Durable repair and rehabilitation of CRCP

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Introduction

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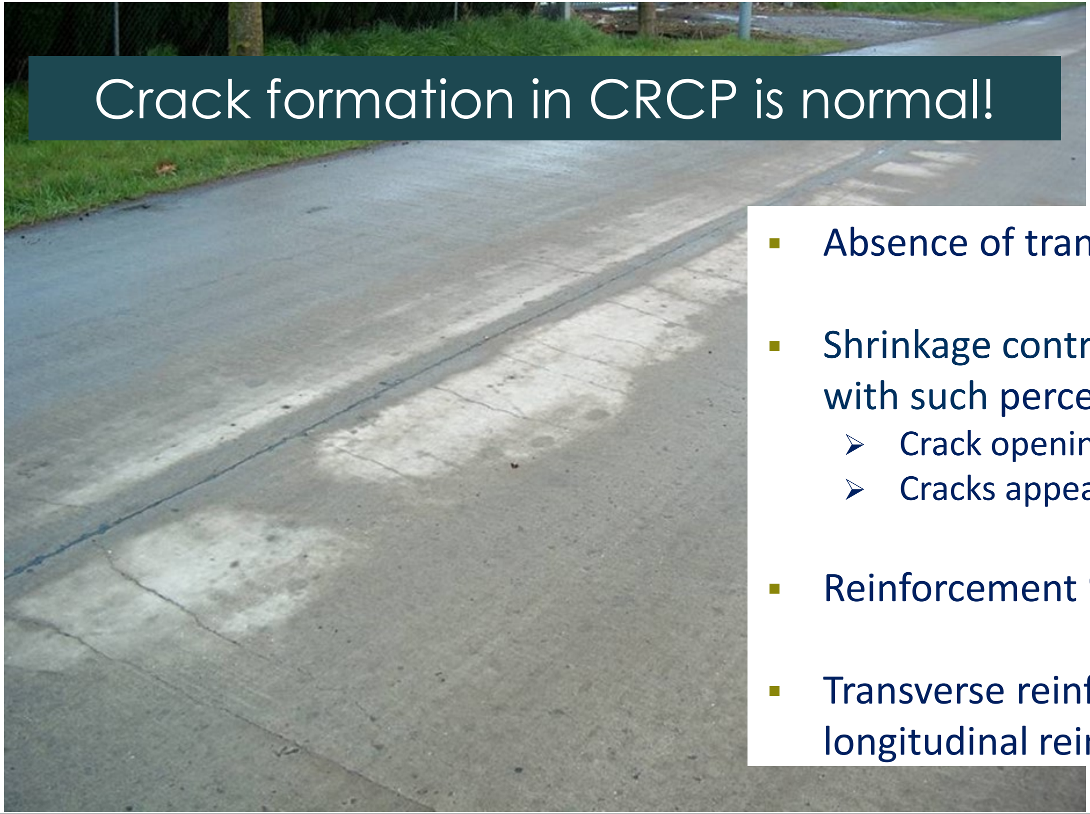
- Distresses typical for CRCP (often different from JPCP)

- How to avoid distresses?
  - Design
  - Construction
  - Maintenance = preventive maintenance

- Repair = restorative/curative maintenance
- Rehabilitation - reconstruction

Recall – principle of CRCP

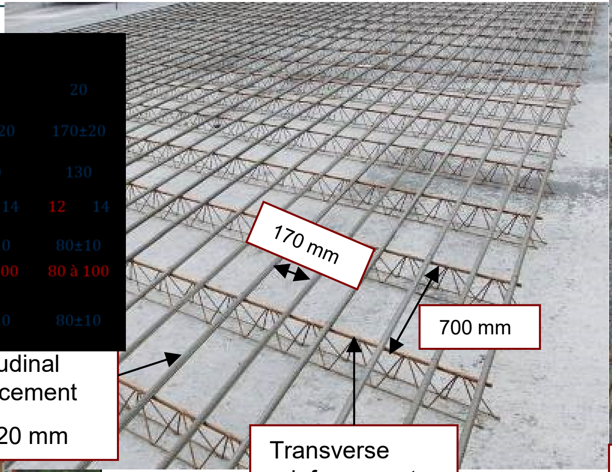


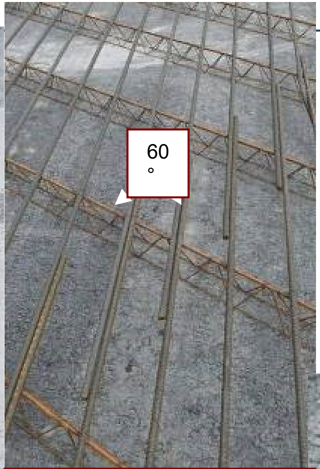
Crack formation in CRCP is normal!

- Absence of transverse (contraction) joints
- Shrinkage controlled by longitudinal reinforcement with such percentage (in the cross section) that:
  - Crack opening stays limited: < 0.5 mm
  - Cracks appear at regular intervals of 0.8 to 1.5 m.
- Reinforcement % = 0.6-0.85 (today: 0.75 in Belgium)
- Transverse reinforcement supporting the longitudinal reinforcement

CRCP – Belgian practice

	( )	( )			
	16	16	20	20	20
	130±20	130±20	180±20	180±20	170±20
	90	100	100	120	130
	12 14	14	14	12 14	12 14
	80±10 70 à 90	80±10	80±10	80±10 80 à 100	80±10 80 à 100
	80±10	80±10	80±10	80±10	80±10





Splicing of the rebars
35 x diameter (700 mm)

Two tied connections per splice

Typical CRCP Distress Types

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- Localized (unwanted) cracking
- Transverse cluster cracking
- Spalling of the cracks
- Steel rupture
- Blow-ups
- Punch-out

CRCP Distress Types

- Transverse cluster cracking
  - Weak concrete (w/c ratio, construction problems, etc.)

CRCP Distress Types

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- Spalling of the cracks
  - From minor to severe
  - Transverse and sometimes longitudinal cracks
  - Inadequate tensile strength at the surface (bleeding, ...)
  - Number of spalled cracks increases with crack spacing

CRCP Distress Types

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- Steel rupture
  - Bad design: stress exceeds tensile strength of the steel
  - Corrosion (construction joints, deicing salts)

Corroded reinforcement bars at transverse construction joint in CRCP

Transverse construction joint in CRCP, with increased risk of water penetration

CRCP Distress Types

- "Blow-ups"
  - Bad compaction of the concrete at construction joints; poorly executed or maintained "day joint"
  - Discontinuities by earlier "temporary" repairs

CRCP Distress Types

- *Punch-out* = most severe potential problem!

  4 essential parameters

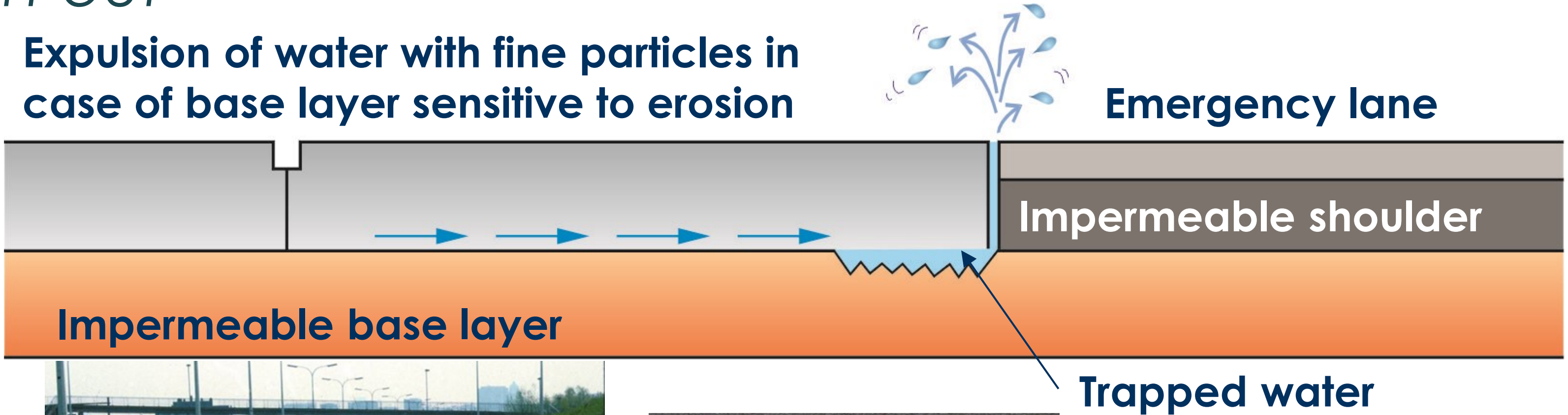
  - Close spacing of transverse cracks (distance < 50 cm)
  - Presence of water between CRCP and base layer
  - Base layer sensitive to erosion
  - Heavy and intense traffic near the slab edge (edge effect)

CRCP Distress Types

- *Punch-out*

CRCP Distress Types

- *Punch-out*



CRCP Distress Types

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- *Punch-out*
  - Systematic loading of the longitudinal joint will inevitably lead to damage, either by the pumping effect, either by increased stresses
  - True for longitudinal construction joints and longitudinal bending joints

CRCP – crack formation

Control of crack formation

- Reinforcement percentage influences distribution and distance of cracks (in Belgium: 0.70-0.75 %, which leads to an average interdistance of ± 1.0 m)
- Elastic limit of reinforcement steel
- **New(er) method: active crack control**
  - Length: 40 cm
  - Spacing: 1.20 m
  - Depth: 4 cm
  - Saw cut: as soon as possible, within 24 hours after concreting

Applied on E313, E17, A8, E420, A7, etc.

Preventing distresses by adequate design and construction

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- Structural design: type, quality and thickness of the sub-base, base and concrete pavement
- Steel reinforcement: %, spacing, level
- Concrete mix quality
- Compaction
- Curing
- Drainage facilities
- Construction joint
  - Extra compaction with manual vibrating poker
  - Extra reinforcement
  - (Lower w/c or extra cement for first and last batches)

Preventing distresses by adequate design and construction

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- Construction joint
  - ...or avoiding the problem by working 24 hours a day!

Preventing distresses by adequate design and construction

- *Punch-outs*
  - Non erodible base layers; drainage
  - Intermediate asphalt course between base and CRCP
  - Extra width at the edge of the slow lane (marking at the inside)
  - Executing hard shoulder and right-hand lane in one phase

(Preventive) Maintenance

- Joint sealing
  - Construction joints
  - Longitudinal joints
    - Between lanes
    - Edge joints (shoulder)
- Crack sealing
  - Only for severely spalled cracks
- Drainage facilities

Repair of CRCP(= curative maintenance)

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- **Full depth repairs**
  - Partial width: punch-outs, local problems
  - Full width: construction joints

- Restore of the continuity of the reinforcement

- Repair of *punch-outs*

  "permanent patching"!

CRCP Full depth repair

- Saw cuts over full depth, perpendicular to longitudinal joint
- Minimum dimensions: 1.50 m - Rectangular shape
- Repair of construction joint:
  - Minimum length 2 m (1 m at each side of joint)
  - Width ≥ slab width (between 2 longitudinal joints)
- Restoration of the base or the intermediate asphalt layer, if needed
- Restoring the reinforcement:

  1) **By drilling and chemical anchorage of reinforcement**
  2) **By liberating the existing reinforcement**

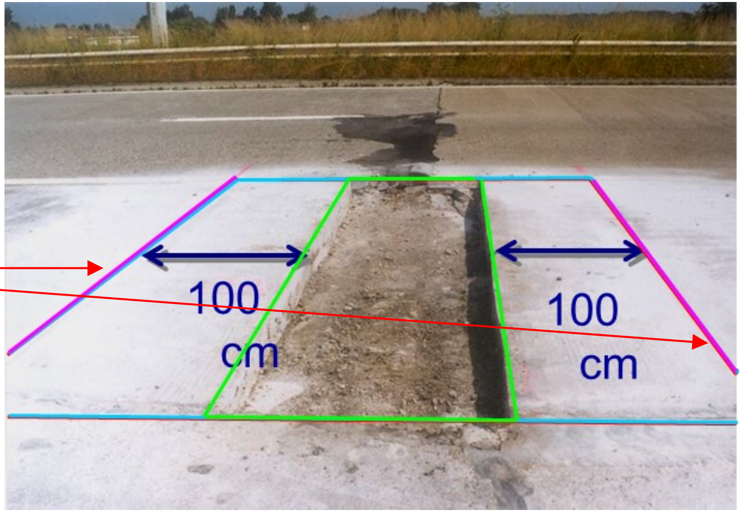
Restoring continuity of reinforcement

- **First method**: *drilling and chemical anchorage of reinforcement*

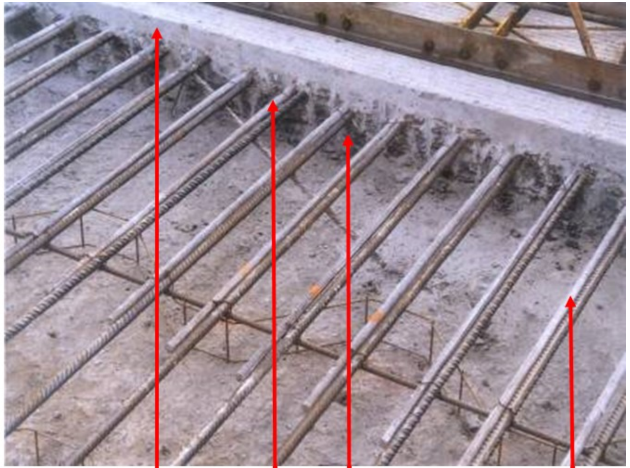
Restoring continuity of reinforcement (2)

- **Second method**: *liberating existing reinforcement*
  - 2 extra saw cuts, 4-6 cm deep, in order to remove the concrete and make free the existing reinforcement

Extra saw cuts



CRCP full depth repair: restoring reinforcement



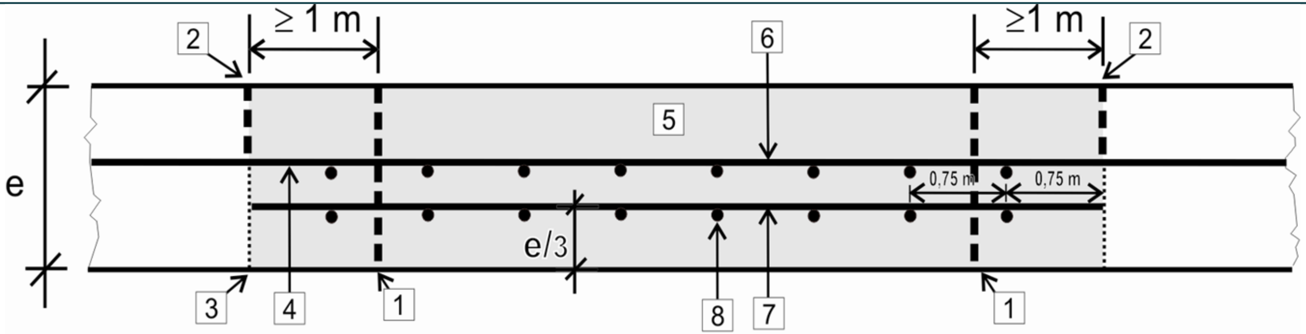
Saw cut at a depth of 4 cm

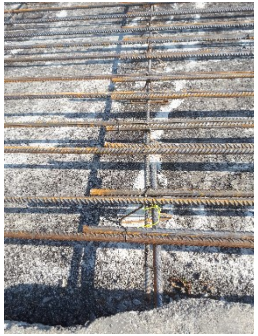
Longitudinal reinforcement kept in place

Vertical face on the existing concrete

Tied reinforcement splice

CRCP full depth repair (zone < 8 m)





1. Saw cut over full depth
2. Saw cut with limited depth, ca. 5 cm
3. Removal of the concrete (carefully and manually) - sound vertical face
4. Keeping in place of existing reinforcement steel over 1 m
5. Broken up concrete
6. New reinforcement steel - tied splice over 0.8 -1 m with min. 2 connections per splice
7. Extra reinforcement steel in lower third part of the pavement (optionally)
8. Transverse reinforcement, perpendicular to road axis

CRCP repair with (ultra)fast-track concrete (*UFT*)

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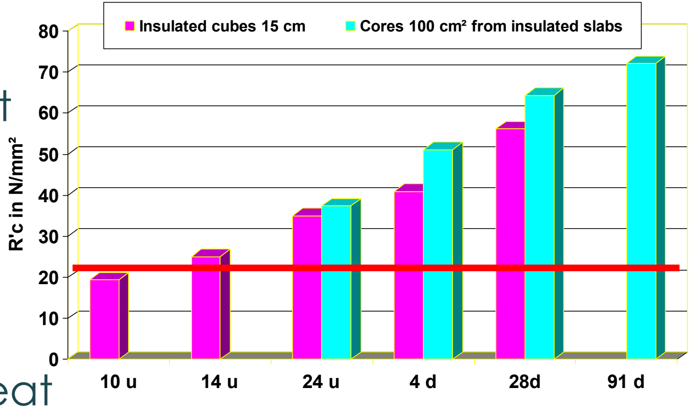
- Limiting nuisance to road users by reducing the time of execution
  - Well organized worksite
  - Use of (ultra)fast concrete mixes
    - Opening to traffic within 3 days or less
    - Compressive strength on cores or insulated cubes ≥ 40 N/mm²

BUT ALSO for CRCP:

- High strength before the cooling of the first night
- 20 N/mm² at an age of 10-12 hours

THEREFORE

- Repair in the morning
- Use of insulation plates to keep the hydration heat



CRCP full depth repair

CRCP full depth repair (zone > 8 m, cf. CCT Qualiroutes)

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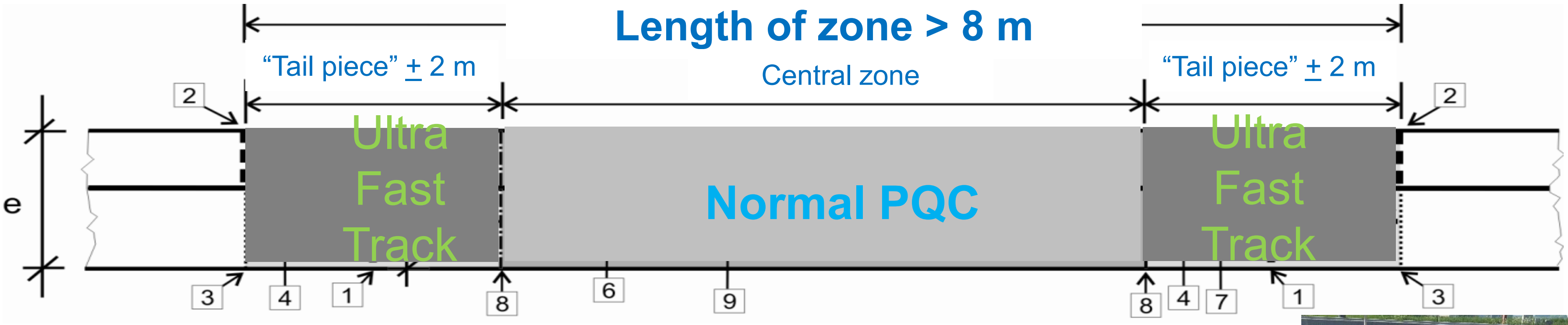
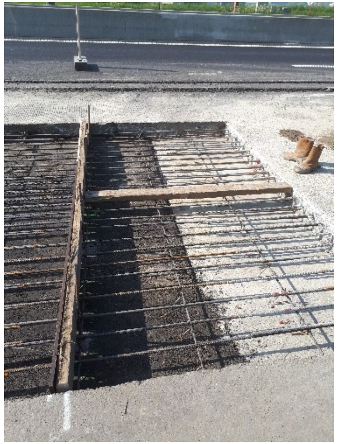


1. Saw cut over full depth
2. Saw cut 5 cm
3. Removal of concrete - sound vertical face
4. Keeping in place of the reinforcement steel over 1 m
5. Broken up concrete
6. New reinforcement steel (central zone + "tail pieces") - with tied splice over 1 m
7. Extra reinforcement steel ("tail pieces") in lower third part of the pavement
8. Vertical face
9. Transverse reinforcement



CRCP Full depth repair: case study HALLE 2008

Case study Halle 2008

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Case study Halle 2008

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Case study Halle 2008

Case study Halle 2008

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Reconstruction: case study of A10/E40 in Ternat

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- Problem statement
  - 2002: test track on A10/E40 between Groot-Bijgaarden and Ternat (kmpt. 6.2 – 8.3)
  - CRCP put in place on partially milled asphalt pavement, maintaining part of the existing asphalt + the existing lean concrete base layer
  - After positive evaluation of test track: CRCP applied on entire A10 of Flemish Brabant territory (kmpt. 2.0 – 15.0)
  - However, after some years: *punch-out* in test track?

Case study of A10/E40 in Ternat (2018)

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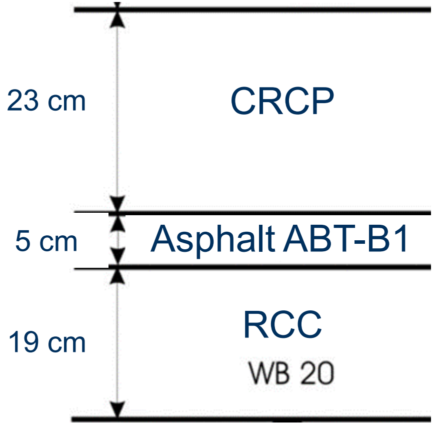
- Solution
  - Core drillings executed in 2017: in part of test track zone, only very thin asphalt layer present on existing lean concrete; in other zones sufficient asphalt thickness
  - Reconstruction with following design:
    - 23 cm CRCP
    - 5 cm intermediate asphalt layer (ABT-B)
    - 19 cm roller-compacted concrete base
    - 30 cm subbase layer (type I)



  - Only emergency and right-hand lane rehabilitated

Case study of A10/E40 in Ternat (2018)

- Some numbers…
  - Total project: ca. 16 400 m³ concrete
  - 4 400 m³ RCC
  - 3 670 m³ CRCP
  - 1 670 m³ Concrete safety barriers (cast in place)

Case study of A10/E40 in Ternat (2018)

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- Execution
  - Breaking of the concrete pavement

Case study of A10/E40 in Ternat (2018)

- Execution
  - Cold milling of existing asphalt layer

Case study of A10/E40 in Ternat (2018)

- Execution
  - Putting in place of RCC

Case study of A10/E40 in Ternat (2018)

- Execution
  - Intermediate asphalt layer

Case study of A10/E40 in Ternat (2018)

- Execution
  - Construction of concrete pavement and safety barriers ("*New Jerseys*")



Case study of A10/E40 in Ternat (2018)

- Points of attention during construction
  - Anchorage with existing structure

Case study of A10/E40 in Ternat (2018)

- Points of attention – construction / "day joint"

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