



Type K, Shrinkage Compensating Concrete



James River Paper Mill
Eugene, OR



Lithia Chrysler Jeep
Dodge Dealership
Medford, OR



Toyota North America
Parts Distribution Center
Ontario, CA



Michigan DOT
Bridge Construction
Grand Rapids, MI



John Wayne Airport
Parking Garage
Irvine, CA

KSC™ Concrete Technical Guide

Guidelines for Specifying and Using

- KSC™ Technology
- KSC™ Cement
- Komponent®
- System K™



CTS Cement Manufacturing Corp.
www.ctscement.com
800-929-3030



KSC™ Concrete Technical Guide

Type K, Shrinkage Compensating Concrete



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Introduction

KSC™ is a shrinkage compensating concrete technology based on the Klein Expansive Cement as described in ASTM C 845-04, Type K cement.

KSC provides an effective way to minimize cracking, curling, and shrinkage in concrete. By producing controlled compressive forces in the concrete, KSC reduces the detrimental tensile forces. KSC is designed to ideally keep tensile forces below the cracking level.

KSC Concrete has been successfully used in all types of structures to counteract drying-shrinkage cracking.



A Simplified Look at How KSC™ Concrete Works

Shrinkage compensation is similar to placing a concrete bar in a very strong clamp, in which the length of the bar just fits, then heat the bar. The bar tries to expand but it cannot due to the restraint of the clamp, and the bar is in compression.

As the bar cools, the compression is reduced until the bar reaches its original temperature and length. If we further cool the bar, it gets shorter than its original length, and there will be a gap between the ends of the bar and the clamp.

In the case of KSC Concrete, expansion is caused by an expansive cement which, when restrained, places the concrete in compression.

Drying-shrinkage in concrete is similar to cooling the concrete bar. The cooling reduces the compression in the concrete bar until the concrete bar is no longer compressed and has its original length. Further cooling the concrete bar would produce a gap between the bar and the clamp. In concrete, shortening often results in drying-shrinkage cracking.

The properties of concrete are complex and vary with time. When it is first cast, it has no strength or stiffness. Over time, it gains strength and stiffness, shrinks, and is subject to changes in temperature, moisture content and loading. In spite of all this, with KSC technology it is possible to produce crack-free concrete.



As KSC Concrete cures, compressive forces are built up in the concrete. These compressive forces make a more durable, crack-free concrete possible.



When ordinary portland cement (PC) cures, tensile forces commonly build up in the concrete, leading to cracking, curling, and shrinking.



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KSC™ Concrete Technology

KSC is a shrinkage compensating concrete technology based on the Klein Expansive Cement as described in ASTM C 845-04, Type K cement. KSC Concrete has been successfully used in all types of structures to counteract drying-shrinkage cracking.

In shrinkage-compensating concrete, the cement expands during the first week after it is cast, which slightly compresses the concrete. Later, as the concrete dries, it shrinks. This shrinkage reduces the compression in the concrete. If the expansion is sufficient to keep the concrete in compression, no cracking can occur. If it can keep the drying-shrinkage tensile stress in the concrete lower than the tensile strength of the concrete, the concrete will be drying-shrinkage crack-free. This is called Shrinkage Compensating Cement Concrete, (KSC Concrete) in which expansion against restraint causes compressive stress in the concrete. This compressive stress compensates for tensile forces in the concrete due to drying shrinkage.

Generally, the required restraint for shrinkage compensation is provided by

either reinforcing steel or System-K nonmetallic fibers.

Shrinkage reinforcing steel (about 0.15%), or 2 pounds of System-K fibers per cubic yard, are sufficient to provide restraint for KSC concrete.

There is no upper limit to the amount of restraint to make KSC Concrete work. "Infinite (100%) restraint," such as casting a slab against an adjacent slab, will induce a compression in concrete of about 100 psi which subsequent drying-shrinkage reduces to about zero.

The cement used in KSC Concrete is a mixture of a ground expansive clinker and Portland cement. ASTM Type K cement is made in a cement plant by inter-grinding Type K expansive clinker with Portland cement clinker and gypsum in the proper proportions. It is sold as a finished cement.

Another method used to make KSC Concrete is by using KSC Komponent. Komponent is a blend of ground Type K expansive clinker and gypsum. Komponent is mixed with Portland cement concrete in the ready mix truck to



Type K, Shrinkage Compensating Concrete



make KSC concrete.

In each method, about 85% of the cement for KSC Concrete is Portland cement and about 15% is either ground Type K clinker or KSC Komponent. The amount of expansive energy in the concrete is determined by the amount of expansive compound in the cementitious material.

In System-K flooring system, the Komponent concrete is mixed with special fibers. The fibers provide restraint and replace traditional slab on grade reinforcing steel.

The amount of Komponent used in the concrete mix is generally about 60 to 120 pounds per cubic yard. This is determined by design and job requirements. Contact a CTS Cement representative for information and suggested mix designs.

Komponent is sometimes added to high shrinkage aggregate mixes to achieve the same shrinkage level as low shrinkage aggregates. The use of lower levels of Komponent produces the effects of a shrinkage reducing admixture.

Stress risers in the concrete, such as splicing all of the reinforcing bars in the same place, re-entrant corners etc., will sometimes overcome the effects of shrinkage-compensation and small crack may occur at these locations.

To obtain the best results with KSC concrete it must be properly cured, ideally a minimum of seven days of wet curing. Crack-free floor slabs have been constructed with KSC concrete with joint spacing up to 200 feet. Typically, the premium cost of the KSC Concrete in floor slabs is offset by eliminating saw cut joints and sealing which reduces future maintenance costs. The curling of KSC floor slabs at joints is substantially less than in conventional concrete slabs, and in most cases there is no measurable curling in the KSC concrete floor slab.

KSC Type-K Cement, KSC Komponent, and KSC System-K are available nationwide from CTS Cement Manufacturing Corp., which has trained sales and service personnel in major cities throughout the country.



**Type K, Shrinkage
Compensating Concrete**

KSC™ Typical Mix Designs



KSC CONCRETE

KSC Type-K Cement	560 lbs
Sand, ASTM C-33	1095 lbs
Aggregate, ASTM C-33	1800 lbs
Water	41 gal
Water Reducer, ASTM C-949	24 oz

Performance

Slump	5.75 in
Expansion, 7 day	.045 %
Compressive Strength 7 day	3400 psi
Compressive Strength 28 day	4500 psi

KSC GROUT MIX

Portland Cement Type I/II/V	846 lbs
KSC Komponent®	100 lbs
Sand, ASTM C-33	2640 lbs
Aggregate, ASTM C-33	0 lbs
Water	52 gal
Water Reducer, ASTM C-949	0 oz

Performance

Slump	8 in
Expansion, 7 day	.045 %
Compressive Strength 7 day	4800 psi
Compressive Strength 28 day	7250 psi

KSC KOMPONENT CONCRETE

Portland Cement Type I/II/V	470 lbs
KSC Komponent®	90 lbs
Sand, ASTM C-33	1095 lbs
Aggregate, ASTM C-33	1800 lbs
Water	41 gal
Water Reducer, ASTM C-949	24 oz

Performance

Slump	5.75 in
Expansion, 7 day	.045 %
Compressive Strength 7 day	3400 psi
Compressive Strength 28 day	4500 psi

NOTE: The Mix Designs provided here are for reference only. Performance will vary depending on regional conditions. Trial batching is required to determine actual performance for each project. Contact CTS Cement for the most current mix design recommendations.



Type K, Shrinkage Compensating Concrete

RECOMMENDED SPECIFICATION FOR KSC CONCRETE USING KSC TYPE-K CEMENT

CEMENT: Cement shall be KSC Type-K Cement, an expansive hydraulic cement, conforming to ASTM C 845 as manufactured by CTS Cement Manufacturing, 11065 Knott Avenue, Cypress, CA 90630. Contact: CTS Cement at 1-800-929-3030 for further details and suggested mix designs for a particular use.

AGGREGATE: Any sound, non-reactive well-graded aggregate suitable for Portland cement concrete as per ASTM C 33.

ADMIXTURES: Generally, admixtures that are suitable for regular Portland cement concrete may be used with KSC Cement. CTS representatives should be contacted to confirm compatibility of any admixture.

CEMENT CONTENT: Recommended cement content is a minimum of 658 lbs of KSC cement per cubic yard for bridge decks, parking decks, treatment plants, containment vessels, and other structures exposed to severe weather changes, de-icing salts, and chemicals. Recommended KSC cement content for 4000 psi, non-air entrained concrete for use in floor slabs is a minimum of 560 lbs per cubic yard. For 4000 psi, air entrained concrete for use in exterior floor slabs; a minimum of 610 lbs per cubic yard is recommended.

WATER/CEMENT RATIO: The recommended water/cement ratio is 0.5.

AIR CONTENT: For air entrained concrete, a 5% +/-1% air content is recommended.

MIXING TIME: Limit mixing and placing time to 90 (ninety) minutes as specified by ACI.

SLUMP: Recommended slump is 5" +/- 1 at the point of placement.

REINFORCING STEEL: There are no specific reinforcing steel requirements or details to successfully use KSC Type-K concrete. The reinforcement designed for a regular Portland cement concrete project is all that is needed for KSC Type-K cement concrete structure.

In the case of slabs on grade, steel reinforcement of about 0.15% both ways is used for restraint (For a 6" thick slab, this is about #4's at 2 foot centers both ways). The reinforcing steel should be positioned in the upper half of the slab with a minimum of 1 1/2" cover.

PLACEMENT AND FINISHING: Precautions should be taken to prevent concrete temperatures exceeding 90 degrees. Slab areas as great as 20,000 square feet are attainable with adequate manpower. Placements generally recommended are from a 1:1 to a 3:1 length to width ratio, however that ratio may be exceeded to meet job conditions. Normal finishing techniques should be followed to produce the required finish. Due to KSC Cement concrete's lack of bleed water, finishing operations can be started as soon as the concrete is ready for finishing. Should plastic shrinkage conditions occur, fog sprays or the use of a spray-on liquid evaporation suppressor should be used. ACI "Weather Concrete" practices are recommended.

CURING: A 7-day water cure is strongly recommended.

PRE-POUR MEETING: A pre-pour meeting is strongly advised and the CTS representative notified as to the meeting date as early as possible.



Type K, Shrinkage Compensating Concrete

RECOMMENDED SPECIFICATION FOR KSC CONCRETE USING KSC KOMPONENT®

CEMENT: Cement shall be a combination conforming to ASTM C 845 composed of Portland cement and KOMPONENT® as manufactured by CTS Cement Manufacturing, 11065 Knott Avenue, Cypress, CA 90630. Generally about 85% of a local Portland cement and 15% of KOMPONENT is used. Contact: CTS Cement at 1-800-929-3030 for further details and suggested mix designs for a particular use.

AGGREGATE: Any sound, non-reactive well-graded aggregate suitable for Portland cement concrete as per ASTM C 33.

ADMIXTURES: Generally, admixtures that are suitable for regular Portland cement concrete may be used with KSC KOMPONENT system. CTS representatives should be contacted to confirm compatibility of any admixture.

CEMENT CONTENT: Recommended cement content for a normal 4000 psi concrete mix with an expansion between 0.035 and 0.050 per cent is 470 pounds of local Portland cement and 90 pounds of KSC KOMPONENT.

WATER/CEMENT RATIO: The recommended water/cement ratio is 0.5.

AIR CONTENT: For air entrained concrete, a 5% +/-1% air content is recommended.

MIXING TIME: Limit mixing and placing time to 90 (ninety) minutes as specified by ACI.

SLUMP: Recommended slump is 5" +/- 1 at the point of placement.

REINFORCING STEEL: There are no special reinforcing steel requirements or details to

successfully use KSC KOMPONENT concrete. The reinforcement designed for a regular Portland cement concrete is all that is needed for a KSC KOMPONENT cement concrete structure. In the case of slabs on grade, steel reinforcement of about 0.15% both ways is used for restraint (For a 6" thick slab, this is about #4's at 2 foot centers both ways). The reinforcing steel should be positioned in the upper half of the slab with a minimum of 1 1/2" cover.

PLACEMENT: and Finishing: Precautions should be taken to prevent concrete temperatures exceeding 90 degrees. Slab areas as great as 20,000 square feet are attainable with adequate manpower. Placements generally recommended are from a 1:1 to a 3:1 length to width ratio, but that ratio may be exceeded to meet job conditions. Normal finishing techniques should be followed to produce the required finish. Due to KSC concrete's lack of bleed water, finishing operations can be started as soon as the concrete is ready for finishing. Should plastic shrinkage conditions occur, fog sprays or the use of a spray-on liquid evaporation suppressor should be used. ACI "Hot Weather Concrete" practices are recommended.

CURING: A 7-day water cure is strongly recommended.

PRE-POUR MEETING: A pre-pour meeting is strongly advised and the CTS representative notified as to the meeting date as early as possible.



Type K, Shrinkage Compensating Concrete

RECOMMENDED SPECIFICATION FOR TYPE-K EXPANSIVE CEMENT CONCRETE USING KSC SYSTEM-K™

CEMENT: Cement shall be either KSC Type-K Cement, an expansive hydraulic cement, conforming to ASTM C 845 as manufactured by CTS Cement Manufacturing Co., 11065 Knott Avenue, Cypress, CA 90630 or a combination conforming to ASTM C845 composed of Portland cement and KOMPONENT® as manufactured by CTS Cement Manufacturing Co. Contact: CTS Cement at 1-800-929-3030 for further details and suggested mix designs for a particular use.

AGGREGATE: Any sound, non-reactive well-graded aggregate suitable for Portland cement concrete as per ASTM C 33.

ADMIXTURES: Generally, admixtures that are suitable for regular Portland cement concrete may be used with KSC System-K™ concrete. CTS representatives should be contacted to confirm compatibility of any admixture.

CEMENT CONTENT: Recommended cement content is a minimum of 658 lbs per cubic yard for slabs exposed to severe weather conditions, de-icing salts, and chemicals. Recommended cement content for 4000 psi, non-air entrained concrete for use in floor slabs, the cement content is a minimum of 560 lbs per cubic yard. For 4000 psi, air entrained concrete for use in exterior floor slabs; a minimum of 610 lbs per cubic yard is recommended.

WATER/CEMENT RATIO: The recommended water/cement ratio is 0.5.

AIR CONTENT: For air entrained concrete, a 5% +/-1% air content is recommended.

MIXING TIME: Limit mixing and placing time to 90 (ninety) minutes as specified by ACI.

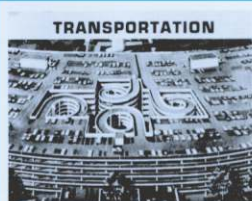
SLUMP: Recommended slump is 5" +/- 1 at point of placement.

REINFORCING: The CTS KSC fibers are ac in the amount of 1 bag per cubic yard of con to provide sufficient restraint to the concrete. the perimeter, 2 #4 re-bars are recommende 1-1/2" inches from any edge of the slab. Additional reinforcement requirements may b required as per the engineer.

PLACEMENT AND FINISHING: Precautions should be taken to prevent concrete temperatures exceeding 90 degrees. Slab ar as great as 20,000 square feet are attainable adequate manpower. Placements generally recommended are from a 1:1 to a 3:1 length width ratio, but that ratio may be exceeded to meet job conditions. Normal finishing technic should be followed to produce the required fi Due to KSC Cement concrete's lack of bleed water, finishing operations can be started as as the concrete is ready for finishing. Should plastic shrinkage conditions occur, fog spray the use of a spray-on liquid evaporation suppressor should be used. ACI "Hot Weathr Concrete" practices are recommended.

CURING: A 7-day water cure is strongly recommended.

PRE-POUR MEETING: A pre-pour meeting i strongly advised and the CTS representative notified as to the meeting date as early as possible.



TRANSPORTATION

Chicago, IL • O'Hare Parking Structure



Dallas, TX • Love Field



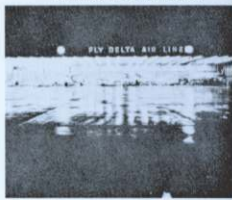
Fairborn, OH • Highway Bridge Deck



Los Angeles, CA • Japan Airlines Ramp at LAX



Long Island, NY • Pan American at JFK



Atlanta, GA • Delta Airlines Ramp



INDUSTRIAL PROJECTS

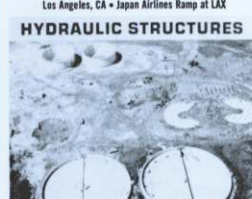
Fogelsville, PA • F. & M. Schaefer Brewery



Columbus, OH • J. C. Penney Catalogue Distribution Center



Bedford, OH • Fisher-Fazio-Costa, Corp.



HYDRAULIC STRUCTURES

Vicksburg, MS • Sewage Treatment Plant



Atlanta GA • Water Treatment Plant



Potomac, MD • Washington Suburban Sanitary Commissi



ARCHITECTURAL CONCRETE

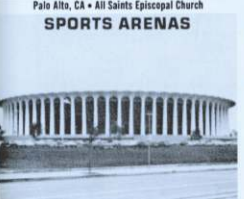
Palo Alto, CA • All Saints Episcopal Church



Malibu, CA • J. Paul Getty Museum



Arlington, TX • American Airlines Stewardess College



SPORTS ARENAS

Los Angeles, CA • The Forum



Boston, MA • Boston Garden



Bloomington, MN • Metropolitan Sports Center (Hockey Rink)

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