# The OptiPave System

TCPavements®
PAVEMENT INNOVATION

OptiPave®
TCPavements®

FORTA®
CONCRETE FIBER

# FORTA®

## FORTA® CONCRETE FIBER


Supplies the highest quality synthetic reinforcement fibers and services to the global concrete industry.

## OptiPave™

TCPavements™

Provides the most cost effective and sustainable design to compete with asphalt paving, utilizing advanced engineering.

## FORTA® ASPHALT FIBER


Most trusted asphalt fiber reinforcement technology, products and services.

## FORTA® DELIVERY SYSTEMS


Fiber dispersing equipment that delivers performance, accuracy and reliability.

# Credit where credit's due!

## In the design and development of the OptiPave System®

**Dr. Juan Pablo Covarrubias**
TCP Inventor
Professor Catholic University and Universidad Los Andes
Chief Engineer HDM-4 Concrete Models
Ex ACI and ISCP Board Member

**Dr. Michael Darter, PE**
Emeritus Professor of Civil & Environmental Engineering at U of IL
Principal Engineer at ARA
Principal Investigator (PI) of MEPDG and StreetPave fatigue equations

**Jerry Holland, PE**
Director of Engineering Services at Structural Service Inc. (SSI)
Expert on the impact of curling in flatwork design

**Dr. Lev Khazanovich, PE**
Professor at University of Pittsburgh
Co-Developer of ISLAB™, the structural basis of MEPDG & OptiPave™
Co-Developer of MEPDG

**Dr. Jeff Roesler, PE**
Professor at University of IL
Conducted physical tests to calibrate OptiPave™
Developed the slab-to-beam relationship for OptiPave™

**Robert Rodden, MsC**
Megaslab™
Ex Gerente Técnico ACPA
Ex Gerente Ingeniería PNA-TCP
OptiPave Interface

**Mauricio Poblete, MsC**
Ingeniería Civil U- Chile
Modelo de suelo OptiPave

**Dr. Dan Zollinger, PE**
Professor at Texas A&M University
Developed the LTE model for MEPDG & OptiPave™

# Paradigm : Thickenss as fundamental value

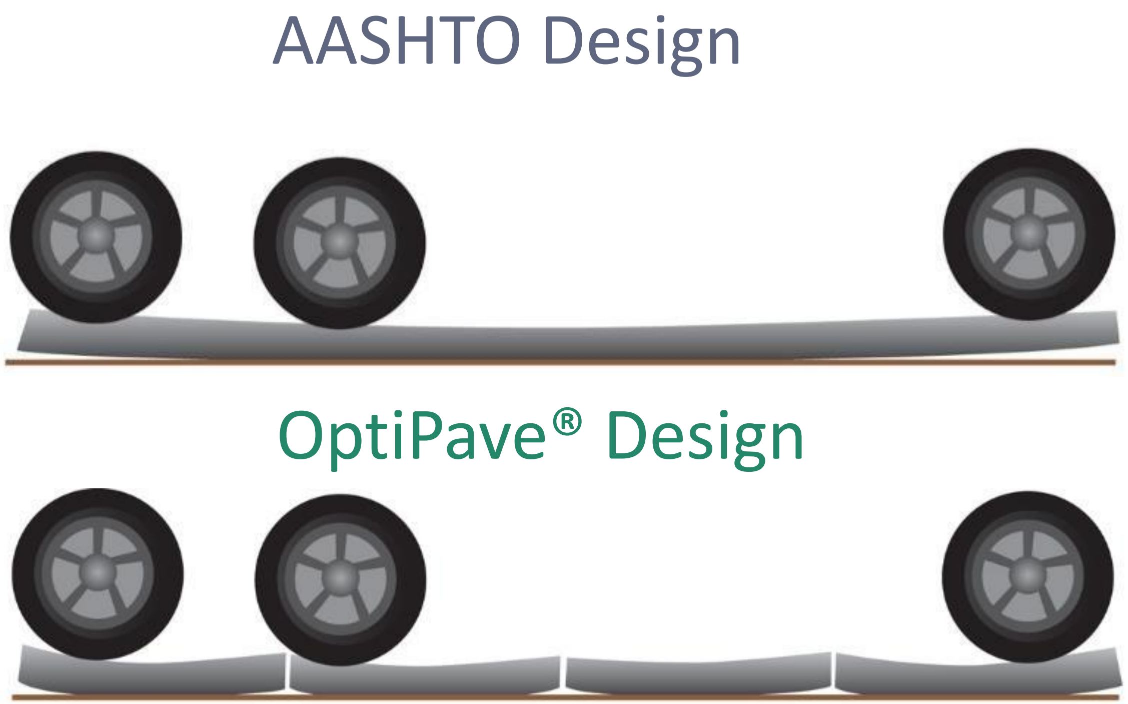
- Design of Seaports


35 cm

10 cm

# OptiPave Design Concept

Pavement panels must have a dimension so that each one is loaded by only one wheel or a set of wheels (tandem) at the same time



# OptiPave Optimizes Slab Geometry

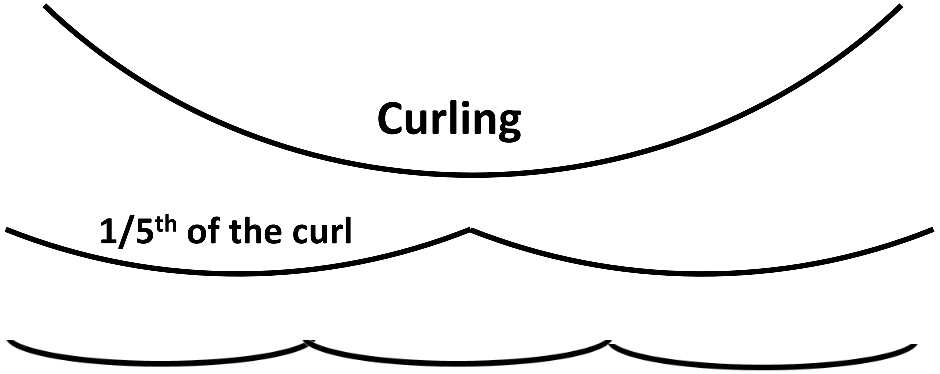
## Conventional Design

Thickness = 10” (250mm)
Slab Size = 12’ x 15’ (3.7 x 4.5m)

## OptiPave Design

Thickness = 6.5” (160mm)
Slab Size = 6’ x 6’ (1.8 x 1.8m)

Graphic illustrates axle spacing of a standard 80kip U.S. legal limit 18-wheeler




TCP reduces joint spacing to minimize curl and prevent both sides of the slab from being loaded at the same time.

This reduces stress, allowing slab thickness to be reduced for cost savings while maintaining reliable performance.

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## Juan Pablo Covarrubias T.

Inventor of TCP

- Manager, Cement and Concrete Association of Chile

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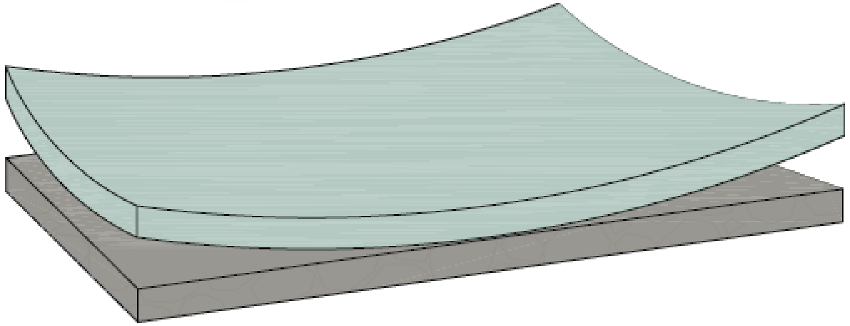
innovación en pavimentos



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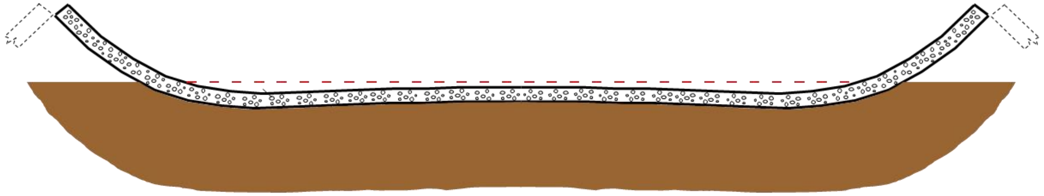
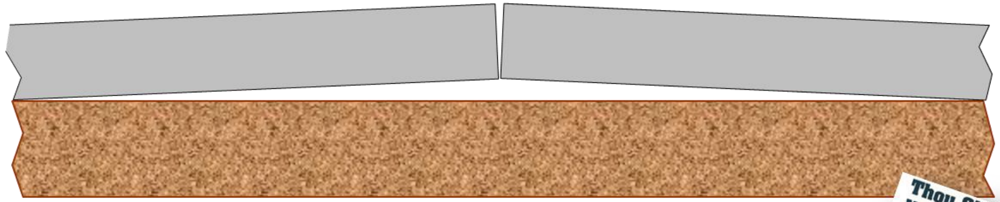
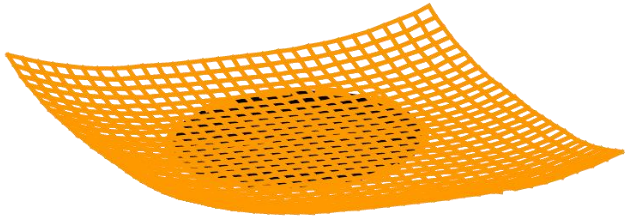
- Expert on the impact of curling in flatwork design

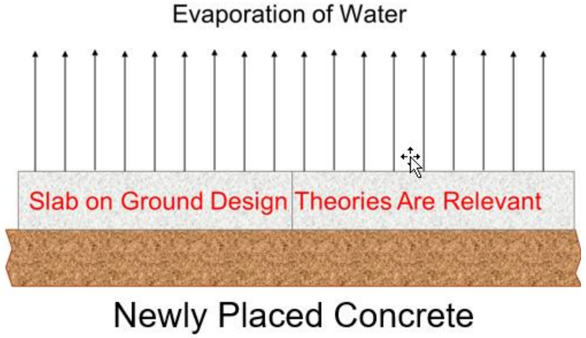
Structural Services, Inc.

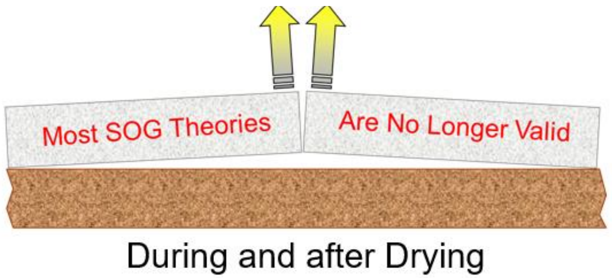







Thou Shalt Not Curl Nor Crack...(hopefully)

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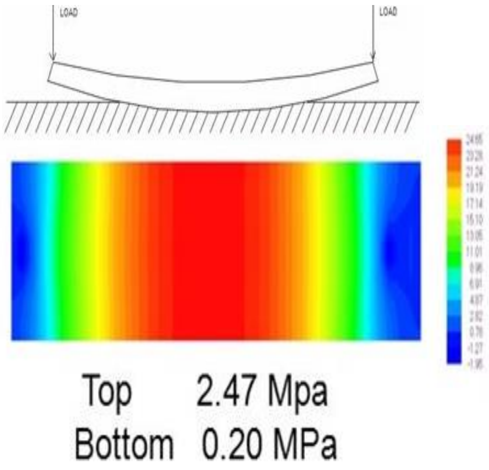
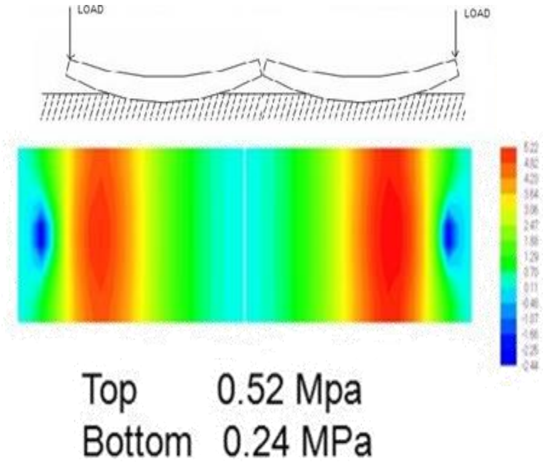
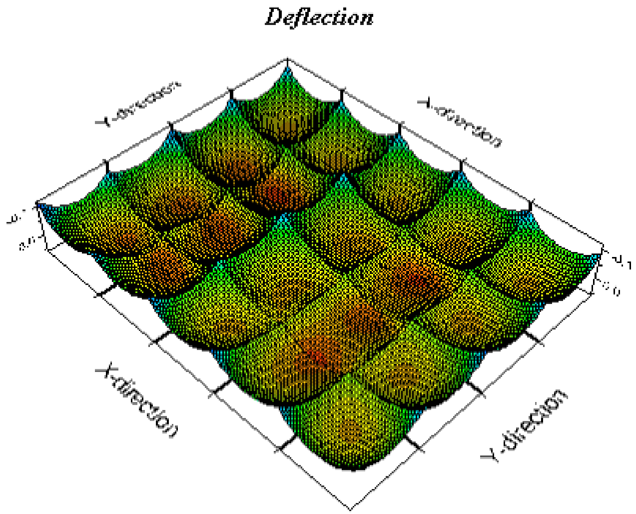
Professor at University of Pittsburgh

- Co-Developer of ISLAB™, the structural basis of MEPDG & OptiPave™
- Co-Developer of MEPDG

ISLAB 2000
finite element analysis for rigid pavements

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Professor at University of Illinois

- Conducted physical tests to calibrate OptiPave™
- Developed the slab-to-beam relationship for OptiPave™

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN



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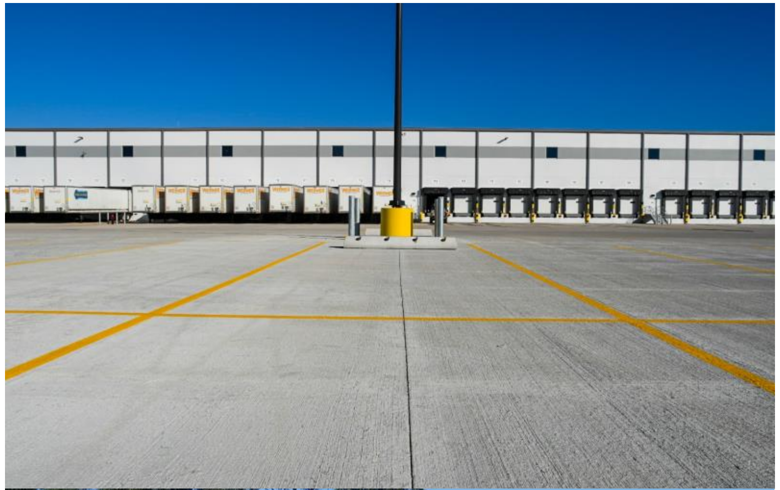
## Features & Recommendations of TCP® design

- Small Slabs (Half a Lane x 1,20 to 2,5 m)
- Granular Base (Fine Material < 8%),
  - Geotextile Interlayer between Subgrade and base, if necessary
- Asphalt Base or Cement Treated Base
  - Geotextile Interlayer between concrete and base
- Thin Joint Cut Sawing (1,9mm- 2,5mm width)
- No Joint sealing required
- No need of dowels and tie bars (except on Construction Joints)



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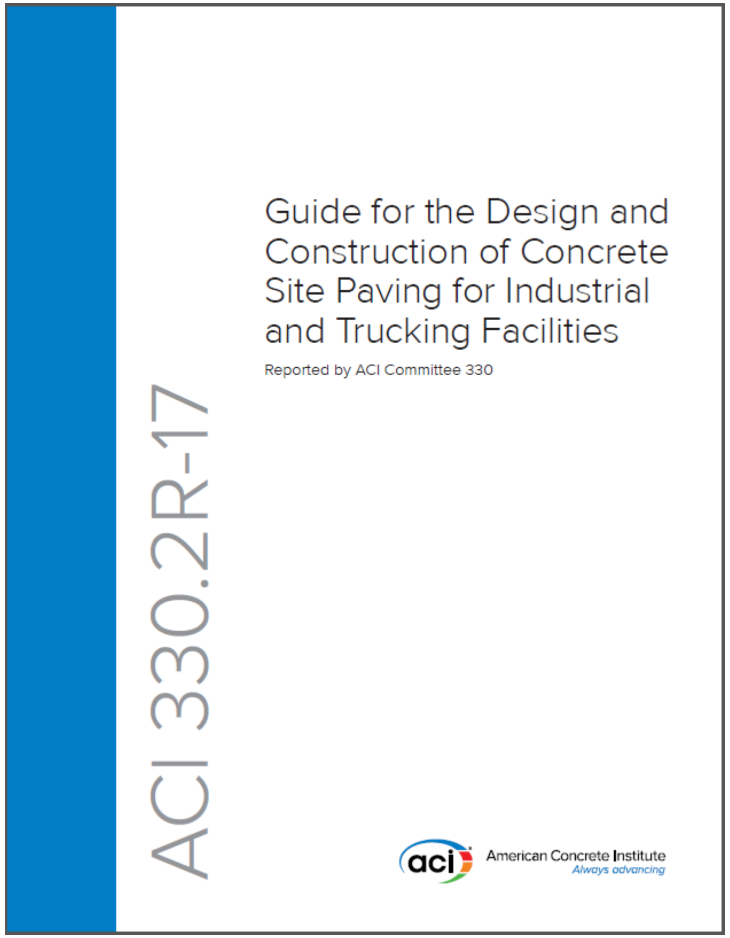
# Incorporated in ACI 330.2R-17



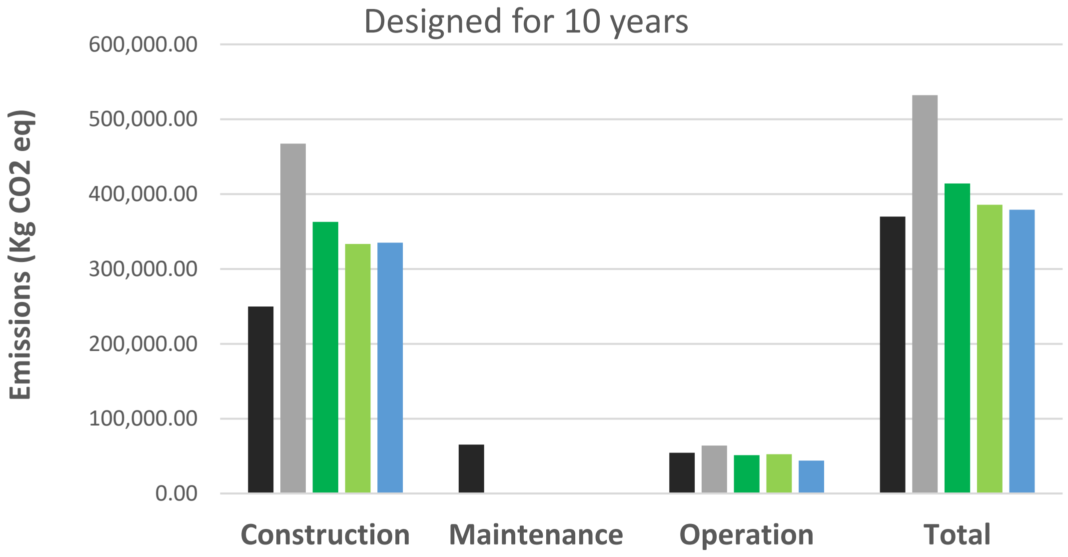


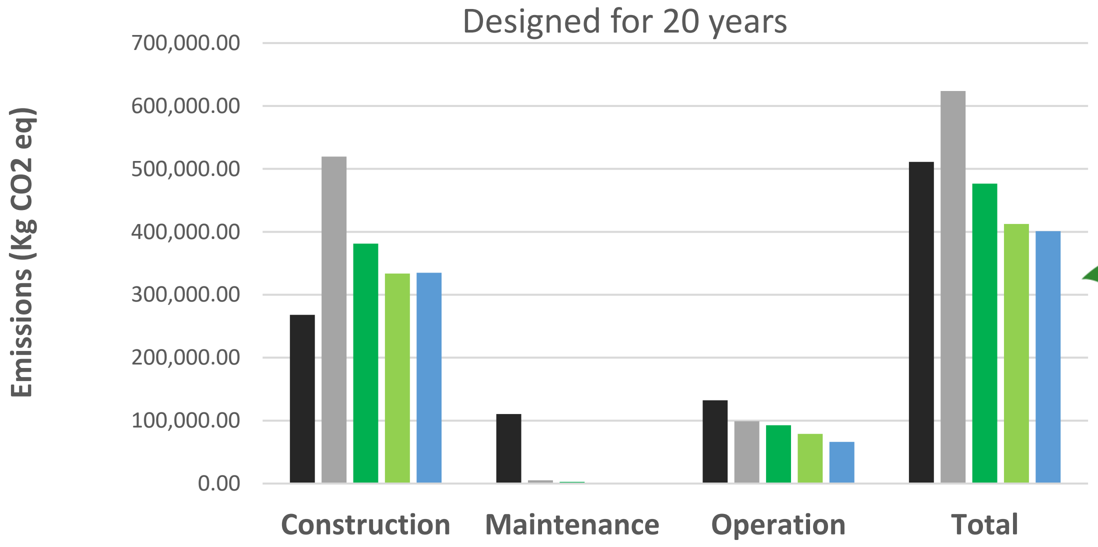

one surpasses the failure limits specified by the user. The version of DARWin-ME™ available through AASHTO is different from the previous research-grade software of AASHTOWare (MEPDG), although the basic structure of the program follows closely to the previous versions (http://www.aashtoware.org/Pavement/Pages/default.aspx). Many features have been added, including the ability to generate optimized design, perform sensitivity analyses, run batch mode files, and numerous others.

**B.1.3** *TCpavements*—This software is mechanistic-based and specifically developed to design concrete pavements for any set of climate, traffic, subgrade/subbase layers, and material inputs. Critical tensile stresses have been calculated using finite element analysis for a variety of mechanical and thermal loading conditions and load positions. This methodology designs the concrete pavement thickness by optimizing the slab size to suit a given geometry of truck wheel and axle spacing. The design is based on an unbonded system with granular, HMA, stabilized, or concrete base. The key principle of the design method is to configure the slab size so that not more than one set of wheels are on any given slab, thereby minimizing the critical top tensile stress in each slab. Slab cracking is determined based on the concrete fatigue and performance models used for the AASHTO MEPDG, calibrated with full-scale test sections. The design method is also able to efficiently design lower volume concrete roads and industrial pavements that are not completely covered with existing pavement design methods (Covarrubias 2012). With this method, thicknesses can be designed as low as 3 in. (75 mm) for projects with low traffic volumes, such as parking lots and subdivision roads, over granular base layer with typically 6 x 8 ft (1.8 x 2.4 m) or 6 x 6 ft (1.8 x 1.8 m) panels, depending on traffic configuration. Because of short slabs, curling stresses are also reduced and higher load-transfer efficiency is maintained across the joints relative to conventional jointed concrete pavements with larger slab sizes.

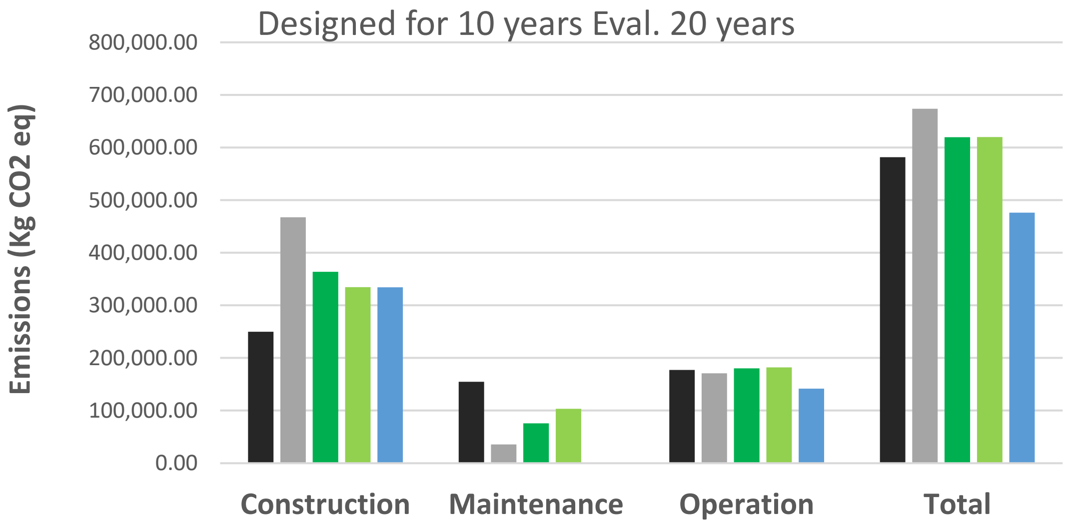
mended a 6 in. (150 mm
be used to provide a c
pumping, that a maximu
200 pci (54 MN/m³) be
of rupture (MOR) of 55
dowels be used for joint
B.2.2 *Loading data*-
subjected to the followi
B.2.2.1 *Over-the-roa*
per day will enter and
materials for prestresse
will enter fully loaded
owner does not have
facility, so the architec
major arterial traffic.
exiting the facility each
products. An annual gro
lished by the owner for
loaded and delivered to
will remain for a minim
loaded trailers will app
(7711 kg) on each suppo
transferred from the sup
in. (300 x 300 mm) san
B.2.2.2 *Lift trucks*—
certain prestressed con
truck has a dual-wheel
axle. The tire pressure
approximately 100 psi (
that have been provided
B.2.2.3 *Gantry crane*
transport prestressed co
to processing and loadi
each with a maximum l
pressure of 100 psi (0.7
B.2.3 *Thickness desi*
thickness should be dete

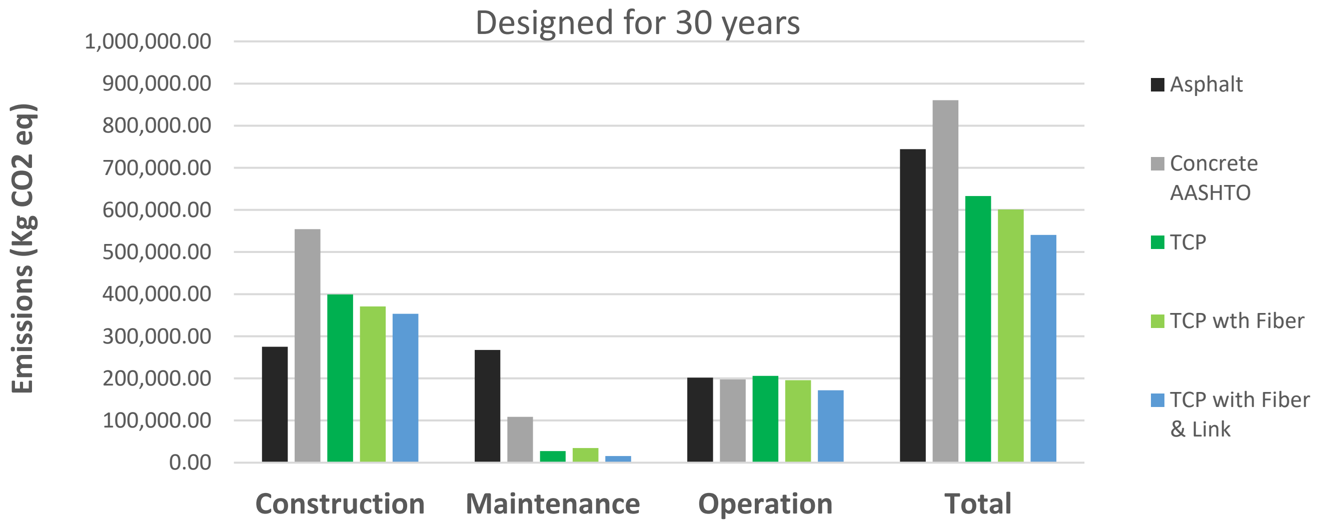
# Sustainability Benefits with OptiPave




SUSTAINABLE PAVEMENT



# Analysis Results

Concrete Pavement Life Cycle Environmental Assessment & Economic Analysis: A Manitoba Case Study

M. Alauddin Ahammed, Ph.D., P.Eng.
*Manitoba Infrastructure, Winnipeg, Manitoba, Canada*

S. Sullivan, M.A.Sc, P.Eng., LEED AP
*Cement Association of Canada, Toronto, Ontario, Canada*

G. Finlayson, C. Goemans, P.Eng., J. Meil
*Athena Sustainable Materials Institute, Ottawa, Ontario, Canada*

Mehdi Akbarian, Ph.D.
*Department of Civil & Environmental Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA*

- This study demonstrates that the transportation sector can have a significant impact on the reduction of environmental impacts by adopting sustainable material, design, construction and maintenance practices.
  - 5% reduction in GHG emissions, and 3% reduction in total life cycle cost with the adoption of the new concrete mix design and dowel/tie bar configurations.
  - 6% reduction in GHG emissions, and 11% reOptiPave TCPavements in total life cycle cost with the adoption of a short slab ( ) design.
  - 16% reduction in GHG emissions, and 18% reduction in total life cyclOptiPave TCPavements ith the use of ternary concrete mix, using a short slab ( ) design and extending the pavement service life by five years.

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## Applications

### Any pavement supported over ground with vehicles circulating

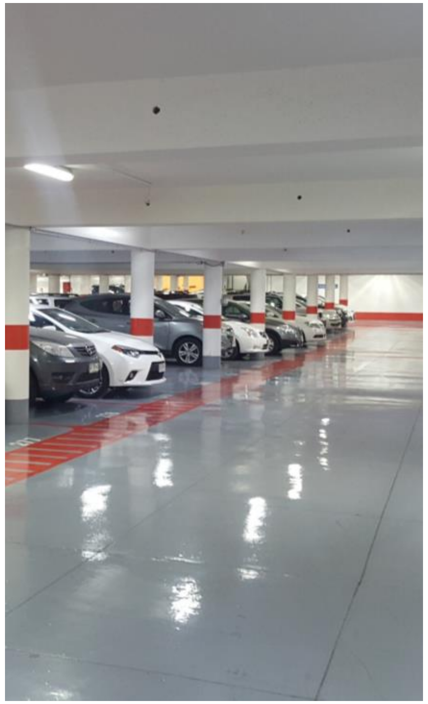
Highways

Low Volume Roads

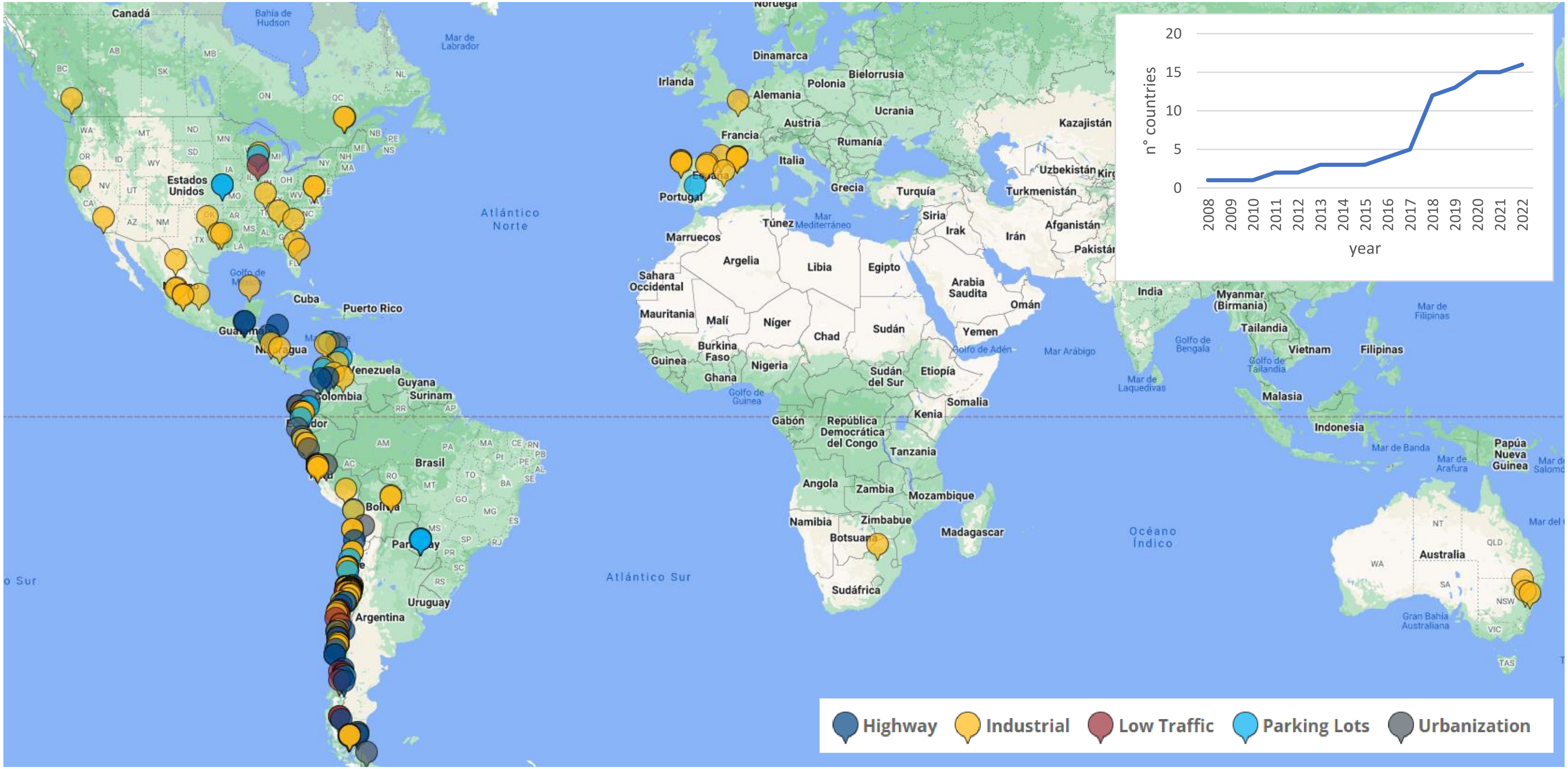
Industrials

Urbanizations

Parking Lots



# Overall summary



# Ruta 60 Ch Camino La Pólvora, Valparaiso, Chile

**Thickness**

23 cm FRC

**Traffic**

5.000 trucks/day

**Year built**

2016

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# Ruta 257 Ch Cerro Sombrero – Onaissin, Chile

**Thickness**

14 cm FRC

**Traffic**

(300 trucks/day)

**Year built**

2012

First “long” OptiPave” Project.

# Home Depot, Houston TX

**Thickness**

14 cm FRC

**Traffic**

4.000.000 EE

**Year built**

2021

Paved area:250.000 m2

Saves: 2.400.000 usd

# CD Sodimac, Lo Espejo


**Thickness**

14 cm

**Traffic**

10.000.000 EE

**Year built**

2008

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# CD Walmart, Lo Aguirre


**Thickness**

15 cm

**Traffic**

10.000.000 EE

**Year built**

2011

96.000 m2

Walmart Chile

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# Saga Falabella

**Thickness**

14 cm

**Traffic**

5.000.000 EE

**Year built**

2019

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# Urbanizacion Torobayo Valdivia

**Thickness**

8 cm

**Traffic**

50.000 EE

**Year built**

2013

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# Parking Lot Municipalidad de Providencia

**Thickness**

10 cm

**Traffic**

50.000 EE

**Year built**

2014

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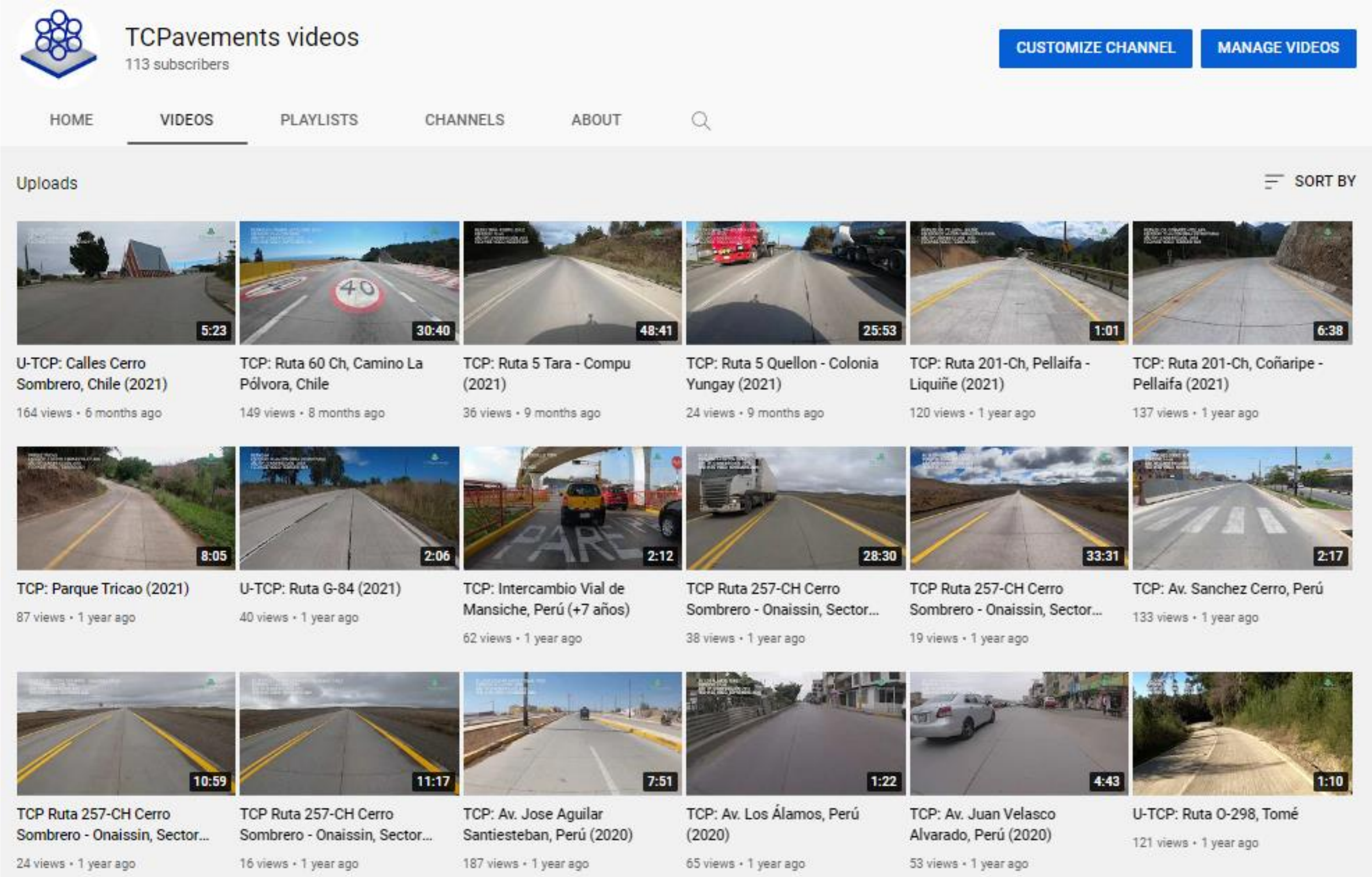
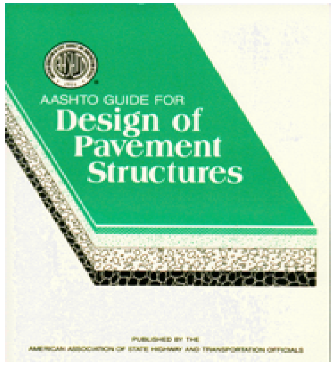
# Project tracking on YouTube



# Evolution of Concrete Pavement Design




**AASHTO**
1962-1998
10 inputs
"Performance"
Field Data

**THE 40 YEAR DIVIDE**

**ACPA**
2005-present
12 inputs
Crack & Fault
**FEA** + Field Data

**TCPavements**
2009-present
≈ 50 inputs
Crack, Fault, IRI
**FEA** + Field Data

**AASHTO**
2009-present
≈ 1,000 inputs
Crack, Fault, IRI
**FEA** + Field Data

**Increasing Complexity = More Accurate Models & More Opportunity for Optimization!**

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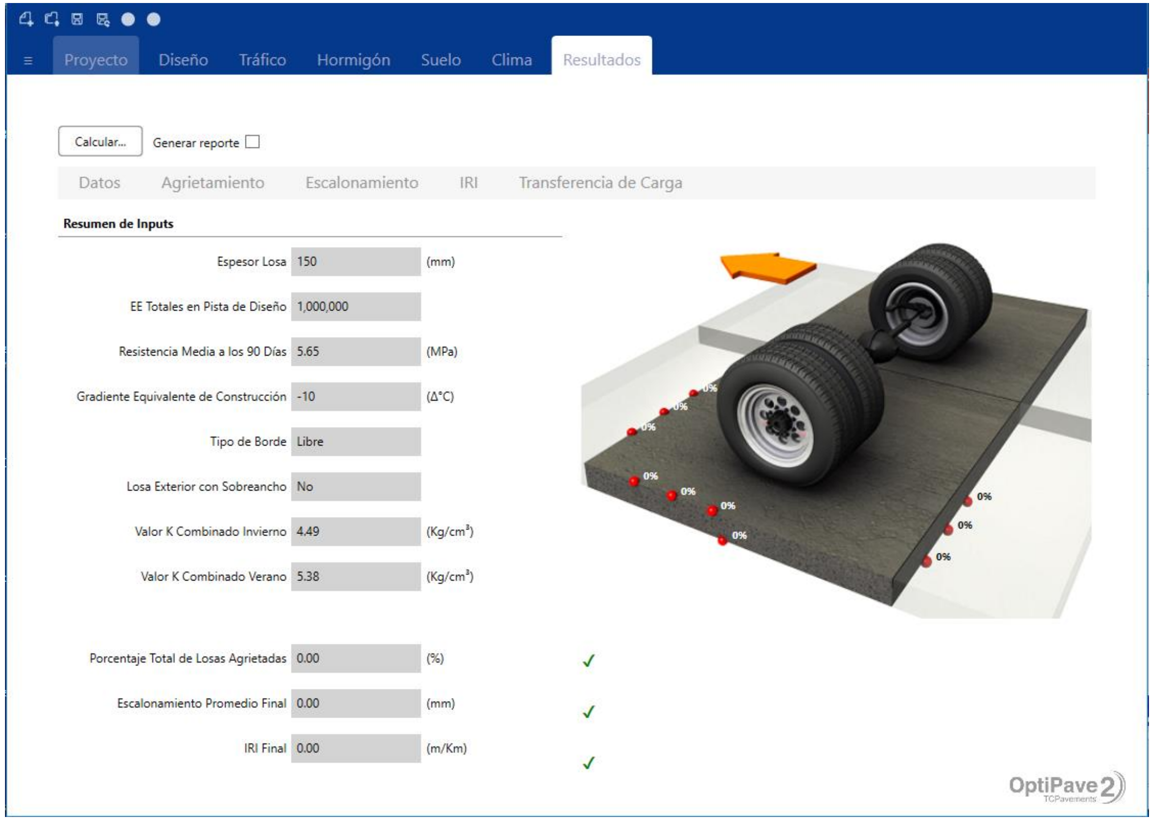
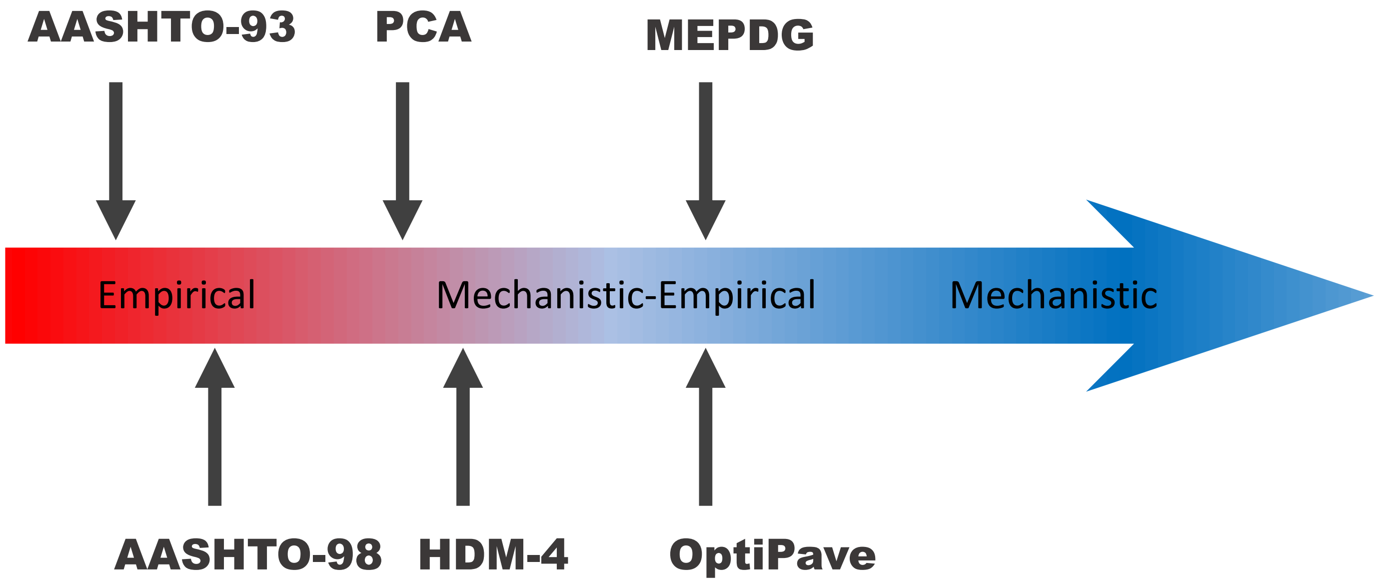
# TCPavements®: OptiPave2

- Concrete Pavement Design Software, developed exclusively for the design of TCP Pavements.



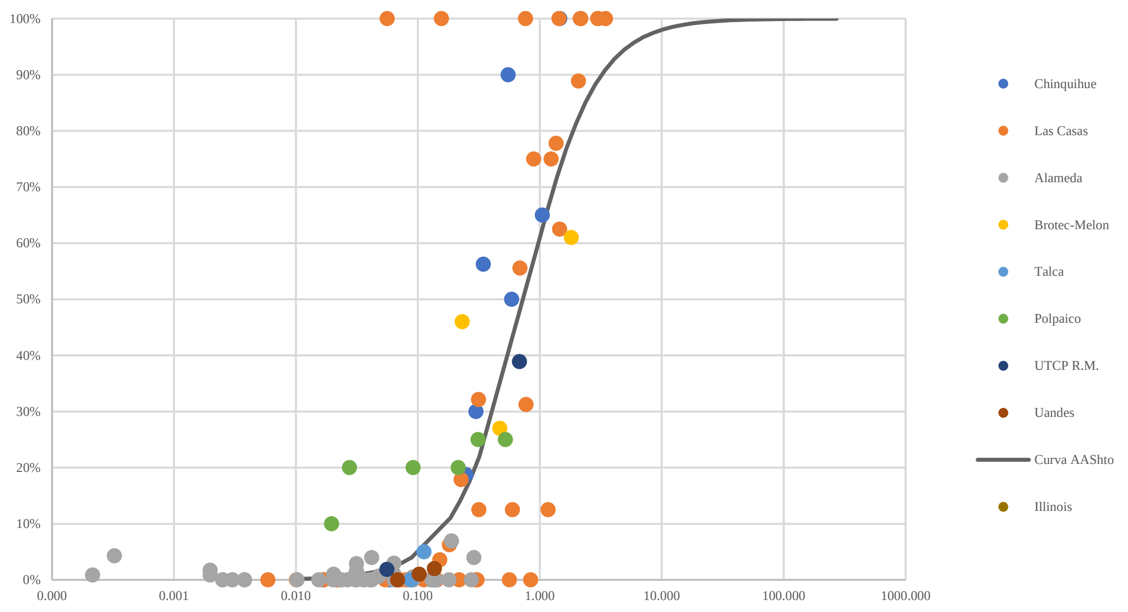



# Learning and Experience

# Fatigue

$$Log(N) = 2 * \left(\frac{\sigma}{MOR * C_1 * C_2}\right)^{-1.22}$$

Agrietamiento Longitudinal

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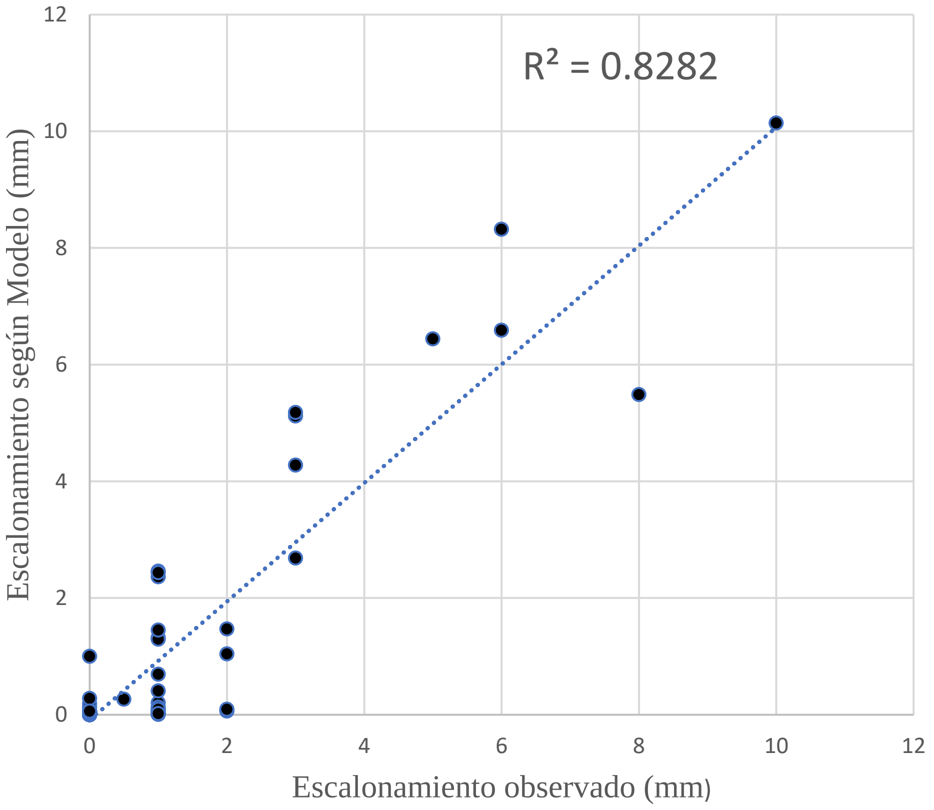
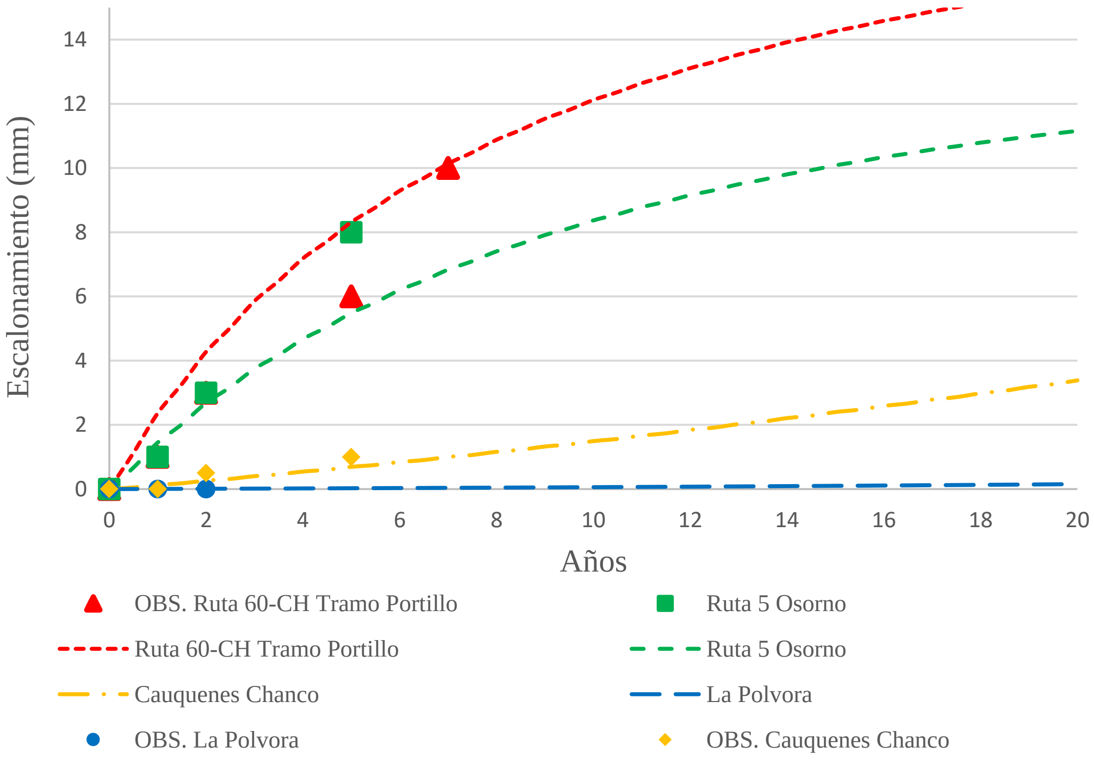
# Reformulación de Ecuación Escalonamiento

- $Fault_m = \sum_{i=1}^{m} \Delta Fault_i$
- $\Delta Fault_i = C_{34} \cdot (FAULTMAX_{i-1} - Fault_{i-1})^2 \cdot DE_i \cdot C_8$
- $FAULTMAX_0 = C_{12} \cdot \delta_{MAX} \cdot \left[Log(1 + C_5 \cdot 5^{EROD}) \cdot Log\left(\frac{P_{200} \cdot 100 \cdot \left(\frac{Wetdays}{Dren^{C_{10}}}\right)^{C_9}}{P_S}\right)\right]^{C_6}$
- $FAULTMAX_i = FAULTMAX_{i-1} + \frac{C_7}{10^6} \cdot DE_i \cdot C_8 \cdot [Log(1 + C_5 \cdot 5^{EROD})]^{C_6} \cdot \left[Log\left(\frac{(P_{200} \cdot 100 \cdot \left(\frac{Wetdays}{Dren^{C_{10}}}\right)^{C_9}}{P_S}\right)\right]^{C_6}$

$$IRI = IRI_I + C1\ CRK + C2\ SPALL + C3\ TFAULT + C4\ SF$$

# Correlación Modelo V/S Mediciones

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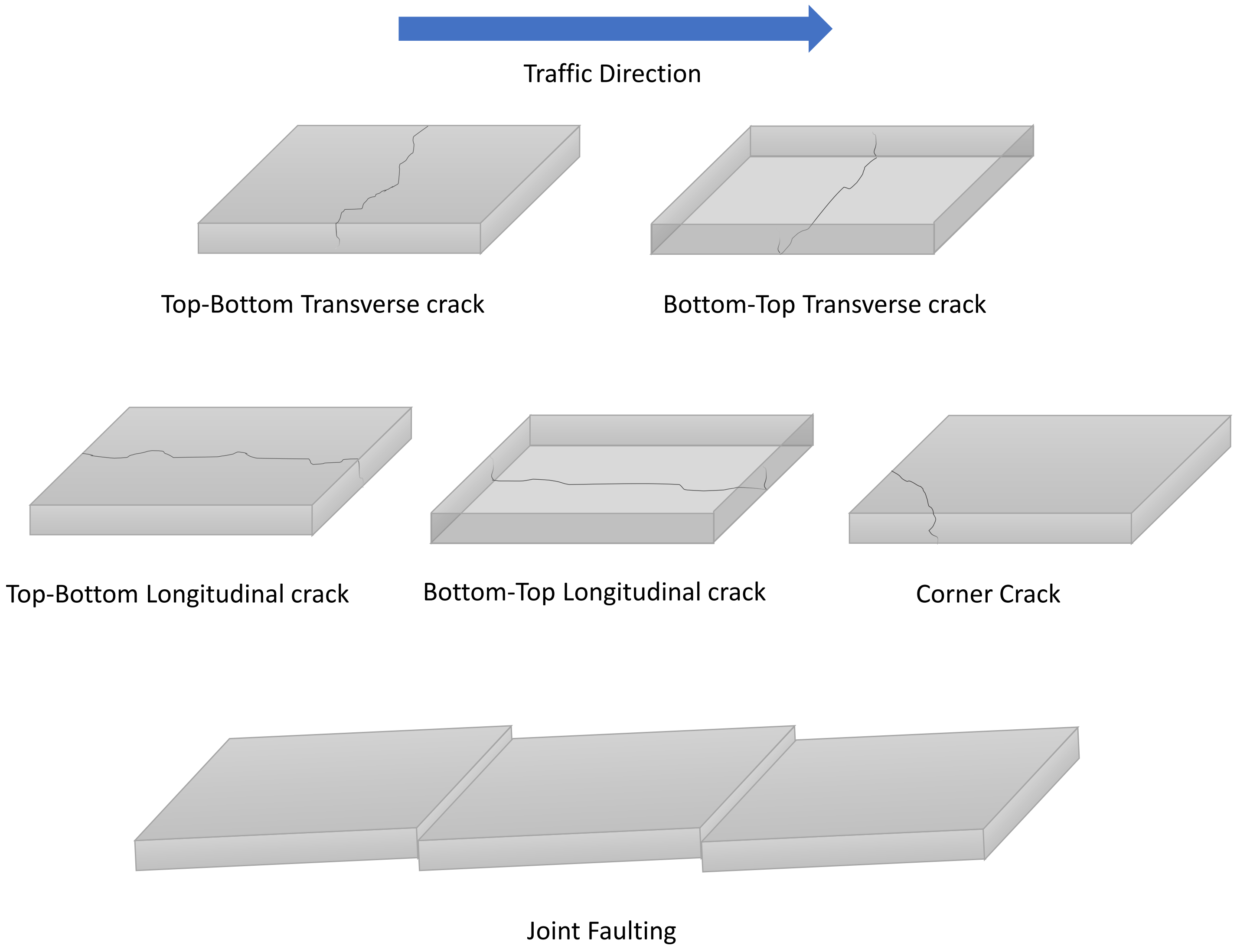
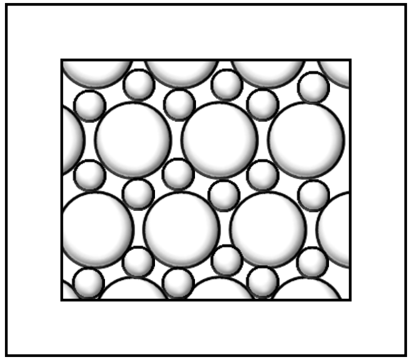
# Possible failure modes in a slab



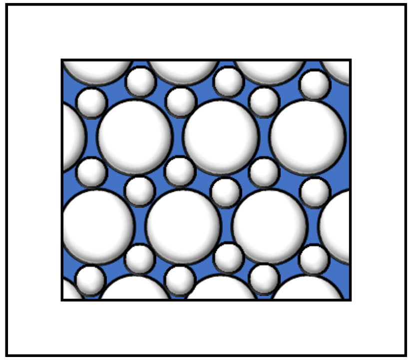
# Joint Sealing

- A methodology must be found to avoid them:
  - First Iteration (2007):
    - Bases with 5% fines
    - Cutting saw of 1.9mm (Thin Blades)
  - Second Iteration (2012)
    - Bases with 8% fines
    - Cutting saw of 2.5mm (Thin Blades)
  - Third Iteration:
    - Bases up to 12% fines in dry climates

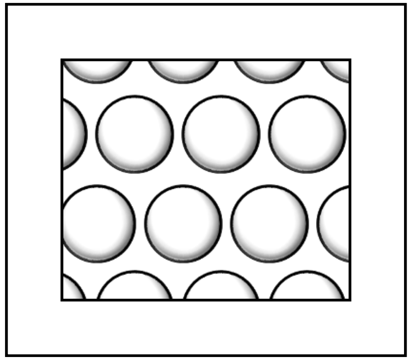
## Granular base **with high** content of fines



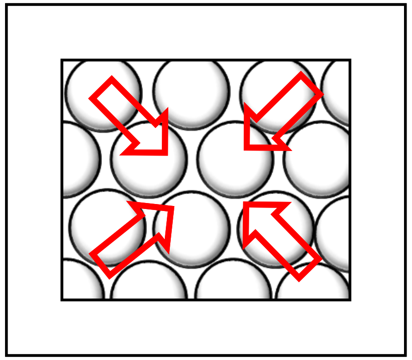
Fine material separates
coarse material



In the presence of water and traffic,
there is potential for washing fines

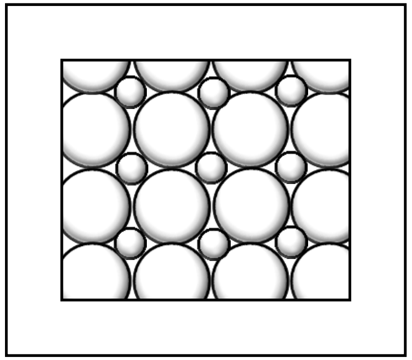


Coarse material is
separated from each other

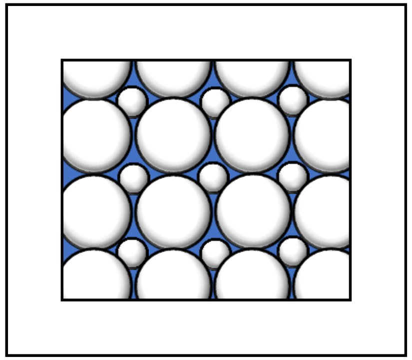


Coarse material sticks together
and de-compaction occurs

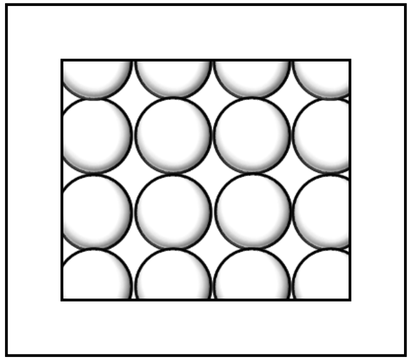
## Granular base **with low** content of fines



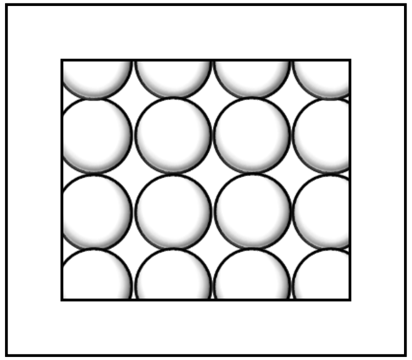
Coarse material is touching each other,
there is no thin material to separate it



In the presence of water and traffic,
there is potential for washing fines



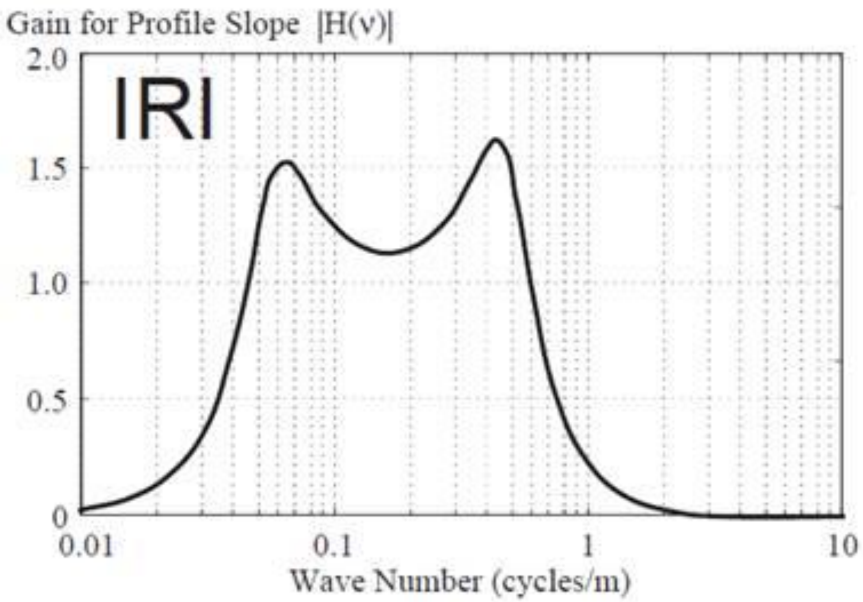
Thick material keeps touching each
other, with no space between them



No de-compaction occurs
at the base

# IRI (International Roughness Index)

- First public project measured: Cauquenes - Chanco
- Joint spacing: 2.3 m (7.5 ft)
- The intention was to reduce the number of cuts by 20%
- IRI measurements were slightly higher than expected



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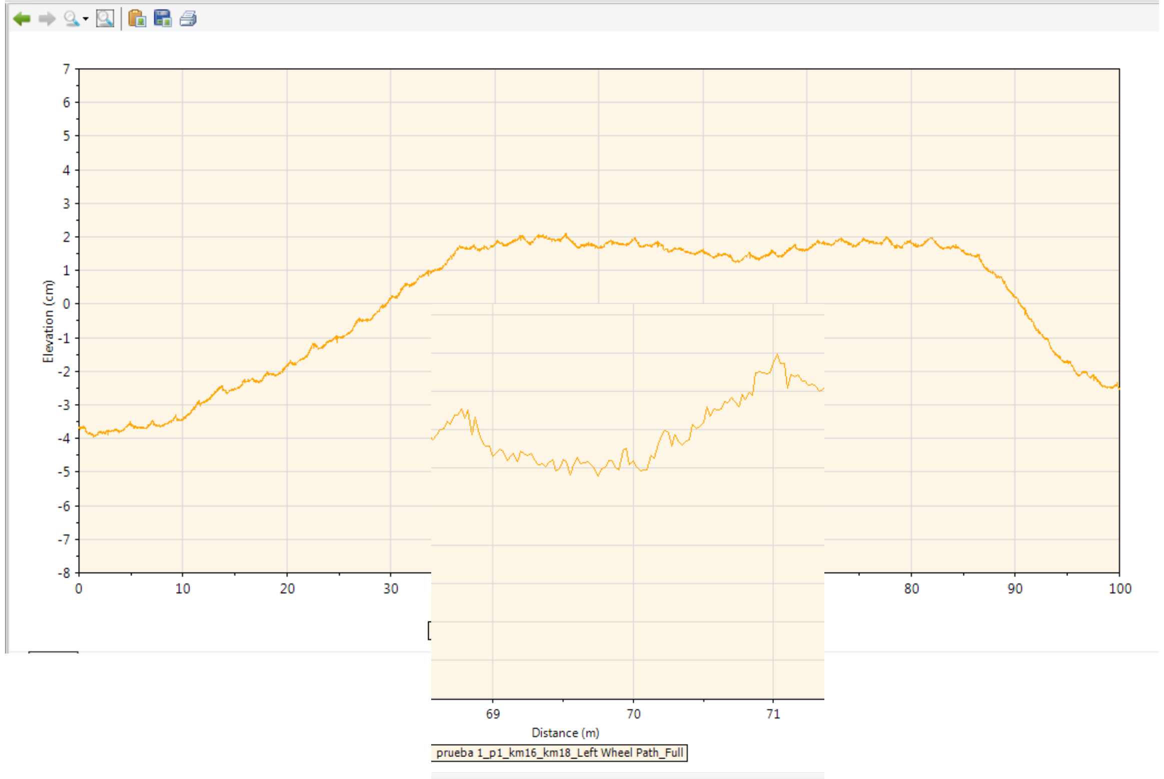
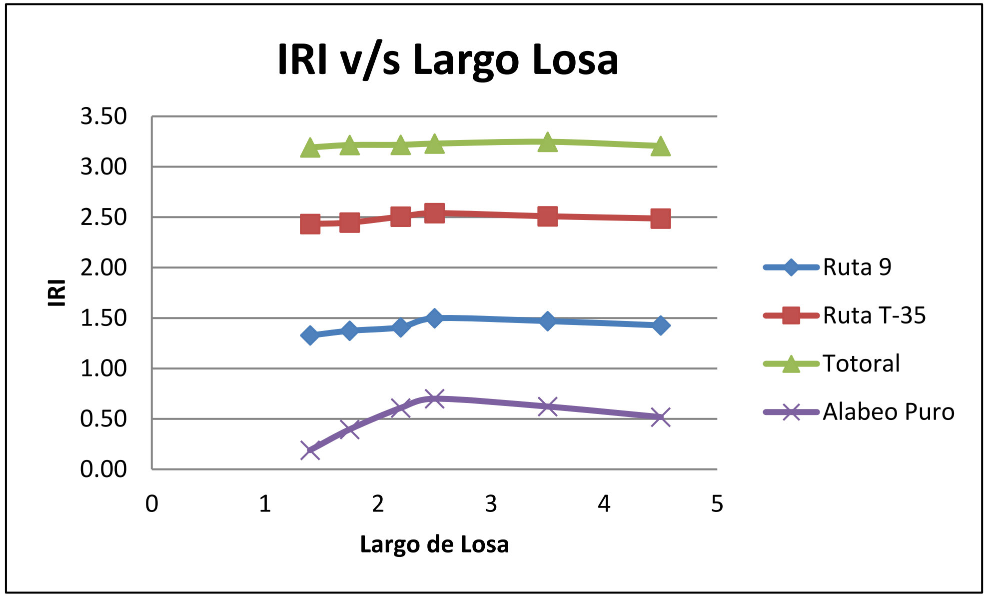


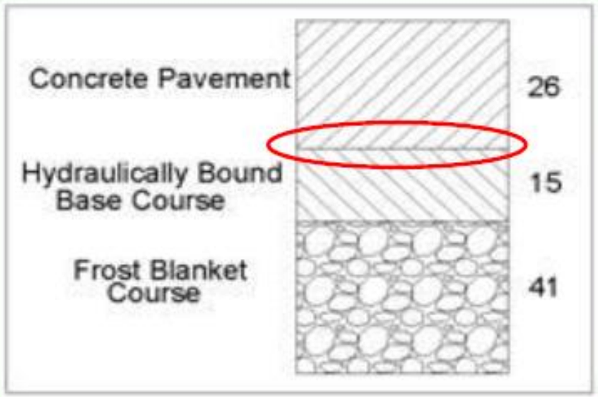



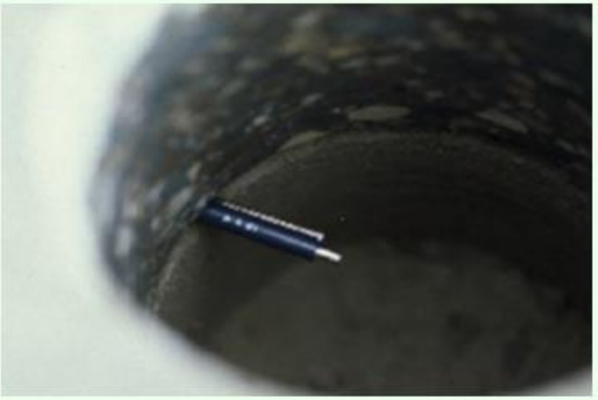

- Conclusions: use 6 ft joint spacing in areas with slabs curling
- Only in places with flatter pavements or with Transfer Bars: slabs > 2m (6.5 ft)

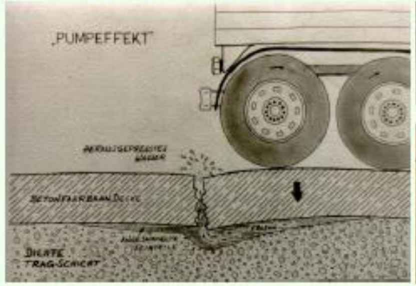
# Geotextile

**Concrete Pavement Surfaces from 1980 to 2001**

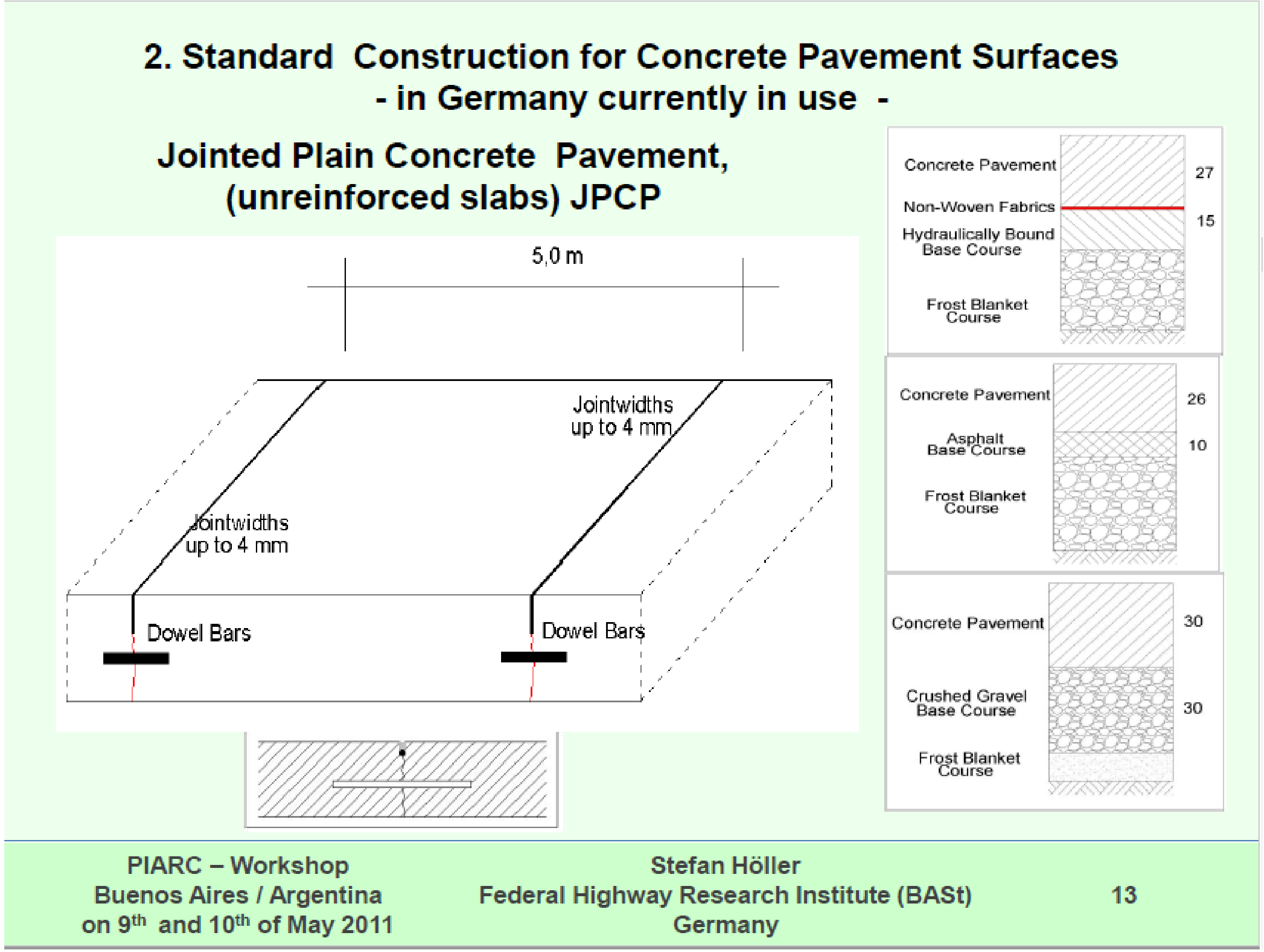
**Problems of Erosion and Water Pumping**






# Geotextile


2. Standard Construction for Concrete Pavement Surfaces
- in Germany currently in use -
Jointed Plain Concrete Pavement,
(unreinforced slabs) JPCP
5,0 m
Jointwidths
up to 4 mm
Jointwidths
up to 4 mm
Dowel Bars
Dowel Bars
Concrete Pavement
27
Non-Woven Fabrics
Hydraulically Bound
Base Course
15
Frost Blanket
Course
Concrete Pavement
26
Asphalt
Base Course
10
Frost Blanket
Course
Concrete Pavement
30
Crushed Gravel
Base Course
30
Frost Blanket
Course
PIARC – Workshop
Buenos Aires / Argentina
on 9th and 10th of May 2011
Stefan Höller
Federal Highway Research Institute (BASt)
Germany
13

# ATLAS: Accelerated Pavement Testing

- Traffic: 50,000 ESALs

## Type of Behavior

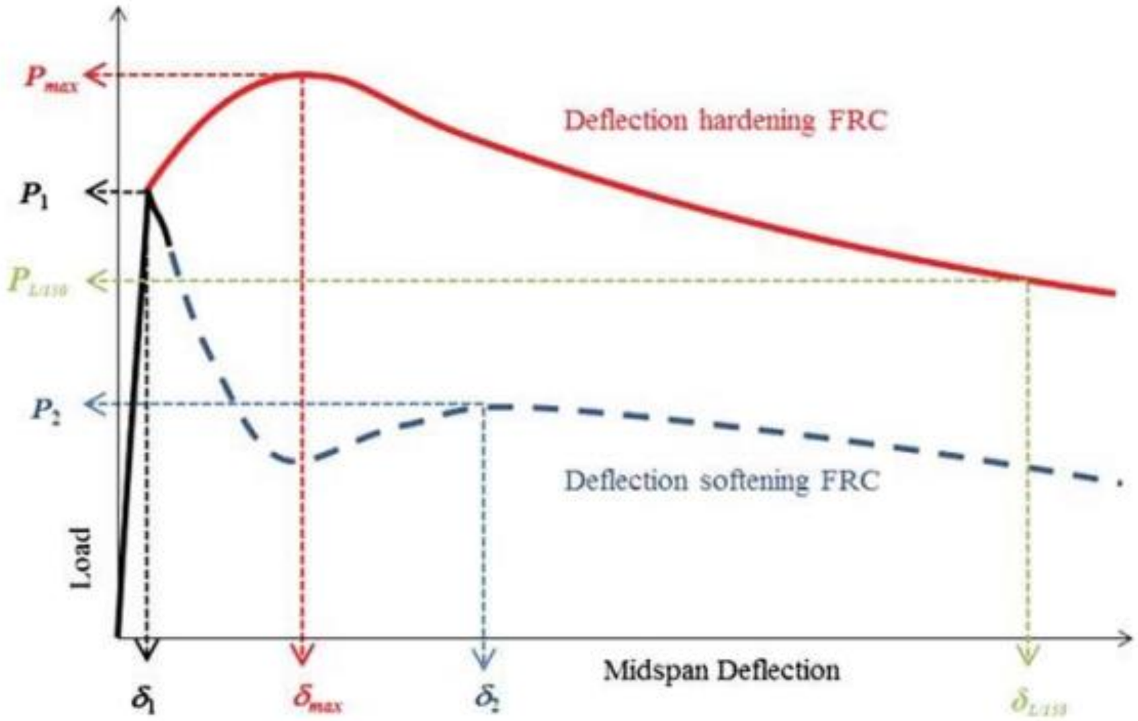
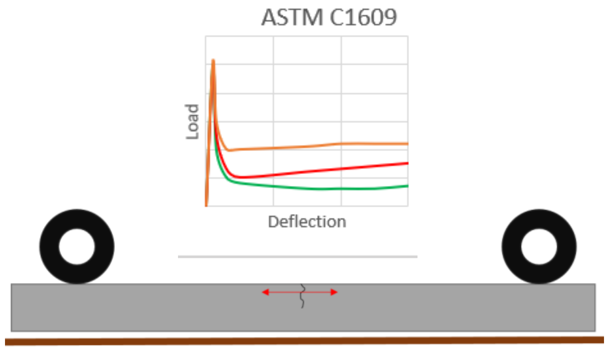
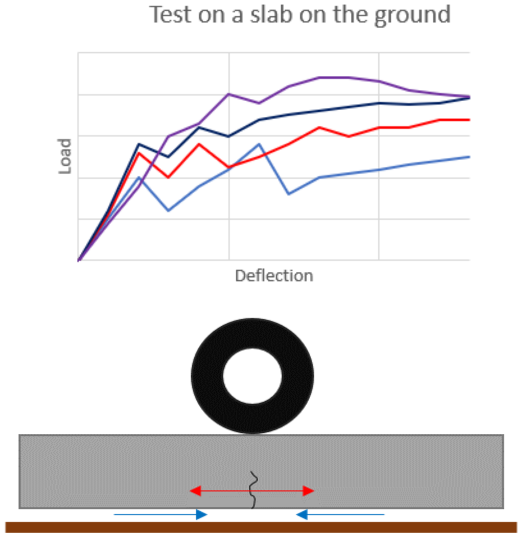
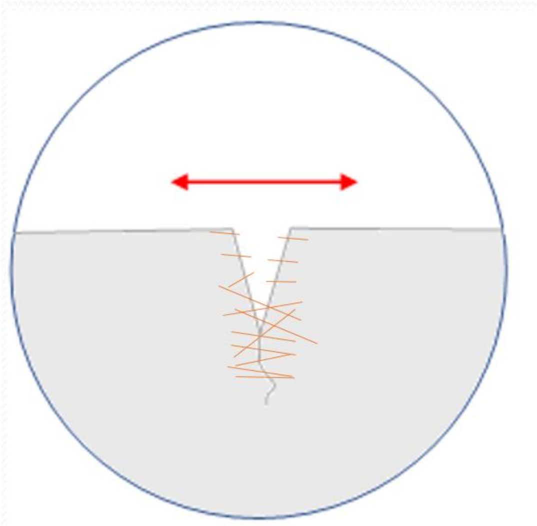


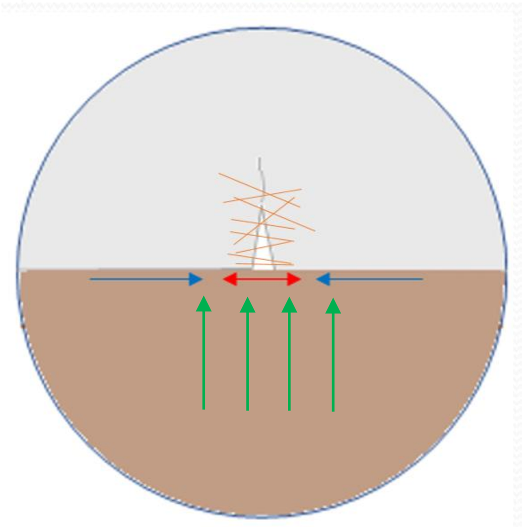

**Figure 2.3** Typical load-deflection curves of FRC

# Top-Bottom vs Bottom-Top cracks





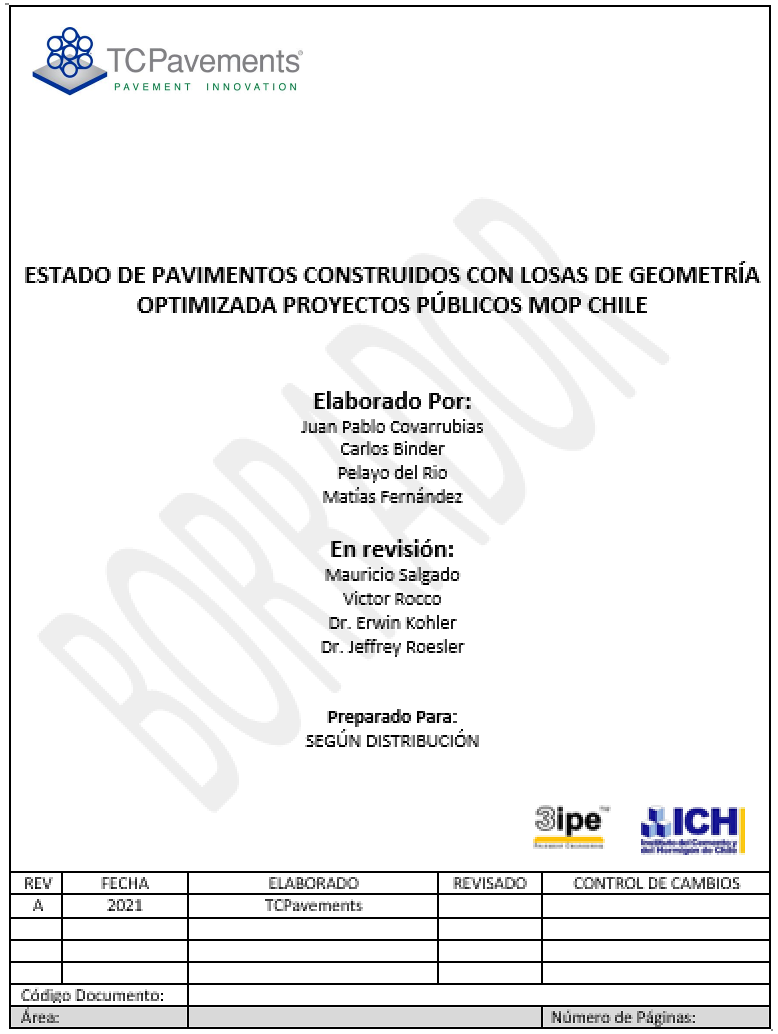
- Top-Bottom cracks
  - Free edge, no restriction (base) to prevent displacement
  - The fiber is not capable of supporting large displacements (except in large doses)
- Bottom-Top cracks
  - Due to the geometry, the cracks cannot be opened as in the case of Top-Bottom cracks
  - The support under the slab induces tension against displacement
  - Friction occurs that restricts the opening of the crack
  - Efforts are redistributed

# Measured Results

Thin Concrete
Pavements

# Case Studies

| Nombre proyecto | Año | Espesor de Losas (cm) | Fibra (R3e, L/150)) | Largo losas (cm) | Tramo dm (km) | Tránsito de diseño (EE) |
|---|---|---|---|---|---|---|
| Ruta M50 Cauquenes-Chanco I | 2012 | 17 | no | 220 | 15,220-28,600 | 8.000.000 |
| Ruta 5 Quellón-Yungay | 2014 | 17 | no | 175 | 1.272.474,5-1.257.385,0 | 20.000.000 |
| Ruta 5 Tara-Compu | 2014 | 17 | no | 175 | 1.214.237,5-1.239.365,0 | 20.000.000 |
| Ruta 60 Ch Camino La Pólvora | 2016 | 23* | 1 MPa | 175 | 0,260-16.680 | 189.000.000 |
| Ruta 257 Ch Cerro Sombrero-Onaissin I | 2012 | 14* | 1 MPa | 175 | 0,000-15,300 | 15.000.000 |
| Ruta 257 Ch Cerro Sombrero-Onaissin III | 2015 | 14* | 1 MPa | 175 | 15,300-58,800 | 15.000.000 |
| Ruta G84 | 2013 | 10* | 1 MPa | 175 | 22.750-23.250 | 1.000.000 |
| Ruta P46 Sara de Lebu-Pangue | 2016 | 8* | 1 MPa | 175 | 0,000-9,000 | 200.000 |
| Ruta 9 Cerro Castillo | 2009 | 12 | 1 MPa | 220 | 304.723-203.233 | 500.000 |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BORRADOR

ESTADO DE PAVIMENTOS CONSTRUIDOS CON LOSAS DE GEOMETRÍA OPTIMIZADA PROYECTOS PÚBLICOS MOP CHILE

**Elaborado Por:**
Juan Pablo Covarrubias
Carlos Binder
Pelayo del Rio
Matías Fernández

**En revisión:**
Mauricio Salgado
Victor Rocco
Dr. Erwin Kohler
Dr. Jeffrey Roesler

**Preparado Para:**
SEGÚN DISTRIBUCIÓN

| REV | FECHA | ELABORADO | REVISADO | CONTROL DE CAMBIOS |
|---|---|---|---|---|
| A | 2021 | TCPavements | | |

Código Documento:
Área: Número de Páginas:

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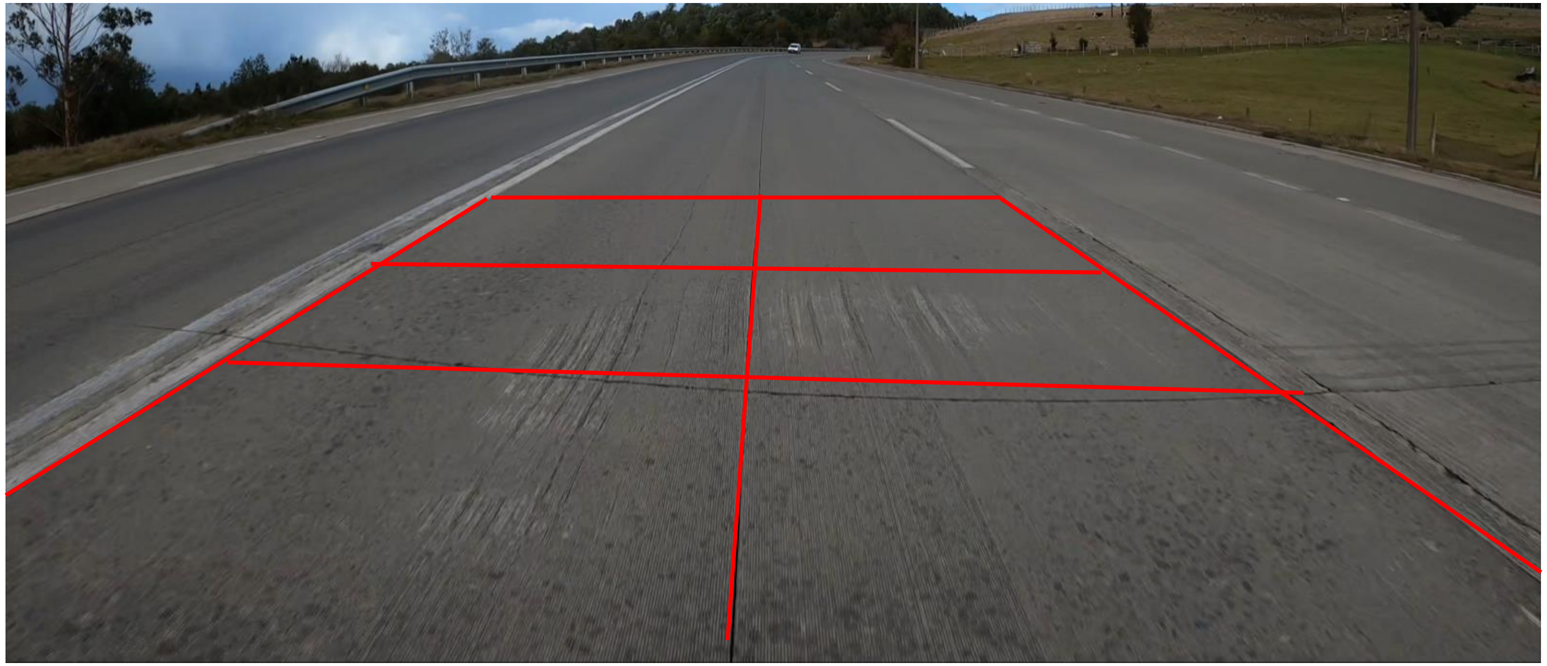
# Methodology

- Use of IRI results carried out by the National Highway Laboratory and complemented with measurements carried out by the 3ipe company in the year 2020-2021.
- Comparison of results with simulations calculated with OptiPave2 software for each project.
- IRI measurements performed by:
  - LNV
  - Dynatest
  - 3ipe
- Cracking:
  - Visually measure fatigue cracking
  - Photograph every 1 second of video
  - Measure cracking observed in the next 6 slabs of the advancing track



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# Route M-50 Cauquenes – Chanco I

## General Background

**Concrete thickness:** 17 cm (7.7’’)

**Joint spacing:** 2.3 m (7.5 ft)

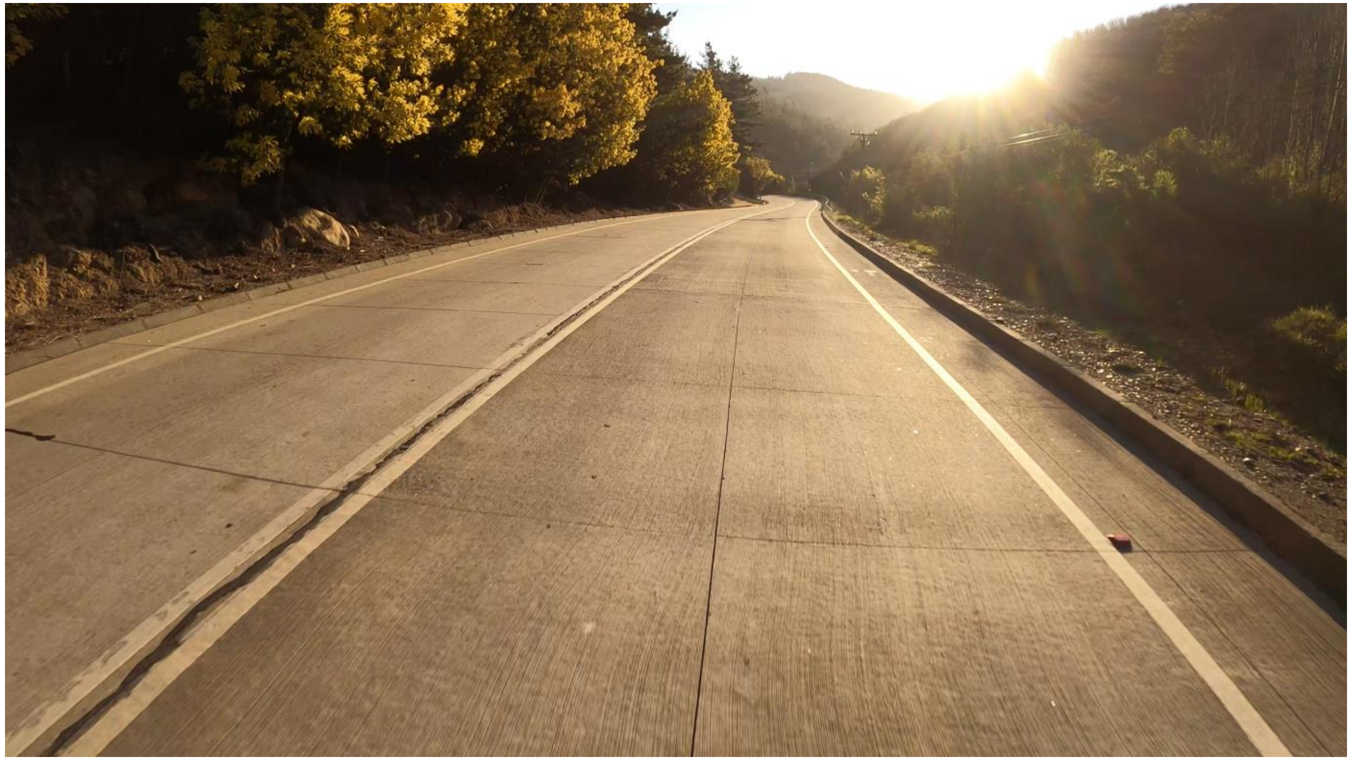
**Granular Subbase CBR>80%:** 15 cm

**Traffic:** 8.000.000 ESALs

**Design life:** 10 years

**Year of construction:** 2012

**Average precipitation:** 690 mm/year



August 2020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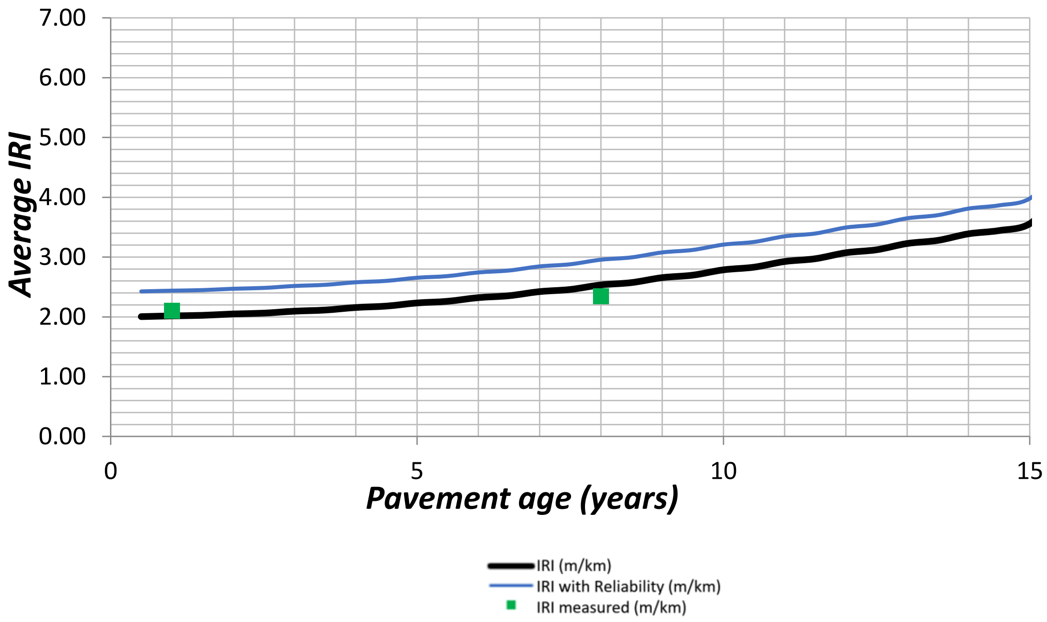
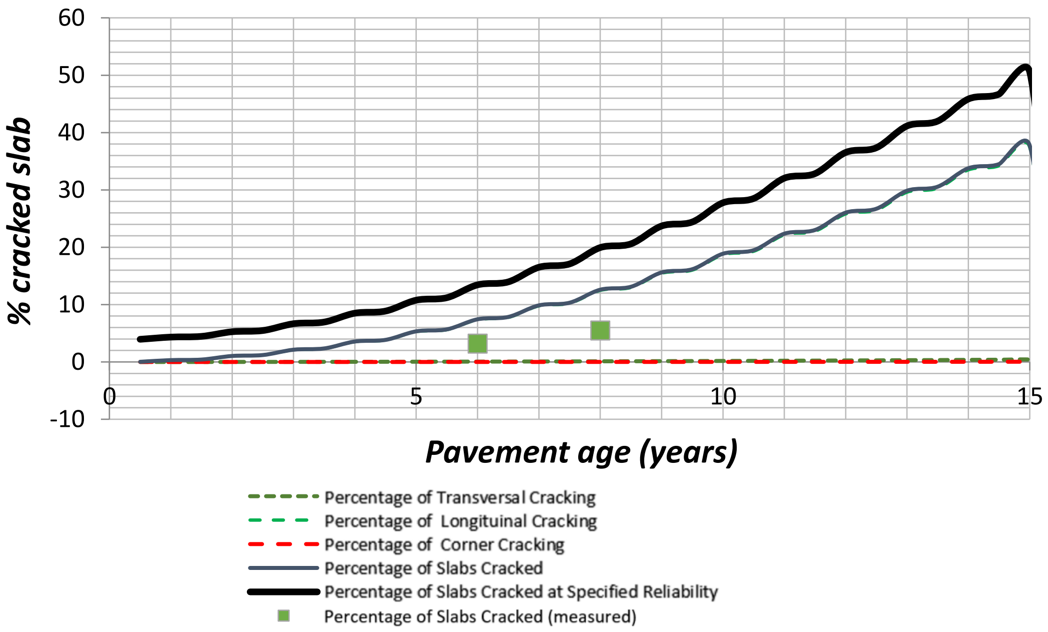
# Route M-50 Cauquenes – Chanco I

| Parameter | Evaluation | 2012 | 2018 | 2020 |
|---|---|---|---|---|
| IRI (m/km) | Measured | 2,1 | No Data | 2,35 |
| | Design at 80% Reliability. | 2,43 | 2,74 | 2,88 |
| Cracking (%) | Measured | No Data | 5,0% | 5,50% |
| | Design at 80% Reliability. | 3,96% | 11,20% | 17,10% |

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# Ruta 60 Ch, Camino La Pólvora

## General Background

**Concrete Thickness:** 23 cm FRC (9´´)

**Joint Spacing**: 1.75m (6 ft)

**Support**: Old asphalt pavement

**Traffic:** 189.000.000 ESALs

**Design life:** 20 years

**Year of construction:** 2016

**Average precipitation:** 422 mm/year


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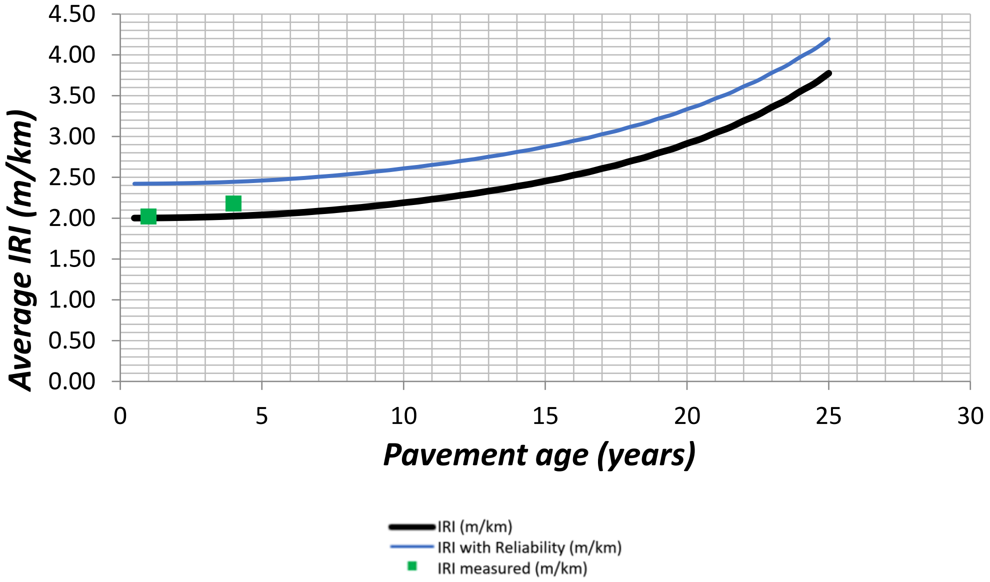
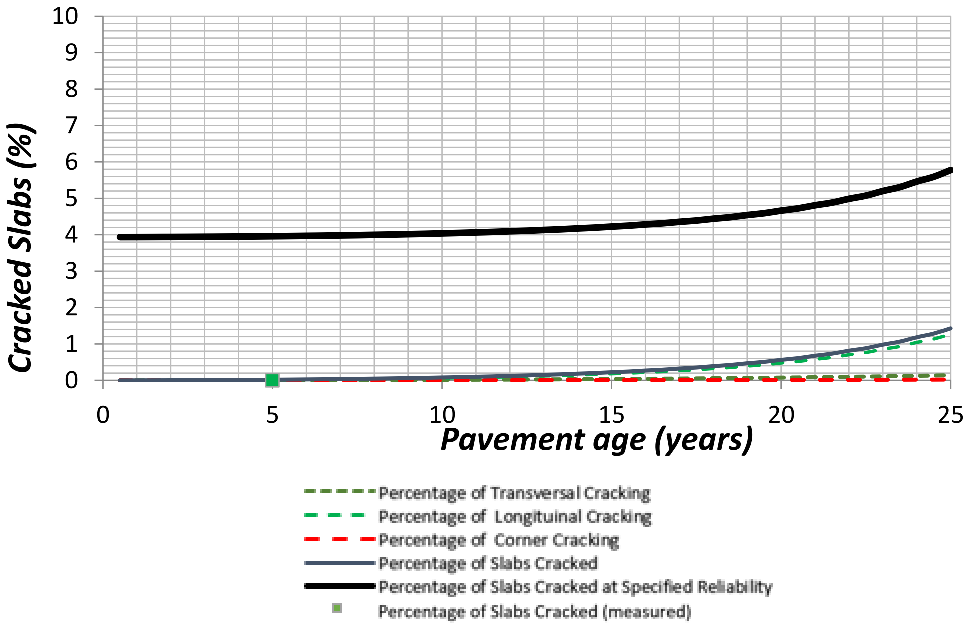
# Ruta 60 Ch, Camino La Pólvora

| Parameter | Evaluation | 2016 | 2020 | 2021 |
|---|---|---|---|---|
| IRI (m/km) | Measured | 1,9 | 2,11 | |
| | Design at 80% Reliability. | 2,42 | 2,44 | |
| Cracking (%) | Measured | < 0,5% | No Data | < 0,5% |
| | Design at 80% Reliability. | 3,94% | 3,95% | |

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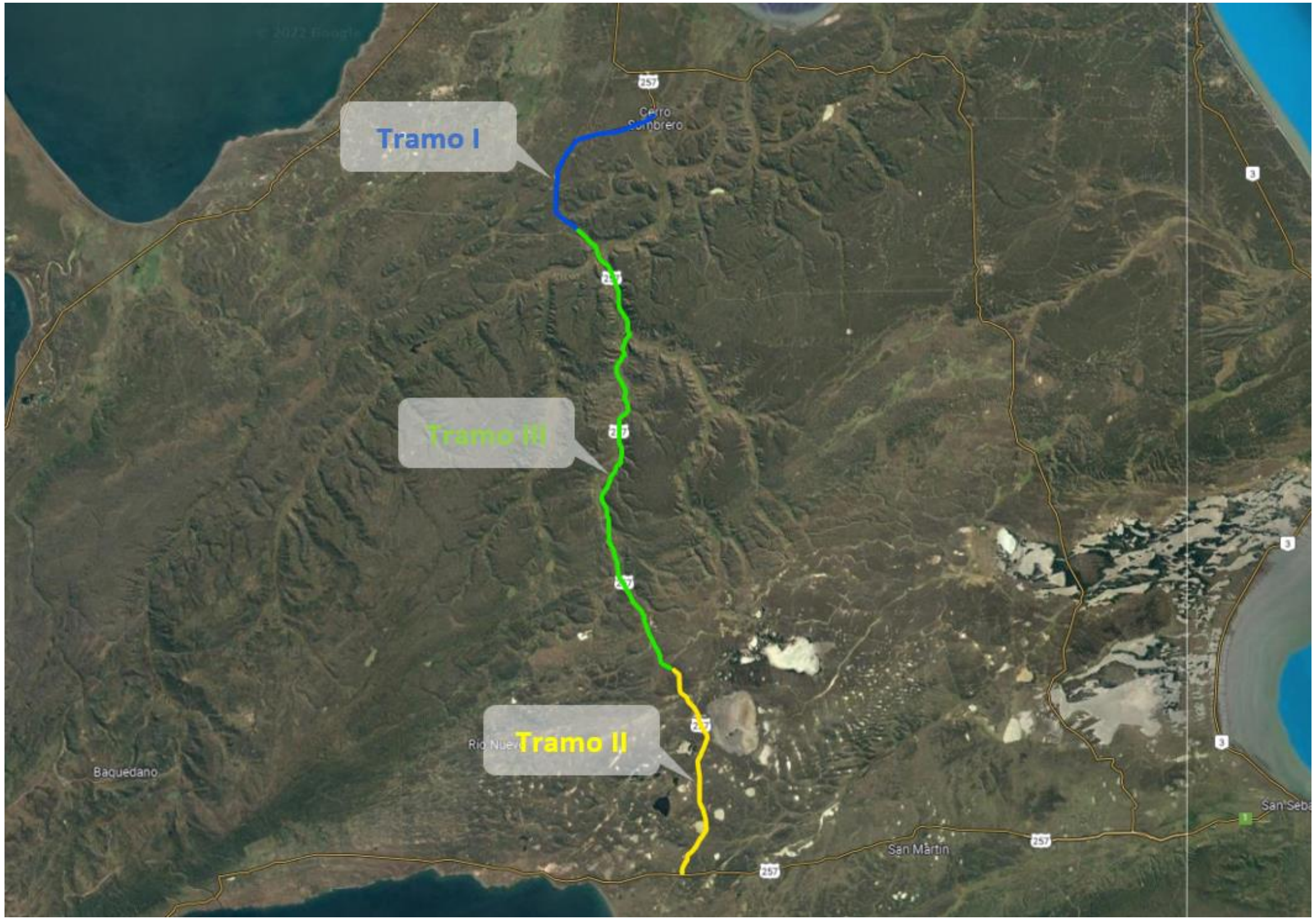
# Ruta 257 Ch Cerro Sombrero – Onaissin, Tierra Del Fuego, Chile




- Section I
  - OptiPave System
  - Thickness: 14 cm FRC
  - Year: 2012
- Section II
  - Traditional Slabs
  - Thickness: 20 cm
  - Year: 2014
- Section III
  - OptiPave System
  - Thickness: 14 cm FRC
  - Year: 2015

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Canadá
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Mar de Labrador
Noruega
Finlandia
Rusia
Dinamarca
Irlanda
Bielorrusia
Polonia
Alemania
Ucrania
Kazajistán
Mongolia
Austria
Francia
Rumanía
Italia
Uzbekistán
Kirguistán
España
Portugal
Grecia
Turquía
Turkmenistán
China
Estados Unidos
Océano Atlántico
Túnez
Mar Mediterráneo
Siria
Afganistán
Marruecos
Nepal
Golfo de México
México
Cuba
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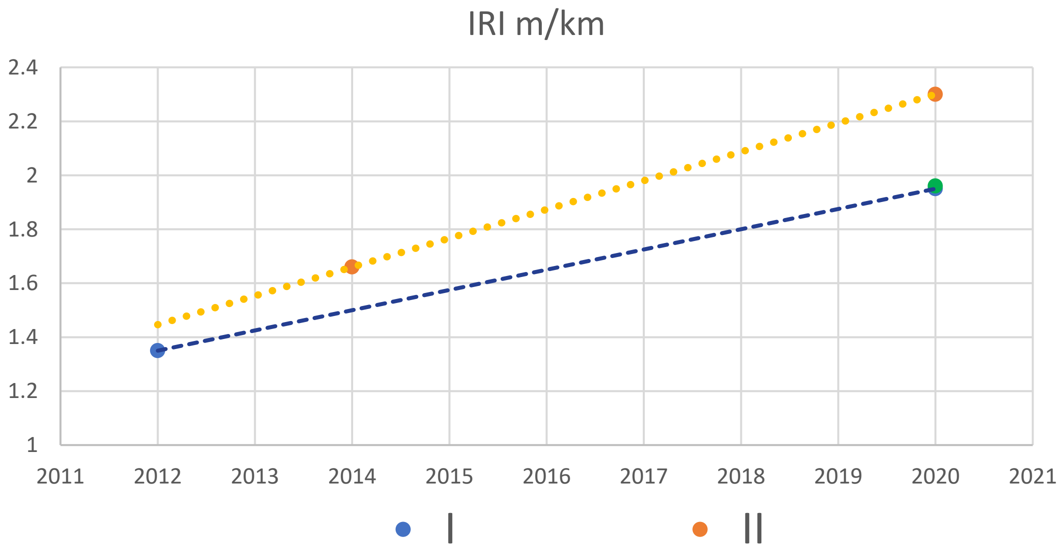
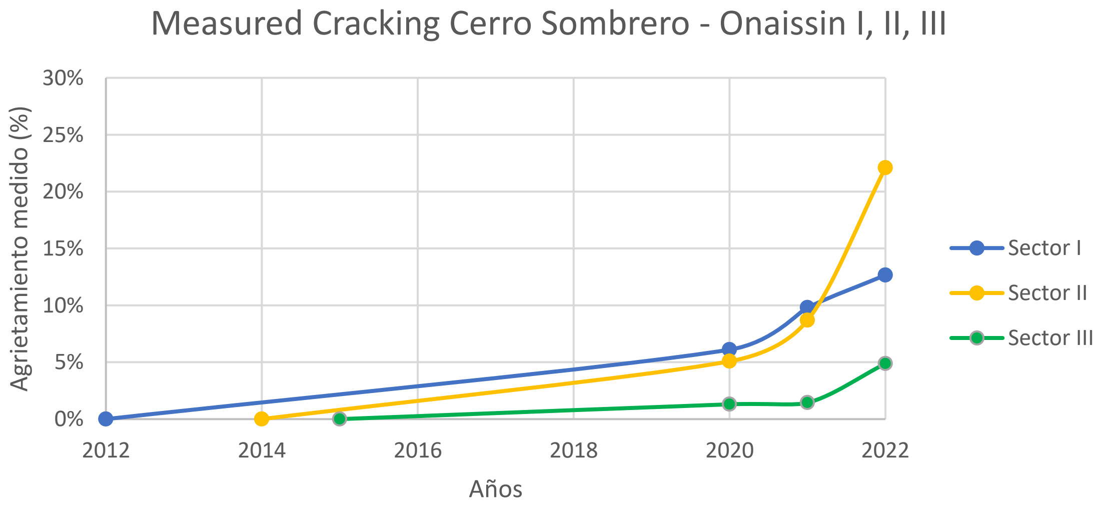
Guatemala
Nicaragua
Venezuela
Guyana
Surinam
Colombia
Ecuador
Brasil
Perú
Bolivia
Paraguay
Chile
Uruguay
Argentina
Filipinas
Google

# Comparision between Sections: Cerro Sombrero - Onaissin

## Sections I, II and III

| Cerro Sombrero - Onaissin | Year of construction | Cracking (%) 2021 | Cracking (%) 2022 | IRI 2020 |
|---|---|---|---|---|
| I (TCP) | 2011 | 9,80 | 12,46 | 1,95 |
| II (JPCP) | 2014 | 8,69 | 18,49 | 2,30 |
| III (TCP) | 2015 | 1,44 | 4,88 | 1,96 |

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# Summary projects presented

## Highways Behavior (IRI)

| Project | Initial IRI (m/km) | Measured IRI | | OptiPave Projection |
|---|---|---|---|---|
| | | Year | IRI (m/km) | IRI (m/km) |
| Ruta M-50, Cauquenes – Chanco I | 2,1 | 8 | 2,35 | 2,88 |
| Ruta 5, Quellón-Colonia Yungay | 1,88 | 6 | 2,27 | 2,5 |
| Ruta 5, Tara – Compu | 1,89 | 5 | 2,18 | 2,45 |
| Ruta 60 Ch, Camino La Pólvora | 1,9 | 4 | 2,18 | 2,44 |
| Ruta 257 Ch, Cerro Sombrero – Onaissin 1 | 1,35 | 9 | 1,95 | 2,51 |
| Ruta 257 Ch, Cerro Sombrero – Onaissin 3 | ?? | 5 | 1,96 | 2,46 |

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# Summary projects presented

## Highways Behavior (Cracking)

| Project | Measured Cracking | | OptiPave projection |
|---|---|---|---|
| | Year | Cracking (% of slabs) | Cracking (% of slabs) |
| Ruta M-50, Cauquenes – Chanco I | 8 | 5,50 | 17,10 |
| Ruta 5, Quellón-Colonia Yungay | 7 | 2,38 | 5,18 |
| Ruta 5, Tara – Compu | 7 | 3,81 | 5,44 |
| Ruta 60 Ch, Camino La Pólvora | 5 | < 0,5 | 3,96 |
| Ruta 257 Ch, Cerro Sombrero – Onaissin 1 | 9 | 9,80 | 6,15 |
| Ruta 257 Ch, Cerro Sombrero – Onaissin 3 | 6 | 1,44 | 6,15 |

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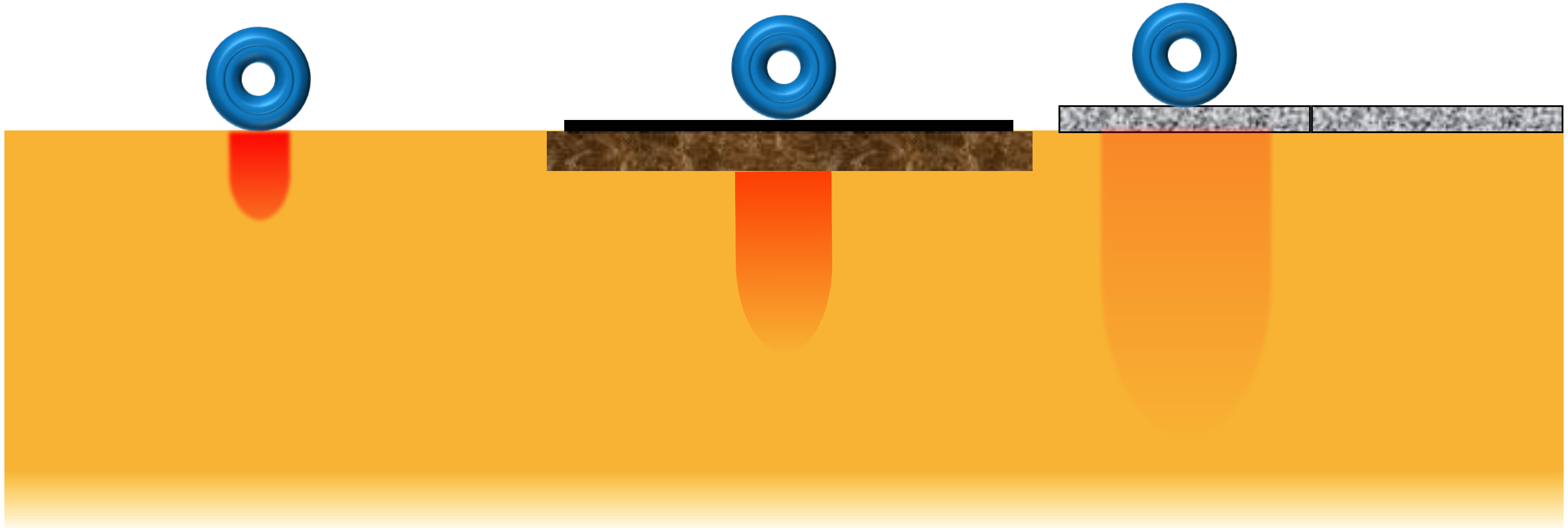
# OptiPave system for LVR

# OptiPave system for LVR (U-TCP)

- Hypothesis



# Tests

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# Mahuidanche – Misión Inglesa (before)

**Thickness**

8 cm (3'') FRC

**Traffic**

50.000 ESALs

**Year built**

2012

YouTube https://www.youtube.com/watch?v=3JEQRtej0BM

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# Mahuidanche – Misión Inglesa (after)

**Thickness**

8 cm (3’’) FRC

**Traffic**

50.000 ESALs

**Year built**

2012

YouTube https://www.youtube.com/watch?v=3JEQRtej0BM

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# Macro-Synthetic Fiber on Concrete

## For U-TCP

- Distribution of cracks at the base-pavement interface
- Increased resistance to cyclic loads or fatigue
- Allows concrete bonding between cracks
- Improves the post-cracking life of the pavement



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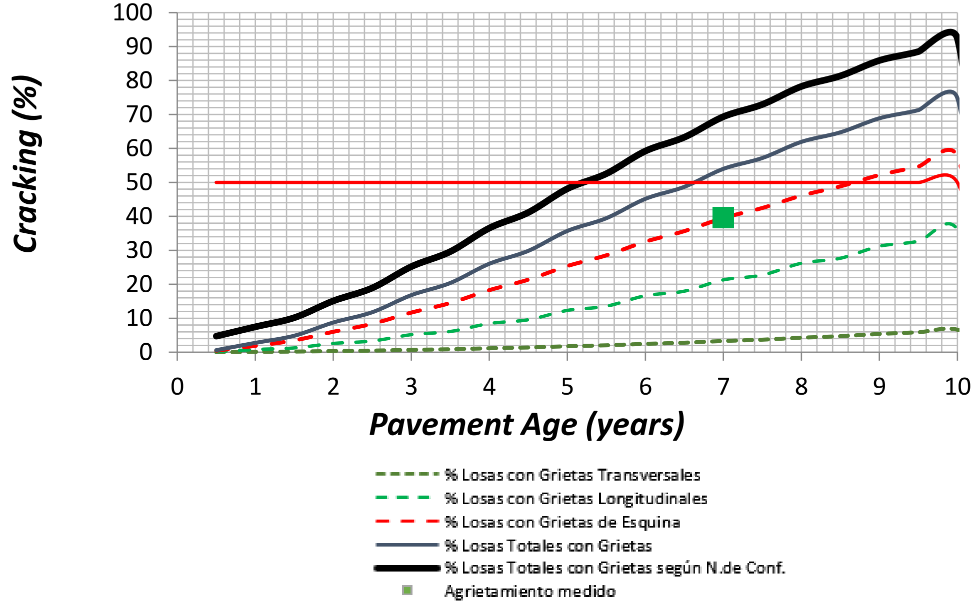
# Failure Mode Route G-84 (U-TCP)

## September 2015

# Failure Mode after 8 years ( Designed for 5)

# Route G-84

- Year of Construction: 2013
- Concrete Thickness: 10cm FRC
- Lenght: 0,5 km
- Slab Support: No base
- Design Traffic: 1.000.000 ESALs
- Design Life: 5 years




| | Orientación Oeste-Este | | | Orientación Este-Oeste | | |
|---|---|---|---|---|---|---|
| | Tipo de agrietamiento | | | Tipo de agrietamiento | | |
| | **Longitudinal** | **Transversal** | **Esquina** | **Longitudinal** | **Transversal** | **Esquina** |
| **Losa izquierda** | 31% | 6% | 8% | 57% | 13% | 27% |
| **Losa derecha** | 29% | 4% | 6% | 22% | 10% | 10% |
| **Porcentaje de losas agrietadas** | **Por pista** | 30% | | 43% | | |
| | **Total** | 37% | | | | |

# Sara de Lebu – Pangue (después)

**Thickness**

8 cm FRC

**Traffic**

5 trucks/day

**Year built**

2015

Slope with 25% inclination

YouTube https://www.youtube.com/watch?v=gFqYzQ773Ao

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# Bahía Murta

**Thickness**

10 cm FRC

**Traffic**

10 trucks/day

**Year built**

2016

YouTube https://www.youtube.com/watch?v=IReXiqhV_sI&t=8s

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# Camino a Lago Pollux, Coyhaique

**Thickness**

10 cm FRC

**Traffic**

200.000 EE

**Year built**

2019

Paved directly by the Ministry

# Torres del Paine – Acceso Sarmiento


**Thickness**

8 cm FRC

**Traffic**

50.000 EE

**Year built**

2018

YouTube https://www.youtube.com/watch?v=O8VlP9NnHsY

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# Thank You