The Use of Steel Fiber Concrete in Combination with Post Tensioning

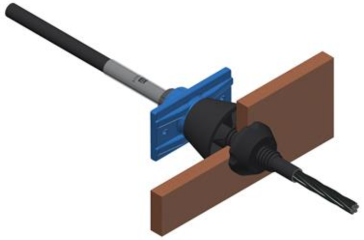
∑ slab

Dramix® 4D · Dramix® 5D · Bekaert

+

Sum of complementary reinforcing systems

Sum of two companies combining their strengths



ccl®

PATENT PENDING

σ slab

Dramix® Steel Fibres

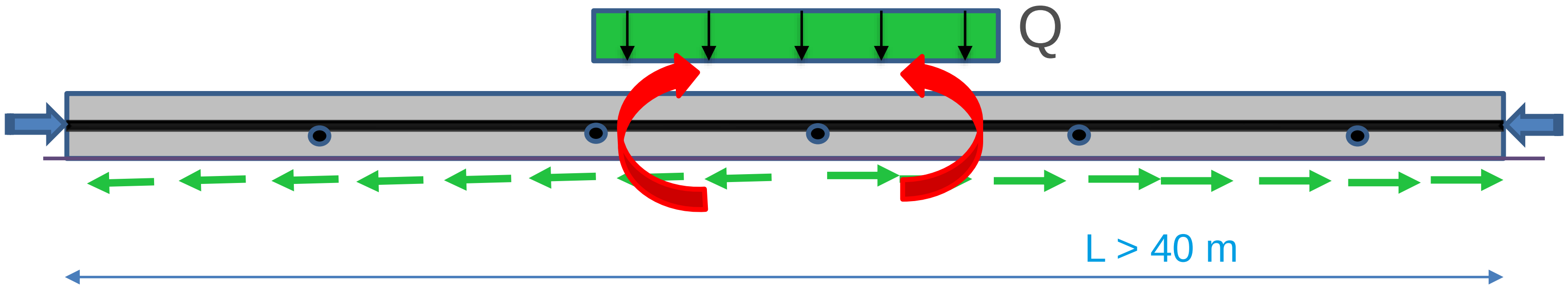
- Starts working after the initiation of cracking = Passive reinforcement
- Impart post-crack/ residual flexural strength to concrete
- Impart ductility to the structure
- Design is based on “inelastic” or “yield line” method

Post-tensioning

- Works on the principle of indirectly increasing the “first” crack strength of concrete by pre-compression of the section = Active reinforcement
- No post crack capacity available
- Failure mode is brittle and no ductility is foreseen
- Design is based on “elastic” method

SigmaSlab® : Basic principles

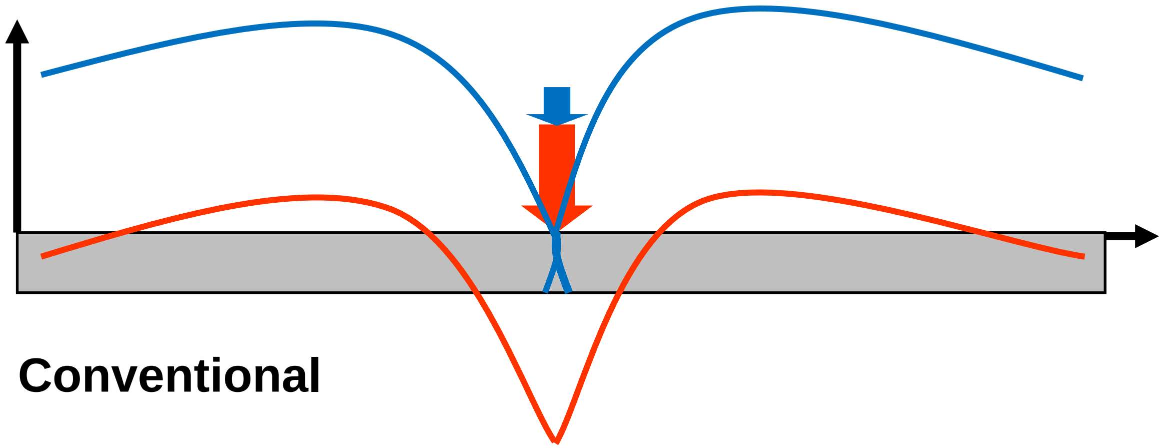
- ✓ Stresses due to acting forces are taken by Dramix® steel fibres with additional help due to pre-compression of the section due to PT. Additionally, PT allows larger joint spacing
  - ✓ Higher loads ➔ Higher Dramix® dosage ➔ ULS
  - ✓ Higher joints spacing and/or higher restraint factor ➔ Closer spaced tendons ➔ SLS
- ✓ Stresses due to restraint shrinkage are taken by Dramix® steel fibres in the section
- ✓ Smaller crack openings ➔ Higher Dramix® dosage
- ✓ An overall cost and time saving solution!



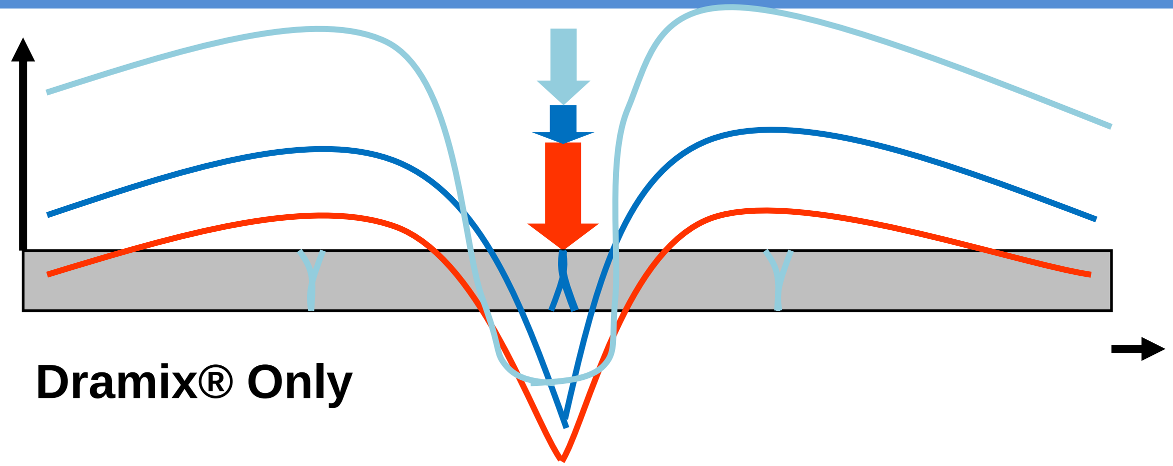
Σ ➡ = *CCL XU Unbonded or XF Bonded PT*

Σ ↻ = *Dramix® Steel Fibres*

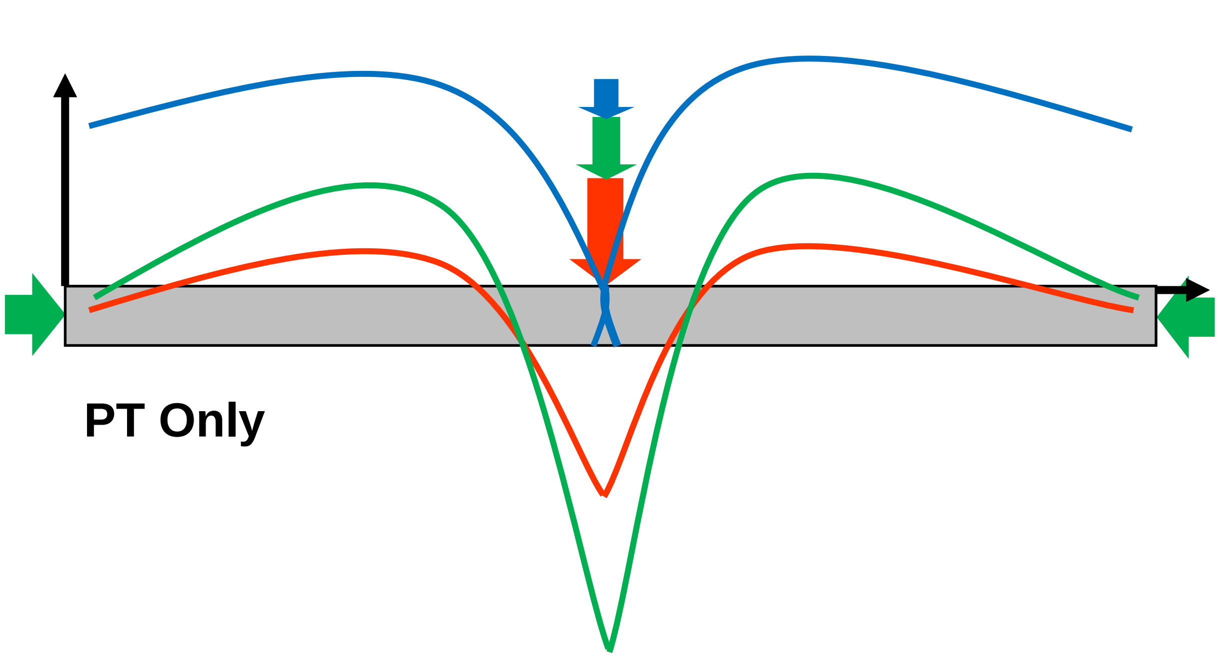
SOG behavior for various reinforcing systems in ULS



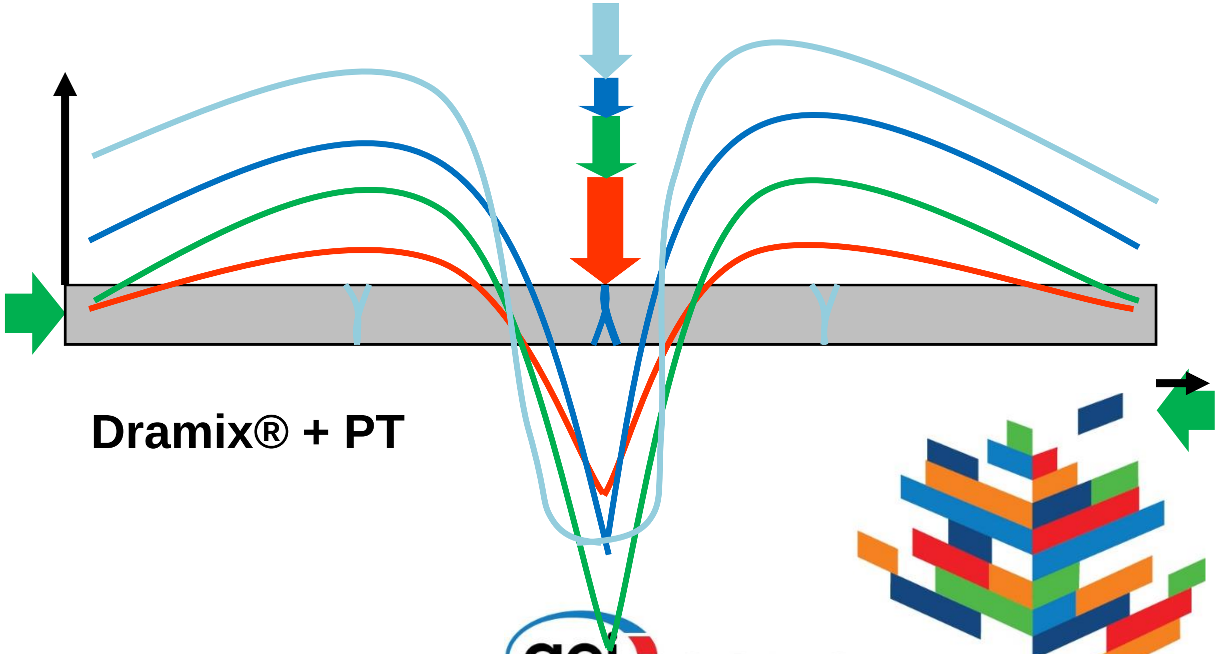
Conventional



Dramix® Only



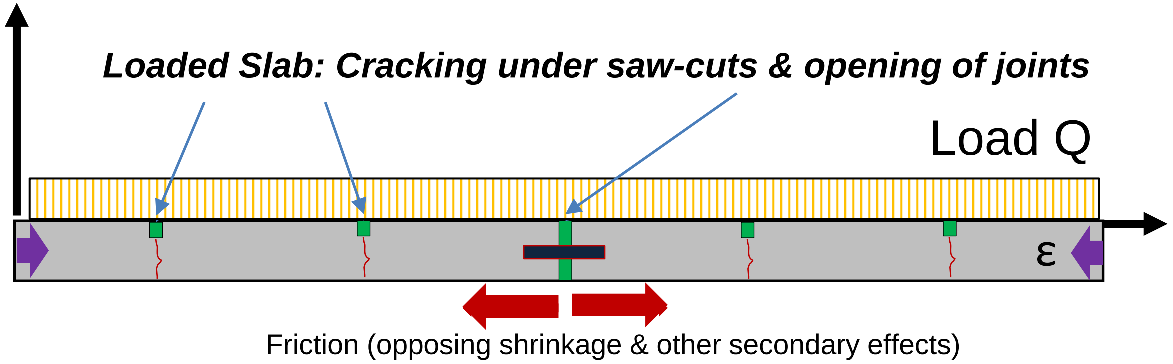
PT Only



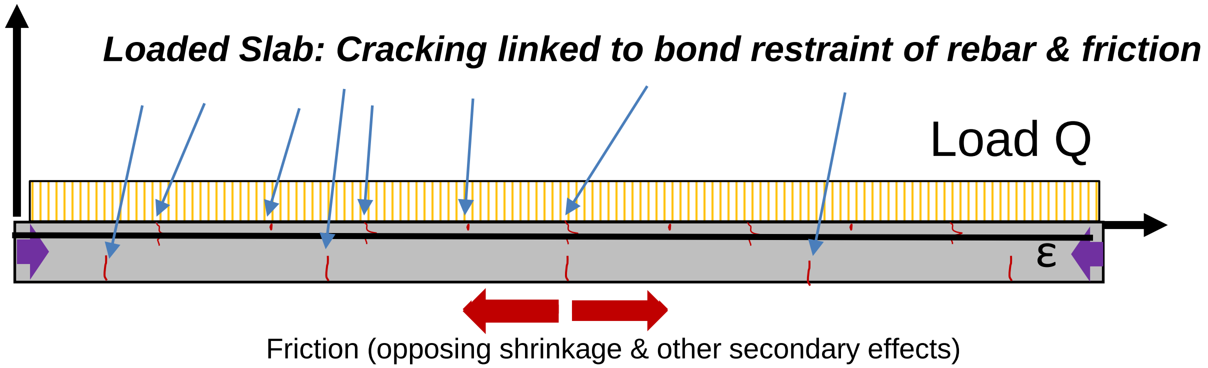
Dramix® + PT

SOG behavior for various reinforcing systems in SLS

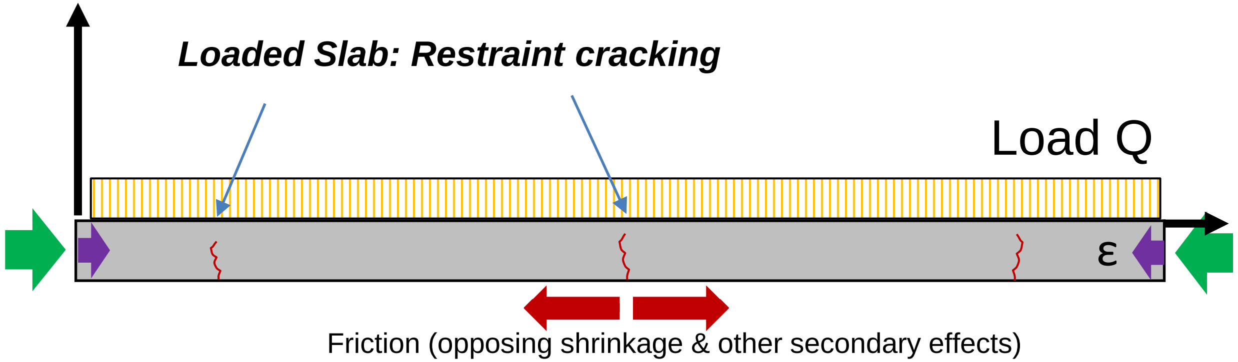
Conventional/ Dramix® Only



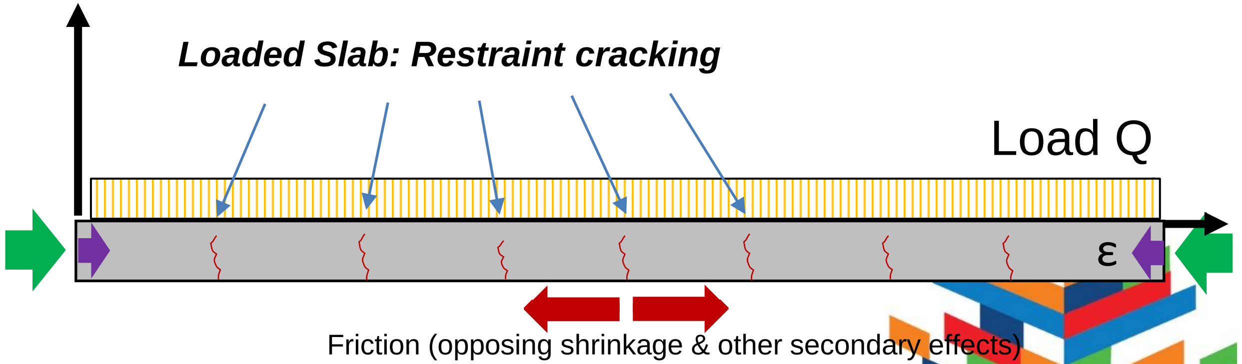
Dramix® + Reinforcement



PT Only



SigmaSlab®

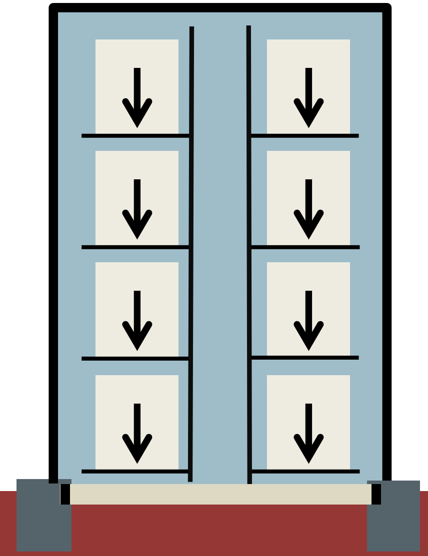


Field of applications – Sigmaslab 3 systems

Sigmaslab® G

Ground supported slabs

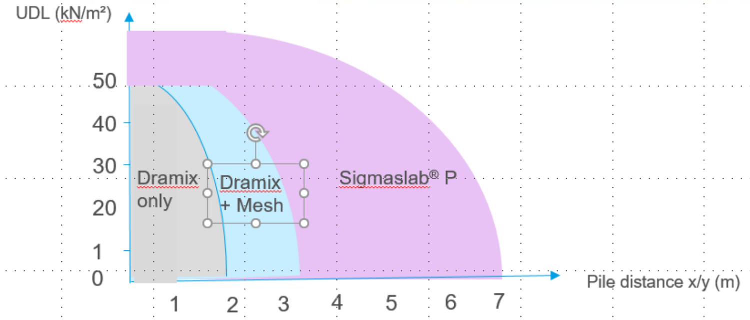
- Seamless floors (*Joint spacing >>> 130 ft*)
- Clad Racks
- Foundation rafts
- Outdoor concrete pavements

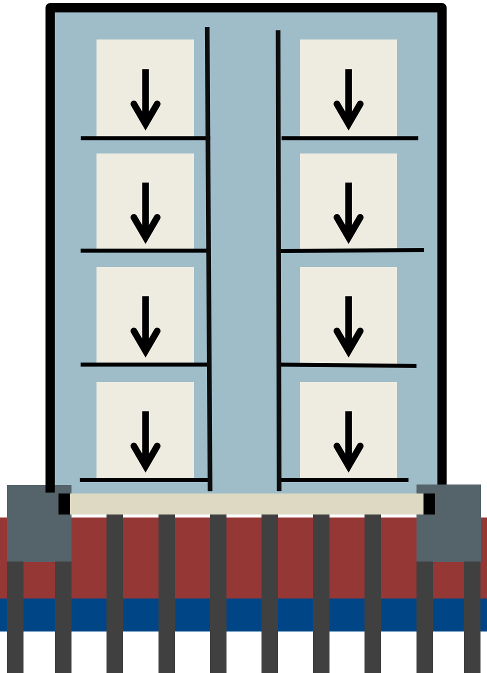


Sigmaslab® P

Pile supported ground slabs

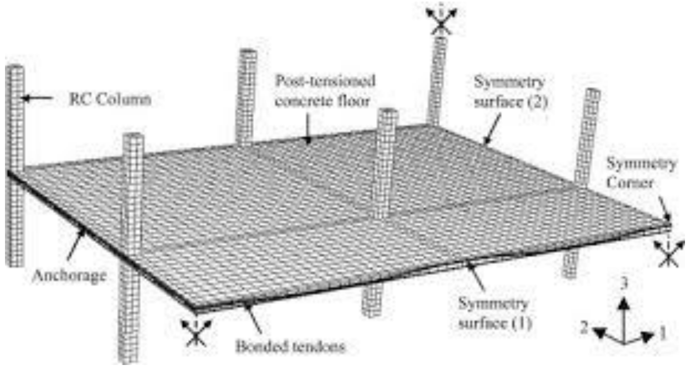
- Scope





Sigmaslab® E

Elevated decks & Mezzanines



Innovative flooring solutions – Aertssen outdoor pavement

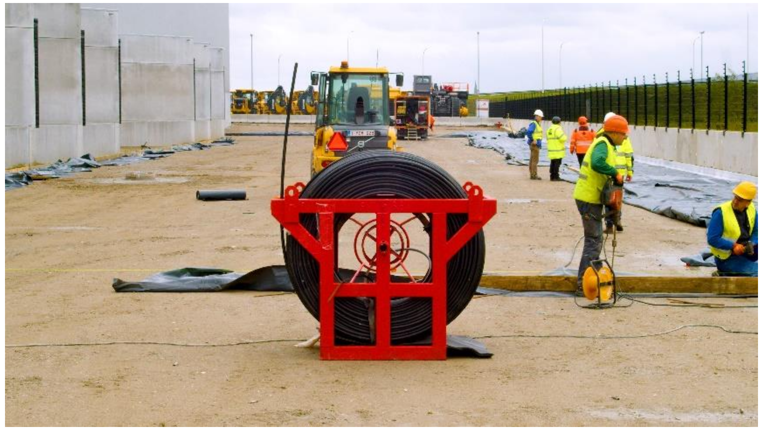
Aertssen warehouse next to brand new company HQ, new loading bay area.

Flooring contractor: Delporte.

- Optimal combination of Dramix® steel fibers and post-tensioning system from CCL.
- Faster, safer and easier installation process, CO_2 and cost savings for contractor.
- Longer life & lower maintenance for end-user.

Reference 1 : Aertssen – Belgium – Outdoor pavement





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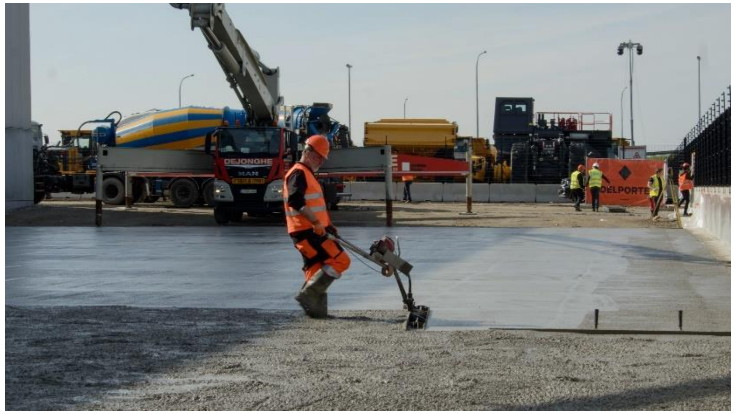

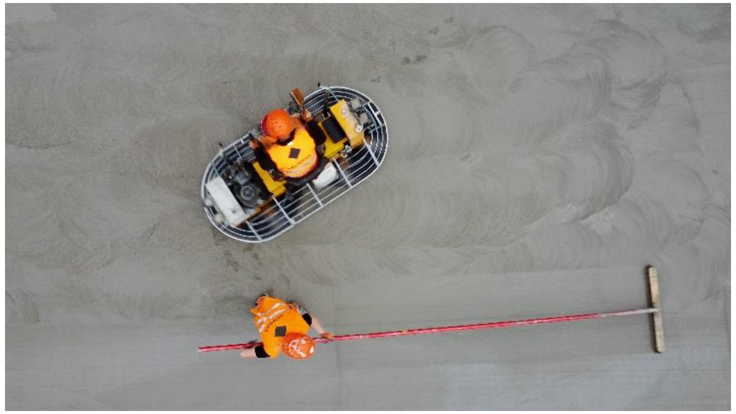

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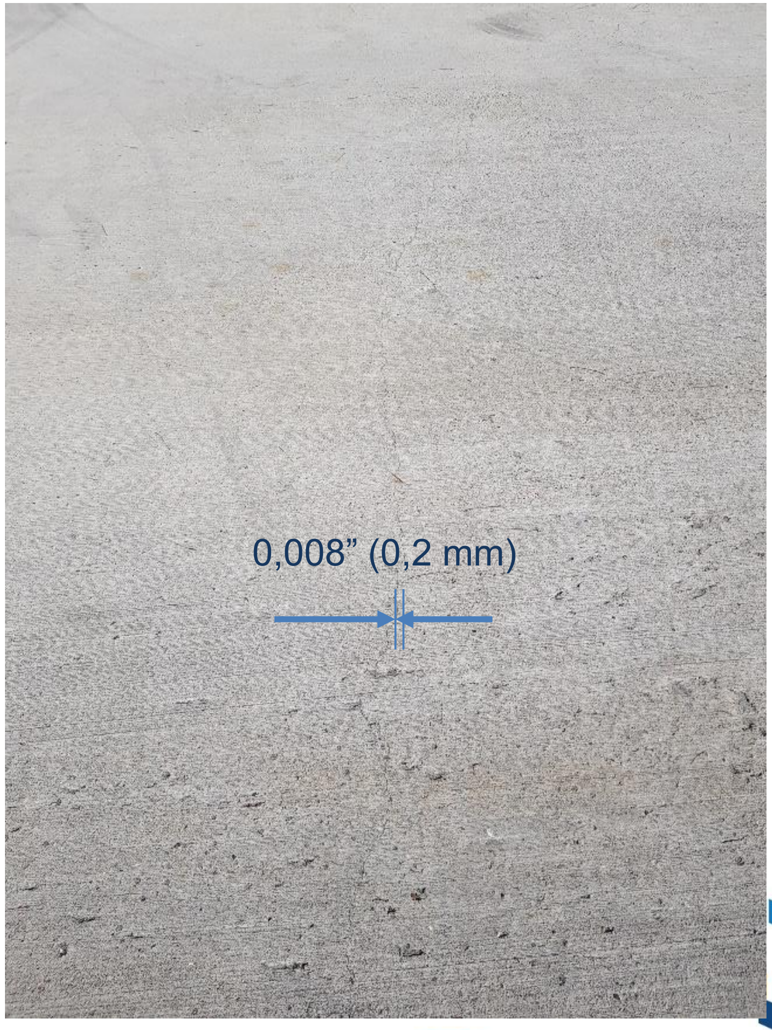
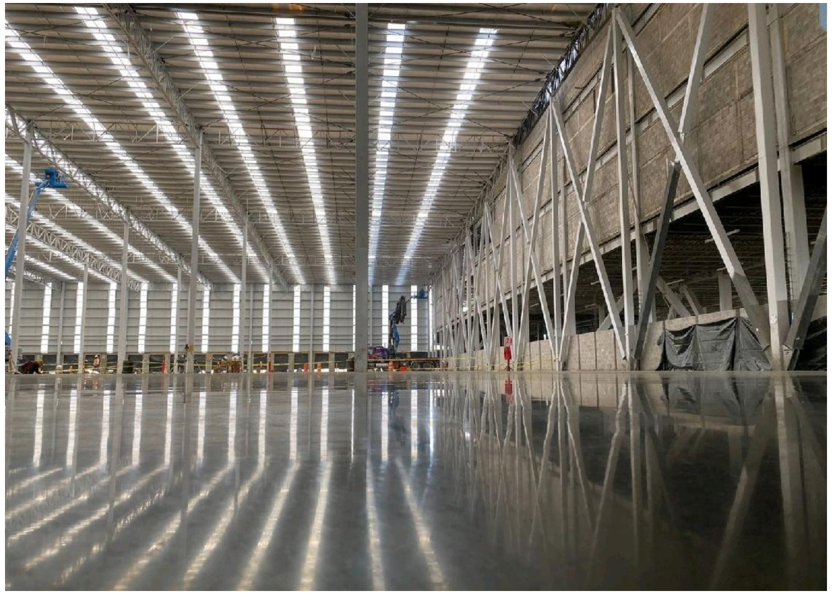


Reference 2 : Coppel – Mexico – Distribution centre



Type : Sigmaslab® G

Surface : 655.000 ft² (60.819 m²)

Slab thickness : 6,7 inch (170 mm)

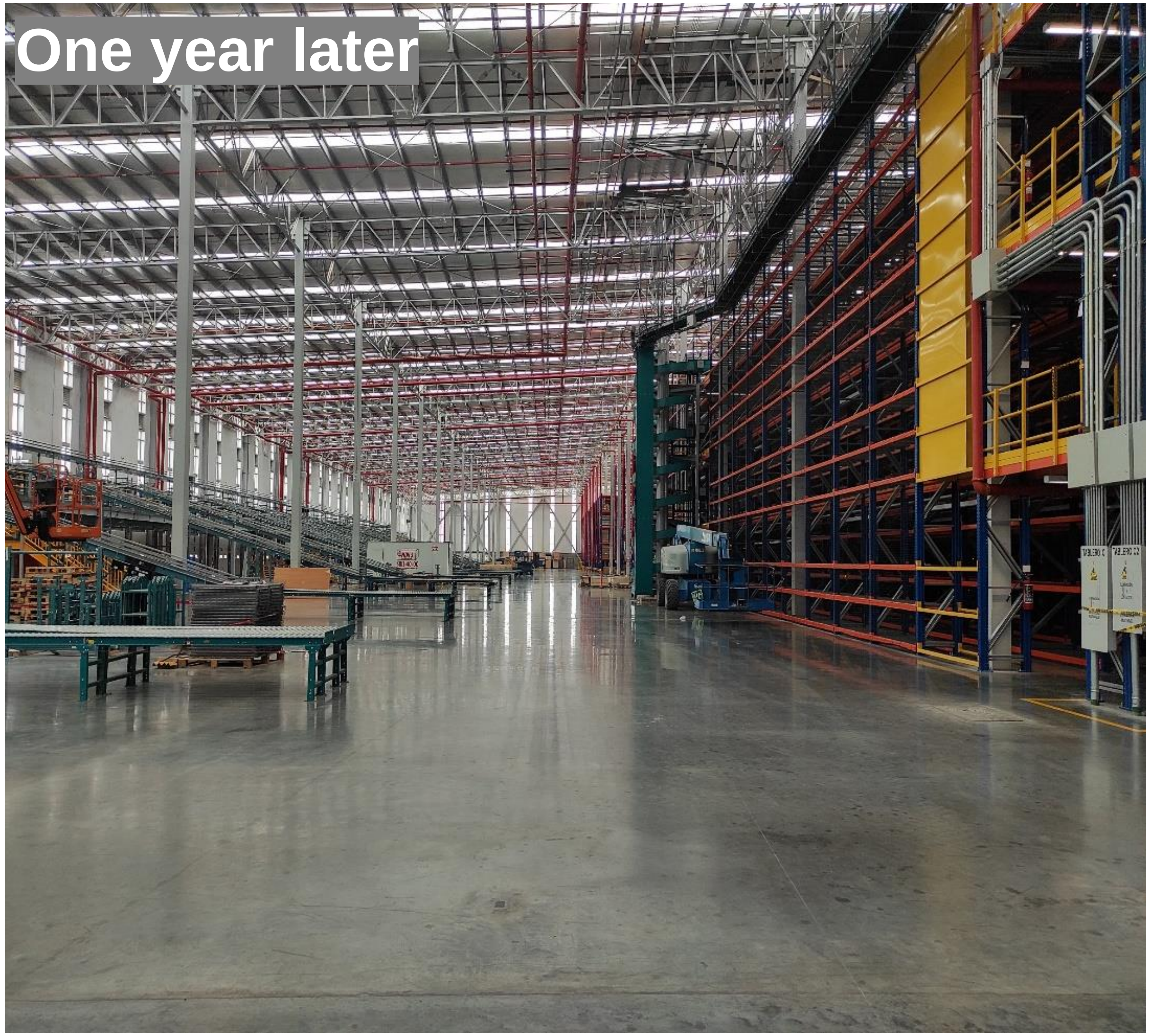
Fibre type : Dramix® 4D 65/60BG

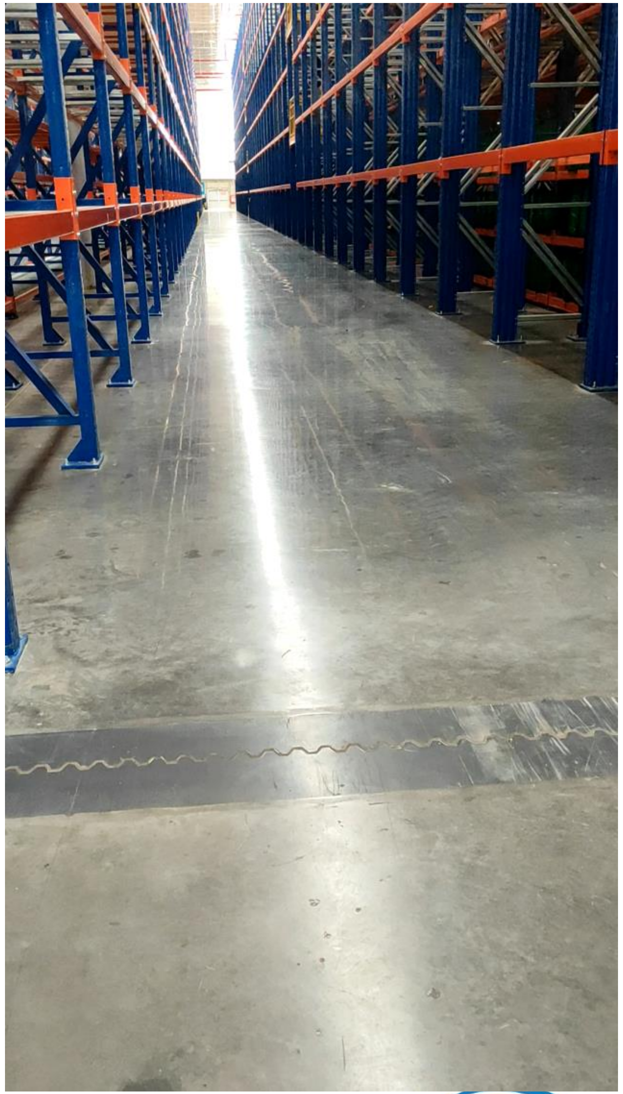
Fibre dosage : 42 pcy (25 kg/m³)

Strand spacing : 13 ft (4 m (2 strands per duct))

PT system : bonded

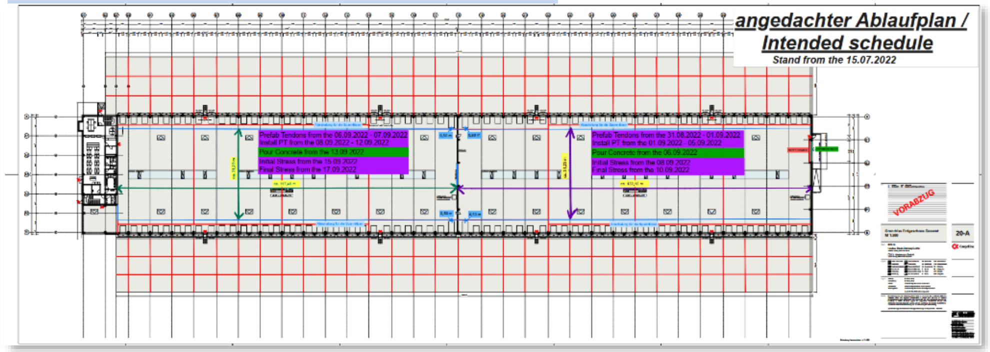
Reference 2 : Coppel – Mexico – Distribution centre





Reference 3 : CDC – Germany – Distribution centre

Executed : August 2022

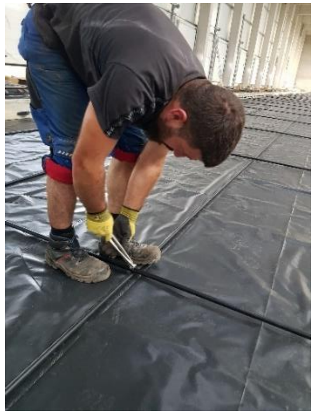


CDC
Cargoline Allee 1
36272 Niederaula
Germany

- Total area : 80,500 ft² (7.482 m²)
  - Area 1 : 102 (31,23) x 385 ft (117,48 m jointless)
  - Area 2 : 102 (31,23) x 400 ft (122,10 m jointless)
- Slab thickness : 7 inch (180 mm) 4500 psi (C30/37)
- Reinforcement :
  - 42 pcy (25 kg/m³) Dramix® 4D 65/60BG
  - 0,62 inch (15,7 mm) Strands 4,9 x 8,2 ft (1,5 x 2,5 m)

Materials

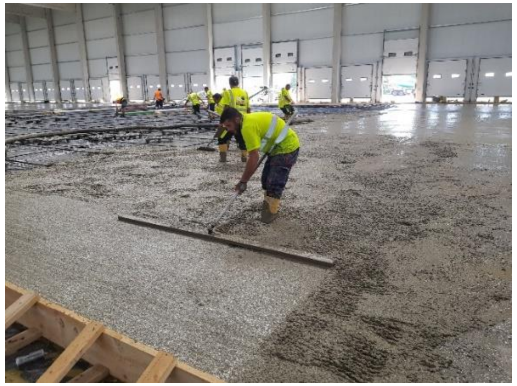
Preparation



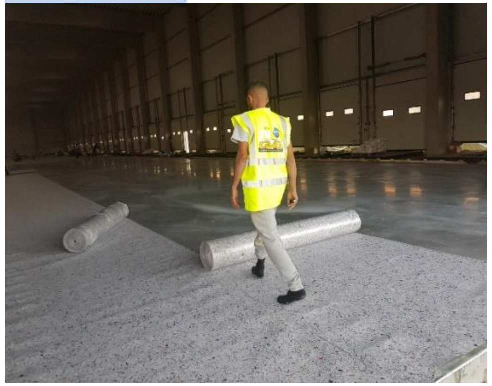
Reference 3 : CDC – Germany – Distributtion centre

Casting

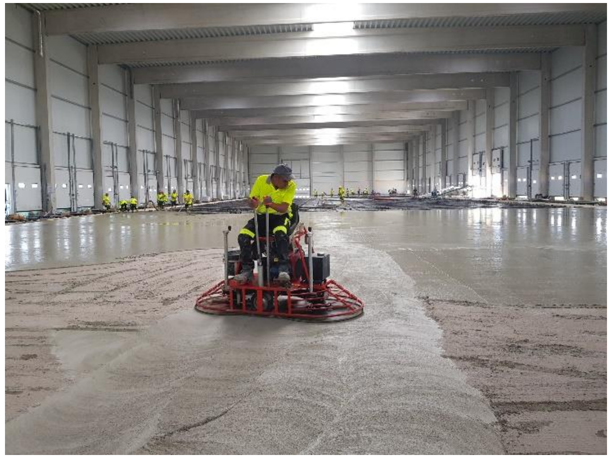




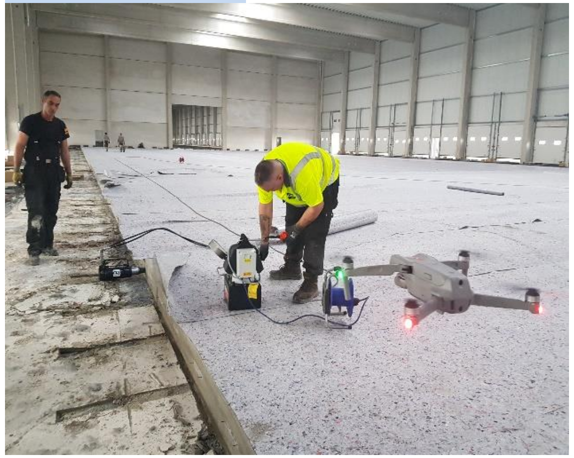
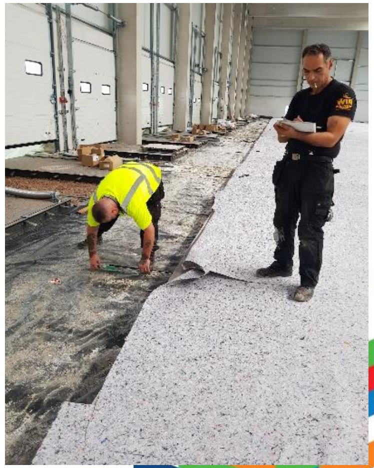
Curing




Finishing

Stressing


6 months later
No joints
Jointless area’s up to 200,000 ft²
70 % less steel
50 % less labour
50 % faster construction
50 % CO_2 reduction
20 % lower total cost of ownership (TCO)
This is the sound you’ll hear driving on the floor...

SigmaSlab® E : Virginia Tech Testing Overview

Objectives

- Evaluate performance of SigmaSlab® as a construction system in comparison with traditional PT + Rebar slabs
- Investigate performance of banded-uniform vs banded-banded tendon arrangement joint with PTI

Thanks to

Virginia Tech 1872

Evaluation

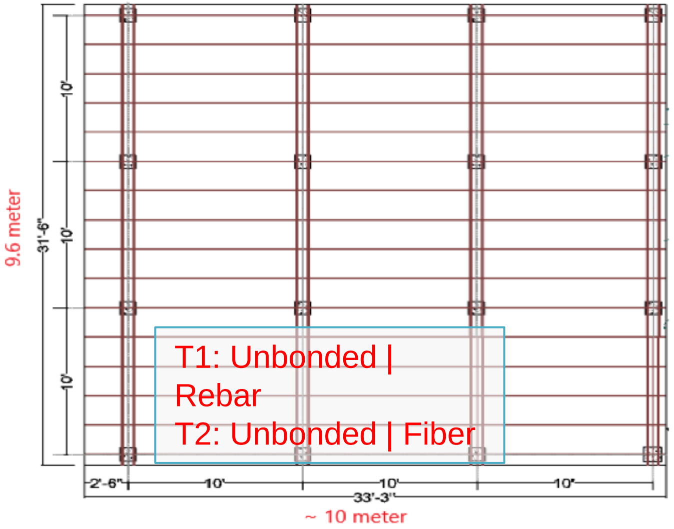
- Assess flexural behavior at service for deflection and cracking
- Assess flexural behavior at ultimate, failure load and mechanism
- Determine requirements for minimum reinforcement in positive and negative moment regions
- Assess PT layout of banded-uniform vs band-banded.

Testing Program – Five Test Slabs over 3 years

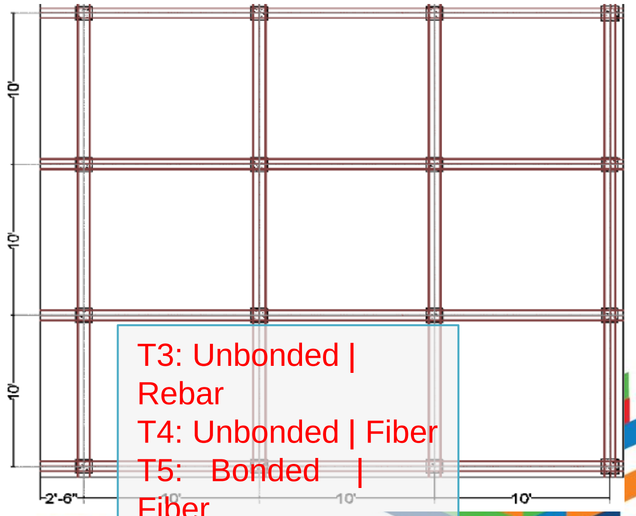
Full-scale Prototype | Third-Scale

- Spans : 9m | 3m
- Slab : 22.5cm | 7.5 cm
- PT : Unbonded

- Reinf : Rebar | Fiber
- PT Layout : Banded-Unif | Banded-Banded
- PT System : Unbonded | Bonded



Specimen	PT System	Layout	Rebar
T1	Unbonded	Banded-Uniform	Rebar
T2	Unbonded	Banded-Uniform	Fiber
T3	Unbonded	Banded-Banded	Rebar
T4	Unbonded	Banded-Banded	Fiber
T5	Bonded	Banded-Banded	Fiber



Sample Crack Behavior

Crack mapped at every 10 psf (0.5 kN/m^2) for each load cycle!

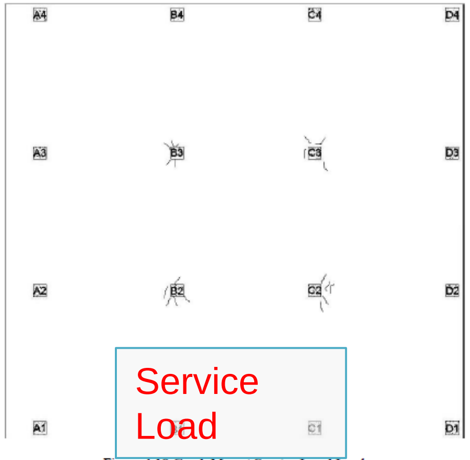


Figure 4.10-Crack Map at Service Level Load

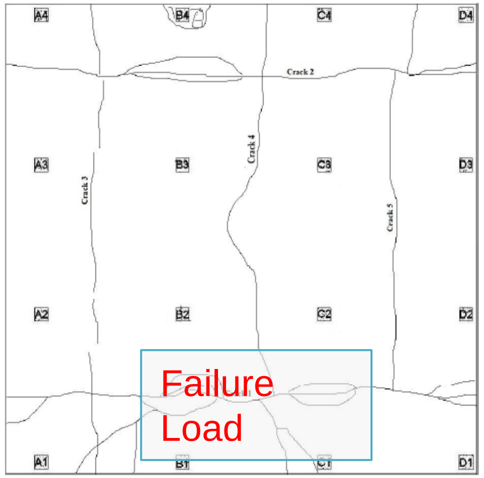


Figure 4.27-Bottom of Slab Crack Pattern at Ultimate Load

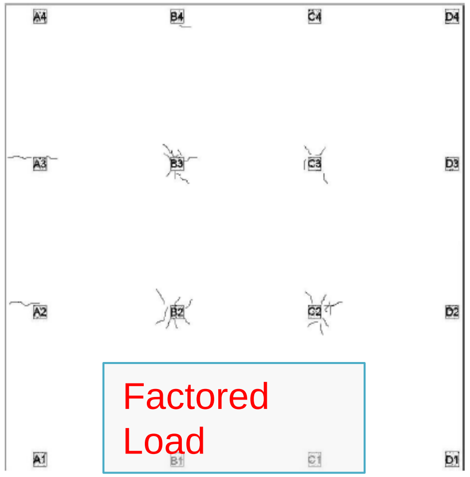


Figure 4.16-Top of Slab Crack Pattern at Factored Load

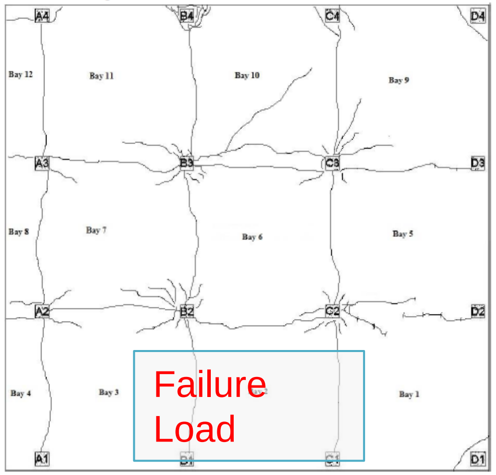


Figure 4.26-Top of Slab Crack Pattern at Ultimate Load

Specimen T1

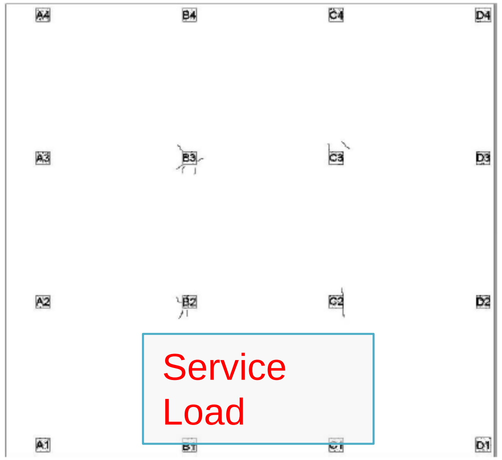


Figure 6.8-Crack Map at Service Level Load

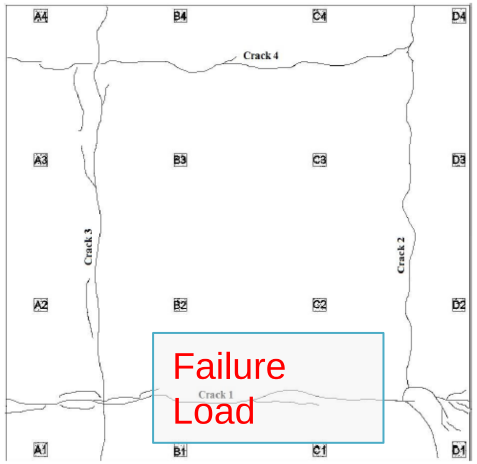


Figure 6.23-Bottom of Slab Crack Pattern at Ultimate Load

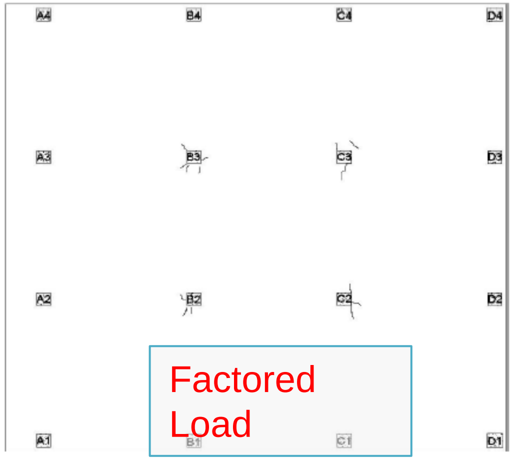


Figure 6.14-Top of Slab Crack Pattern at Factored Load

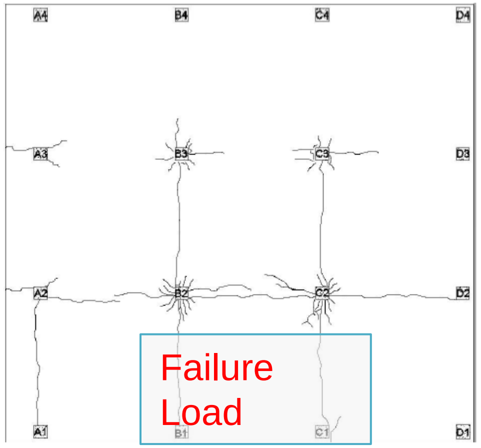


Figure 6.22-Top of Slab Crack Pattern at Ultimate Load

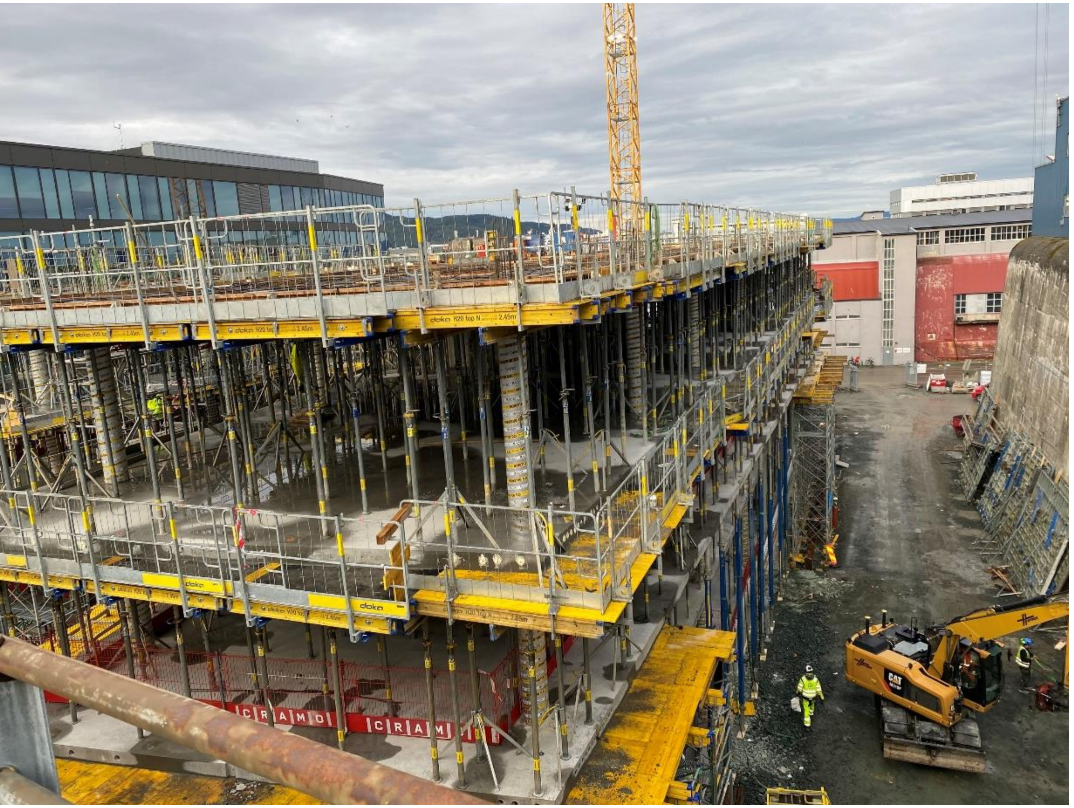
Specimen T4

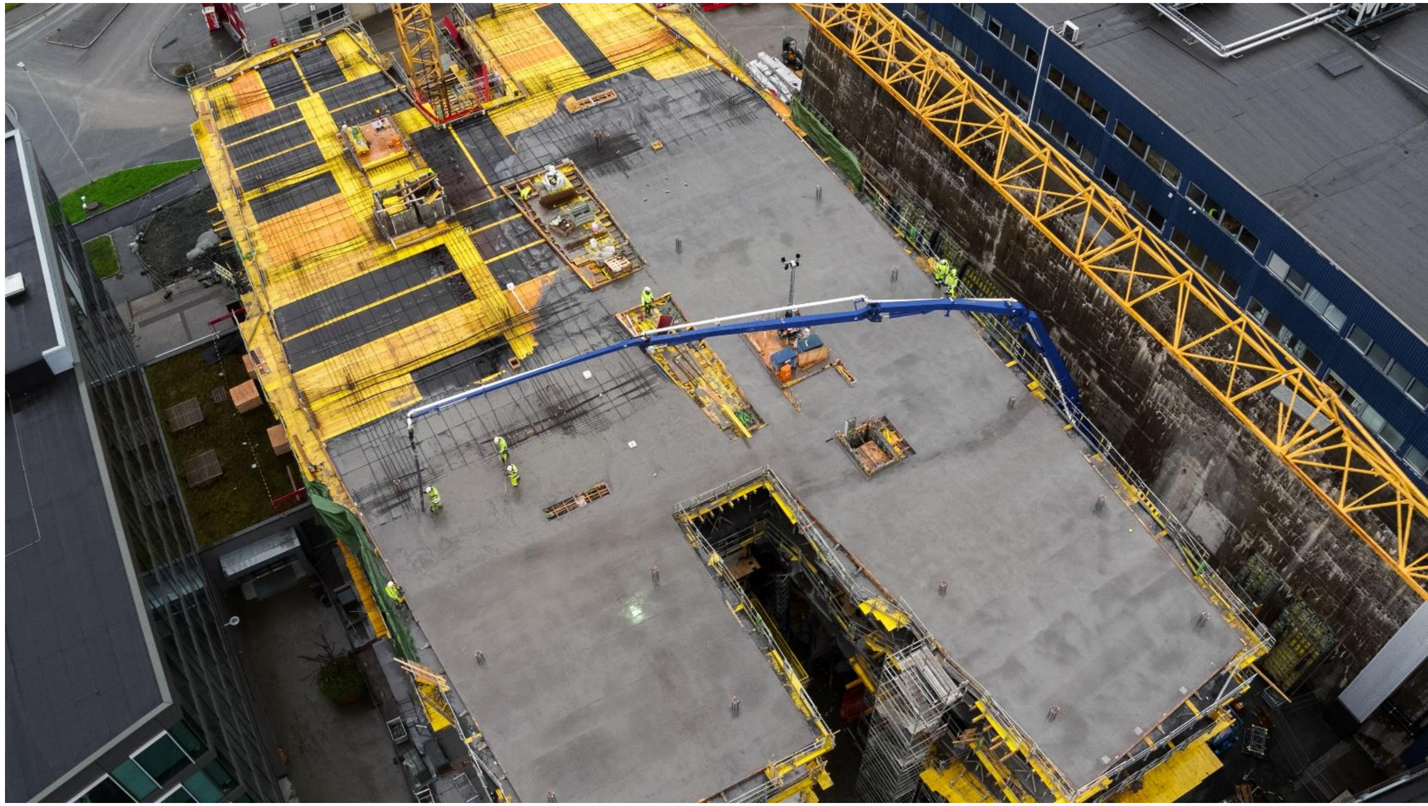
• Summary Results

Measurement	Specimen T1	Specimen T2	Specimen T3	Specimen T4	Specimen T5
Maximum deflection at 80 psf of applied load (before bottom crack)	0.152 in.	0.197 in.	0.159 in.	0.133 in.	
Maximum characteristic crack width at service load	0.25 mm (0.010 in.)	0.24 mm (0.010 in.)	0.20 mm (0.008 in.)	0.10 mm (0.008 in.)	
Maximum characteristic crack width at factored load	0.30 mm (0.012 in.)	0.34 mm (0.008 in.)	0.20 mm (0.008 in.)	0.15 mm (0.008 in.)	
Maximum strain in bottom slab reinforcement at service	45 (μstrain)	-	59 (μstrain)	-	
Maximum strain in top slab reinforcement at service	166 (μstrain)	-	174 (μstrain)	-	
Maximum concrete surface strain on top of slab at service	363 (μstrain)	500 (μstrain)	303 (μstrain)	100 (μstrain)	
Applied load at first bottom crack	84 psf 82.3 psf	80 psf	80 psf	130 psf	320 psf
Ultimate applied load	211.2 psf	174 psf	199.8 psf	231.4 psf	
Yield line analysis ultimate load with ACI f_r	314 psf	310 psf	303.9 psf	337.5 psf	
Ultimate load (Applied + self-weight + dead load compensation)	194 psf 321.2 psf	284 psf	309.8 psf	343.9 psf	430 psf

Design Factored Applied Load SDL+LL = 84 psf = 4.2 kN/m2
Design Factored Total Load SW+SDL+LL = 194 psf = 9.6 kN/m2

Reference 1 : Nyhavna Project – Trondheim (Norway)






QUESTIONS