 0.19 (0.0074) |
| Spacing factor, mm (in.) | 0.18 (0.0071) | 0.20 (0.0078) | 0.16 (0.0063) | 0.16 (0.0063) | 0.21 (0.0085) |
| Air voids less than 0.5 mm (0.0197 in.) Hardened air, % | 3.77 | 3.73 | 3.52 | 3.79 | 3.20 |
| Avg. chord length, mm (in.) | 0.12 (0.0047) | 0.13 (0.0052) | 0.11 (0.0042) | 0.11 (0.0043) | 0.13 (0.0053) |
| Spacing factor, mm (in.) | 0.15 (0.0061) | 0.18 (0.0069) | 0.15 (0.0058) | 0.14 (0.0055) | 0.19 (0.0073) |
| **Cement Z – Constant W/C** Plastic air, % | 5.80 | 6.50 | 5.50 | 5.70 | 6.50 |
| Total air voids Hardened air, % | 5.61 | 5.87 | 5.09 | 3.80 | 5.69 |
| Avg. chord length, mm (in.) | 0.12 (0.0048) | 0.18 (0.0070) | 0.16 (0.0063 | 0.16 (0.0064) | 0.22 (0.0087) |
| Spacing factor, mm (in.) | 0.14 (0.0054) | 0.20 (0.0077) | 0.19 (0.0074) | 0.22 (0.0085) | 0.25 (0.0097) |
| Air voids less than 0.5 mm (0.0197 in.) Hardened air, % | 4.66 | 4.10 | 3.30 | 2.89 | 3.84 |
| Avg. chord length, mm (in.) | 0.10 (0.0041) | 0.13 (0.0052) | 0.11 (0.0043) | 0.13 (0.0051) | 0.16 (0.0064) |
| Spacing factor, mm (in.) | 0.13 (0.0050) | 0.17 (0.0067) | 0.16 (0.0062) | 0.20 (0.0077) | 0.22 (0.0085) |





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