High-Performance Concrete CONTAINMENT STRUCTURES

SHRINKAGE-COMPENSATING
CONCRETE TECHNOLOGY

KOMPONENT®

by CTS Cement Manufacturing Corp.

THE CHALLENGE

Preventing leaks and spills of water, wastewater, fertilizers, chemicals and other bulk materials from concrete containment structures are key concerns for owners, agencies, engineers and communities alike.

PREVENTING CONTAMINATION from external impurities is essential to maintaining the integrity of the contained material. Proper design and construction of these containment structures is crucial to ensuring the health and safety of workers, the public, and the environment.

Leaking structures also result in unscheduled downtime and expensive, recurring repairs. Well designed, reliable concrete containment structures can overcome these difficult challenges. Komponent® Shrinkage-Compensating Cement technology offers a proven solution.

KOMPONENT® SHRINKAGE-COMPENSATING CEMENT TECHNOLOGY, based on calcium sulfoaluminate (CSA) cement chemistry, has been used in concrete containment structures and treatment facilities since 1963. It provides an integral approach to durable, watertight containment construction.

This advanced cement technology offers significant value in concrete structure designs. Its unique chemistry minimizes or eliminates shrinkage cracking, improves sulfate resistance, simplifies designs, eases construction challenges, minimizes maintenance, and prevents costly repairs due to early deterioration and failure.

SOLUTIONS

Komponent® Shrinkage-Compensating Cement technology is used to create shrinkage-compensating concrete solutions. It is available in three configurations to provide design flexibility and economy project to project.

1 KOMPONENT® is an expansive cementitious additive.

It is blended with regional portland cement to create ASTM C845 Type K Cement used in Type K Shrinkage-Compensating Concrete, System-K™ Shrinkage-Compensating Concrete, low shrinkage concrete, and non-shrink grout materials. Komponent can be added at the production plant or on the job site in proportions that achieve the specified amount of shrinkage compensation.

2 TYPE K CEMENT is a pre-blended, pre-packaged cement.

It consists of 15% Komponent and 85% portland cement. It is used to create Type K Shrinkage-Compensating Concrete, System-K™ Shrinkage-Compensating Concrete, low shrinkage concrete and non-shrink grout materials. Type K pre-blended cement provides consistent, high-quality results. It is ideal for projects where the quality of local portland cement is inadequate or inconsistent.

3 SYSTEM-K™ is a fiber reinforced shrinkage-compensated concrete.

It is ideal for slab-on-grade applications with minimal or no reinforcing steel. It includes engineered 1/4” synthetic monofilament K-Fiber™ and Komponent blended with regional portland cement. These short, synthetic microfibers provide sufficient drying shrinkage restraint and improve the durability of the finished concrete. System-K™ offers a cost effective alternative to typical steel reinforced concrete slabs.

COMMON APPLICATIONS

- Clarifiers & Digesters
- Concrete Containment/Storage
- Containment Structures
- Mixing and Loading Pads
- Secondary Containment
- Elevated Tank Pads
- Mechanical/Electrical Corridors
- Pump Stations
- Valve & Mixing Containment
- Dewatering Buildings
- Tunnels
- Underground Storage & Processing
- Filtration Plants
- Treatment & Storage Facilities
- Sewage Management Structures
- Cooling Tower Basins
- Concrete Reservoirs
- Hazardous Waste Containment
- Grouting

System-K™ Applications

- Filling & Packaging Areas
- Equipment Storage & Warehousing
- Utility & Maintenance Buildings
- Truck Washing Areas
- Laboratories
- Administration & Control Buildings

WHAT IS CSA CEMENT?

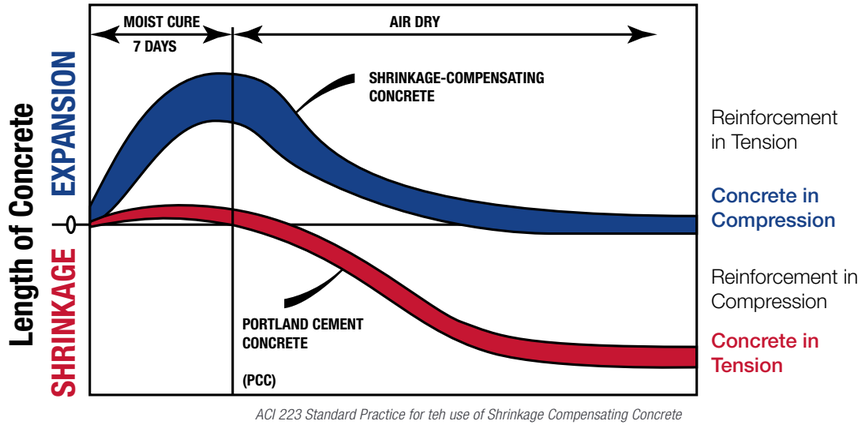
Calcium sulfoaluminate (CSA) cement is engineered to overcome the key challenges of portland cement – namely, excessive shrinkage and susceptibility to sulfate attack. CSA cement shares many of the same cement compounds as portland cement, with one uniquely different compound ($C_4A_3\overline{S}$) that is largely responsible for its ability to outperform portland cement. Its consumption of water molecules during hydration eliminates bleed water and prevents voids and capillaries that lead to drying shrinkage. In addition, it maximizes strength gain through controlled ettringite formation. CSA has no detectable C_3A content, the compound that reacts with sulfates, so its use helps improve sulfate resistance of the concrete, reduces maintenance costs, and addresses costly challenges related to restraint-to-shortening in post-tensioned structures.

WHAT IT IS NOT

CSA cement technology is often confused with calcium aluminate (CA) cement. CA cement is known for unfavorable results like strength regression, increased porosity, and restricted, non-structural use. CSA cement ($C_4A_3\overline{S}$) is a completely different chemistry with significantly different and superior performance.

HOW IT WORKS

Shrinkage-Compensating Cements develop compressive stresses in concrete during hydration that later counteract tensile stresses induced by shrinkage.



ACI 223 Standard Practice for teh use of Shrinkage Compensating Concrete

The $C_4A_3\bar{S}$ in Komponent® combines with free lime in the concrete to form ettringite. The ettringite formation produces controlled expansion of the concrete during the first seven days of wet curing following placement. This initial expansion compensates for the shrinkage of concrete during drying.

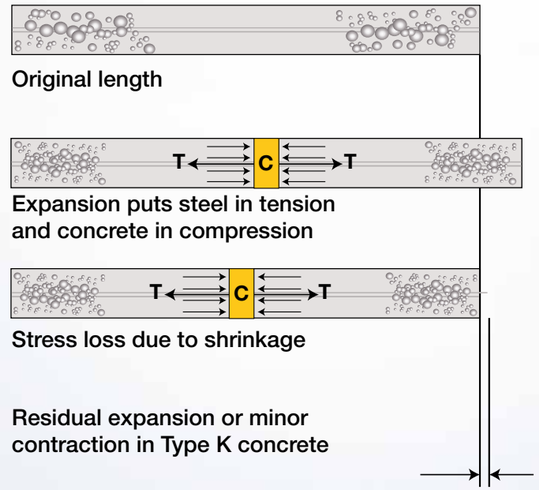
Drying shrinkage cracks occur in conventional concrete slabs when movement caused by shrinkage is resisted by an external restraint, such as friction with the subgrade. It produces tensile stress that literally "tear" the concrete apart because concrete is weak in tension.

Komponent® Shrinkage-Compensating Cement technology prevents drying shrinkage cracking by counteracting tensile stress. Shrinkage-compensating concrete is placed with some form of restraint, usually in the form of reinforcing bars or post-tensioning tendons. Concrete expansion puts the reinforcement into tension. The tensioned reinforcement, like a stretched rubber band holding together a stack of papers, puts the concrete into compression, where it is the strongest.

The initial expansion of shrinkage-compensating concrete minus subsequent drying shrinkage yields a net shrinkage usually close to zero.

DOES IT WORK LIKE A SHRINKAGE-REDUCING ADMIXTURE?

Shrinkage-reducing admixtures (SRAs) are designed to delay shrinkage by reducing the surface tension of pore water. This decreases capillary stress and shrinkage induced during drying. Over time, the surface tension effects diminish and the excess free water is released, resulting in delayed drying shrinkage. Komponent technology chemically binds the water molecules within the ettringite structure. Once chemically bound, they cannot be separated.



ACI 223, SECTION 1.2

"…expansion will induce tension in the reinforcement and compression in the concrete. On subsequent drying the shrinkage merely relieves the expansive strains…"

PERFORMANCE ADVANTAGES

> "Because it is the C_3A that is attacked by sulfates, the concrete vulnerability can be reduced by using cements low in C_3A…"
> *(ACI 365.1R-00, Service-Life Prediction)*

Minimize Cracking

Komponent® Shrinkage-Compensating Cement technology offers an effective and economical way to minimize or eliminate drying shrinkage cracking. By preventing cracks, it helps prevent penetration of contaminants and deterioration of the concrete, and safeguards contained materials from external pollutants.

Improve Sulfate Resistance

Concrete in water, wastewater treatment and liquid containment structures must be resistant to sulfate attack from aggressive ground water and sulfate laden soils. Because Komponent® contains no C_3A, the element attacked by sulfates, the sulfate resistance of the concrete containment structure can be increased in direct proportion to the amount of Komponent® used in the mix design. Using Komponent® with Type V portland cement maximizes sulfate resistance, while using it with Types I – IV portland cement helps improve its sulfate resistance in proportion to the amount used in the mix design.

Lower Permeability

Concrete in contact with water, wastewater and other liquids must be dense, impermeable, and free of substantial cracking which can lead to pollution of water supplies, wastewater and ground contamination.

"The restrained expansion of shrinkage-compensating concrete produces a dense matrix which serves to reduce the permeability as compared to corresponding concrete made with other types of portland cement at the same cement content." (ACI Committee 223 Report "Guide for the Use of Shrinkage-Compensating Concrete")

Type K Shrinkage-Compensating Concrete creates high density concrete with very low permeability. Very low permeability concrete (< 1000 coulombs) can be achieved with appropriate mix designs. Low permeability and high density performance also provides exceptional freeze/thaw resistance, making it an ideal solution in cold climates.

High Density

Since "most sanitary engineering structures will be exposed to the elements…adequate provision must be made to avoid atmospheric, ground water and frost damage. Structures subject to movement of liquids must be resistant to erosion. In this respect, a smooth surface finish is important." (ACI Committee 350 Report "Concrete Sanitary Engineering Structures")

The high slumps of Type K Shrinkage-Compensating Concrete provide ease of concrete placement by traditional pouring and pumping practices. High slump results in a smooth, dense surface with minimal surface defects in vertical wall applications that typically require patching.

Increase Abrasion Resistance

Shrinkage-compensating concrete has an abrasion resistance 30% to 40% higher than portland cement concrete. (ACI 223, Section 2.5.7) This is due to Komponent's efficient consumption of mix water that effectively eliminates bleed water. This keeps the water cement ratio of the surface consistent with designed strengths and improves abrasion resistance. Eliminating the need to wait for bleed water evaporation also helps speed time to completion.

DESIGN ADVANTAGES

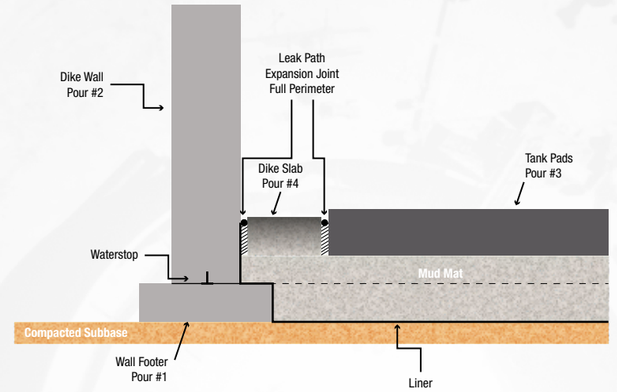
Komponent® technology offers many design advantages with no special structural requirements. It actually simplifies designs.

Monolithic Pours

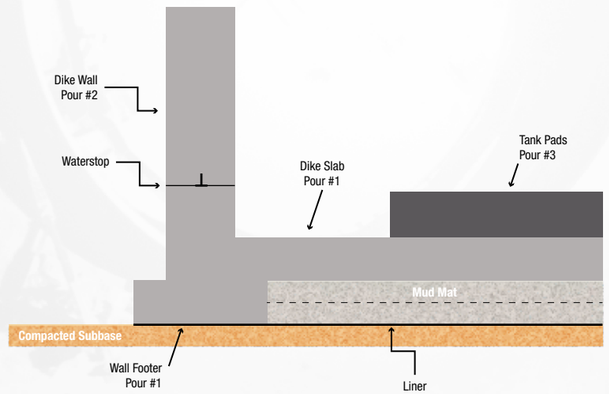
In both primary and secondary concrete containment, watertight construction is often required. With Komponent® technology, watertight performance is enhanced by mitigating shrinkage cracking and restraint to shortening (RTS) challenges, allowing placement of more monolithic pours. Integral transitions of walls and curbs can be placed without the need for joints, creating an impermeable, liquid tight structure offering maximum protection. Komponent technology is ideal for “no-joint zones”, sumps and depressions.

Wall-to-floor construction details are simplified and wet joints and water stops can be eliminated. Reduced construction costs and installation times can be achieved, and long-term maintenance costs are minimized.

DESIGN COMPARISON



TRADITIONAL DESIGN Design using conventional concrete and traditional joint requirements.



TYPE K DESIGN Design using Type K Shrinkage-Compensating Concrete, eliminating expansion joints and reducing slab pours

Simplify design with Komponent

Fewer Joints

With Komponent® technology control joints can be significantly reduced or eliminated. Due to the expansive mechanism engineered to compensate for drying shrinkage, control joints can be minimized or eliminated. This helps simplify design requirements and reduce installation costs associated with joint construction.

TRADITIONAL DESIGN

Containment specifications for structures exposed to the atmosphere usually require 20 to 30 foot horizontal spacing of wall construction joint with expansion/contraction joints at 50 to 60 feet.

TYPE K DESIGN

With Type K, construction joints for structure walls can be placed at 75 feet with expansion/contraction joints at a modular 100 to 130 feet. This substantially reduces joint materials and water stops, reduces formwork, and decreases labor and construction costs.

Large containment pad placements of up to 150 feet x 150 feet can be accomplished with minimal or no control joints. Reduced joint requirements mean fewer load transfer details are required, which reduces the cost of dowel placement and crack repairs that often result when dowels are not installed properly.

Increased joint spacing of up to 150 feet is achievable, and larger slab sizes of up to 20,000 to 30,000 square feet can be poured in one mobilization. Increased length to width ratios of up to 3:1 can be placed, creating long, narrow sections between construction joints. Fewer pad joints significantly reduce the costs associated with tooling and/or saw cutting, and caulk and seal treatments.

Fewer joints and minimal, if any, cracking substantially reduces leakage points and opportunities for pollutants to enter the structure. Minimizing these paths of migration prevents moisture and other contaminants from reaching the reinforcing steel and reduces corrosion potential. No crack paths and fewer joints improves the integrity of the structure and prevents the egress of processed water and other contained liquids, and the entry of or external contaminants.

> ACI 223 Standard Practice for the Use of Shrinkage-Compensating Concrete, "…on subsequent drying, the shrinkage merely relieves the expansive strains." This minimizes or eliminates cracking, making control joints unnecessary, as noted in Section 3.4.5 "… contraction joints are eliminated…."

Dimensional Stability

Komponent® technology effectively overcomes the movement typically experienced with traditional concrete when the shrinkage and drying contraction of portland cement concrete cures and dries out. Its dimensional stability from original plastic state to hardened in-service use eliminates restraint to shortening (RTS) challenges and helps prevent deterioration associated with positive and negative moments due to tank loads.

Reduced Reinforcement

Thinner wall and floor slabs can be engineered. Distributed reinforcing steel designed to hold concrete together and minimize crack width due to shrinkage cracking can be reduced.

Design provision for water retention structures using traditional concrete walls usually require 0.3 percent shrinkage steel for walls 12 inches thick or less, and joint spacing of 30 feet or less. Steel percentage requirements increase proportionally with greater distance between joint spacing, up to a maximum of 0.6 percent. With Type K cement concrete, many designers specify 0.3 percent shrinkage steel as a maximum rather than a minimum.

Fewer joints improves the integrity of the structure

CONSTRUCTION ADVANTAGES

Many construction advantages can also be achieved with Komponent® Shrinkage-Compensating Cement technology that contribute to project efficiency and on-time project completion.

Improve productivity

Ease of Installation

Larger concrete placement sizes, increased joint spacing, fewer construction joints, fewer rubberized water stops, and fewer structural joint details mean easier installation sequencing and reduced material requirements.

High slump achieves excellent pumpability for high volume efficiency. Ease of workability around large diameter, double mat rebar helps improve productivity. No special or additional reinforcing details are required.

Reduced Installation Time

Larger, monolithic pours reduce mobilization requirements and installation time and contribute to substantial cost savings.

LARGER PLACEMENTS

Reduced construction time can be achieved by larger placements. Larger placements on sloped basins can eliminate traditional base slab and topping (two phase) construction.

ELIMINATE CHECKERBOARD CASTING

The ability to eliminate checkerboard casting with vertical gang forming also contributes to improved project efficiencies. Walls can be stripped within 24 to 48 hours followed by wet curing with mats or blankets for 7 days to maximize the performance of shrinkage-compensating concrete, producing dense, abrasion resistant, high-quality concrete.

LOWER COST OF CONSTRUCTION

Lower cost of construction with higher productivity is achievable using standard crew sizes. Larger placements can be poured within the same timeframe using traditional equipment, placement and finishing methods.

LOW LIFECYCLE COSTS

Properly designed and constructed concrete containment structures using Komponent Shrinkage-Compensating Cement technology contribute to long life and low maintenance.

The wide variety of advantages Komponent® technology offers reduces overall project costs and minimizes maintenance and repair costs. It provides maximum protection and can extend the service life two to three times that of traditional designs – providing the lowest life cycle cost concrete containment solution.

Komponent's low permeability, high density, and improved sulfate resistance can reduce or eliminate the need for sealants and coatings, which can contribute to additional cost savings. When required or preferred for a project, Komponent® technology is compatible with common industry coatings, additives, adhesives and primers used within the water, wastewater and secondary containment industry.

Quality concrete design requires:

1. Specifying the proper concrete mix.
2. Specifying the correct design details.
3. Following correct construction practices to place the concrete.

Komponent® Shrinkage-Compensating Cement technology helps simplify all three to maximize performance while simplifying design, detailing and placement. It offers value to the entire project team – Owners, Designers, Engineers and Contractors. It is a proven industry solution where durability and long-term performance are not only desirable, but mandatory.

Complementary Products

For concrete containment tanks and other concrete structures in need of repair or maintenance, CTS Cement offers a complete line of high-performance, CSA cement-based Rapid Set® products used for a wide range of concrete maintenance and repair solutions. Rapid Set's very high early strength products offer maximum durability and sulfate resistance without sacrificing performance.

Service & Support

CTS Cement supports the demanding requirements of the design and construction communities, owners and facility management teams throughout each project. We offer a wide range of support for each Komponent project – from educational presentations to owners, designers, engineers, construction teams, and facility management to pre-construction meetings and hands-on jobsite support.

The CTS Technical and Engineering teams are also available to assist with materials testing, mix designs, specifications, details and pour planning. Our experienced team is available to help ensure your Komponent projects are successful.

Contact us for assistance with product selection, specifications, samples, mix designs, and other project support needs

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