History of OptiSlab

From Research Idea to Production-Ready Engineering Software

Juan Pablo Covarrubias V. | LTPisos | Aug 2026

Juan Pablo Covarrubias V.

- Managing Director of OptiPave LLC , FORTA Groupe
- Director LTPisos
- **Director of ISCP**
- Professor at U. Católica , U. Chile

The Journey

A decade of innovation: 2012–2026

Paradigm: Thickness as a fundamental value

- Port Design:

35 cm

10 cm

A Decade of Innovation: 2012–2026

2012–15 · Analytical Foundation

~OptiFloor, first iteration , very simplified models of stress calculation

2015–17 · OptiLoad

Completed NN

2017–19 · OptiWheels

Forklifts, point loads, distributed loads

2021 · OptiSlab Born

Molina + Melón: unified platform, economic eval

2021–24 · Eng. + Economics

Cost optimisation as core design objective

2025, OptiSlab 4.13 ·

600+ projects, 7 countries, 5M+ m²

Collaboration: Birth of OptiSlab

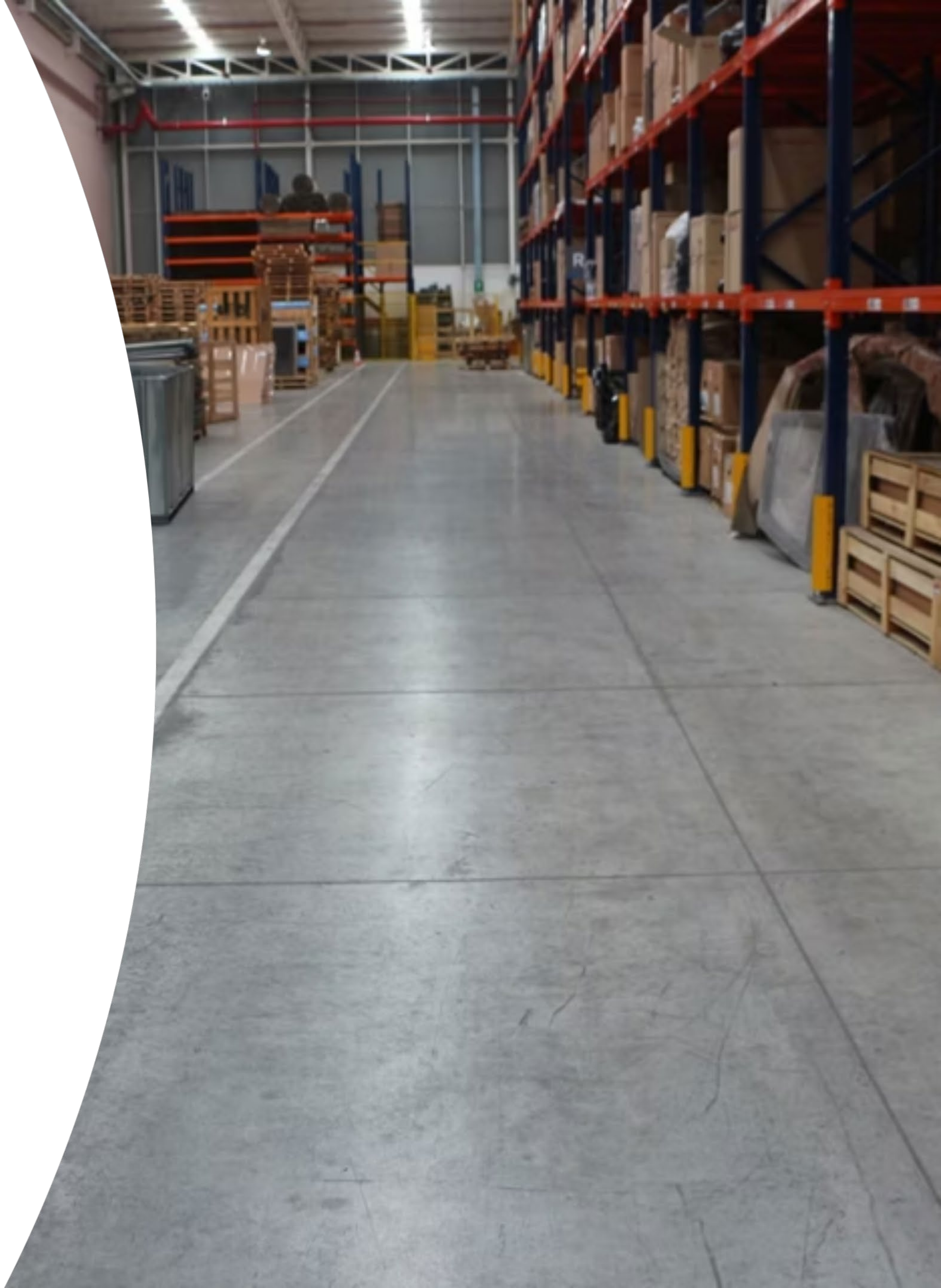
Partnership with Rodrigo Molina and Melón (Chile's largest construction materials supplier) transformed OptiLoad into a comprehensive design platform.

Key additions:

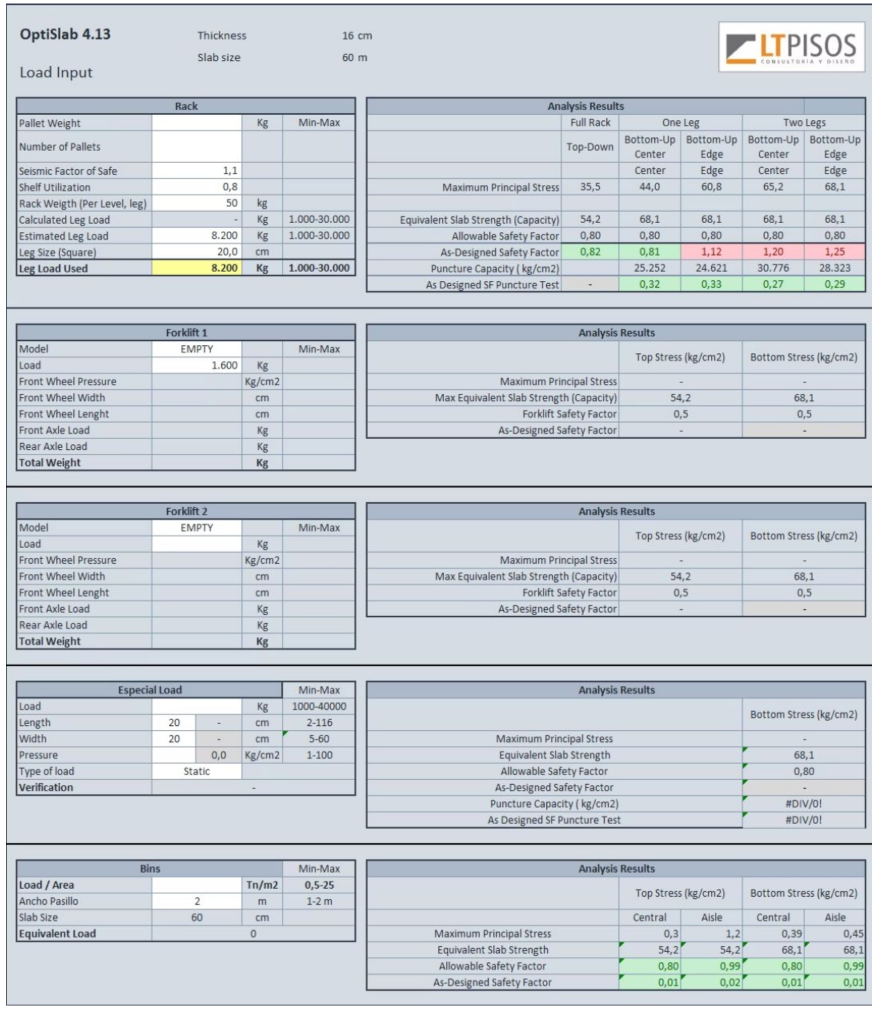
- Integrated load scenarios (racks, forklifts, distributed loads)
- Expanded case library covering diverse project types
- Economic evaluation of alternative solutions

The name 'OptiSlab' was formalised.

This partnership brought together academic research rigor with industrial -scale deployment capability, creating the foundation for a tool that could serve the global market.



OptiSlab Interface: The Design Spreadsheet



OptiSlab 4.13 Thickness 16 cm
Slab size 60 m

Load Input

Rack			
Pallet Weight		Kg	Min-Max
Number of Pallets			
Seismic Factor of Safe	1,1		
Shelf Utilization	0,8		
Rack Weigth (Per Level, leg)	50	kg	
Calculated Leg Load	-	Kg	1.000-30.000
Estimated Leg Load	8.200	Kg	1.000-30.000
Leg Size (Square)	20,0	cm	
Leg Load Used	**8.200**	**Kg**	**1.000-30.000**

Analysis Results	Full Rack	One Leg		Two Legs	
	Top-Down	Bottom-Up Center	Bottom-Up Edge	Bottom-Up Center	Bottom-Up Edge
		Center	Edge	Center	Edge
Maximum Principal Stress	35,5	44,0	60,8	65,2	68,1
Equivalent Slab Strength (Capacity)	54,2	68,1	68,1	68,1	68,1
Allowable Safety Factor	0,80	0,80	0,80	0,80	0,80
As-Designed Safety Factor	0,82	0,81	1,12	1,20	1,25
Puncture Capacity (kg/cm2)		25.252	24.621	30.776	28.323
As Designed SF Puncture Test	-	0,32	0,33	0,27	0,29

Forklift 1			
Model	EMPTY		Min-Max
Load	1.600	Kg	
Front Wheel Pressure		Kg/cm2	
Front Wheel Width		cm	
Front Wheel Lenght		cm	
Front Axle Load		Kg	
Rear Axle Load		Kg	
Total Weight		**Kg**	

Analysis Results	Top Stress (kg/cm2)	Bottom Stress (kg/cm2)
Maximum Principal Stress	-	-
Max Equivalent Slab Strength (Capacity)	54,2	68,1
Forklift Safety Factor	0,5	0,5
As-Designed Safety Factor	-	-

Forklift 2			
Model	EMPTY		Min-Max
Load		Kg	
Front Wheel Pressure		Kg/cm2	
Front Wheel Width		cm	
Front Wheel Lenght		cm	
Front Axle Load		Kg	
Rear Axle Load		Kg	
Total Weight		**Kg**	

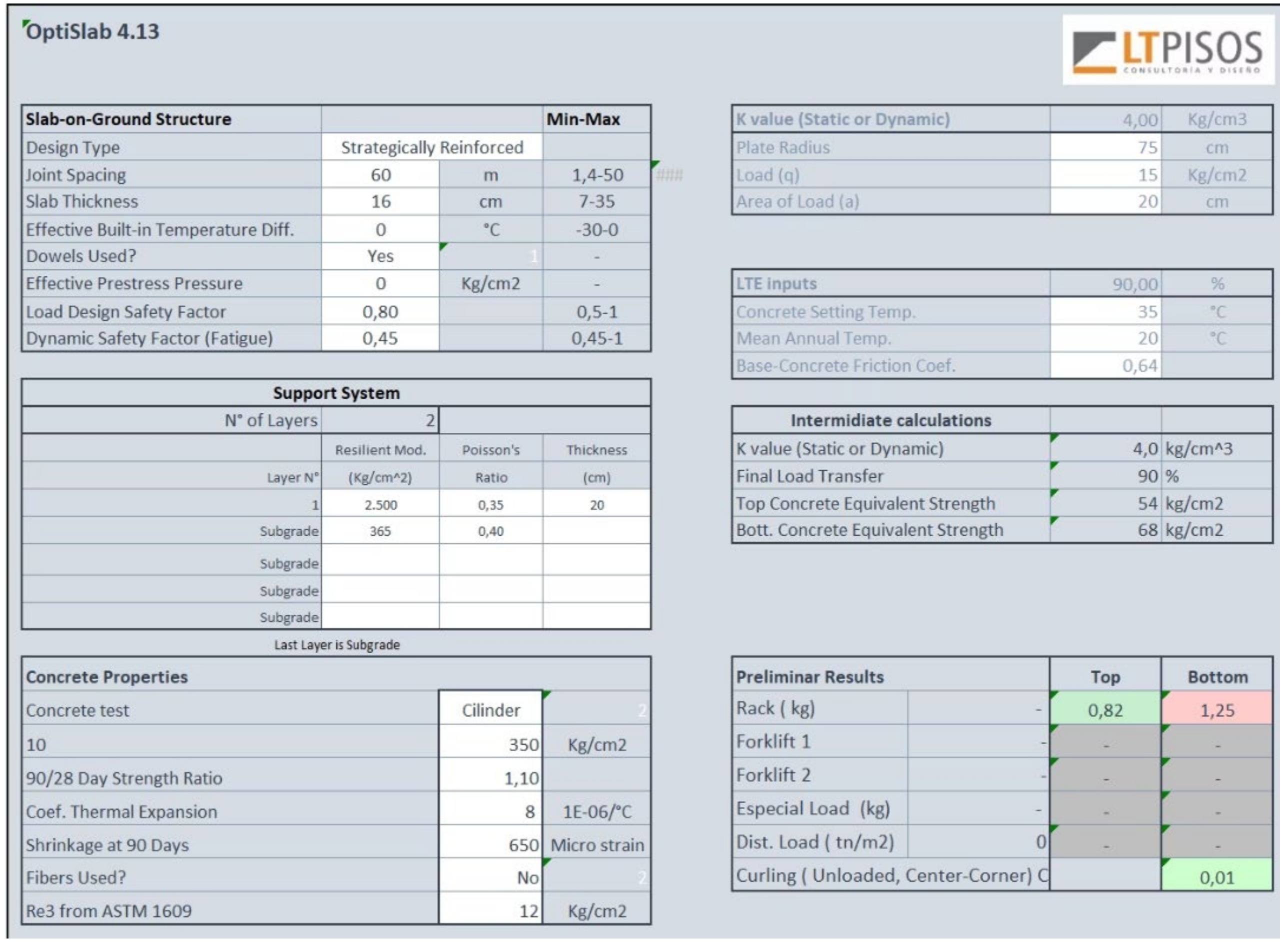
Analysis Results	Top Stress (kg/cm2)	Bottom Stress (kg/cm2)
Maximum Principal Stress	-	-
Max Equivalent Slab Strength (Capacity)	54,2	68,1
Forklift Safety Factor	0,5	0,5
As-Designed Safety Factor	-	-

Especial Load				Min-Max
Load			Kg	1000-40000
Length	20	-	cm	2-116
Width	20	-	cm	5-60
Pressure		0,0	Kg/cm2	1-100
Type of load	Static			
Verification	-			

Analysis Results	Bottom Stress (kg/cm2)
Maximum Principal Stress	-
Equivalent Slab Strength	68,1
Allowable Safety Factor	0,80
As-Designed Safety Factor	-
Puncture Capacity (kg/cm2)	#DIV/0!
As Designed SF Puncture Test	#DIV/0!

Bins			Min-Max
Load / Area		**Tn/m2**	**0,5-25**
Ancho Pasillo	2	m	1-2 m
Slab Size	60	cm	
Equivalent Load	0		

Analysis Results	Top Stress (kg/cm2)		Bottom Stress (kg/cm2)	
	Central	Aisle	Central	Aisle
Maximum Principal Stress	0,3	1,2	0,39	0,45
Equivalent Slab Strength	54,2	54,2	68,1	68,1
Allowable Safety Factor	0,80	0,99	0,80	0,99
As-Designed Safety Factor	0,01	0,02	0,01	0,01



OptiSlab 4.13

Slab-on-Ground Structure			Min-Max
Design Type	Strategically Reinforced		
Joint Spacing	60	m	1,4-50
Slab Thickness	16	cm	7-35
Effective Built-in Temperature Diff.	0	°C	-30-0
Dowels Used?	Yes		-
Effective Prestress Pressure	0	Kg/cm2	-
Load Design Safety Factor	0,80		0,5-1
Dynamic Safety Factor (Fatigue)	0,45		0,45-1

K value (Static or Dynamic)	4,00	Kg/cm3
Plate Radius	75	cm
Load (q)	15	Kg/cm2
Area of Load (a)	20	cm

LTE inputs	90,00	%
Concrete Setting Temp.	35	°C
Mean Annual Temp.	20	°C
Base-Concrete Friction Coef.	0,64	

Support System			
N° of Layers	2		
	Resilient Mod.	Poisson's	Thickness
Layer N°	(Kg/cm^2)	Ratio	(cm)
1	2.500	0,35	20
Subgrade	365	0,40	
Subgrade			
Subgrade			
Subgrade			

Last Layer is Subgrade

Intermidiate calculations	
K value (Static or Dynamic)	4,0 kg/cm^3
Final Load Transfer	90 %
Top Concrete Equivalent Strength	54 kg/cm2
Bott. Concrete Equivalent Strength	68 kg/cm2

Concrete Properties		
Concrete test	Cilinder	
10	350	Kg/cm2
90/28 Day Strength Ratio	1,10	
Coef. Thermal Expansion	8	1E-06/°C
Shrinkage at 90 Days	650	Micro strain
Fibers Used?	No	
Re3 from ASTM 1609	12	Kg/cm2

Preliminar Results		Top	Bottom
Rack (kg)	-	0,82	1,25
Forklift 1	-	-	-
Forklift 2	-	-	-
Especial Load (kg)	-	-	-
Dist. Load (tn/m2)	0	-	-
Curling (Unloaded, Center-Corner) C			0,01

Left: Load input sheet (Module 1) | Right: Design sheet (Module 2 + results)

A complete multi -load design check in seconds — replacing weeks of manual FEM work.

Slab Design Spreadsheet

Inputs considered:

- Concrete strength, MOR ranging from 2 to 7 MPa
- k-value, ranging from 2 to 20 kg/cm3
- Joint spacing, ranging from 1.5 to 10 m
- Load transfer efficiency (LTE) as an average across the joint, ranging from 0 to 95%
- Dowels
- Equivalent linear temperature difference, ranging from 0 to -30 C
- Load magnitude, ranging from 1 to 30 tons (metric) per point
- Applied area of load (assumed square), ranging from 100 to 1,000 cm2
- Existing Slab-to-beam capacity ratio incorporated

Responses predicted:

- Maximum stress (top-down and bottom-up)
- Maximum deflection (load- or curl-related)

Design criteria:

- Maximum allowable stress (top and bottom) considering concrete flexural strength, slab-to-beam ratio, fibers, and factor of safety
- Maximum allowable curling

The Problem

Industrial floors designed with 1920s analytical models

Traditional Design Methods: The Gap

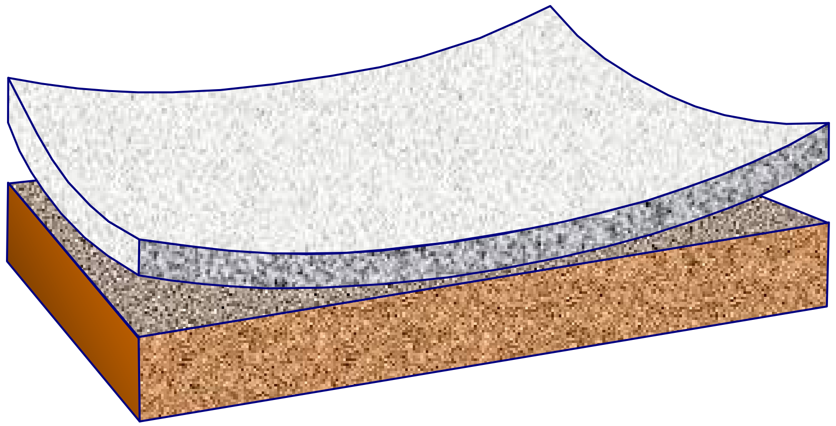
Gap	ACI 360 (Westergaard)	TR34 (Meyerhof)	OptiSlab
Slab Curl	Ignored	Ignored	Modelled
Stress capacity	MOR (lab beam)	Plastic collapse	Slab Capacity
Stress locations	Bottom-up and Corner	Post-crack only	Max principle stress: Top + Bottom
Panel size effect	No	No	Yes (1.4–10 m)

ACI 360 itself warns: its methods give erroneous results when the slab is not in contact with the subgrade.

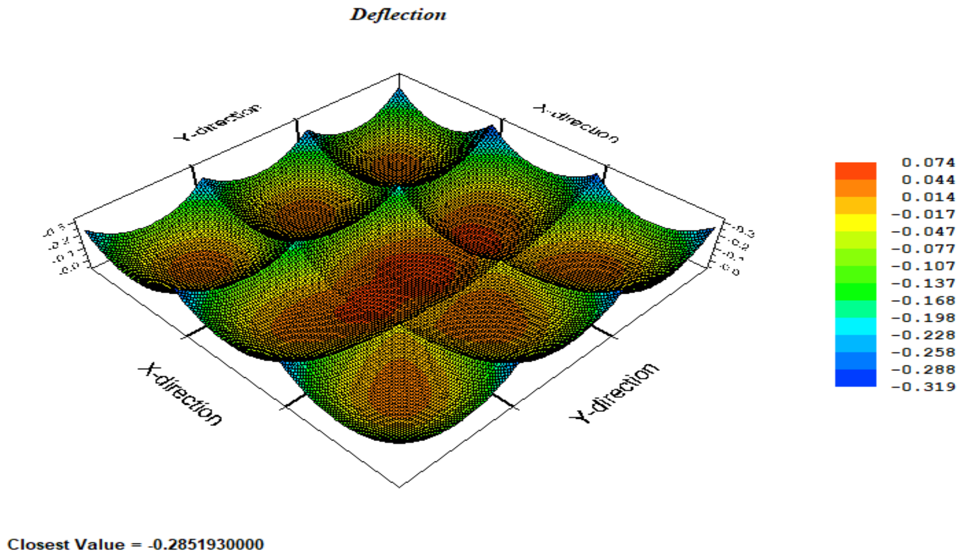
Built in Curl : The Invisible Risk

During concrete placement, the top surface dries and loses heat faster than the bottom. This differential is locked in permanently as the slab hardens, causing edges and corners to curl upward.

OptiSlab represents this effect as a Built-in Temperature Difference:



$$T_{tot} = T_{tg} + T_{mg} + T_{bi} + T_{shr} - T_{crp}$$



3D deflection surface showing slab curling (ISLAB2000)

Why MOR Fails as a Design Property

MOR (Modulus of Rupture) is a 150×150×500 mm lab beam test.

It does NOT represent actual slab capacity in the field.

Slab capacity depends on:

- Slab thickness (not captured by MOR)
- Fiber reinforcement (post-crack toughness)
- Time 28/90 day strength

OptiSlab replaces MOR with a corrected admissible stress:

$$\sigma_{adm} = (R_f + t \cdot s) \cdot F_e \cdot C_1 \cdot C_2 \cdot F_s$$

Fe

28 to 90 days strength

C1

Slab to Beam Ratio (changes with Thickness)

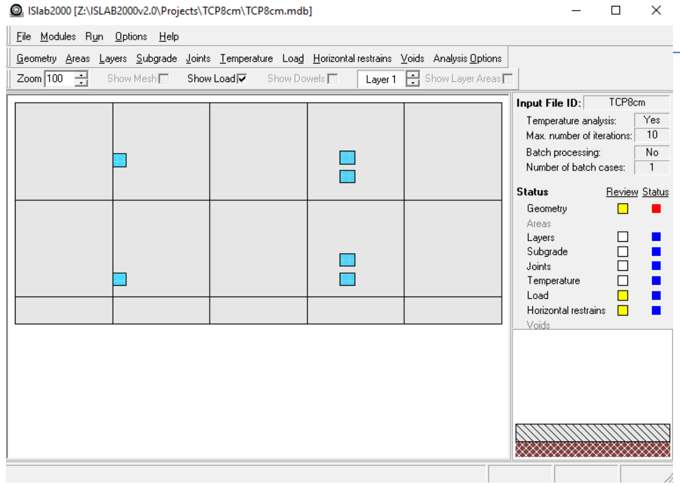
C2

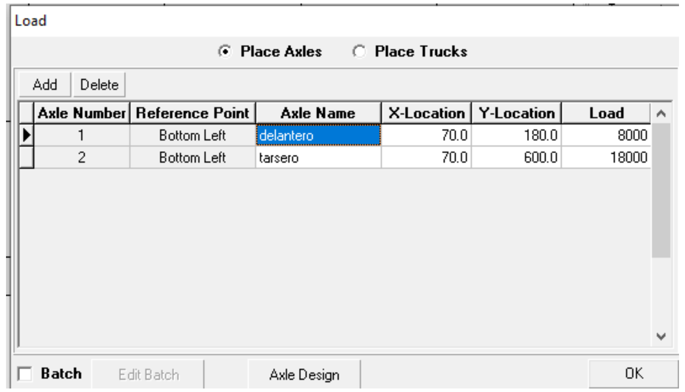
Fiber factor (ASTM C1609)

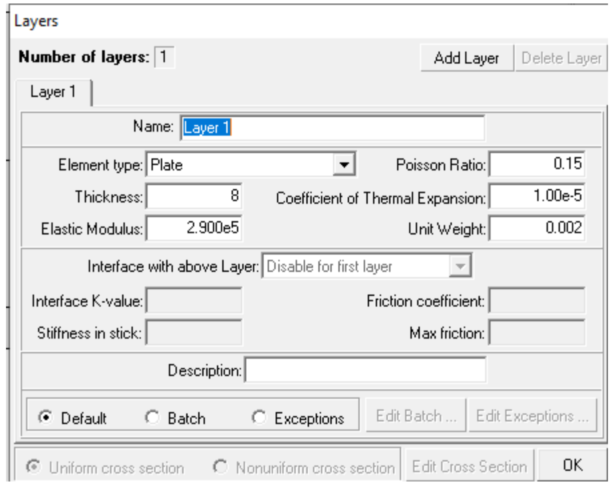
Fs

Safety Factor

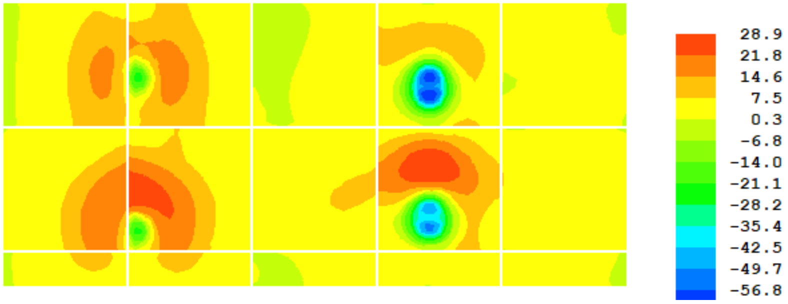
Slab Capacity Paradigm, 8 cm (3,5 in) Pavement)



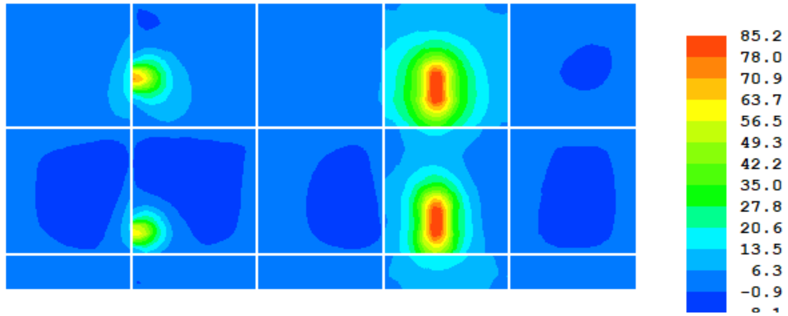




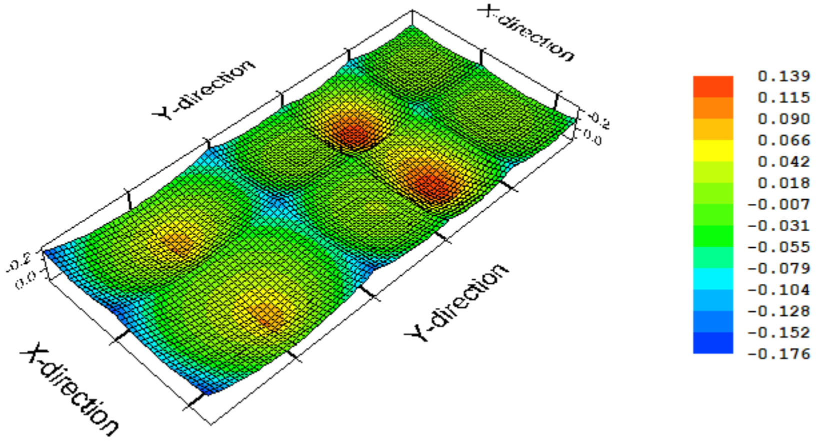
Principal Stresses

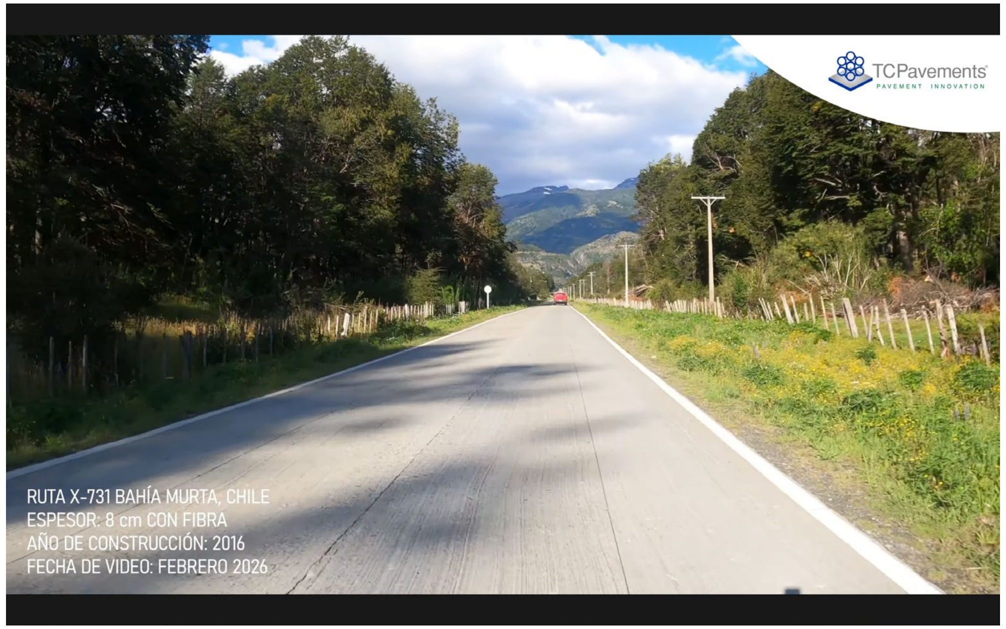


Principal Stresses



Deflection





https://www.youtube.com/watch?v=8sM9jQOus8k&list=PLVPF8GuMdWUcvaJSWXvfLmxIo4u98Zbq_&index=24

The Solution

A mechanistic approach built from first principles

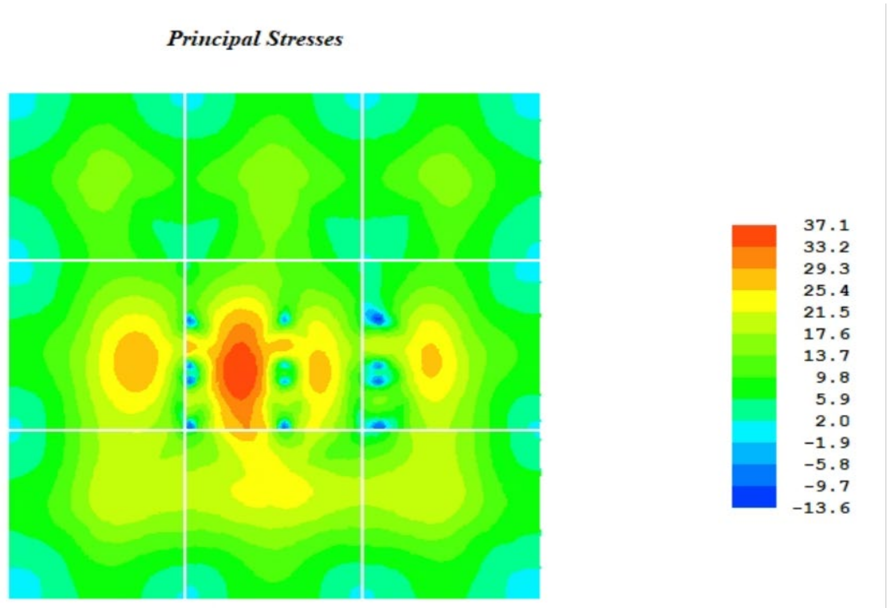
The Engine: ISLAB2000 Finite Element Model

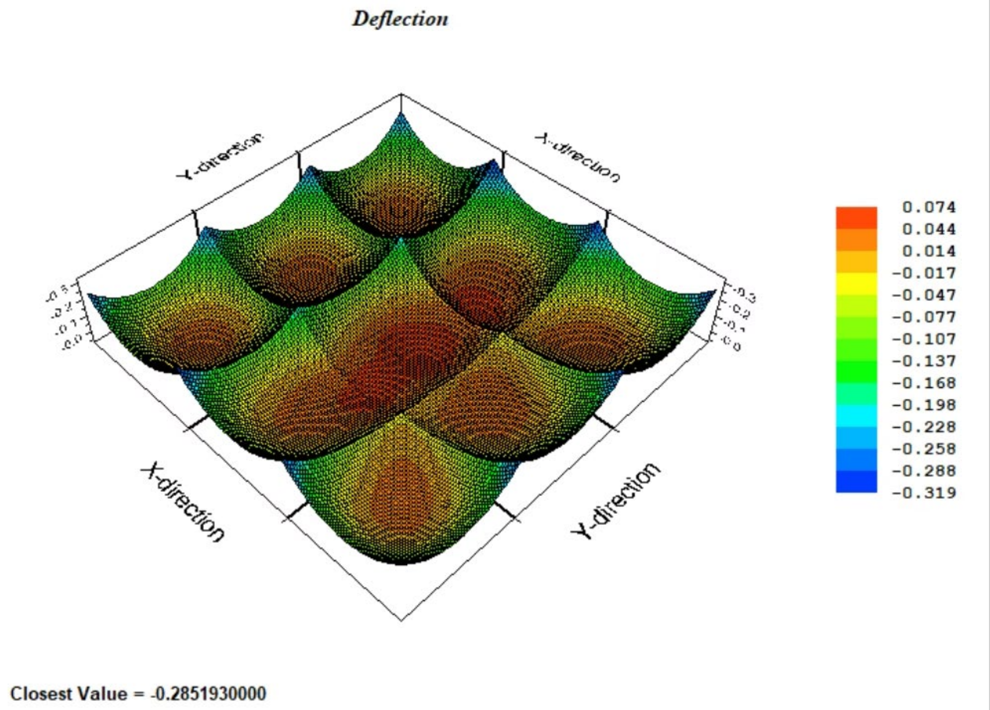
ISLAB2000 is the computational backbone of OptiSlab .

Unlike Westergaard (infinite plate, no curling), ISLAB2000:

- Models finite slab dimensions and real panel geometry
- Accounts for curling (T_bi) and loss of subgrade contact
- Computes load transfer across joints (aggregate interlock, dowels)
- Predicts top-down AND bottom-up stresses simultaneously

~1 million ISLAB2000 runs form the training dataset for OptiSlab's ANN models.





The Science

Neural networks trained on 2 million finite element simulations

Neural Network Surrogates: How They Work

Instead of solving PDEs each time, the ANNs learned the solution from ~1 million pre-computed FEM results.

Inputs:

Slab geometry, material properties, load configuration, temperature gradient

Outputs:

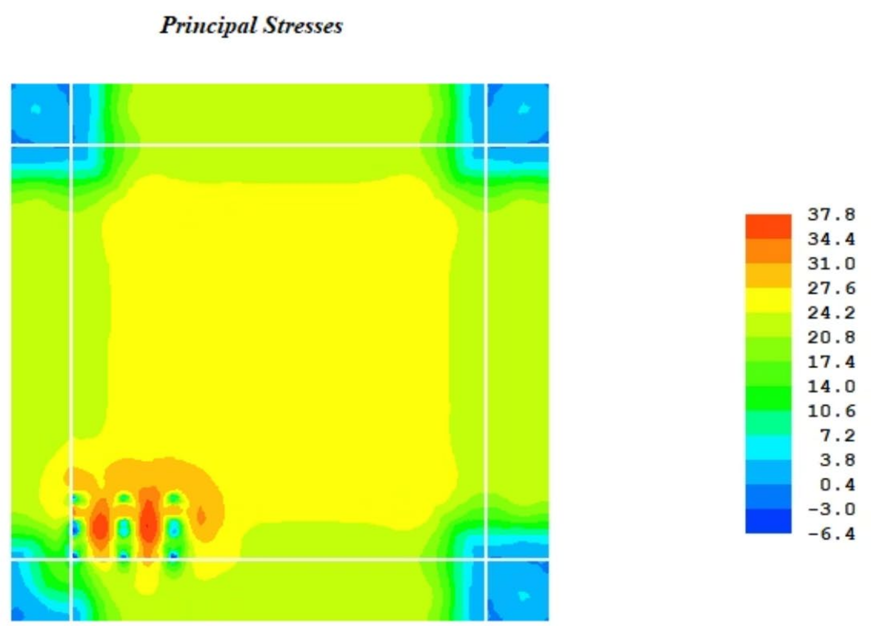
Principal stresses (top and bottom), max deflection for all slab conditions

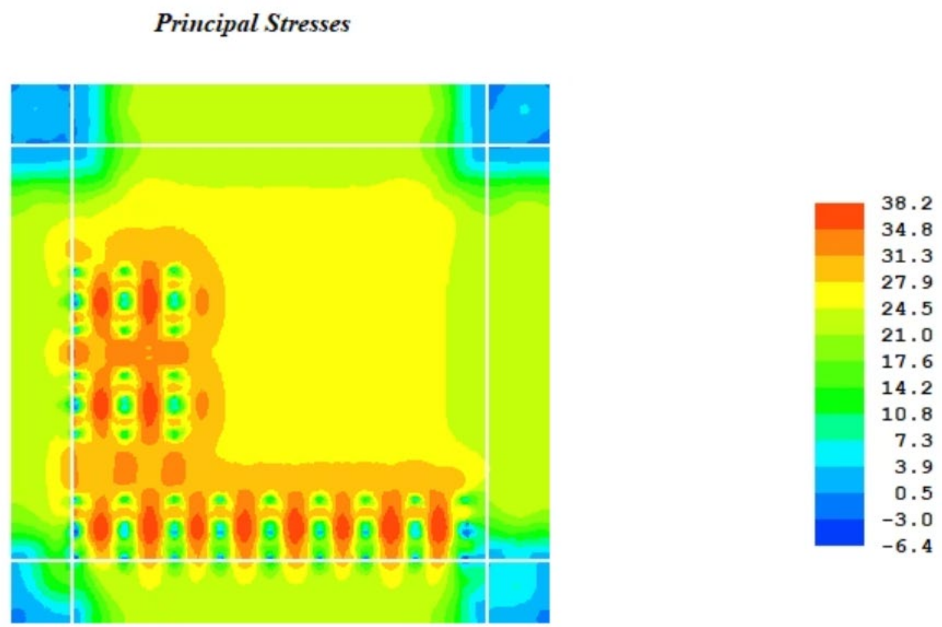
Prediction accuracy: within 5 % of full FEM. Inference time: milliseconds vs. hours for direct FEM

Parameter	Minimum	Maximum
Slab thickness	7 cm	35 cm
Panel size (joint spacing)	140 cm	4000 cm
Rack leg load	1,000 kg	30,000 kg
Individual load	1000 kg	60,000 kg
Design k-value	2 kg/cm³	30 kg/cm³
Curl (EBITD)	−30°C	0°C

ISLAB2000 Stress Fields: Single Rack Analysis

Rack 2,000 kg — Single rack, centered on slab panel

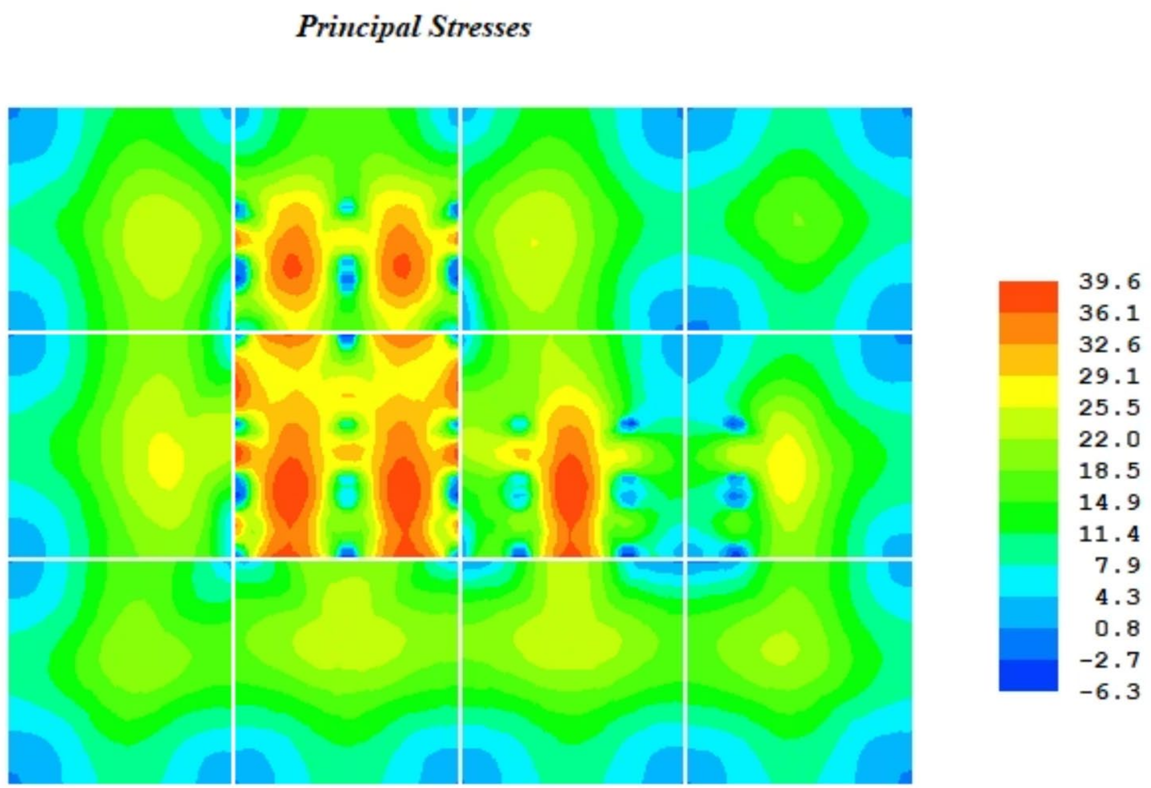


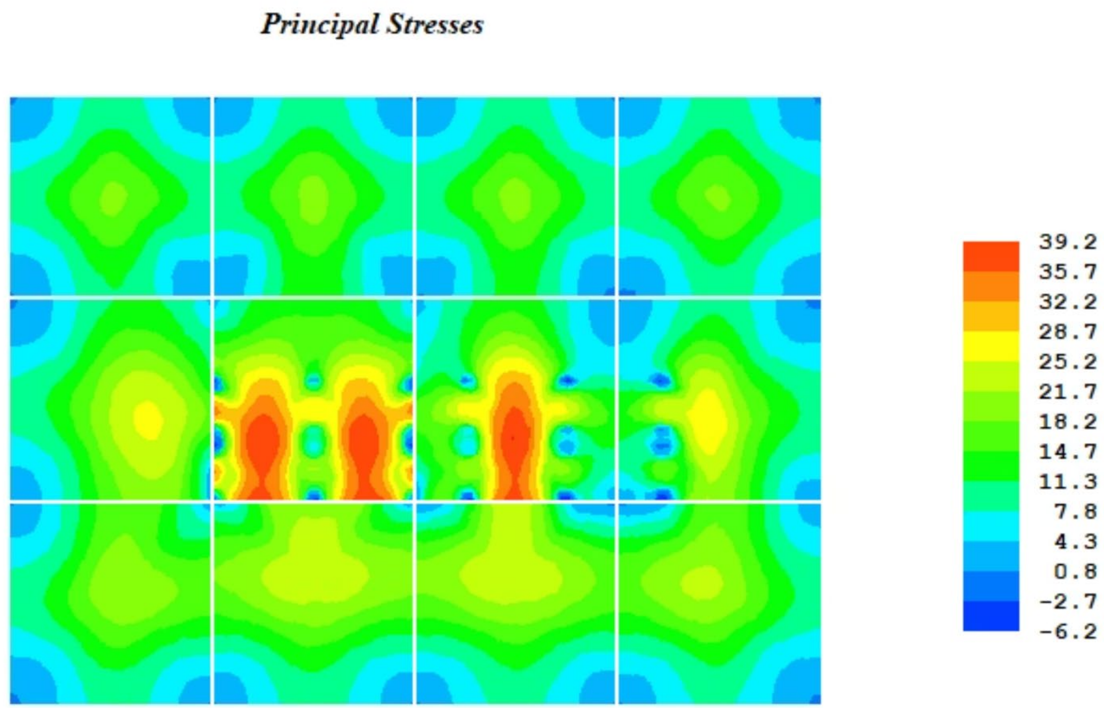


Top stress (left) and Bottom stress (right) — ISLAB2000 FEM output for 17 cm slab, k=8 kg/cm³, ΔT=−15 °C

Even with multiple racks, the stress difference is only ~2.8% — validating OptiSlab's single-rack model.

ISLAB2000 Validation: Multiple Rack Configurations

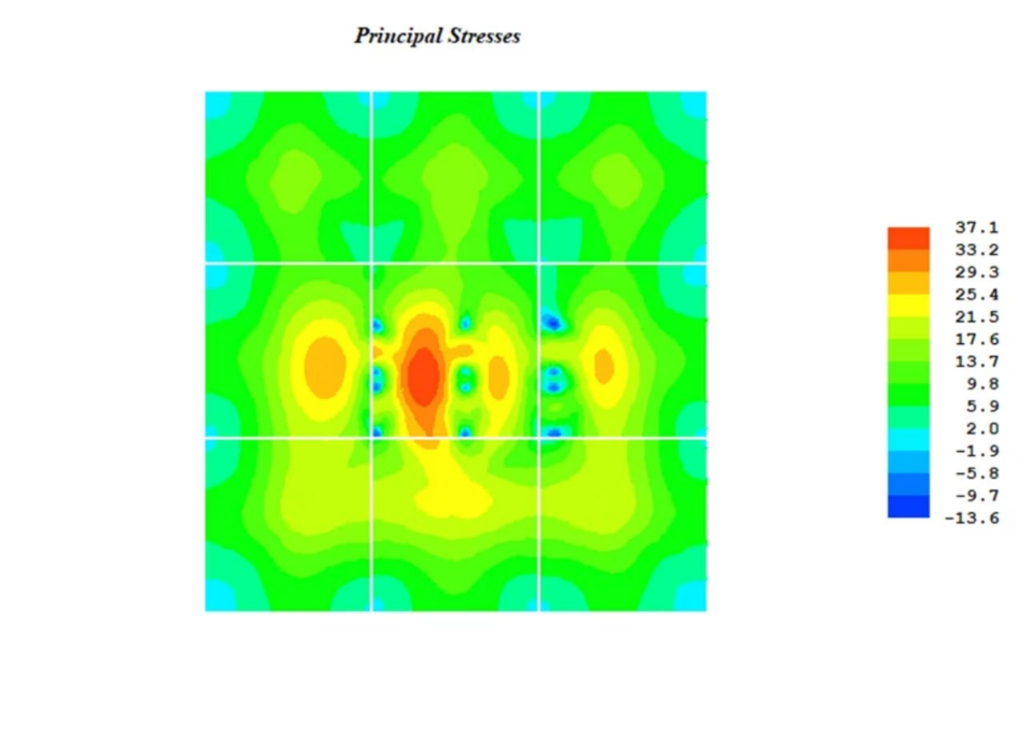


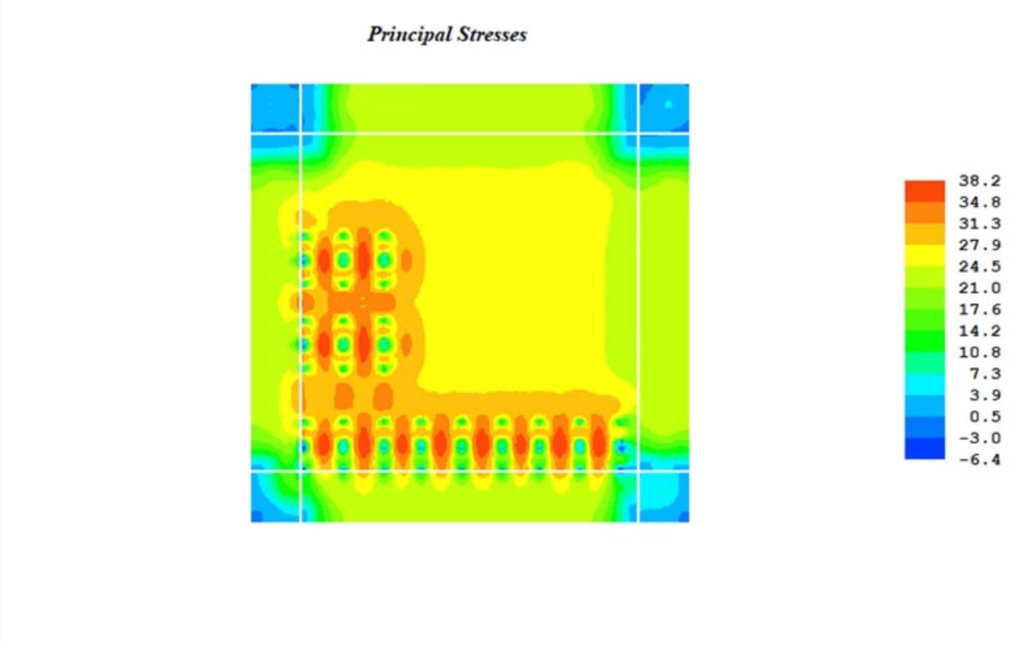


Stress fields from ISLAB2000: top stress distributions for multi -rack configurations validate the single -rack design model.

The 10-Meter Boundary

Systematic ISLAB2000 runs (1.5 m to 10 m)

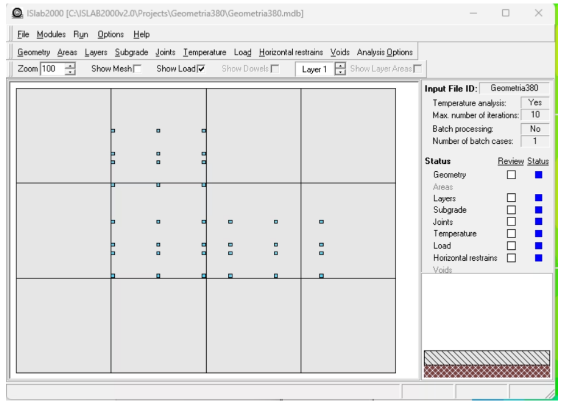


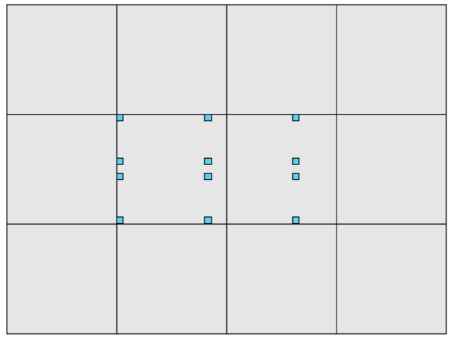


The structural model goes up to 10 m as bigger slabs dont change the answer

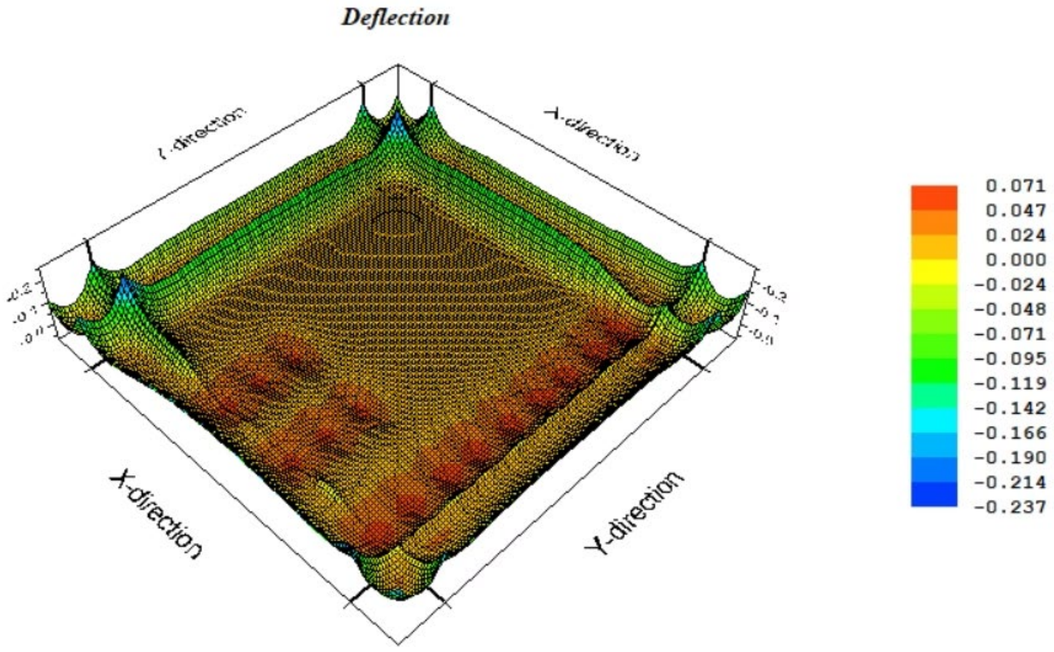
Decision: How to Model Rack Loads

Should the model simulate one rack or many? 600+ systematic ISLAB2000 runs answered definitively





Configuration	Max Stress	Notes
Single rack (centered)	40.3 kg/cm²	Bottom tensile under rac
Two adjacent racks	39.2 kg/cm²	Stress interaction between racks
Difference	**~2.8%**	Within engineering uncertainty



Conclusion: A single rack is conservative, accurate, and reduces training complexity by an order of magnitude.

Punching Shear: The Local Failure Check

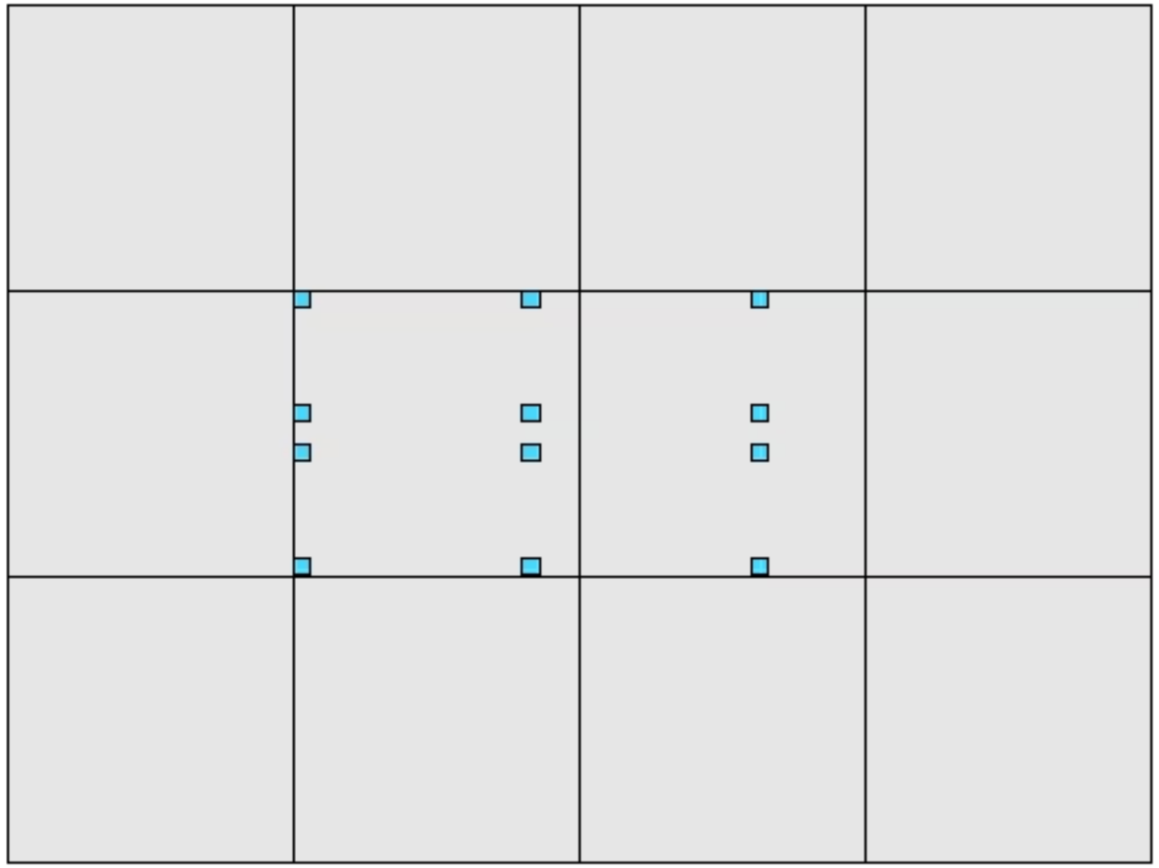
Rack uprights can punch through the slab — a cone-shaped failure surface around the contact footprint.

Both flexural SF and punching SF must be ⩾ 1.0 **simultaneously.**

$$V_c = 0.22\lambda\sqrt{f'_c} \cdot b_0 \cdot d$$

Key modifiers:

- φd = 0.65 (design reduction)
- Fiber contribution: V_fibers = 0.4 · f_res · b0 · d
- Edge factor: φ = 0.75 + 0.25·T (load transfer)
- Support correction: ψk = 1 + 0.3·log(k/0.5)



Fatigue Safety Factor: Why 0.8 and 0.45?

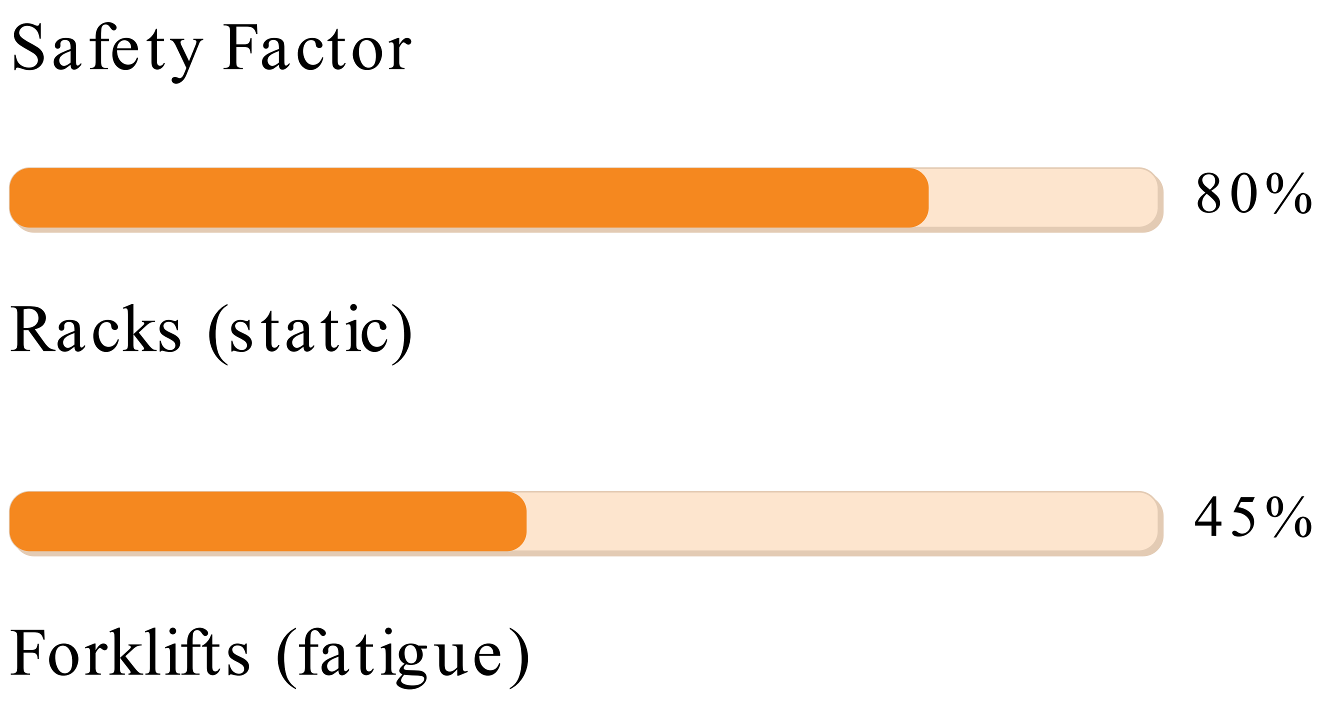
Static loads (racks):

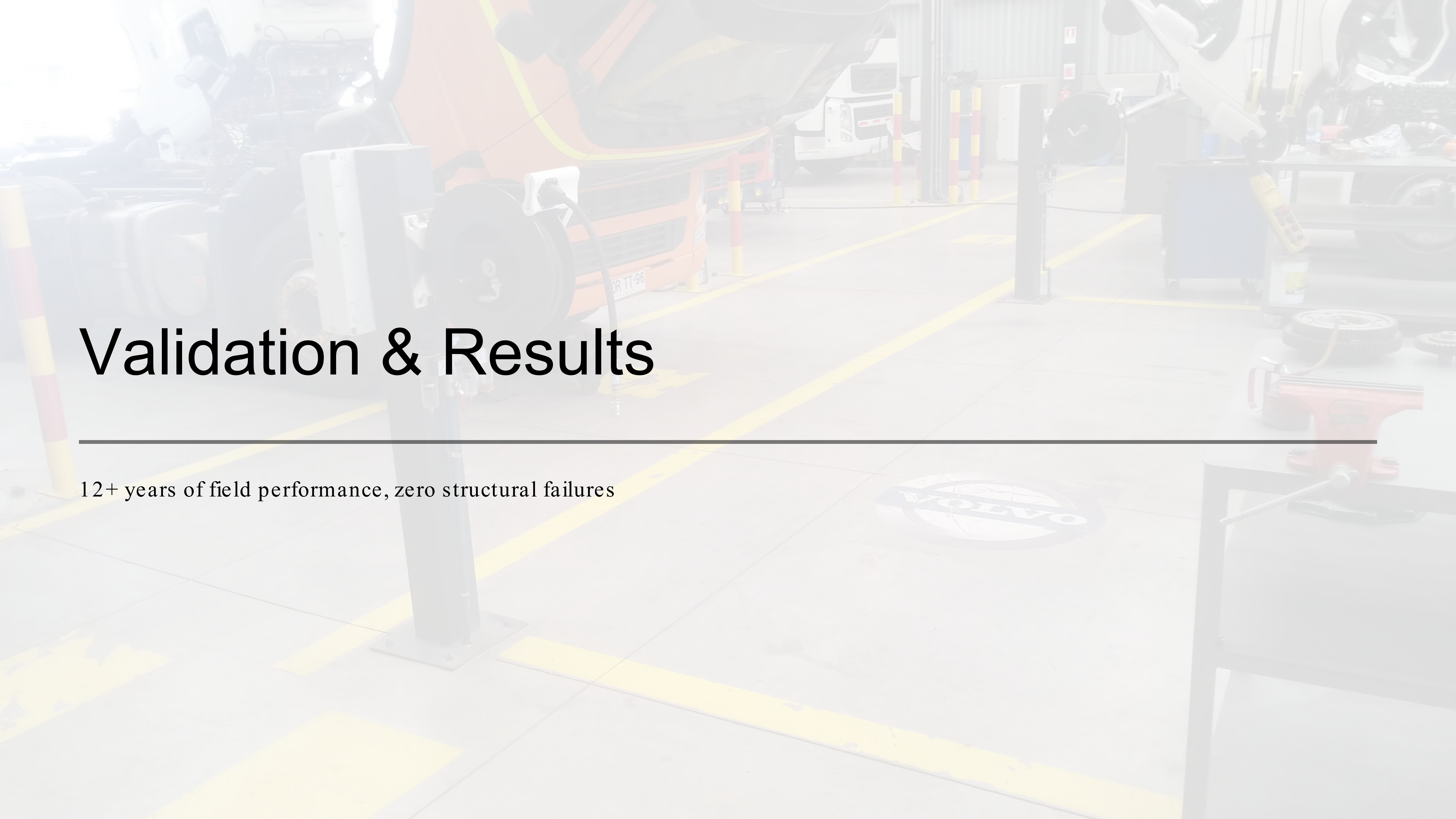
Permanent, same spot for the entire building life. SF = 0.80

Dynamic loads (forklifts):

OptiSlab does NOT perform cycle counting. Instead: a single empirically-validated safety factor.

$$F_{fatigue} = 0.45 \quad \text{(vehicles)} \qquad F_{static} = 0.80 \quad \text{(racks)}$$





Validation & Results

12+ years of field performance, zero structural failures

Seismic Validation of Industrial Floors (Since 2007)

LTPISOS
CONSULTORÍA Y DISEÑO

- Chile: one of the most seismic regions globally (Nazca–South America subduction)

- Floors exposed to major earthquakes:
  - **2010 Maule (Mw 8.8)** → Severe shaking (MMI VIII–IX)
  - **2015 Illapel (Mw 8.3)** → Strong–Severe (MMI VII–VIII)
  - **2014 Iquique (Mw 8.2)**
  - **2016 Chiloé (Mw 7.6)**

- Observed Performance:
  No structural failures in slabs
  Proper joint and load transfer behavior
  Damage limited to Bolts and non-structural aspects

Validation: Multiple Layers, 15 Years

FEM Benchmark

All stress models validated against ISLAB2000

Experimental

Independent research by Prof. Jeffrey Roesler (U. of Illinois) on FRC slab structural behaviour

Load Transfer

MEPDG framework — similar to AASHTO highway pavement design.

Field Performance

Zero structural failures across 600+ projects, 7 countries, 15+ years.

The Future

OptiSlab evolves into the SLABS platform

Uplift Calculation

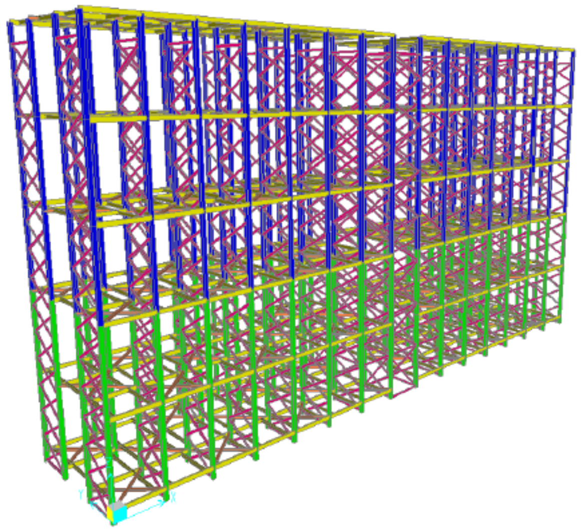
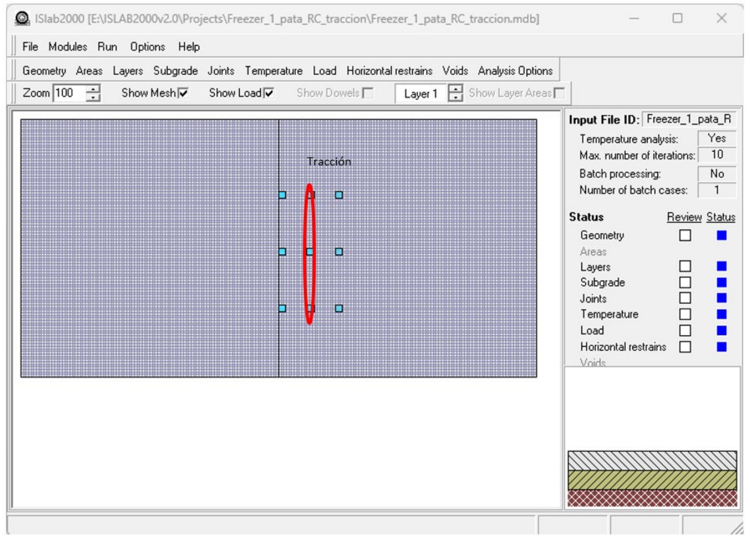
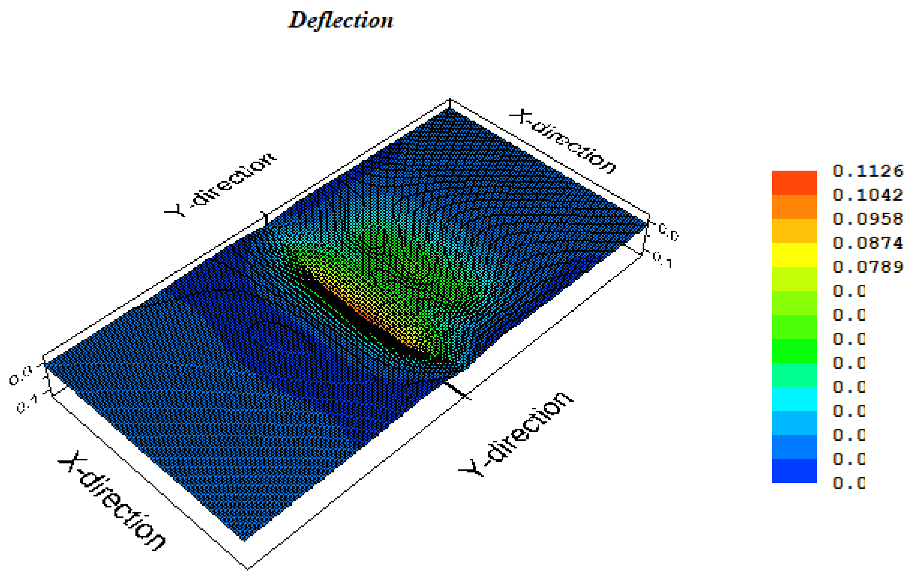
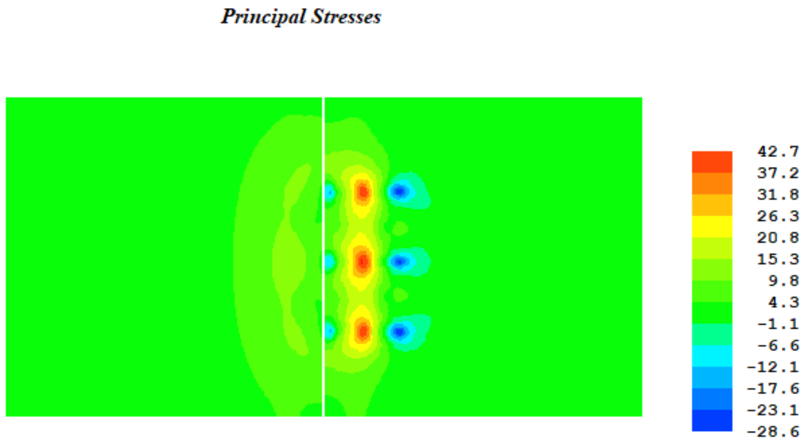
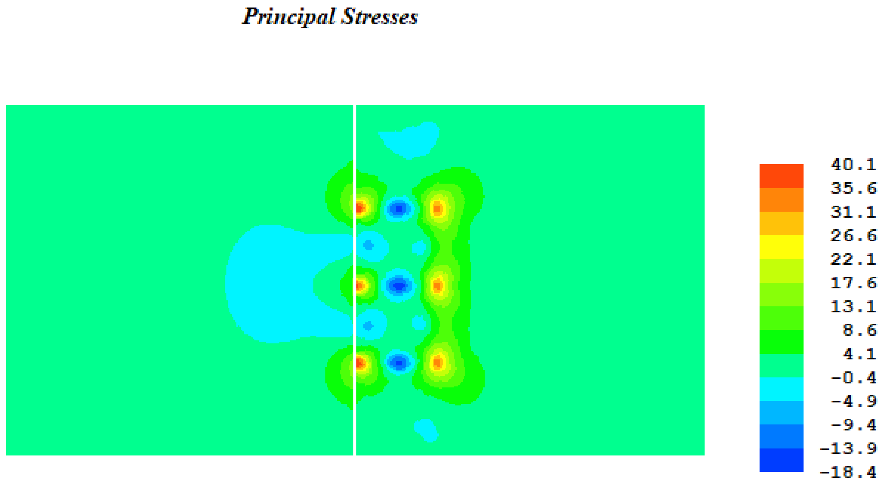


Figura 1: Modelo Computacional de Estantería.

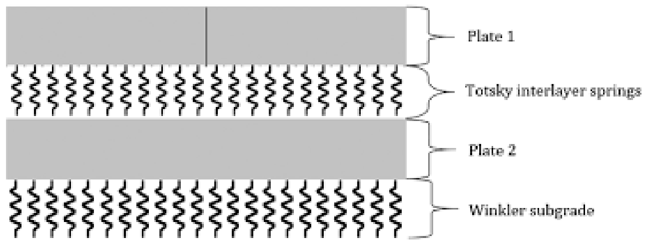




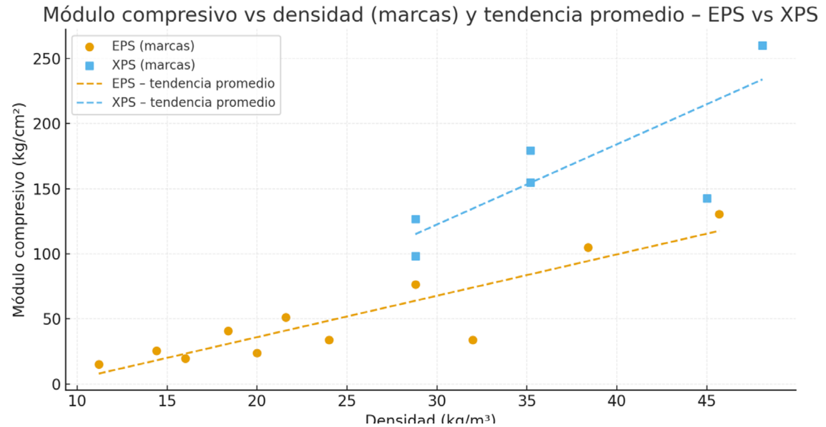


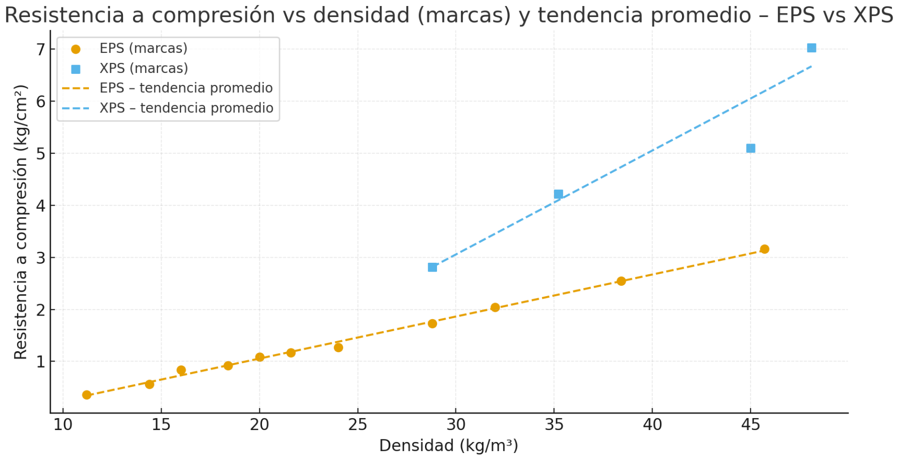


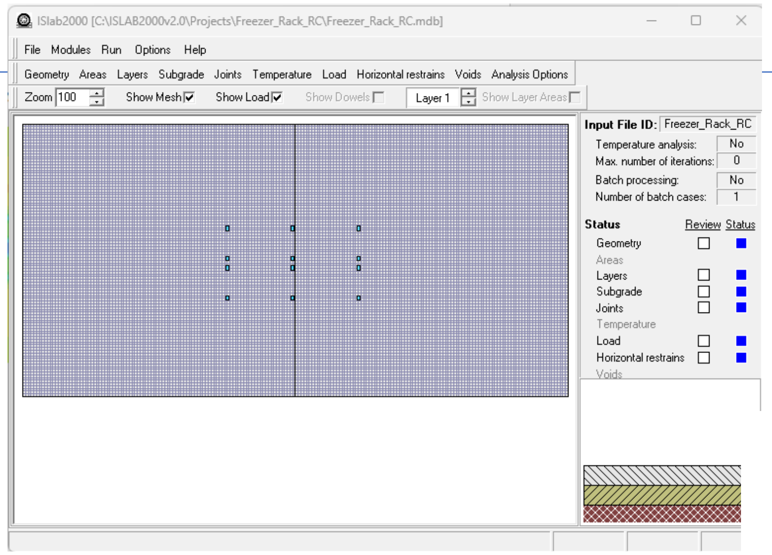
Insulation effect

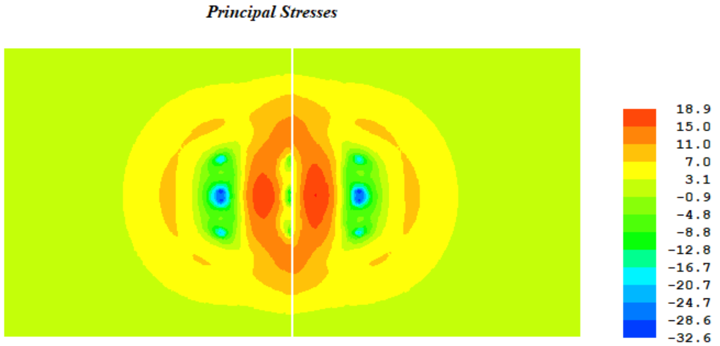


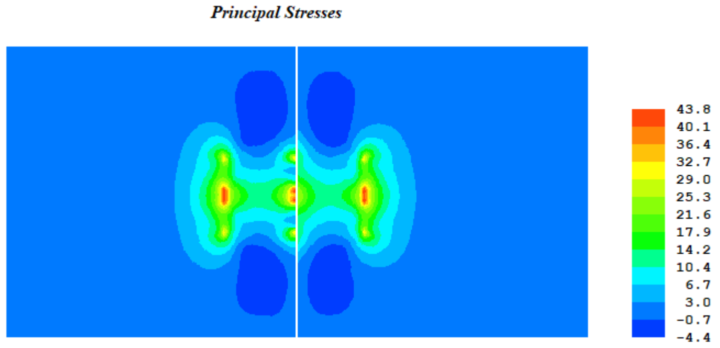
$$K_t = \frac{E}{h}$$

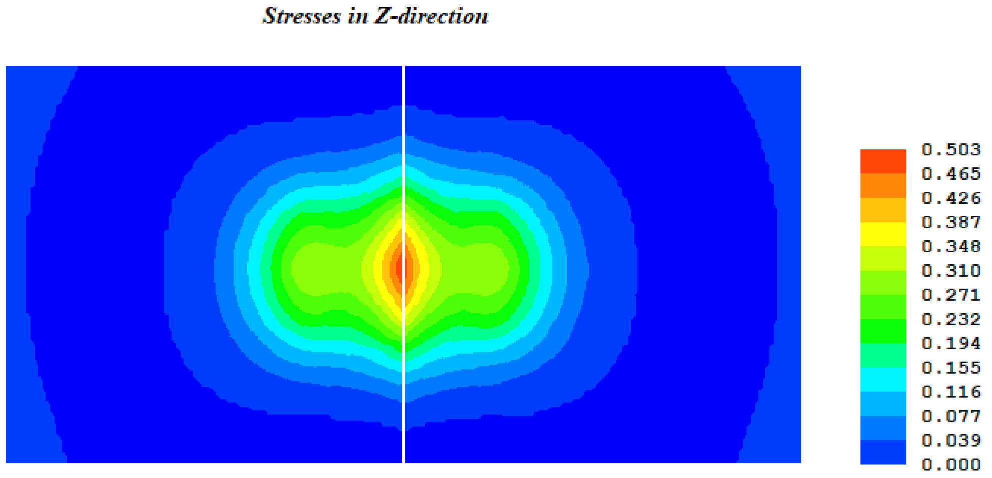












The SLABS Platform — Next Generation

→ **Access**

Web-based interface, platform-independent, real-time collaboration

→ **Models**

Continuous updates, horizontal restraints, improved soil models, dowel optimisation

→ **Community**

Shared case libraries, feedback loops, collaborative validation across firms

→ **Visualisation**

3D stress fields, interactive slab geometry, automatic reporting

→ **Loads**

AGV paths, multi-load combinations, dynamic loading, post-tensioned slabs

Goals:

- Establish mechanistic design as the standard of practice
- Influence ACI 360 and TR34 towards mechanistic frameworks
- Expand adoption in the US and global markets

Thank You

An Invitation to Collaborate

Juan Pablo Covarrubias V.

pablo@tcp.cl