DENKA CSA

SHRINKAGE COMPENSATING CEMENT

INTRODUCTION

Raw materials used in the manufacture of ***Denka CSA*** (Calcium Sulpho Aluminate) include quick-lime, gypsum, bauxite. The mineral composition of ***Denka CSA*** is CaO, $CaSO_4$, $3CaO.3AI_2O_3.CaSO_4$. Calcium sulphoaluminate, anhydrous in form, hydrates to form ettringite. Ettringite occupies a greater volume than the water and anhydrous materials that make it up. Its formulation is accompanied by an increase in absolute volume and therefore a net expansion.

Denka CSA is always mixed with Type GP portland cement and it is called ***Denka CSA*** cement or expansive cement. When mixed in the proper proportions with cement, a cement mortar or concrete expands during the early stages of hydration. This expansion, when restrained, makes it possible to minimise drying shrinkage. Moreover, when the ratio of ***Denka CSA*** to cement is increased its high expansion qualities make it ideal for use in prestressed concrete.

Denka CSA is being used in many sections of construction and by a wide variety of concrete products manufacturers. The advantages and merits of ***Denka CSA*** have been well proven in over 30 years of use in New Zealand.

Denka CSA should not be confused with shrinkage reducing agents. Shrinkage reducing agents do not compensate for shrinkage by expansion and therefore cannot introduce prestress to the concrete.

Lime based expansive agents have different expansion and shrinkage characteristics. Use of these agents can place limits on slab dimensions due to higher long term shrinkage.

HOW IT WORKS – THEORY

Portland cement concrete shrinks as it dries. This shrinkage, if restrained, is conducive to cracking. Cracked concrete has been around such a long time that most people have come to accept it. ***Denka CSA,*** however, is an expansive cement specifically designed to provide dimensional stability during the drying period, which physically compensates for drying shrinkage tensile stresses that may occur in concrete. Therefore, ***Denka CSA*** cement will reduce drying shrinkage cracks in concrete, and with proper design, application and good construction practices, can eliminate them altogether.

The mechanism to overcome drying shrinkage cracks with expansive cement is not difficult to understand. Imagine a piece of reinforced portland cement concrete. The concrete begins to dry out after curing which is accompanied by shrinkage. The concrete is bonded to the reinforcing steel with its shrinkage restrained by the steel. Still, it tries to shrink and in so doing puts the steel into compression. The concrete must then be placed in tension by the familiar law of physics of equal and opposite reactions. Due to the low tensile strength of concrete, only a little restrained shrinkage need occur before the limit is reached and the concrete cracks to relieve the stress. Tensile stresses are also imposed in a concrete slab by friction with the base as the slab tries to shrink.

Denka CSA works in the same situation as follows. As the concrete sets and bonds to the steel, and while the concrete is curing and gaining strength, the expansive reactions cause a slight controlled elongation to the concrete. The bond to the steel causes it to be stretched slightly and places the steel in tension. The equal and opposite law is still at work and the concrete is put in slight compression. It is "precompressed," but at a level of magnitude which is much less than that of conventional prestressing. This controlled expansion is complete in the first few days of the concrete's life. When the expansive concrete begins to dry out, it shrinks as does normal concrete, but unlike normal concrete, the shrinkage is accompanied by the relief of a slight compression built into it – not by tensile stresses being set up. Tensile stresses imposed by the base can largely be eliminated by good preparation and the use of two layers of polythene. When all the drying shrinkage has taken place, ***Denka CSA*** concrete will be relieved of the problems that contribute to drying shrinkage cracking because, ideally, it will never go into tension.

REMEMBER – THE CONCEPT OF EXPANSION AGAINST A RESTRAINT IS ESSENTIAL TO ANY USE OF THIS TYPE OF EXPANSIVE CEMENT.

HOW IT WORKS – ON THE JOB

The number of joints are greatly reduced and cracks are largely eliminated with ***Denka CSA***. This allows designers greater freedom in the layout of concrete placements. The use of ***Denka CSA*** cement also permits greater freedom in the structural design of reinforced and prestressed concrete which can result in a superior structure. This can be accomplished by:

(a) Eliminating construction and shrinkage control joints.
(b) Minimising deflections of structural slabs and beams due to differential shrinkage.
(c) Reducing or eliminating tensile stresses in structural members resulting from drying shrinkage.

Denka CSA cement allows for larger placements. This is particularly useful in large warehouses with high level racking as joints can be minimised or eliminated. The result is greater durability and less damage from forklift traffic. Joint free concrete slabs up to 3900m² (65m x 60m) have been constructed in New Zealand.

In the field of post-tensioned structures, ***Denka CSA*** can help eliminate cracking of slabs, walls or columns due to the long-term shortening caused by shrinkage and axial creep. When a post-tensioned deck is placed with portland cement, it shortens with time – and as it shortens, it pulls with it all the vertical elements such as columns which are tied to it. If the shortening is not controlled by expansion joints, slip joints, or other methods, cracks may occur in the structure.

Denka CSA cement solves the problem this way. As the ***Denka CSA*** cement deck is placed, a controlled growth occurs during the first few days. This early growth begins before the tendons have been stressed, and allows the vertical elements to be minutely pushed outward. After the tendons are stressed, the deck starts to shrink and creep just as regular concrete. The big difference is that the deck is shortening and returning closer to its original dimension (depending on the amount of stress from the tendons). Thus, as time goes on, all the shears and moments in the columns and walls are decreasing, rather than increasing.

There is essentially no difference in the basic principles of designing good durable concrete with expansive cement or portland cement. Water curing for 7 to 10 days or the use of high efficeincy curing compounds are essential for Shrinkage Compensated Concrete.

Although we cannot guarantee that ***Denka CSA*** cement is a remedy for all the problems of cracks in concrete, it will assist in the elimination of drying shrinkage cracks and allow for very large placements without control joints. ***Denka CSA*** should not be used as a crutch to cover bad construction practices, poor subgrade preparation, or the addition of too much water at the job site. When used properly and with knowledge of its potential, it benefits owners, architects, engineers and the concrete industry as a whole.

Specifications and reinforcing guidelines are available on request.