THE FUTURE OF TRANSPORT

Electric road construction: Road infrastructure impacts and solutions

Damien Bateman
TRL - Senior pavement engineer
April 2017

Agenda

- Introduction
- Conventional pavement design
- Existing E-road design methods
  - Advantages and disadvantages of each
- Key findings from FABRIC test sites
- Key findings from WP45
- Conclusions

Introduction

- Project task aims to:
  - Identify the requirements for the construction of E-roads (inductive power transfer systems)
  - Determine how these will align with current road construction and maintenance procedures
  - Evaluate potential impacts on infrastructure and identify possible solutions

Conventional pavement design

- Design methodologies vary across Europe
  - Impact of integration of IPT systems to be similar
- E.g. UK flexible pavements
  - Long Life Pavements (LLPs)
  - Pavements designed to last 40+ years without requiring any major structural rehabilitation
- E-roads expected to provide similar structural performance

E-road design

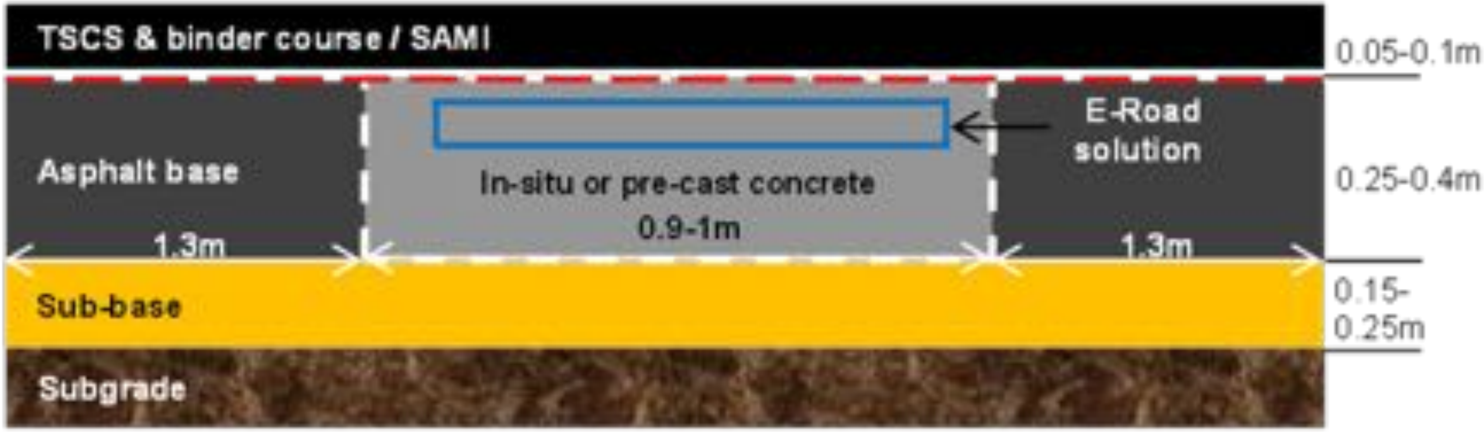
- E-roads should be designed and built to satisfy current standards for conventional pavements
- E.g. Bus routes in the UK, Italy, Germany, Netherlands, and South Korea
- However there is no defined construction methodology
  - IPT system specific

E-road construction types

Four E-road construction methodologies identified from existing IPT systems:

1. Trench-based construction
2. Micro-trench based construction
3. Full lane-width construction
4. Prefabricated full lane-width construction

1. Trench-based construction



(a) In-situ construction (b) Prefabricated system

In-situ build construction (KAIST)

(a) Trench excavation and placement of pipes

(b) 1st Concrete layer

(c) Power supply system

(d) 2nd Concrete layer

(e) Tack coat

(f) Surface course

Precast build construction (KAIST)

(a) Trench excavation and placement of pipes

(b) 1st Concrete layer

(c) Pre-cast system

(d) Placement of pre-cast system

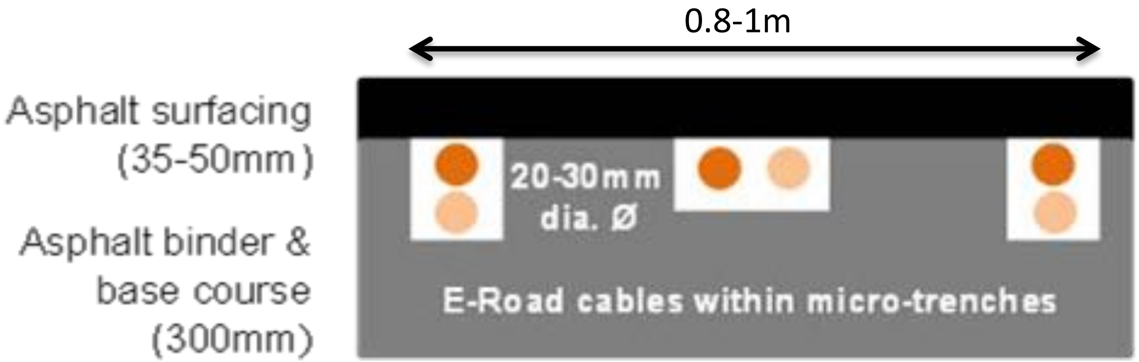
(e) Concrete fill around system

(f) Tack coat and surface layer application

1. Trench-based construction

- Advantages
  - Relatively quick
  - Lower initial costs
  - Possible use of low temp. asphalt (LTA) and non-ferrous aggregates in surface layer
- Disadvantages
  - Introduction of concrete in fully flexible pavement
  - Thermal cracking / reflective cracking
  - Higher maintenance costs

2. Micro-trench based construction

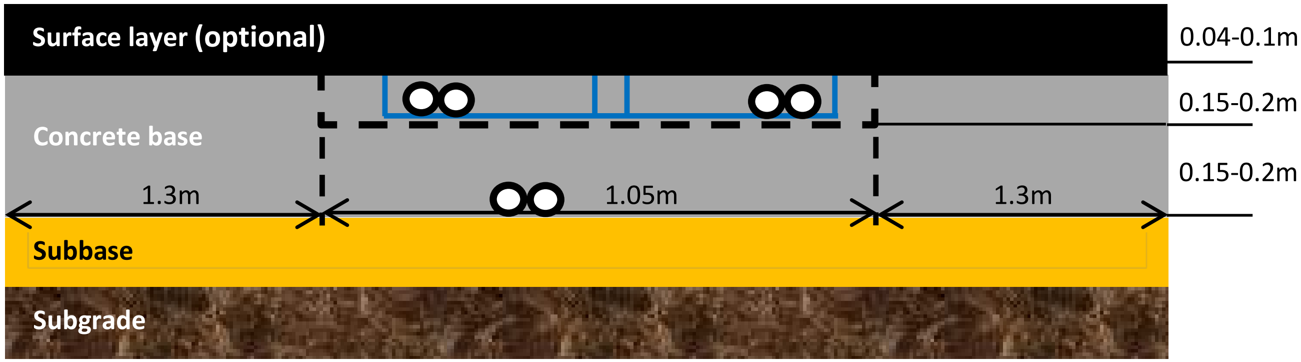


E.g. Italian test site: Micro-trench excavation, placement of coils, and application of cold mix asphalt

2. Micro-trench based construction

- Advantages
  - Relatively quick and low initial costs
  - Use of cold mix asphalt and non-ferrous aggregates in surface layer
  - Minimal damage to existing structure
  - Lower maintenance costs
- Disadvantages
  - Depth of coils limited to air gap allowance (~40-100mm)
  - Coils susceptible to damage from traffic loads

3. Full lane-width construction



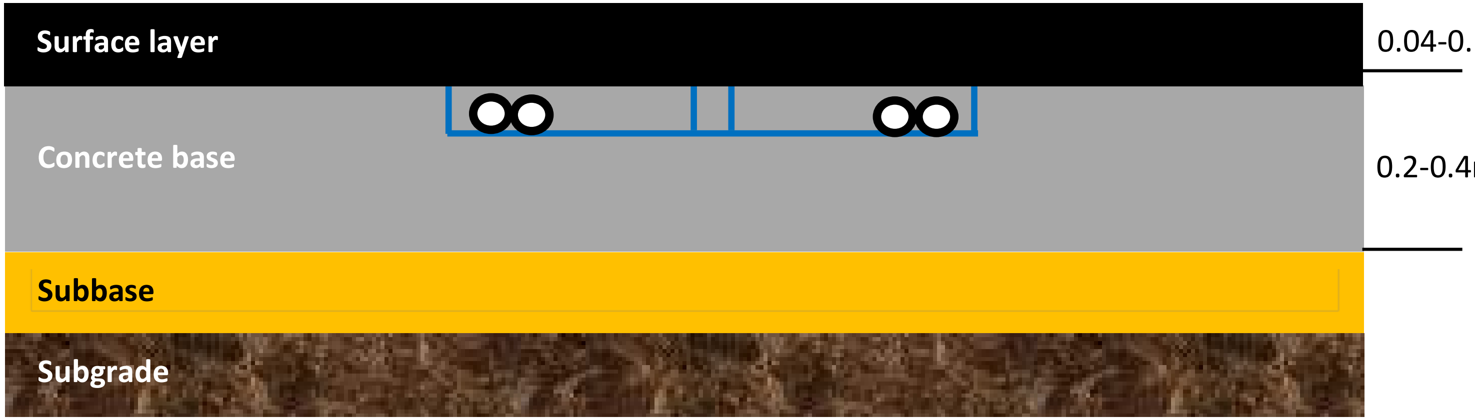
Option 1. In-situ build construction

Option 2. Precast build construction

3. Full lane-width construction

- Advantages
  - Single longitudinal joints at lane interface
  - Likely lower whole life costs than trench construction
  - Factory construction quality (IPT systems built off-site)
  - Concrete protects IPT from effects of paving process (high temp. and compaction)
- Disadvantages
  - Slower construction
  - Requires 2 lane closures
  - Relatively high vehicle movements
  - Potential maintenance issues with transverse joints affecting the adjacent lanes

4. Full lane-width precast construction



Precast build construction

E.g. Installation of Modieslab precast section

4. Full lane-width precast construction

Advantages:

- Relatively quick installation
- Factory construction quality
- Single longitudinal joint(s) at lane interface(s)
- Lower whole life costs

4. Full lane-width precast construction

Disadvantages:

- High initial cost
- Requires two lanes of traffic management
- Joint maintenance
- Potential maintenance issues with transverse joints affecting the adjacent lanes
- Potential disruption to road users due to transport of systems to site
- Precast slabs prone to movement under traffic loading

Agenda

- Introduction
- Conventional pavement design
- Existing E-road design methods
  - Advantages and disadvantages of each
- Key findings from FABRIC test sites
- Key findings from WP45
- Conclusions

Key findings from FABRIC test sites

POLITO results

- Limited knowledge gained on the structural performance of IPT systems in existing roads
- Embedding the coil in concrete resulted in high capacitive coupling between the coil and concrete
  - At high frequencies close to the working frequency of the system
- Solution – insertion of a non-conductive material acting as a dielectric between the coil and ground
- Micro-trench based approach was relatively quick to complete
- Use of cold mix asphalt worked well with IPT equipment

Key findings from WP45

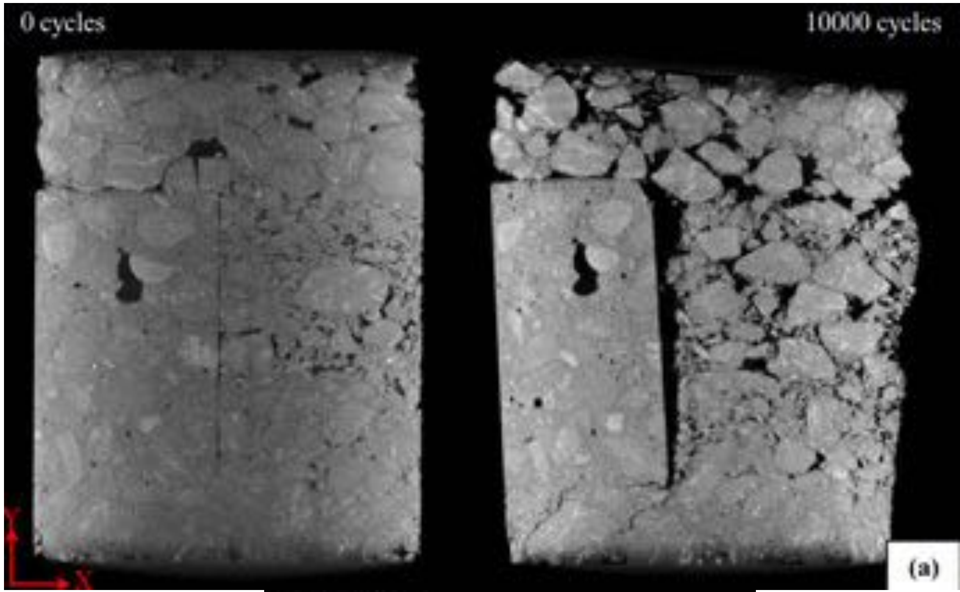
Laboratory testing (KTH)

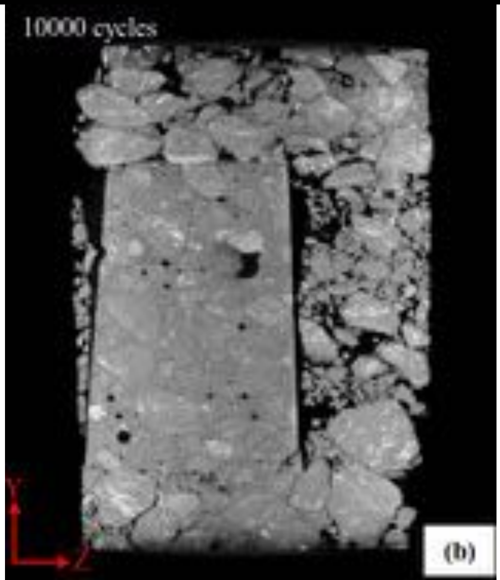
- Significant failure at the interface when subjected to cyclic tension-compression testing
  - More rapid failure of E-road samples

Key findings from WP45 (Cont'd)

Laboratory testing (KTH)

- Higher deformations at the asphalt/concrete interfaces and the corners
- Significant increase of voids





X-ray scanning images before and after 10,000 cycles of dynamic loading

Key findings from WP45 (Cont'd)

Finite Element Analysis results (POLITO and KTH)

- Overlay thickness had a greater effect to the overall structural integrity of E-road in comparison to material stiffness
- The use of joint materials (SAMI, geo-grid, etc.) reduced the level of stress/strain at the base of the asphalt layer
- The bonding at the asphalt/CU interface is critical to E-road structural integrity
  - Especially under braking forces

Conclusions

- Existing E-roads (Europe and South Korea) demonstrate various construction methods
- No defined construction methodology
  - IPT system specific

Conclusions (Cont'd)

- Conventional road materials should be suitable for use in E-roads
  - LTAs and non-ferrous aggregates should be considered in surface layer (if required)
  - Use of non-conductive materials as a dielectric between the coil and road materials

Conclusions (Cont'd)

- Limited knowledge of structural performance of E-roads
- Laboratory testing and theoretical simulations suggest that:
  - Concerns of premature failure at the interface
  - The use of joint materials at the interface may reduce the levels of stress/strain
  - Good bonding at the interface is critical to structural integrity

Thank you!

Questions?