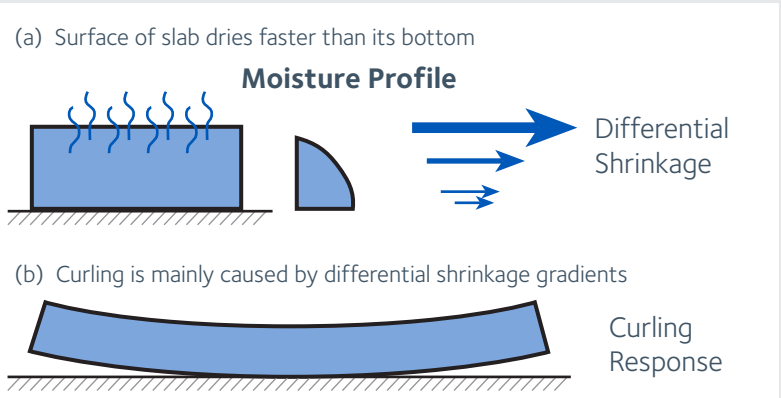
Eclipse® Floor

Effect of Eclipse Floor shrinkage-reducing admixture on curling

Curling is a common problem in slab-on-grade construction. It is a major contributor to cracking in concrete slabs, which leads to higher maintenance cost and reduced service life. Curling becomes a bigger problem when installing super-flat floors. For indoor concrete slabs, curling is almost always caused by a differential moisture gradient in the slabs. As the surface of the concrete slab dries faster than its body and bottom, a differential moisture profile is developed along the thickness of the slab. The surface of the slab shrinks more and quicker than its bottom. This differential drying shrinkage gradient is what causes the concrete slab to curl. The greater the gradient is, the greater the curling. If the curled edges are loaded, such as by forklift trucks, the unsupported curled edges may crack. Then, the crack becomes a maintenance problem. If the curled edges do not crack, they still can be a problem. Vehicles carrying loads may be affected as they encounter the curled edges, or in high bay warehouses, forklifts may not correctly meet the pallets in upper racks. Figure 1 illustrates the curling process. Eclipse® Floor shrinkage-reducing admixture is a liquid admixture specially formulated for use in indoor slab-on-ground concrete construction. Eclipse Floor contains no expansive material, but acts chemically to dramatically reduce the primary internal forces that cause drying shrinkage and curling.

Figure 1 - Schematics of Curling



Laboratory Tests

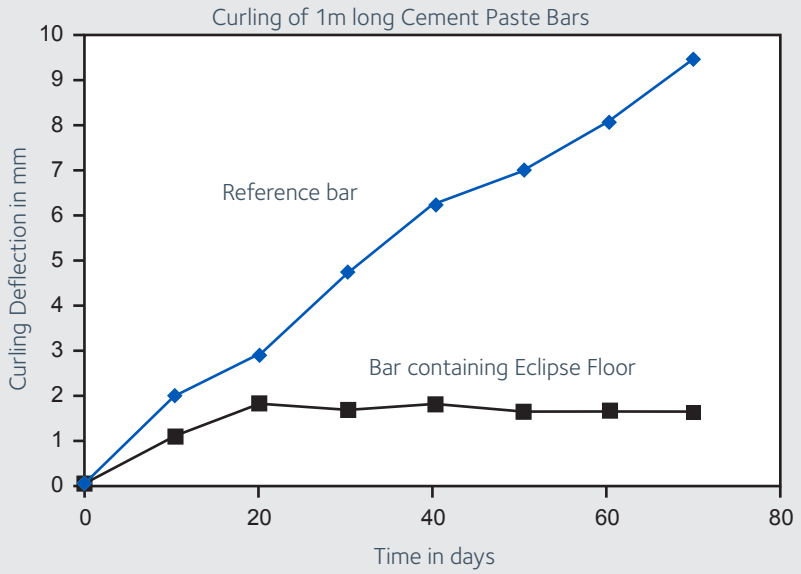
Two different tests were developed in order to measure the impact of Eclipse Floor in curling:

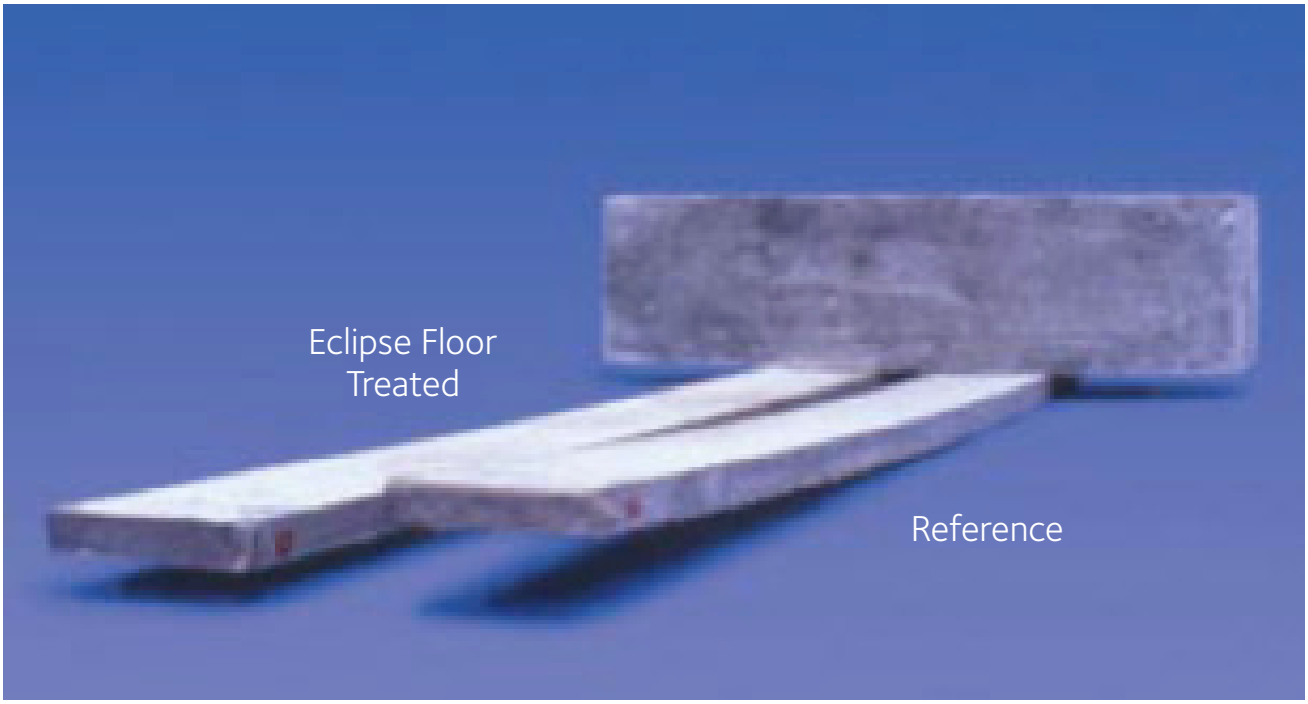
- The first was performed on cement paste bars to examine the effect of Eclipse Floor in a system with very high curling deflections.
- In the second test, concrete beams were used instead, with the intention of obtaining curling data on actual concrete specimens. The results from this test allowed the calculation of the projected curling deflection at the corner of a 5m x 5m slab, 160mm thick.

Cement Paste Test

Two specimen bars of 990mm x 64mm x 12mm were prepared with cement paste at 0.45 water-cement ratio. One bar (the treated bar) was made adding Eclipse Floor shrinkage-reducing admixture to the mix at 5% of water weight [approximately 7.5L / m^3 and the other bar (the reference bar) was made without Eclipse Floor in the mix. The sides and bottom of both specimens were coated with urethane upon stripping in order to insure that evaporation only occurred from the top face of the bar. Since cement paste has much higher shrinkage than concrete, it also exhibits very severe curling, allowing for direct visual confirmation of the effect of Eclipse Floor. As shown in Figure 2, the Eclipse Floor treated specimen curled substantially less than the reference bar. The curling deflection was reduced by as much as 80% in 60 days by adding Eclipse Floor to the cement paste.

Figure 2 - Midpoint Deflection Measurements of Reference Cement Bar vs. Eclipse Floor Treated Bar





In-Situ Shrinkage Measurement

Unrestrained shrinkage beams of 1m x 0.2m x 0.1m were made with two embedded vibrating strain gauges in each. The strain gauges were placed in a longitudinal direction: one at 10mm from the surface and another at the centre of the cross section (50mm down from the centre). Using the embedded strain gauges, the concrete length changes were continuously measured and recorded every 15 minutes for the first 12 days after the pouring date and then on a daily basis until the 30th day.

A commercially produced Ready-Mix concrete with 352kg / m^3 cement content and 0.51 water-cement ratio was used for these beams. The reference beams were made with this concrete and the treated beams were made with the addition of 6.18L / m^3 of Eclipse Floor to the concrete mix (See Table 1 for Eclipse Floor treated and reference concrete mix designs). After 3 day wet curing with plastic and wet burlap, these beams were air-dried in a closed warehouse with 40-50% relative humidity.

Figure 3 - In-Situ Shrinkage Measurements of Beams made with the Reference Mix vs. Beams made with Eclipse Floor Treated Mix

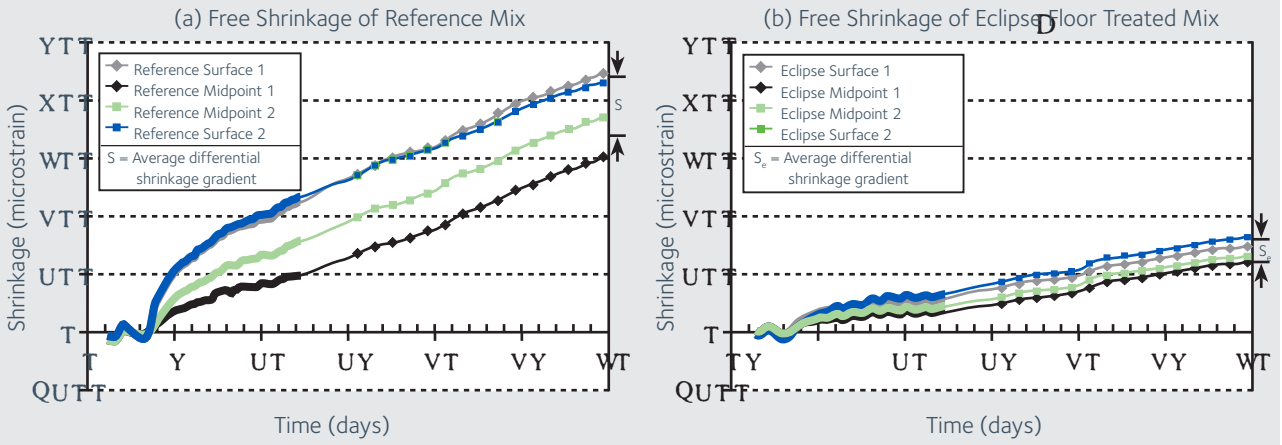


Figure 3 shows the in-situ shrinkage measurement results for the beams (Eclipse Floor treated vs. reference mix). The 30-day shrinkage was reduced by more than 50% with the addition of Eclipse Floor. Also, Eclipse Floor significantly reduced the early age shrinkage, which is very important since it shows the effectiveness of Eclipse Floor in preventing or minimising cracking in the weakest stages of concrete.

The shrinkage difference along the thickness of the concrete beams (difference between midpoint and surface shrinkage in Figure 3) indicates that curling is occurring. When compared to the reference beams, the shrinkage gradient in the Eclipse Floor treated beams is reduced by more than 50%. These results indicate the impact of Eclipse Floor in curling reduction.

Mid-to-Corner Point Deflection Calculation

The mid-to-corner point deflection of a curled slab is calculated using the in-situ shrinkage gradient data. In this calculation, a 5m x 5m slab with 160mm thickness is used as an example. From Figure 3, the average shrinkage gradients between the two sets of strain gauges are measured as 100 x 10-6 and 35 x 10-6 for the reference beams and Eclipse Floor treated beams respectively. This exercise (ignoring gravity effects) shows that a slab made with the reference concrete mix would show a 15.5mm curling deflection at the corner of

Reference Mix	**Eclipse Floor Treated Mix**
The following is known for the corner of a 5m x 5m slab from the reference beam test	The following is known for the corner of a 5m x 5m slab from the Eclipse Floor treated beam test
S = Shrinkage Gradient (Surface-midpoint)=35x10^{-6}	S_e = Shrinkage Gradient (Surface-midpoint)=35x10^{-6}
$2\pi R\frac{\Delta}{360}=3{,}535.65$ $2\pi(R+40)\frac{\Delta}{360}=3{,}536$	$2\pi R_e\frac{\Phi}{360}=3{,}535.88$ $2\pi(R_e+40)\frac{\Phi}{360}=3{,}536$
The solution for the equation system is R = 404,074mm $\Delta = 0.501338^o$	The solution for the equation system is R = 1,178,627mm $\Phi = 0.171887^o$
Using the data and assuming a linear relationship between drying shrinkage gradient and slab thickness, the curling deflection δ at the corner of a 5m x 5m x 160mm thick slab can be found	Using the data and assuming a linear relationship between drying shrinkage gradient and slab thickness, the curling deflection δ_e at the corner of a 5m x 5m x 160mm thick slab can be found
R+160 = 404,234mm $R'=\frac{404.24}{\cos\Delta}=404{,}249.5$mm R" = R'-(re+160) = 5.3mm δ = R"Sin (90°-Δ)=**15.5mm**	R_e+160 = 1,178,787mm $R_e'=\frac{1{,}178{,}787}{\cos\Phi}=1{,}178{,}792.3$mm $R_e"$ = R_e'-(re+160) = 5.3mm δ_e = R_e"Sin (90°-Φ)=**5.3mm**

a 5m x 5m slab with 160mm thickness, whereas a slab made with Eclipse Floor treated concrete would show a curling deflection of 5.3mm. This is a 65.8% reduction in curling deflection by using Eclipse Floor. The actual curling deformation would be somewhat less in practice due to elastic and creep deformations from gravity loading on a longer slab. This exercise demonstrates that the differential shrinkage measurements are in line with field experience for curling and reinforces the value provided by Eclipse Floor in reducing curling.

High Value Floors with Eclipse Floor

Eclipse Floor reduces drying shrinkage and curling of concrete. Therefore, less cracking is expected in Eclipse Floor treated concrete slabs. Along with careful design and practice, the addition of Eclipse Floor to the mix can even enable the extension of joint spacing for any given concrete slab. Overall, Eclipse Floor can help to achieve a higher value flooring system with:

- Less cracking due to reduced drying shrinkage and curling
- Flatter surface due to less curling
- Less joint maintenance cost due to minimum joint openings at a given joint spacing or due to less joints at extended joint spacing
- Longer service life

For more information, consult your local GCP representative.

Table 1 - Concrete Mixture Proportions

Materials	Reference Mix	Eclipse Floor Treated Mix
Cement (ASTM C 150 Type 1)	352kg / m^3	352kg / m^3
10mm Aggregate	326kg / m^3	328kg / m^3
20mm Aggregate	747kg / m^3	739kg / m^3
Fine Aggregate	751kg / m^3	743kg / m^3
Water	180kg / m^3	180kg / m^3
Water Reducer	196mL / 100kg	
Superplasticiser*	456mL / 100kg	326mL / 100kg
Eclipse Floor Shrinkage-Reducing Admixture		6.18L / m^3
Water-Cement Ratio	0.51	0.51

Note: Eclipse Floor contains no water, but still contributes to concrete slump. Therefore, a water-reducing admixture* and a higher dosage of superplasticiser** were added to the reference mix in order to achieve a slump similar to that of the Eclipse Floor treated concrete, while maintaining the same water-cement ratio.

* GCP's ADVA®

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