COST Action FP1004

Final Meeting

15 April – 17 April 2015 – Lisbon, Portugal

Timber-Concrete composite increasing the use of timber in construction

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OUTLINE

- HISTORIC BACKGROUND
- TCC POTENTIAL AND CHALLENGES
- RECENT DEVELOPMENTS
- ANALYSIS AND DESIGN
- SOLUTIONS/APPLICATIONS
- CASE STUDIES ENHANCING TIMBER USE

HISTORIC BACKGROUND

- Started in 20’s 30’s from XX century
- Renovated interest in the 70’s and 80’s – Mostly on rehabilitations
- Several research in the 80,s and 90’s
- Wider use from 90’s namely in building floors and bridge decks

TCC CHALLENGES AND POTENTIAL

Compatibility between materials

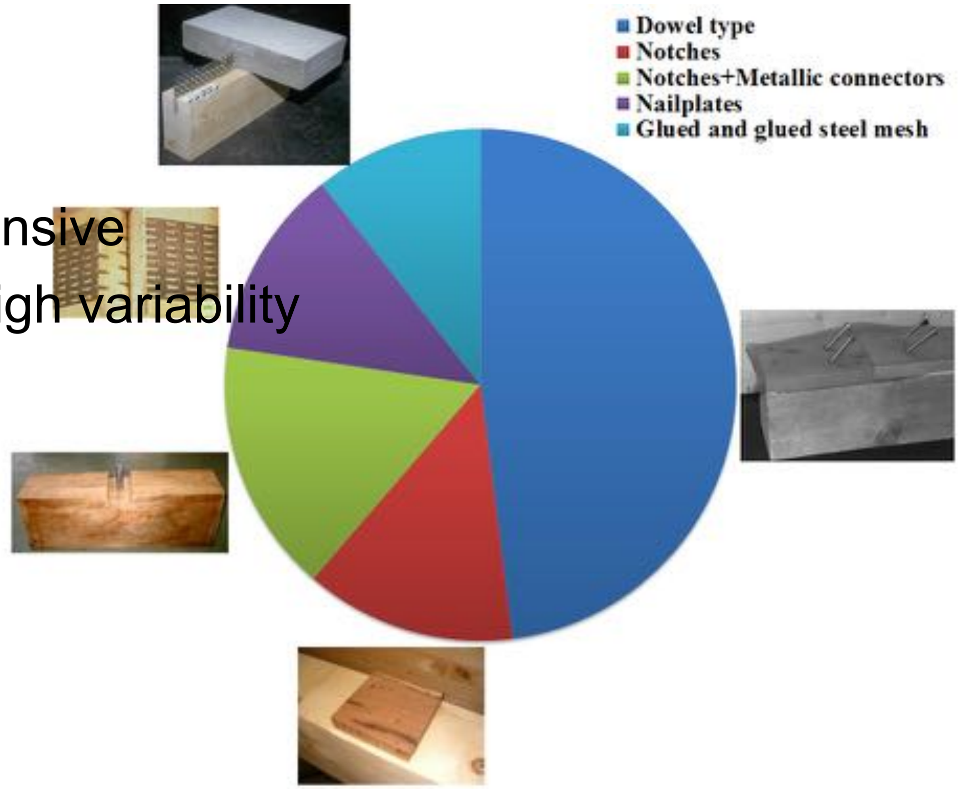
- Different mechano-sorptive behavior
- Different thermal behavior
- Different stiffness

TCC CHALLENGES AND POTENTIAL

Compatibility between materials

Connection systems

- Almost always semi-rigid
- In many cases complex and expensive
- Mechanical performance with a high variability



TCC CHALLENGES AND POTENTIAL

Compatibility between materials

Connection systems

Long term performance

- Several long term phenomena involved (e.g. creep, shrinkage, mechano-sorptive effects)
- Long term performance quite different in both materials
- Lack of simple and accurate model due to the complexity of the phenomena
- Limited knowledge available on the connections long term performance

TCC CHALLENGES AND POTENTIAL

Compatibility between materials

Connection systems

Long term performance

Assembling issues

- Lack of guidelines for erection
- Compatibility of the materials application (e.g. water necessary in the concrete but undesirable on the timber)
- Limited knowledge on the connection between the TCC members and the remain structure
- In many situations propping is required

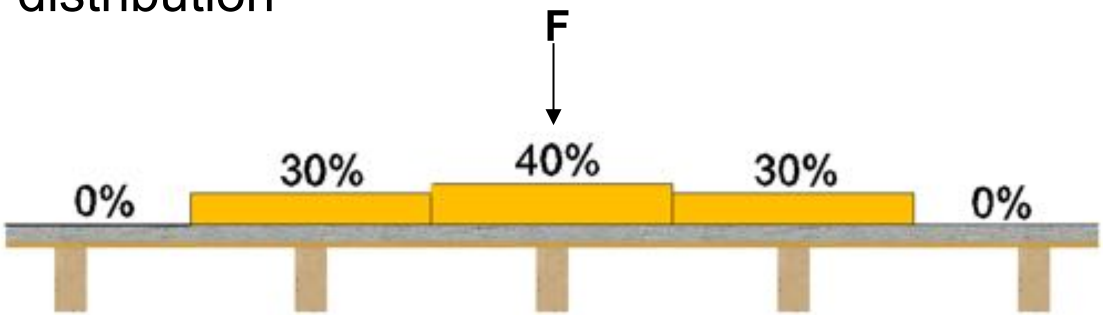
TCC CHALLENGES AND POTENTIAL

Increase mechanical performance

• Load carrying capacity increase up to 2 or 3 times higher than the one from the non composite floor

• Bending stiffness up to 4 times higher than the one from the non composite floor

• Effective transversal load distribution



TCC CHALLENGES AND POTENTIAL

Increase mechanical performance

Improve dynamic performance

- Similar natural frequencies
- Lower perception of the vibrations due to a higher stiffness

TCC CHALLENGES AND POTENTIAL

Increase mechanical performance

Improve dynamic performance

Improve acoustic performance

- Increase the airborne attenuation
- Decrease the impact sound transmission

Floor type	Airborne (dB)	Impact (dB)
Timber	27	96
Timber-concrete	40	69

TCC CHALLENGES AND POTENTIAL

Increase mechanical performance

Improve dynamic performance

Improve acoustic performance

Improve the fire resistance

- Increase barrier to the fire transmission between floors
- Extra protection of the timber members

TCC CHALLENGES AND POTENTIAL

Increase mechanical performance

Improve dynamic performance

Improve acoustic performance

Improve the fire resistance

Improve durability

- Less contact of the timber with water
- Timber more protected from mechanical impact (e.g. vehicle wheels)

TCC CHALLENGES AND POTENTIAL

Increase mechanical performance

Improve dynamic performance

Improve acoustic performance

Improve the fire resistance

Improve durability

Increased thermal inertia

- Higher thermal inertia when compared with a timber solution due to the higher thermal inertia of concrete

CONNECTION SYSTEMS

- The first connections were obtained from timber construction and were not very effective
- The research lead to specific connection systems with improved performance

MATERIALS

- Timber side – LVL and CLT have been increasingly used
- Concrete – Special concretes such as polymeric and lightweight have been used

ASSEMBLING SYSTEMS

- Use of precast concrete member
- Use of complete prefabricated systems

SHORT TERM

γ−method

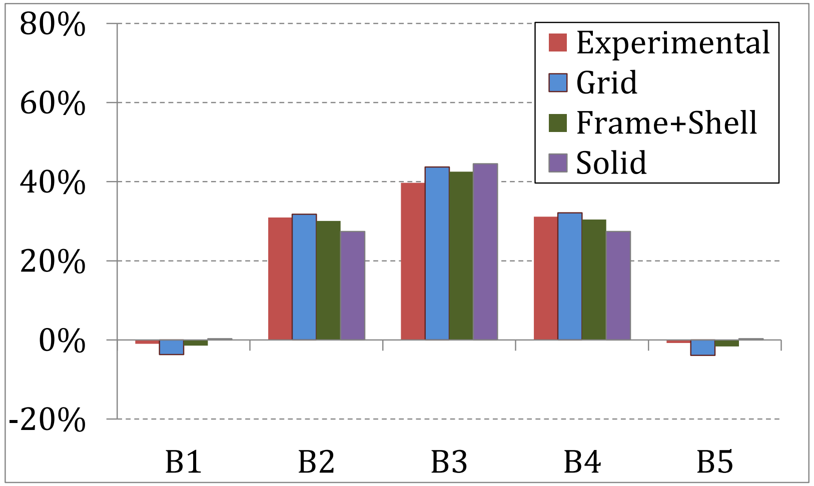
- Simple to use
- Linear elastic method
- Accurate results for engineering purposes

$$(EI)_{ef} \sum_{i=1}^{3} \left(EiIi + \gamma_i E_i A_i a_i^2\right)$$

SHORT TERM

FEM models

- Allow static and dynamic analysis
- Possibility to consider bi- and tridimensional modeling
- Consider (static, load distribution and dynamics)



LONG TERM

Reduced parameters method

- Lead to low accuracy results
- Many important effects are disregarded

Other methods [(Fragiacomo, 2000); (Schaenzlin, 2003)]

•Higher accuracy

•Higher model complexity

•Lack of input data

DESIGN

- No codes for TCC
- In Oceania guidelines (Design Guide Australia & New Zealand Timber Concrete Composite Floor Systems)
- It will be explicitly considered in the next EC5 generation (New code part – Mandate 515)
- Implicitly principles on the current version of the Eurocode (γ−method from annex B and some guidelines for connection stiffness and bridges design)
- Guidelines based on the available code (Ceccotti STEP E13)

Refurbishment/reinforcement of timber floors

- Usually applied to strengthen and refurbishment of old timber floors

Floors in new constructions

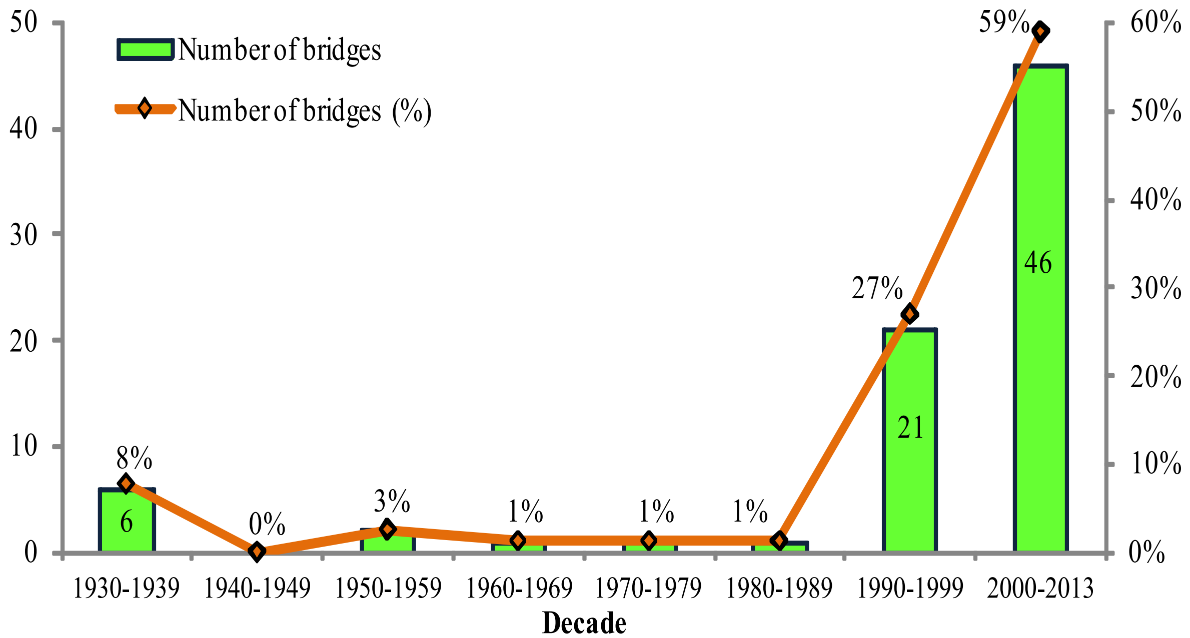
- Increasingly common, namely in multi-storey buildings

Floor or roofs with special requirements

- Dynamic requirements
- Acoustic requirements
- Thermal requirements

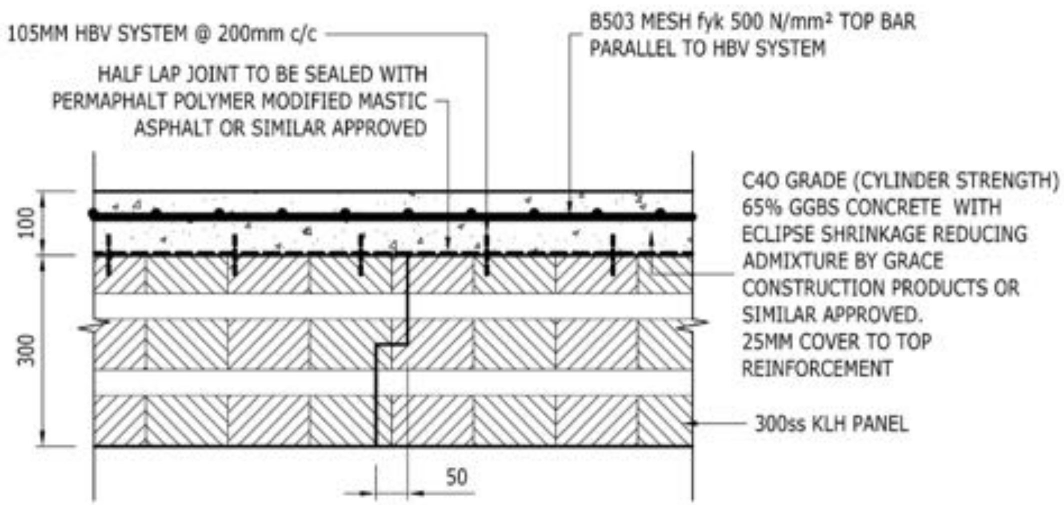
Bridge decks

- Being increasingly used namely in the last two decades (>75%)
- Open new possibilities for traffic bridges



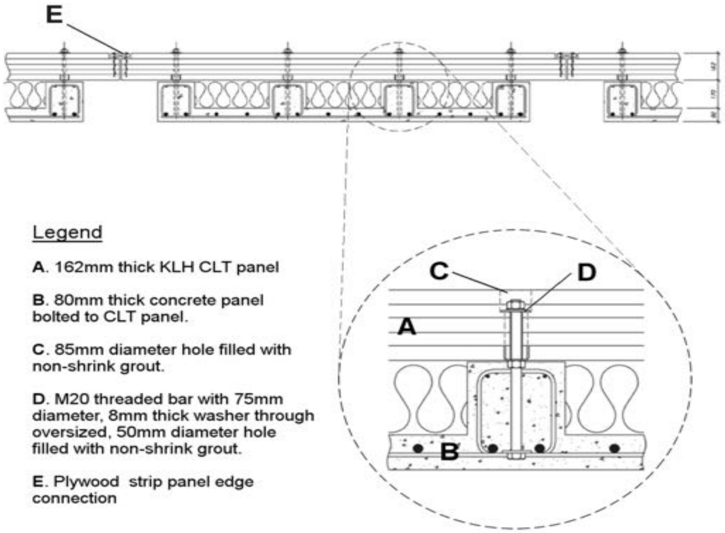
FLOORS – THOMAS CLARKSON SCHOOL DANCE FLOOR UK

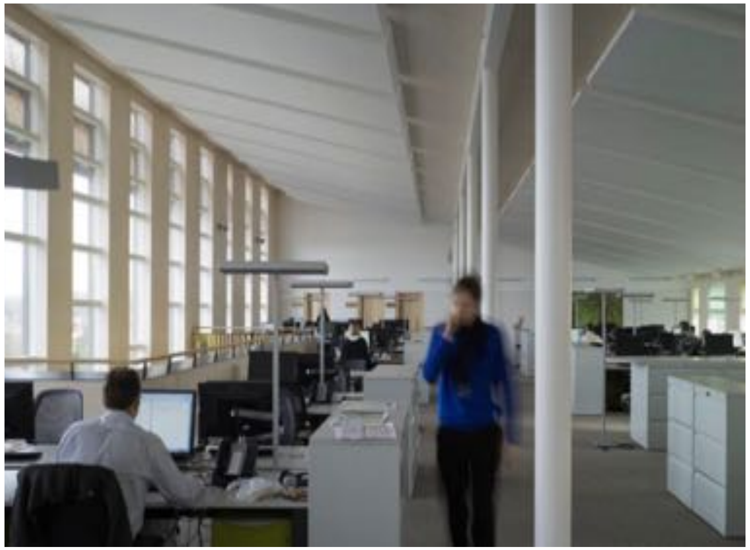
- CLT building due to the poor soil conditions
- Dance floor with 10m span
- 300mm CLT connected to 100mm concrete topping by steel mesh



FLOORS – WOODLAND TRUST HEADQUARTERS, UK

- CLT building
- Objective of minimizing the environmental impact
- Concrete bellow the CLT panels





FLOORS – UBC EARTH SCIENCES BUILDING STAIRCASE, CANADA

- Free standing timber staircase
- Steel mesh connection
- 89mm thick Laminated-Strand-Lumber and 100mm thick concrete

(Curtesy of Equilibrium Consulting)

MULTI-STOREY/PUBLIC BUILDINGS – St ELMO COMPLEX, NZ

- Seismic resistant timber 3 storey building
- 9m floor span
- Prefabricated LVL beams connected to the concrete slab by coach screws

MULTI-STOREY/PUBLIC BUILDINGS – Dr. CHAU CHAK WING BUILDING, AU

- 8m floor span in University class rooms
- GLT beams connected to concrete by coach bolts combined with bird's mouth notches

BRIDGE – SMALL SPAN CURRENT BRIDGE, PORTUGAL

- Current short span bridge for heavy traffic
- Typical T-beam solution for such conditions
- Inserted in natural area where the use of timber is promoted
- Durability even with low maintenance

BRIDGE – LARGE SPAN BRIDGE, VIHANTASALMA FINLAND

- Total span of 182m
- Bridge for heavy traffic
- Composite steel-timber-concrete bridge

THANKS FOR THE ATTENTION