

Royal™ Steel Fibers

Dosage Technical Data

The information contained herein is from testing conducted under contract by the South Dakota School of Mines and Technology and Braun Intertech Corporation, and is described in detail in various reports. The concrete specimens tested were from laboratory, field, and factory mixtures.

These test results show that Royal™ Fibers improve hardened concrete material performance characteristics like other steel fibers do. This is significant because Royal fibers combine the structural advantages of steel fibers and the other advantage of the manufacturer using the product in its own precast operations.

These results are from jobs and experimental investigations about the performance characteristics of concrete reinforced with Royal Fibers. The fibers used were different lengths and dosages.

All the tests were conducted using ASTM Standards. The fresh concrete properties determined were slump, concrete temperature, air content and unit weight. The hardened concrete properties determined were compressive strength, flexural strength (modulus of rupture), and toughness by the Average Residual Strength method described in ASTM C 1399.

Many different mixture proportions were used for the reported data. The mixture differences were for the various applications and not optimized for using steel fibers or fiber dosages. Previous fiber research and experience indicates most mixture proportions do not need significant adjustments for using fibers at most practical and economical dosages. These results of test data should be viewed within the sets and not across sets. The significant issue in these mixtures is comparing fiber dosage and Average Residual Strength (ARS). The ARS is influenced by many fiber factors including: dosage, aspect ratio (length/diameter), strength, and anchoring configuration.

In summary, the fibers primarily affect ARS and the basic concrete material properties are essentially not affected or are as desired and designed. The fibers significance is after the concrete has been cracked. The concrete is not there across the crack but only significant and efficient for anchoring the fibers across the crack opening.

Fibers in concrete generally show detectable behavior between defining difference and optimization. For fiber reinforced concrete, the difference is primarily fiber dosage and further fiber physical details and optimization is primarily about the fiber and concrete interaction.

Toughness Strength

- **Test Standards and Methods**

- ASTM C 1399 – Test Method for Obtaining Average Residual Strength of Fiber Reinforced Concrete

- **Significance of Test**

These tests were designed to show the ductile, elastic/plastic behavior and post crack load carrying capacity of fiber reinforced concrete. The results of these tests yield load deflection curves, ratios and factors that indicate how fiber concrete can be expected to perform under static flexural loads.

- **Test Results**

The results show that Royal Fibers produce substantial toughness improvements to concrete. Royal Fiber Reinforced Concrete (FRC) provides significant post crack load carrying capacity. Average Residual Strength is calculated based on the area under the load deflection curve and is an indication of the FRC's ductility and toughness.

- **Property Improvement Benefits**

Royal Fibers significantly improve toughness properties of concrete. Improved toughness relates to increased durability, increased service life, increased crack resistance and post-crack load carrying capacity. All concrete cracks. Once plain concrete cracks, the concrete fails to carry any load across the cracks. Royal Fibers give concrete the ability to carry loads even when cracked and exhibit the increased post-crack load carrying capacity that other steel fibers do. These property improvements help concrete last longer and help reduce maintenance. That means the service life of a structure may be significantly increased and costly replacement may be delayed. Royal Fibers may also help reduce initial construction cost.

Compressive Strength

- **Test Standards and Methods**

ASTM C 39 – Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens

- **Significance of Test**

Determine compressive strength of concrete samples.

- **Test Results**

During some compression tests plain concrete cylinders failed instantly (brittle failure) shattering into pieces with a loud noise at the first crack while the fiber concrete cylinders continued to sustain the load and underwent large deformations without disintegrating into pieces. The concrete was held together by the fibers. A visual observation of the ultimate failure of the cylinders in compression indicated that the Royal FRC specimens were more ductile. Typically adding any fiber to concrete does not increase compressive strength but some steel fibers at significantly higher volume loadings can increase compressive strength. The significance of these results is Royal FRC concrete compressive strengths can be designed or obtained at a desired value.

- **Test Comparisons**

Each of the other properties of Royal FRC discussed in this data sheet can affect compressive properties. Royal Fibers change the failure mode from brittle to ductile as described previously.

- **Property Improvement Benefits**
Fibers, including Royal Fibers, do not significantly affect concrete compressive strength. So, when using Royal Fiber concrete compressive strength design criteria can be established or maintained. Maintaining compressive strength while adding ductility means that even concrete subject to compressive loads will benefit from the property enhancements discussed in this data sheet.
- **Other Concrete Material Properties**
Fiber dosages and compressive strength usually proportionately affect these other concrete material properties: Modulus of Rupture (Static Flexural Strength), Fatigue Strength and Endurance, Impact Strength, and Crack Width.

Modulus of Rupture (Static Flexural Strength)

- **Test Standards and Methods**
ASTM C 78 – Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
- **Significance of Test**
This test determines the ability of Royal FRC to withstand static loads that will cause deflection and then cracking in the concrete as compared to plain concrete and steel FRC.
- **Test Results**
These results showed that Royal FRC improved early strength against cracking similar to other steel FRC.
- **Test Comparisons**
Modulus of rupture is essentially the same for fiber or no fiber concrete.
- **Property Improvement Benefits**
Royal Fibers do not improve concrete modulus of rupture as compared to plain concrete and similar to other steel fibers. A higher modulus of rupture shows that the fibers can help concrete resist additional cracking due to non-moving loads that may be placed on it during service such as: equipment in manufacturing plants or on offshore drilling platforms, inventory in warehouses, stationary vehicles in parking ramps, stationary airplanes in hangars, water in treatment and storage facilities and the dead load of the structure itself.

Wet-cast concrete Laboratory

40 mm long (1.6 inch) Royal Fiber @ 0.50% dosage (39.2 kcm, 66 pcy) 2.85 Mpa (415 psi)

41 mm long (1.6 inch) competitive Fiber @ 0.50% dosage (39.2 kcm, 66 pcy) 3.15 Mpa (455 psi)

Wet-cast concrete Transit Truck

40 mm long (1.6 inch) Royal Fiber @ 0.57% dosage (44.3kcm, 75 pcy) 1.97 Mpa (285 psi)

50 mm long (2.0 inch) competitive Fiber @ 0.57% dosage (44.3 kcm, 75 pcy) 1.91 Mpa (275 psi)

Dry-cast concrete

40 mm long (1.6 inch) Royal Fiber @ 0.25% dosage (19.6 kcm, 33 pcy) 0.91 Mpa (135 psi)

40 mm long (1.6 inch) Royal Fiber @ 0.50% dosage (39.2 kcm, 66 pcy) 1.43 Mpa (210 psi)

40 mm long (1.6 inch) Royal Fiber @ 0.75% dosage (58.8 kcm, 99 pcy) 3.01 Mpa (440 psi)

Shotcrete placement

19 mm long (0.75 inch) Royal Fiber @ 0.19% dosage (19.6 kcm, 25 pcy) 0.52 Mpa (75 psi)

19 mm long (0.75 inch) Royal Fiber @ 0.38% dosage (29.5 kcm, 50 pcy) 0.77 Mpa (112 psi)

19 mm long (0.75 inch) Royal Fiber @ 0.57% dosage (44.3 kcm, 75 pcy) 1.13 Mpa (164 psi)

Wet-cast Factory Concrete

41 mm long (1.20 inch) Royal Fiber @ 0.25% dosage (19.6 kcm, 33 pcy) 0.64 Mpa (92 psi)

41 mm long (1.20 inch) Royal Fiber @ 0.50% dosage (39.2 kcm, 66 pcy) 1.56 Mpa (226 psi)

41 mm long (1.20 inch) Royal Fiber @ 1.00% dosage (78.0 kcm, 132 pcy) 2.37 Mpa (344 psi)

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