BUILDING TRUST

PRODUCT DATA SHEET

King® MS-D1

SHOTCRETE MATERIAL FOR DRY-MIX PROCESS APPLICATIONS

PRODUCT DESCRIPTION

King® MS-D1 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 watermains
- New construction including slope stabilization, soil-nailing, shaft and tunnel linings, pools, and other concrete structures

Added Steel fiber (ST) reincforcement or
Added Macro-Synthethic 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 post-applied corrosion inhibitors*
- Designed with natural normal-density non-reactive aggregates to eliminate potential alkali-aggregate reactivity (AAR)

*For more information regarding the use of a corrosion inhibitor in conjunction with King® MS-D1, please contact your Sika STM Technical Representative.

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-D1	-
King® MS-D1 X	Level 1
King® MS-D1 X2	Level 2
King® MS-D1 X3	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-D1 STA	High
King® MS-D1 STB	Medium
King® MS-D1 STC	Low
King® MS-D1 STD	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-D1 MFB	High
King® MS-D1 MFC	Medium
King® MS-D1 MFD	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

*For more information regarding the use of a corrosion inhibitor in conjunction with King® MS-D1, please contact your Sika STM Technical Representative.

Portable Water Application (PW)
Product meets the requirements of NSF/ANSI 61

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

EXAMPLES:
- For King® MS-D1 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**.
- For King® MS-D1 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**.
- For King® MS-D1 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**.

PRODUCT INFORMATION

Packaging	66 lb (30 kg) bag 2205 lb (1000 kg) FIBC* Products containing Macro-Synthetic fibers (MF) or Steel fibers (ST) can only be packaged in FIBC* Custom packaging is available to suit specific project requirements *Flexible Intermediate Bulk Container
Shelf Life	12 months in original, unopened packaging
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

TECHNICAL INFORMATION

Compressive Strength

ASTM C116 (MODIFIED)

	King® MS-D1 X	King® MS-D1 X2	King® MS-D1 X3
4 hours		150 psi (1 MPa)	725 psi (5 MPa)
8 hours	725 psi (5 MPa)	870 psi (6 MPa)	1150 psi (8 MPa)
12 hours	1015 psi (7 MPa)	1150 psi (8 MPa)	1500 psi (10 MPa)

COMPRESSIVE STRENGTH ASTM C1604

	King® MS-D1	King® MS-D1 X	King® MS-D1 X2	King® MS-D1 X3
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

MODULUS OF ELASTICITY ASTM C469

7 days	3.9 x 10^6 psi (26.6 GPa)
28 day	4.2 x 10^6 psi (29.0 GPa)

Flexural Strength

ASTM C78

	King® MS-D1	King® MS-D1 X	King® MS-D1 X2	King® MS-D1 X3
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)

King® MS-D1 MF & King® MS-D1 ST	
28 days	1160 psi (8.0 MPa)

Flexural toughness

FLEXURAL PERFORMANCE ASTM C1609

Dosage	First peak strength	$F^{100}{}_{600}$	$F^{100}{}_{150}$
King® MS-D1 STA	906 psi (6.25 MPa)	797 psi (5.50 MPa)	652 psi (4.50 MPa)
King® MS-D1 STB	797 psi (5.50 MPa)	435 psi (3.00 MPa)	398 psi (2.75 MPa)
King® MS-D1 STC	652 psi (4.50 MPa)	435 psi (3.00 MPa)	398 psi (2.75 MPa)
King® MS-D1 STD	580 psi (4.00 MPa)	362 psi (2.50 MPa)	145 psi (1.00 MPa)

MACRO-SYNTHETIC FIBER **ASTM C1550**

King® MS-D1 MFB

Peak applied load	Toughness as a function of flexure			
	10 mm	20 mm	30 mm	40 mm
5620 lbf (25 kN)	> 150 J	> 250 J	> 350 J	> 450 J

King® MS-D1 MFC

Peak applied load	Toughness as a function of flexure			
	10 mm	20 mm	30 mm	40 mm
4495 lbf (20 kN)	> 80 J	> 125 J	> 250 J	> 350 J

King® MS-D1 MFD

Peak applied load	Toughness as a function of flexure			
	10 mm	20 mm	30 mm	40 mm
3370 lbf (15 kN)	> 50 J	> 80 J	> 150 J	> 275 J

STEEL FIBER **ASTM C1550**

King® MS-D1 STA

Peak applied load	Toughness as a function of flexure				
	5 mm	10 mm	20 mm	30 mm	40 mm
8992 lbf (40 kN)	> 100 J	> 215 J	> 350 J	> 450 J	> 500 J

King® MS-D1 STB

Peak applied load	Toughness as a function of flexure				
	5 mm	10 mm	20 mm	30 mm	40 mm
5620 lbf (25 kN)	> 100 J	> 190 J	> 300 J	> 375 J	> 425 J

King® MS-D1 STC

Peak applied load	Toughness as a function of flexure				
	5 mm	10 mm	20 mm	30 mm	40 mm
4496 lbf (20 kN)	> 100 J	> 175 J	> 270 J	> 325 J	> 370 J

King® MS-D1 STD

Peak applied load	Toughness as a function of flexure				
	5 mm	10 mm	20 mm	30 mm	40 mm
4496 lbf (20 kN)	> 40 J	> 80 J	> 125 J	> 150 J	> 175 J

Tensile Strength

TENSILE BOND STRENGTH — **ASTM C1583**

7 days	320 psi (2.2 MPa)
28 days	420 psi (2.9 MPa)

Splitting tensile strength

TENSILE SPLIT STRENGTH — **ASTM C496**

7 days	550 psi (3.8 MPa)
28 days	650 psi (4.5 MPa)

Slant Shear Strength

BOND STRENGTH BY SLANT SHEAR (MODIFIED) — **ASTM C882**

7 days	3060 psi (21.1 MPa)
28 days	3335 psi (23.0 MPa)

Shrinkage

UNIAXAL DRYING SHRINKAGE — **ASTM C157**

	King® MS-D1	King® MS-D1 X	King® MS-D1 X2	King® MS-D1 X3
28 days	0.050%	0.060%	0.060%	0.060%
56 days	0.058%	0.065%	0.065%	0.065%

Coefficient of Thermal Expansion

CRD C-39

28 days	6.5 x 10^{-6} / °F (11.7 x 10^{-6} / °C)

Rapid Chloride Permeability

CHLORIDE ION PENETRABILITY — **ASTM C1202**

700 coulombs

Porosity

AIR CONTENT — **ASTM C457**

6 % ± 2 %

MAXIMUM AIR VOID SPACING FACTOR — **ASTM C457**

0.0118 in (300 µm)

BOILED ABSORPTION — **ASTM C642**

6.0 %

MAXIMUM VOLUME OF PERMEABLE VOIDS — **ASTM C642**

15.0 %

Freeze-Thaw Stability

FREEZE-THAW STABILITY — **ASTM C666**

King® MS-D1	King® MS-D1 X	King® MS-D1 X2	King® MS-D1 X3
100 %	96 %	96 %	96 %

Excellent durability factor

Salt resistance

SALT SCALING RESISTANCE — **ASTM C672**

King® MS-D1	King® MS-D1 X	King® MS-D1 X2	King® MS-D1 X3
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)

Coverage

Approx. 0.5 ft³ per 66 lb bag (0.014 m³ per 30 kg bag)
Approx. 16.5 ft³ per 2205 lb FIBC (0.45 m³ per 1000 kg FIBC)
*May vary according to projects conditions

Set Time — **ASTM C1117**

	King® MS-D1	King® MS-D1 X	King® MS-D1 X2	King® MS-D1 X3
Initial	4 hours	60 minutes	20 minutes	5 minutes
Final	6 hours	70 minutes	30 minutes	10 minutes

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.

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
Crystaline Waterproofing	CW
Portable Water Application	PW
Not Air Entrained	NE
Gradation 2	G2

ENVIRONMENTAL, HEALTH AND SAFETY

For further information and advice regarding transportation, handling, storage and disposal of chemical products, user should refer to the actual Safety Data Sheets containing physical, environmental, toxicological and other safety related data. User must read the current actual Safety Data Sheets before using any products. In case of an emergency, call CHEMTREC at 1-800-424-9300, International 703-527-3887.

APPLICATION INSTRUCTIONS

EQUIPMENT

Special precautions needed when using predampeners with dry blended powdered accelerated shotcrete.

Contact your Sika STM Technical Representative for more information.

SURFACE PREPARATION

- **Repair or rehabilitation**: All surfaces to be in contact with King® MS-D1 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 & King® MS-D1 MF):** All surfaces to be in contact with King® MS-D1 ST and King® MS-D1 MF 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 termperatures 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 or King® MS-D3 X3.
- When using King® MS-D1 MF or King® MS-D1 ST, recommened minimum inside diameter of shotcrete hoses should be 2 inch (50 mm).

Contact your Sika STM 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.

OTHER RESTRICTIONS

See Legal Disclaimer.

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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