

PRODUCT DATA SHEET

King® MS-D1 US

SHOTCRETE MATERIAL FOR DRY-MIX PROCESS APPLICATIONS

PRODUCT DESCRIPTION

King® MS-D1 US is a pre-blended and pre-packaged shotcrete material formulated for dry-mix process applications. It contains Portland cement, silica fume, air-entraining admixture, blended aggregates, along with other carefully selected components. It has greatly enhanced shooting characteristics and physical properties.

USES

Overall:

- Rehabilitation of concrete bridges, dams, reservoirs, tunnels, marine structures, and parking ramps
- Lining and rehabilitation of sewers and watermain
- New construction including slope stabilization, soil-nailing, shaft and tunnel linings, pools, and other concrete structures

Added Steel fiber (ST) reinforcement or added Macro-Synthetic fiber (MF) reinforcement:

- Ground support applications for mining, tunneling, and other underground openings
- Rehabilitation of marine structures
- Lining and rehabilitation of sewers and other tunnels
- Slope stabilization, soil-nailing, shaft and tunnel linings

CHARACTERISTICS / ADVANTAGES

- Air-entrainment provides superior resistance to freeze-thaw cycling and salt-scaling resistance
- Improved adhesive and cohesive plastic properties
- Significantly reduced rebound, resulting in lower material usage

- Improved ability to build greater thicknesses in a single pass in both vertical and overhead orientations
- Improved resistance to water wash-out
- Improved resistance to sulphate attack
- Very low permeability
- Low shrinkage
- Compatible with integral, pre-applied and/or postapplied corrosion inhibitors
- Designed with natural, normal-density non-reactive aggregates to eliminate potential alkali-aggregate reactivity (AAR)

OPTIONAL FEATURES & BENEFITS

Accelerator-Level

- Improved performance in presence of running water
- Allows for earlier re-opening of traffic lanes on bridges and in tunnels
- Superior ability to build greater thicknesses in a single pass in both vertical and overhead orientations

Product	Dosage Level
King® MS D-1 US	N/A
King® MS D-1 X US	Level 1
King® MS D-1 X2 US	Level 2
King® MS D-1 X3 US	Level 3

Micro-Synthetic Fiber (SY)

- Micro-Synthetic fibers reduce cracking caused by intrinsic stresses
- Type III synthetic fiber in accordance with ASTM C1116
- Grade FR Class I shotcrete in accordance with ASTM C1480

Steel Fiber Content (ST)

- Significantly increased load carrying capacity
- Significantly increased energy absorbing capacity (toughness)

- Significantly increased impact resistance
- Low permeability
- Reduction of cracking due to drying shrinkage

Product	Dosage of Fibers
King® MS D-1 STA US	High
King® MS D-1 STB US	Medium
King® MS D-1 STC US	Low
King® MS D-1 STD US	Very Low

Macro-Synthetic Fiber Content (MF)

- Significantly decreased wear on placing equipment and accessories when compared with steel fibers
- Ideal for use in manways or other areas where people may come in contact with the shotcrete surface
- Significantly increased load carrying capacity
- Significantly increased energy absorbing capacity (toughness)
- Significantly increased impact resistance
- Improved adhesive and cohesive plastic properties
- Low permeability

Product	Dosage of Fibers
King® MS D-1 MFB US	High
King® MS D-1 MFC US	Medium
King® MS D-1 MFD US	Low

Corrosion Inhibitor (CI)

- Corrosion inhibitor protects steel reinforcement and other metals embedded in concrete from corrosion induced by carbonation or chlorides
- Pre-blended corrosion inhibitor provides the correct dosage to enhance corrosion protection

Portable Water Application (PW)

- Product meets the requirements of NSF/ANSI 61

Graduation (G2)

- By default King® MS-D1 US, King® MS-D1 ST US, and King® MS-D1 MF US are blended to meet ACI 506 “Guide to Shotcrete”, Table 1.1, Gradation No. 1 (No Added Abbreviation)
- King® MS-D1 G2 US, King® MS-D1 ST G2 US and King® MS-D1 MF G2 US are blended to meet ACI 506 “Guide to Shotcrete”, Table 1.1, Gradation No. 2 (G2)

EXAMPLES:

- For King® MS-D1 US with a level 2 dosage of accelerator, a high dosage of macro-synthetic fibers, and gradation No. 1, the name of the product would be: King® MS-D1 X2 MFB US
- For King® MS-D1 US with a level 3 dosage of accelerator, with micro-synthetic fibers, and gradation No. 2, the name of the product would be: King® MS-D1 X3 SY G2 US
 - For King® MS-D1 US with a high dosage of steel fibers, a level 2 dosage of accelerator, and gradation No. 1, the name of the product would be: King® MS-D1 X2 STA US

Product Data Sheet

King® MS-D1 US

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PRODUCT INFORMATION

Packaging	65 lb (29.5 kg) bag 2200 lb (999 kg) bulk bag Products containing Macro-Synthetic fibers (MF) or Steel fibers (ST) can only be packaged in bulk bags Custom packaging is available to suit specific project requirements
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Shelf Life	12 months in original, unopened packaging
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Storage Conditions	Store in a dry, covered area, protected from the elements For optimum performance, it is recommended to store the material between 40°F - 95°F (5°C - 35°C) Underground Environments Physical properties may be adversely affected if material is stored in temperatures below 40°F (5°C) and should be allowed to warm to ambient underground temperatures before application
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Compressive Strength			ASTM C116 (modified)
Age	King® MS-D1 X US	King® MS-D1 X2 US	King® MS-D1 X3 US
4 hrs	N/A	150 psi (1 MPa)	725 psi (5 MPa)
8 hrs	725 psi (5 MPa)	870 psi (6 MPa)	1150 psi (8 MPa)
12 hrs	1015 psi (7 MPa)	1150 psi (8 MPa)	1500 psi (10 MPa)

ASTM C1604				
Age	King® MS-D1 US	King® MS-D1 X US	King® MS-D1 X2 US	King® MS-D1 X3 US
1 day	2175 psi (15 MPa)	3000 psi (21 MPa)	3000 psi (21 MPa)	3000 psi (21 MPa)
3 days	4060 psi (28 MPa)	4060 psi (28 MPa)	4060 psi (28 MPa)	4060 psi (28 MPa)
7 days	4640 psi (32 MPa)	4640 psi (32 MPa)	4640 psi (32 MPa)	4640 psi (32 MPa)
28 days	6000 psi (42 MPa)	6000 psi (42 MPa)	6000 psi (42 MPa)	6000 psi (42 MPa)

Modulus of Elasticity in Compression		ASTM C469
Age		Modulus
7 days		3.9 x 10 ⁶ psi (26.6 GPa)
28 days		4.2 x 10 ⁶ psi (29.0 GPa)

Flexural Strength			ASTM C78	
Age	King® MS-D1 US	King® MS-D1 X US	King® MS-D1 X2 US	King® MS-D1 X3 US
7 days	940 psi (6.5 MPa)	870 psi (6.0 MPa)	870 psi (6.0 MPa)	870 psi (6.0 MPa)
28 days	1085 psi (7.5 MPa)	1015 psi (7.0 MPa)	1015 psi (7.0 MPa)	1015 psi (7.0 MPa)

Tensile Strength		Split Tensile Strength	(ASTM C496)
Age			
7 days		550 psi (3.8 MPa)	
28 days		650 psi (4.5 MPa)	

Shrinkage

	(ASTM C157)			
Age	King® MS-D1 US	King® MS-D1 X US	King® MS-D1 X2 US	King® MS-D1 X3 US
28 days	0.050%	0.060%	0.060%	0.060%
56 days	0.058%	0.065%	0.065%	0.065%

Tensile Adhesion Strength

Age	Bond Strength	(ASTM C1583)
7 days	320 psi (2.2 MPa)	
28 days	420 psi (2.9 MPa)	

Coefficient of Thermal Expansion

Age	Expansion	(CRD C39)
28 days	6.5 x 10 ⁻⁶ in/in/°F (11.7 x 10 ⁻⁶ cm/cm/°C)	

Slant Shear Strength

Age	Bond Strength	(ASTM C882) Modified
7 days	3060 psi (21.1 MPa)	
28 days	3335 psi (23.0 MPa)	

Freeze-Thaw Stability

	(ASTM C666)		
King® MS-D1 US	King® MS-D1 X US	King® MS-D1 X2 US	King® MS-D1 X3 US
100%	96%	96%	96%

Porosity

Air Content	(ASTM C457)
6 ± 2%	
Spacing Factor	(ASTM C457)
0.0118 in (300 µm)	
Boiled Absorption	(ASTM C642)
6.0%	
Max Volume of Permeable Voids	(ASTM C642)
15.0%	

Salt resistance

	(ASTM C672)		
King® MS-D1 US	King® MS-D1 X US	King® MS-D1 X2 US	King® MS-D1 X3 US
0.020 lb/ft² (0.10 kg/m²)	0.035 lb/ft² (0.17 kg/m²)	0.040 lb/ft² (0.20 kg/m²)	0.240 lb/ft² (1.2 kg/m²)

Flexural toughness

Dosage	First peak strength	F ¹⁰⁰ ₆₀₀	ASTM C1609 F ¹⁰⁰ ₁₅₀
King® MS-D1 STA US	906 psi (6.26 MPa)	797 psi (5.50 MPa)	652 psi (4.50 MPa)
King® MS-D1 STB US	797 psi (5.50 MPa)	435 psi (3.00 MPa)	398 psi (2.75 MPa)
King® MS-D1 STC US	652 psi (4.50 MPa)	435 psi (3.00 MPa)	398 psi (2.75 MPa)
King® MS-D1 STD US	580 psi (4.00 MPa)	362 psi (2.50 MPa)	145 psi (1.00 MPa)

Macrosynthetic Fiber**ASTM C1550**

King® MS-D1 MFB US Toughness as a function of

flexure				
Peak applied load	10 mm	20 mm	30 mm	40 mm
5620 lb ft (25 kN)	> 150 J	> 250 J	> 350 J	> 450 J
King® MS-D1 MFC US Toughness as a function of flexure				
Peak applied load	10 mm	20 mm	30 mm	40 mm
4495 lb ft (20 kN)	> 80 J	> 125 J	> 250 J	> 350 J
King® MS-D1 MFD US Toughness as a function of flexure				
Peak applied load	10 mm	20 mm	30 mm	40 mm
3370 lb ft (15 kN)	> 50 J	> 80 J	> 150 J	> 275 J
Steel Fiber ASTM C1550				
King® MS-D1 STA US Toughness as a function of flexure				
Peak applied load	10 mm	20 mm	30 mm	40 mm
8992 lb ft (40 kN)	> 215 J	> 350 J	> 450 J	> 500 J
King® MS-D1 STB US Toughness as a function of flexure				
Peak applied load	10 mm	20 mm	30 mm	40 mm
5620 lb ft (25 kN)	> 190 J	> 300 J	> 375 J	> 425 J
King® MS-D1 STC US Toughness as a function of flexure				
Peak applied load	10 mm	20 mm	30 mm	40 mm
4496 lb ft (20 kN)	> 175 J	> 270 J	> 325 J	> 370 J
King® MS-D1 STD US Toughness as a function of flexure				
Peak applied load	10 mm	20 mm	30 mm	40 mm
4496 lb ft (20 kN)	> 80 J	> 125 J	> 150 J	> 175 J

Rapid Chloride Permeability	700 Coulombs	(ASTM C1202)
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APPLICATION INFORMATION

Coverage	Approx. 0.49 ft³ per 65 lb bag (0.014 m³ per 29.5 kg bag) Approx. 16.5 ft³ per 2200 lb bulk bag (0.45 m³ per 1000 kg bulk bag) *May vary according to projects conditions
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Thinner	(ASTM C 1117)			
	King® MS-D1 US	King® MS-D1 US	King® MS-D1 US	King® MS-D1 US
Initial	4 hrs	60 min	20 min	5 min
Final	6 hrs	70 min	30 min	10 min

BASIS OF PRODUCT DATA

Results may differ based upon statistical variations depending upon mixing methods and equipment, temperature, application methods, test methods, actual site conditions and curing conditions. Results may differ based upon statistical variations depending upon mixing methods and equipment, temperature, application methods, test methods, actual site conditions and curing conditions. The data in this data sheet was obtained under controlled conditions with material and ambient temperatures of 70 °F (21 °C). Higher or lower temperatures can respectively accelerate or delay setting time and early-age compressive strength gain.

AVAILABILITY/WARRANTY

Each of the following descriptors / features have the possibility of being included in a specific mix design; Either on their own, or combined with any other descriptors / features.

Descriptors / Features of accelerator dosages:

Accelerator	X - Level 1
	X2 - Level 2
	X3 - Level 3

Descriptors / Features of fiber dosages:

Steel Fibers	STA - High
	STB - Medium
	STC - Low
	STD - Very Low
Micro-synthetic Fibers	SY
Macro-synthetic Fibers	MFB - High
	MFC - Medium
	MFD - Low

Descriptors / Features of other technologies:

Corrosion Inhibitor	CI
Anti-microbial	AM
Crystalline Waterproofing	CW
Potable Water Application	PW
Non Air-entrained	NE
Gradation 2	G2

APPLICATION INSTRUCTIONS

EQUIPMENT

Special precautions needed when using predampeners with dry blended powdered accelerated shotcrete. Contact your Sika Technical Representative for more information.

SURFACE PREPARATION

▪ Repair or rehabilitation:

All surfaces to be in contact with King® MS-D1 US and its variations must be free from dust, oil, grease or any other foreign substances that may interfere with the bond of the material. Remove all loose or delaminated concrete providing a roughened surface and a minimum of 1 inch (25 mm) clearance behind any corroded reinforcing steel. The perimeter of the repair area should be saw-cut a minimum of ¾ inch (20 mm). Clean the area to be repaired with potable water, leaving the concrete saturated but free of standing water (SSD).

▪ Rock surfaces (King® MS-D1 ST US & King® MS-D1 MF US):

All surfaces to be in contact with King® MS-D1 ST US and King® MS-D1 MF US must be free from dust, oil, grease or any other foreign substances that may interfere with the bond of the material. Remove all loose or delaminated

rock. Clean the area with potable water, leaving the substrate saturated but free of standing water (SSD).

APPLICATION

Apply in accordance with the ACI 506 "Guide to Shotcrete" publication. Performance of in-place shotcrete relies heavily upon application techniques. The shotcrete material, equipment and key personnel should be pre-qualified prior to project start-up to ensure optimum quality of in-place shotcrete.

OPTIMUM PERFORMANCE

Product should not be applied when ambient, substrate, and material temperatures are below 40°F (5°C) or above 95°F (35°C)

- For adverse temperatures, follow ACI recommendations for Cold / Hot Weather Concreting
- For cold temperature applications, use King® MS-D3 X2 US or King® MS-D3 X3 US
- When using King® MS-D1 MF US or King® MS-D1 ST US, the recommended minimum inside diameter of shotcrete hoses should be 2 inch (50 mm)

Contact your Sika Technical Representative for more information.

CURING TREATMENT

Curing is essential to optimize physical properties of the shotcrete and minimize plastic shrinkage. Product should be cured immediately after material has reached initial set in accordance with ACI 308 "Guide to Curing Concrete". Continuously moist cure for a minimum period of seven (7) days. Alternatively, moist cure for a minimum period of 24 hours and apply a curing compound that complies with ASTM C309. Curing is particularly critical in rapid moisture loss conditions such as high temperatures, high winds and low humidity.

Underground Environments

Good curing conditions are beneficial to optimizing physical properties. Although the high relative humidity commonly found in underground environments provides for good curing conditions, additional curing is often appropriate and should be performed in accordance with ACI 308 "Guide to Curing Concrete"

CLEANING OF TOOLS

Clean all tools and equipment after use with water. Once hardened, the product can only be removed mechanically.

LEGAL DISCLAIMER

- **KEEP CONTAINER TIGHTLY CLOSED**
- **KEEP OUT OF REACH OF CHILDREN**
- **NOT FOR INTERNAL CONSUMPTION**
- **FOR INDUSTRIAL USE ONLY**
- **FOR PROFESSIONAL USE ONLY**

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Prior to each use of any product of Sika Corporation, its



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