2nd INTERNATIONAL CONFERENCE
TIMBER BRIDGES
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Influence of concrete cracking on wood concrete composite bridges

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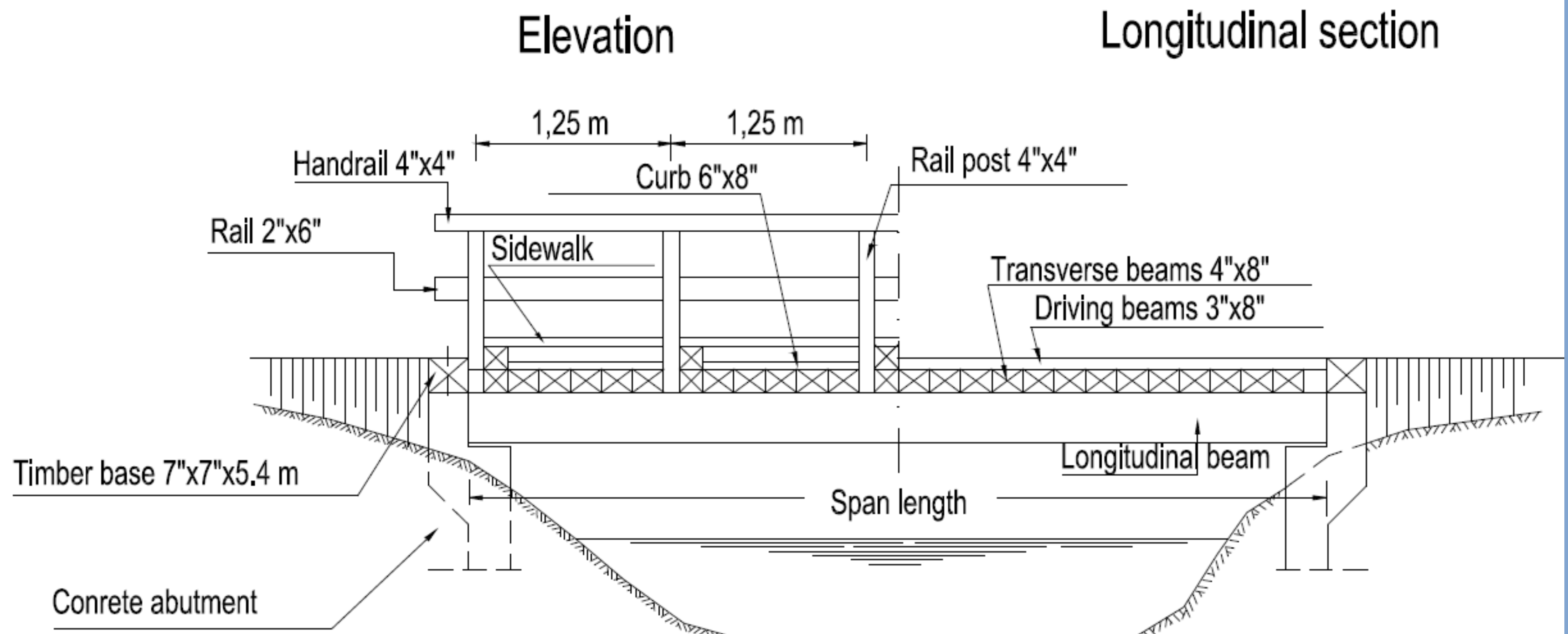
Contents

Introduction

- Concrete cracking reduces concrete stiffness
- Reduced concrete stiffness increases deformations and timber stresses
- Concrete cracking must be considered in the design
- Design recomendations vary from neglecting the effect to a stiffness reduction of 60%

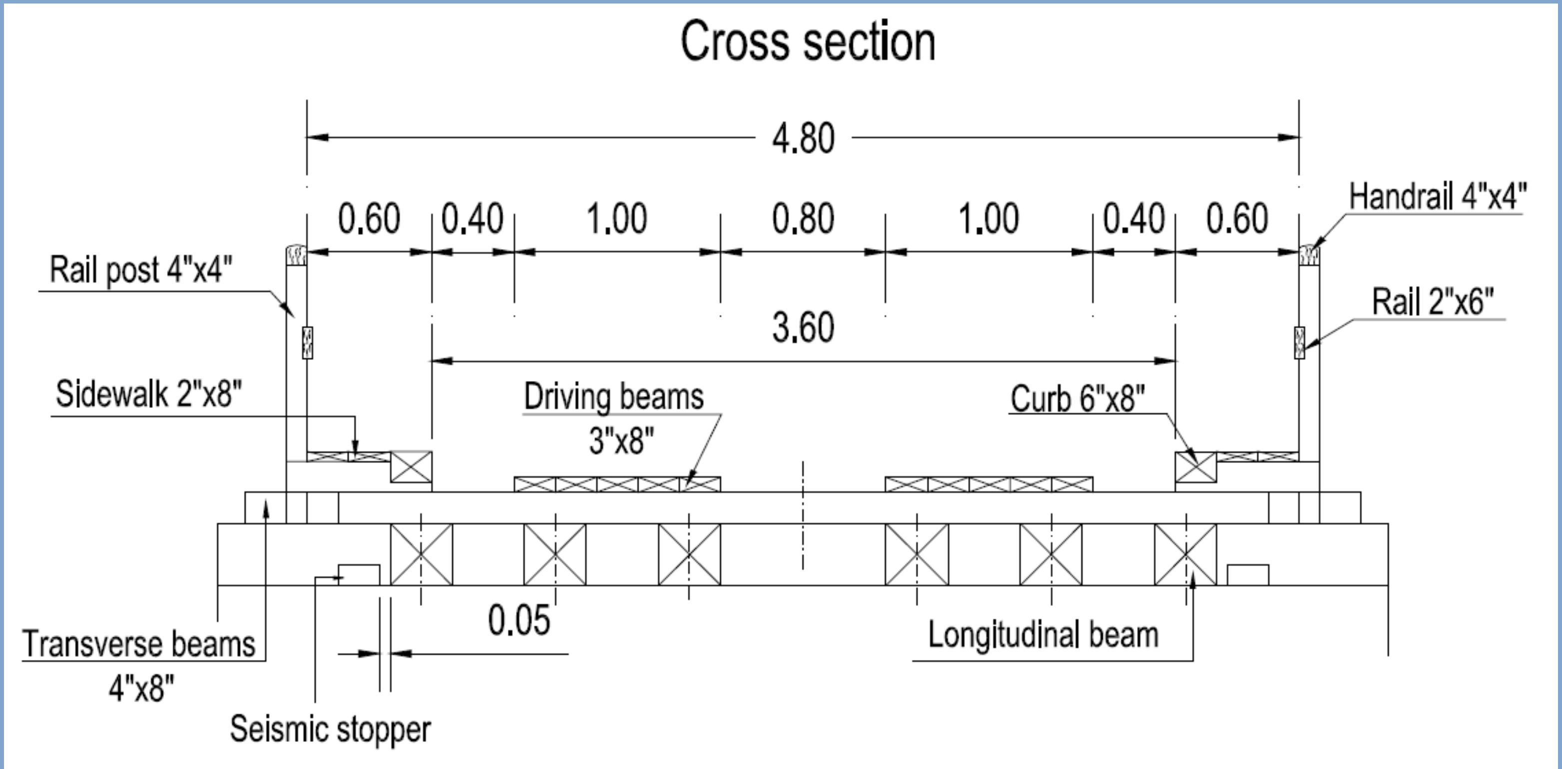
Timber bridges en Chile

- About 2/3 of all Chilean bridges have a wooden deck (≈4000 timber bridges)
- Simply supported beam bridges <10 m
- Chilean oak or Chilean beech covered with hot creosot



Timber bridges en Chile

- 4 or 6 longitudinal beams
- Exposed to very high humdity (>2500 mm per year)
- Service life of about 6 years



Timber bridges en Chile

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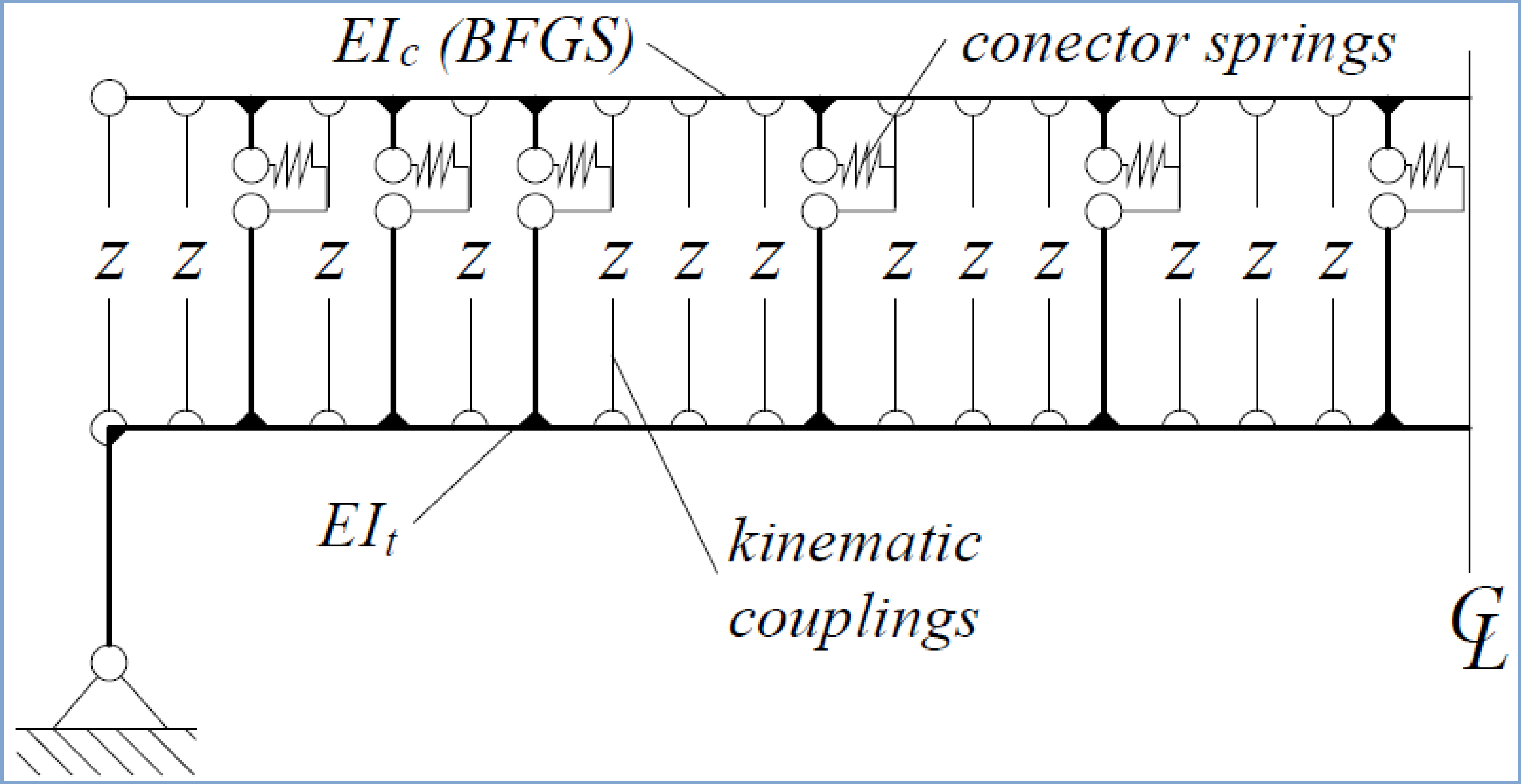
Methodology

- Parameterized FEM analysis model
- First calibration with test data from literature
- Own laboratory tests
- Final calibration of the FEM model
- Parametric study of different geometries
- General design recomendations

Methodology

- **Parameterized FEM analysis model**



Methodology

- **Parameterized FEM analysis model**

Concrete slab	Timber beam	General
Depth	Depth	No lineal load-displacement behaviour of the connection
Modulus of elasticity	Modulus of elasticity	Distribution of reinforcement
Tensile resistance	Creep	Type of loading and load history
Tension stiffening	Shrinkage	Length and width
	Swelling	

Methodology

- **First calibration with test data from literature**

van der Linden M. L. R., *Timber-Concrete Composite Floor System*, Technische Universiteit Delft, 1999.

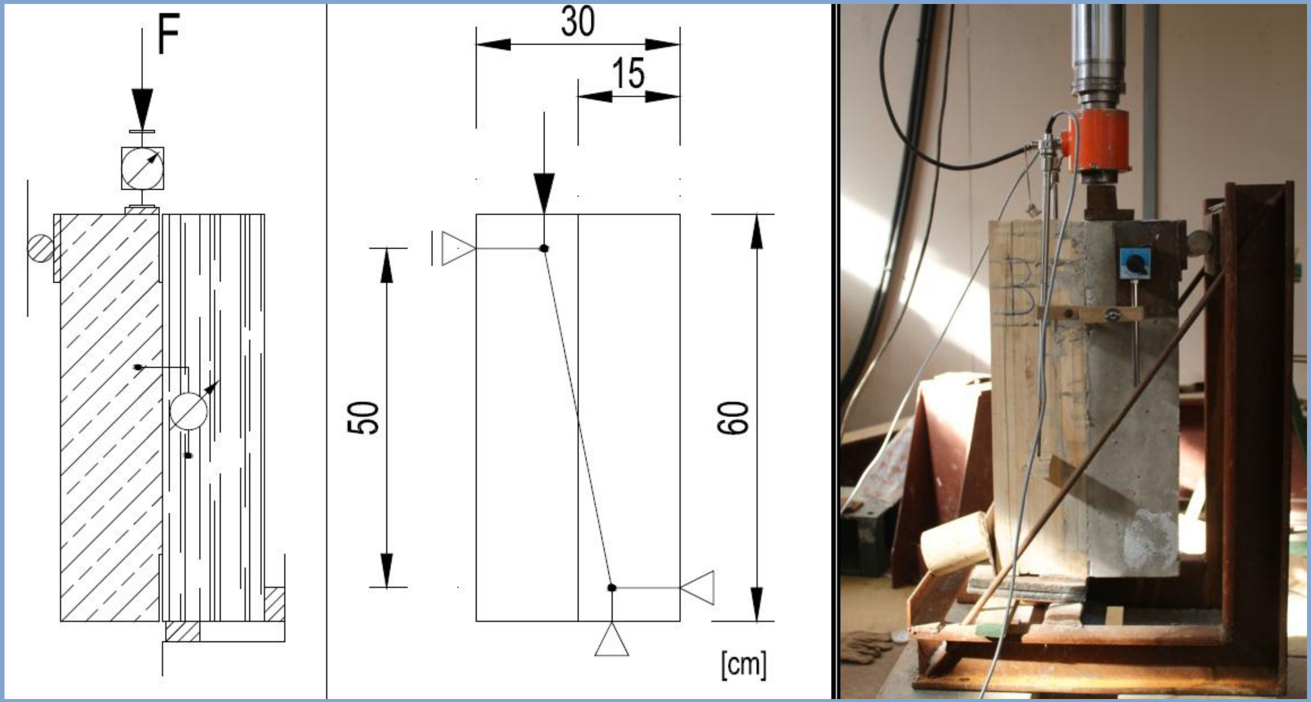
Yeoh D., *Behaviour and Design of Timber-Concrete Composite Floor System*, University of Canterbury, 2010.

Ávila L., *Cálculo de un puente de vigas mixtas madera-hormigón basado en parámetros de diseño experimentales*, Universidad Austral de Chile, 2012.

Klingenberg T., *Determinación experimental de Parámetros de Diseño para Puentes de Vigas Mixtas Madera-Hormigón*, Universidad Austral de Chile, 2012.

Methodology

- Own laboratory tests
- Shear tests with a gap: 0 mm, 2 mm, 4 mm, 6 mm

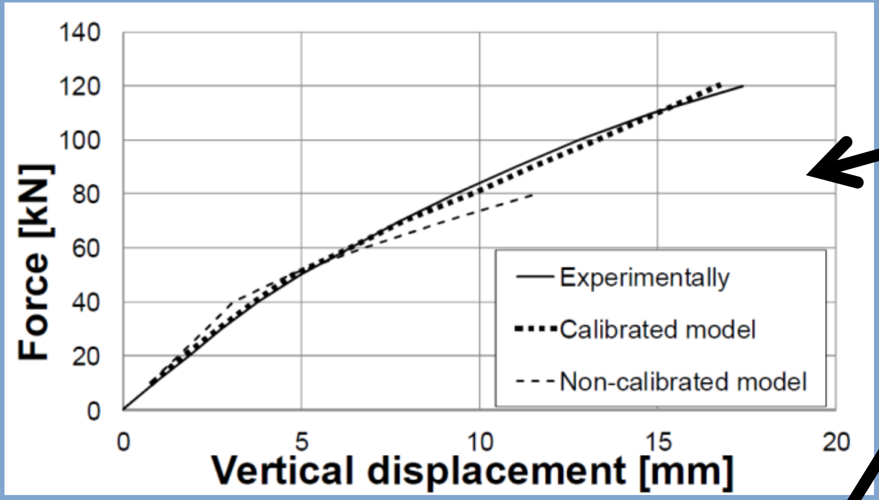


Methodology

- Own laboratory tests
- Bending tests, 3 m long, concrete 15 cm and 20 cm, timber 30 and 50 cm

Results

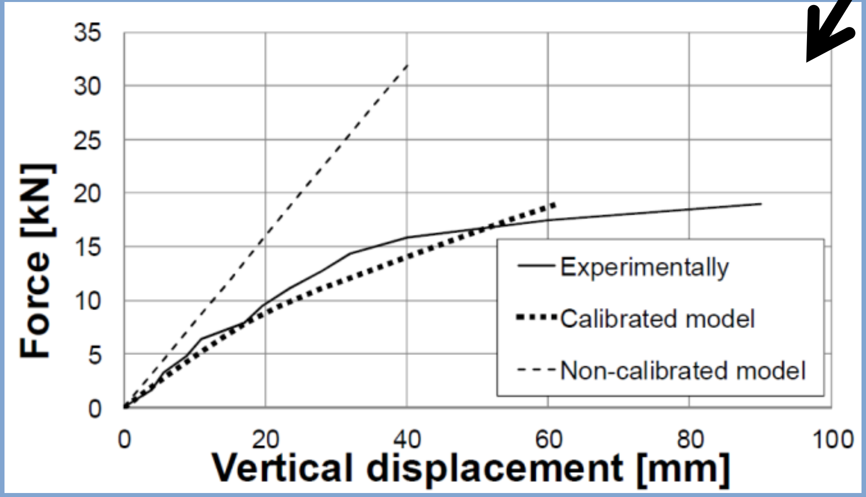
- First calibration with test data from literature

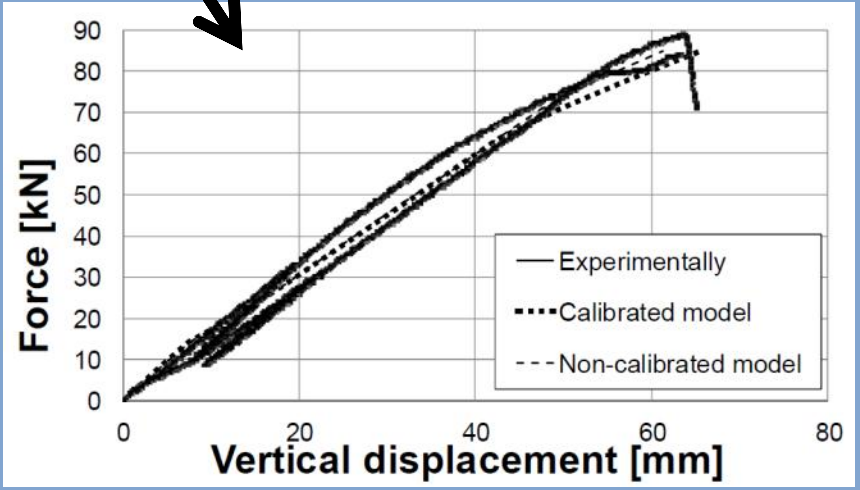


Klingenberg

Van der Linden

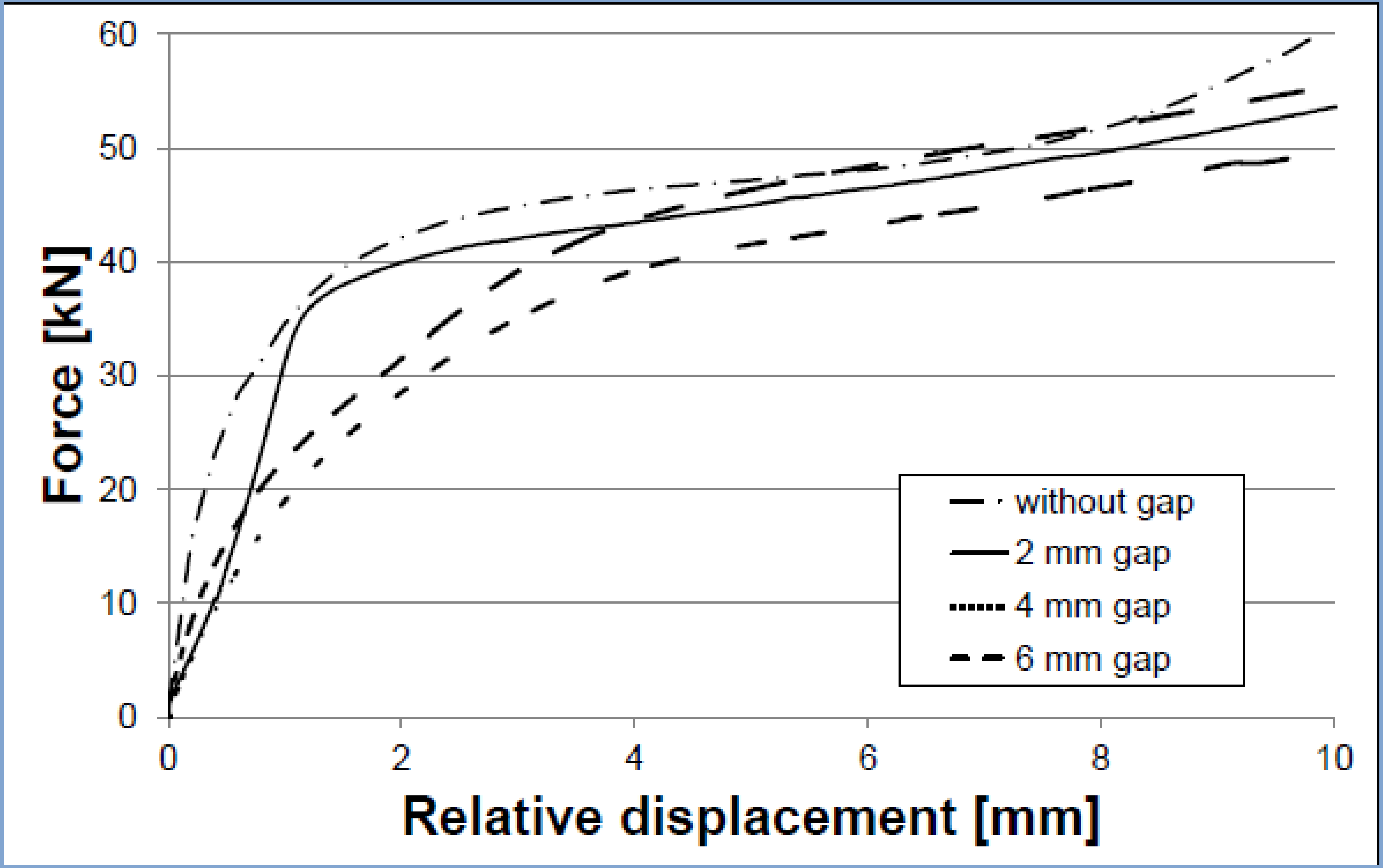
Yeoh





Results

- **Shear tests**



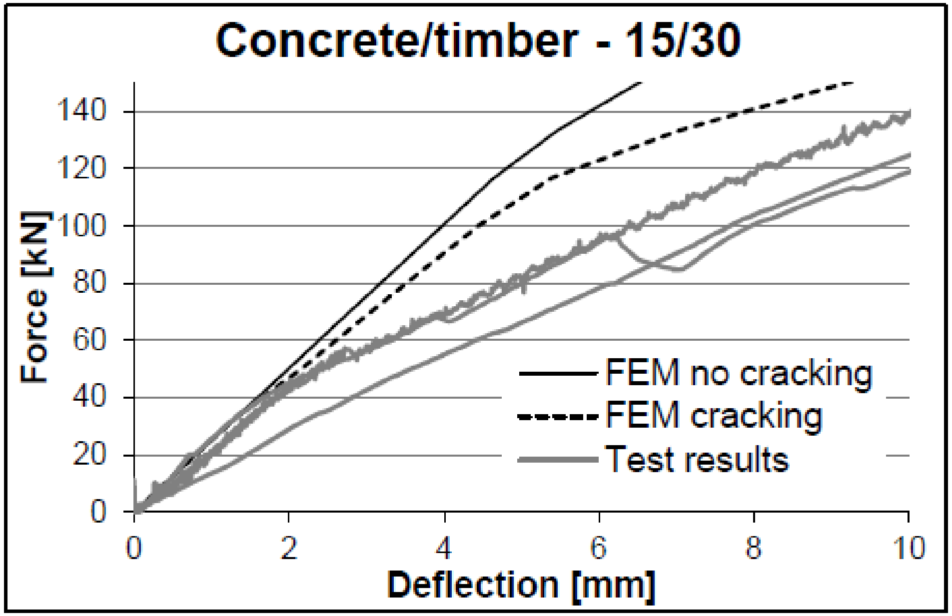
Results

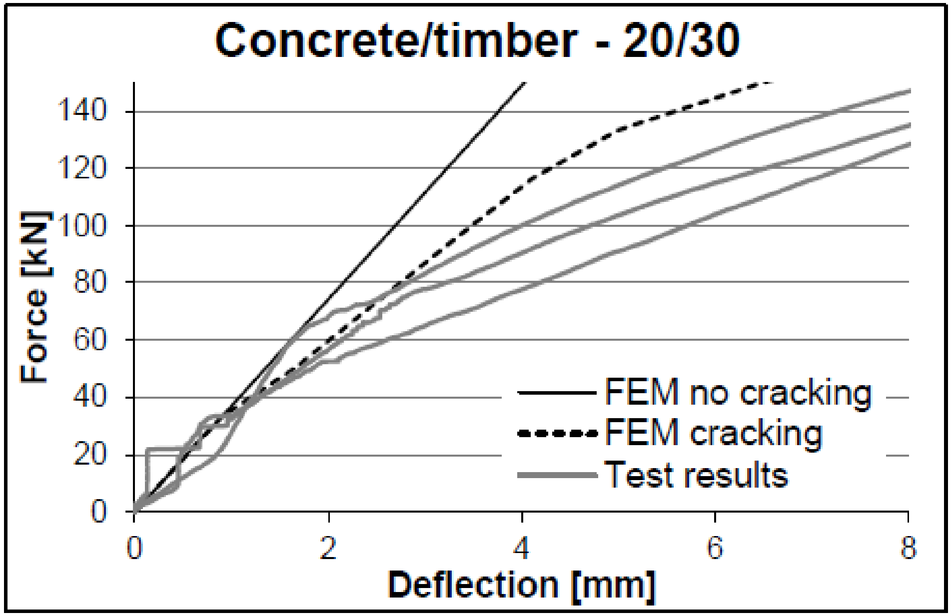
- **Shear tests**

Test specimen	F_u [kN]	F_{40} [kN]	F_{10} [kN]	u_{40} [mm]	u_{10} [mm]	k_{ser} [kN/mm]	mean k_{ser} [kN/mm]	
0 mm-1	68	27.2	5.5	0.42	0.04	14.34		
0 mm-2	59	23.6	4.7	0.41	0.04	12.73	12.57	100%
0 mm-3	57	22.9	4.6	0.48	0.05	10.64		
2 mm-1	54	21.6	5.4	0.861	0.103	5.34		
2 mm-2	50	19.9	5.0	0.705	0.173	7.01	5.98	48%
2 mm-3	48	19.2	4.8	0.708	0.065	5.60		
4 mm-1	53	26.5	5.3	1.396	0.201	4.44		
4 mm-2	42	21	4.2	0.864	0.08	5.36	5.16	41%
4 mm-3	44	22	4.4	0.924	0.152	5.70		
6 mm-1	40	20	4	1.609	0.178	2.80		
6 mm-2	43	21.5	4.3	1.206	0.163	4.12	3.58	28%
6 mm-3	45	22.5	4.5	1.367	0.186	3.81		

Results

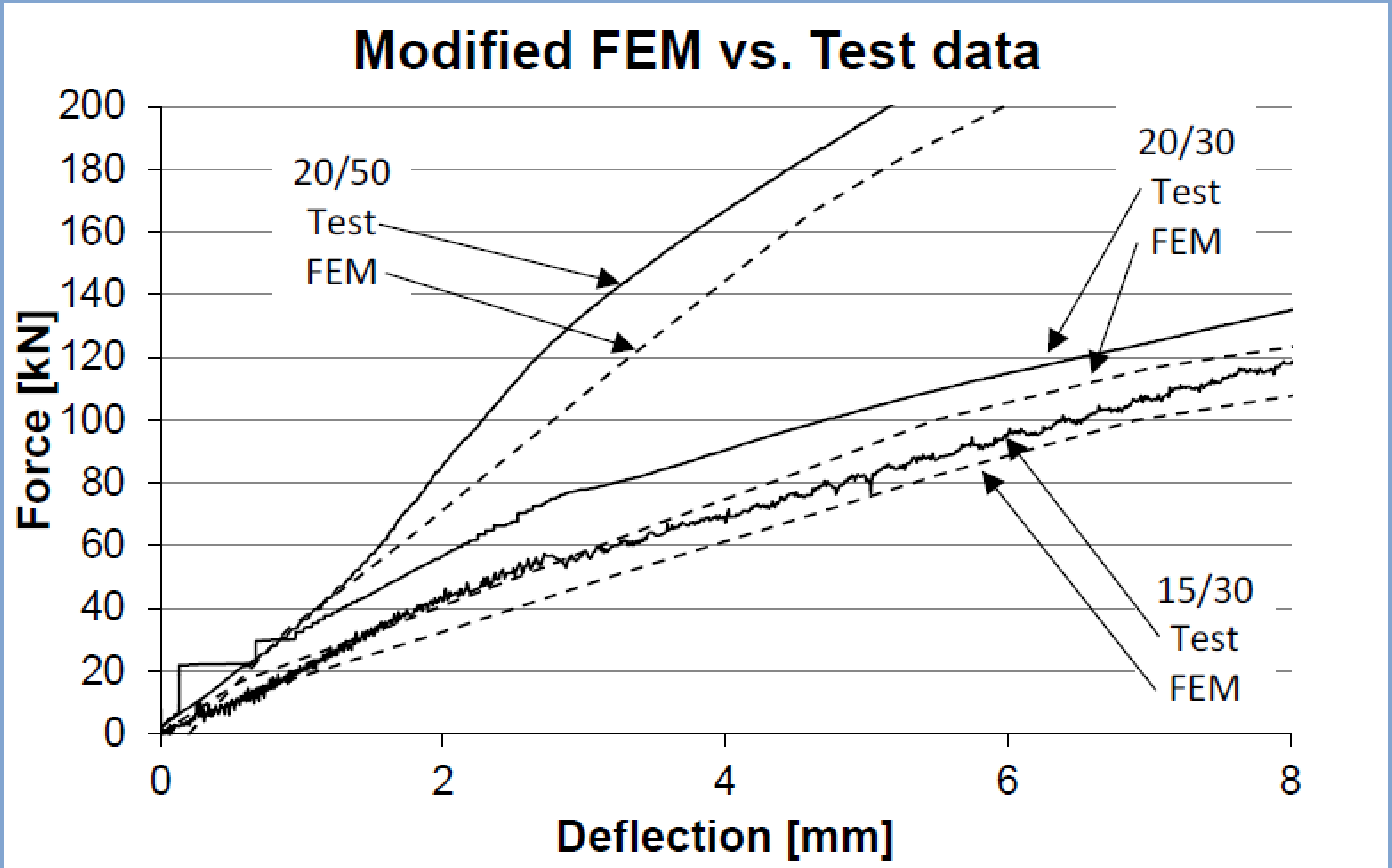
- **Bending tests**





Results

- Final calibration of the FEM model
- Reduction of the connector stiffness by about 60%



Conclusions

- Chile has a big need for durable timber bridges
- Wood concrete-composite bridges can be the solution
- There is no satisfying design recomendation for concrete cracking in TCC beams
- FEM analysis show that concrete cracking alone does not explain the documented stiffness reduction
- Shear test show that concrete cracking reduces substantially the stiffness of bar-type shear connectors

Conclusions

- The analysis model predicts correctly the initial elastic behavior and the crack initiation load
- When concrete cracking occurs, the slip modulus must be reduced
- Preliminary, a stiffness reduction by about 60% leads to a safe design

Thanks for your attention!

Acknowledgements

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