Design and construction of industrial pavements – the comparison with road pavements

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Outdoor industrial and heavy-duty concrete pavements (OIHD-CP)

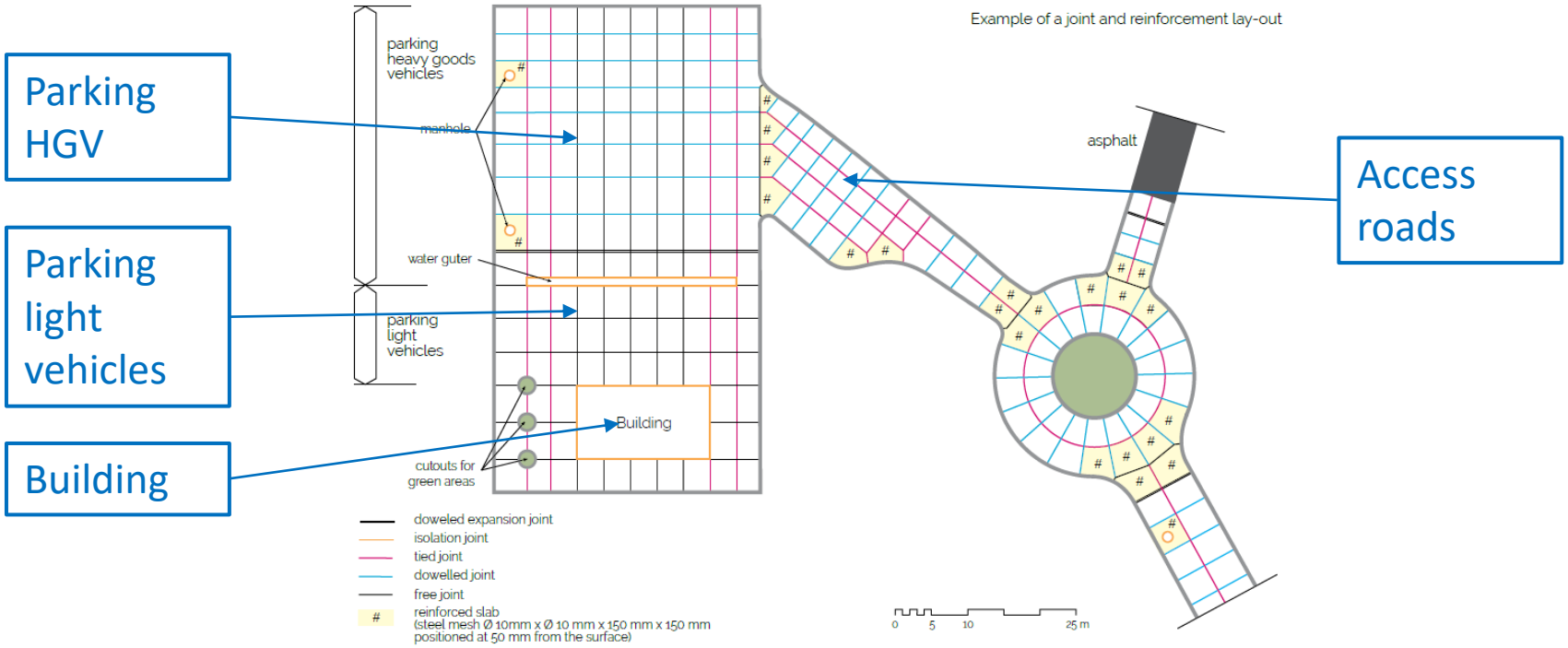
- Different types and applications
  - Commercial zones
    - Access roads
    - Loading and unloading areas (docks)
    - Storage areas
    - Parking areas
    - …

Outdoor industrial and heavy-duty concrete pavements (OIHD-CP)

- Different types and applications
  - Heavy-duty pavements
    - Port areas
    - Airports (Runway – Taxiway – Apron)

Outdoor industrial and heavy-duty concrete pavements (OIHD-CP)

- Or a combination of different functions



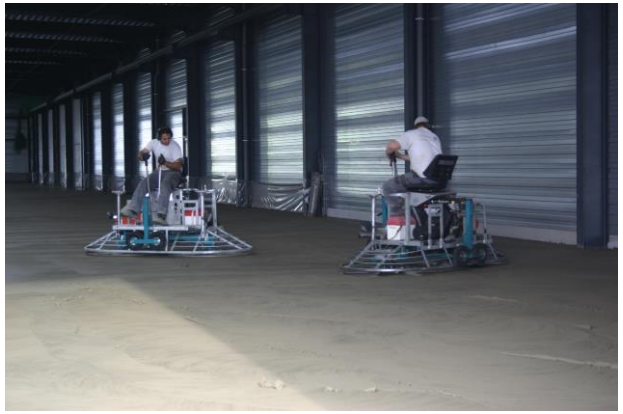
Outdoor vs. indoor

- Exposure conditions
  - Outdoor weather
    - greater daily and annual temperature change
    - rain, snow, frost, freeze-thaw effects & de-icing salts ! !

    Attention: this is also possible in indoor car parks if the salt is carried by the tyres of the cars
    - potential ingress of rainwater in the pavement structure

Outdoor vs. indoor

- Surface finishing technique
  - Internal floor:
    - mostly finished by power floating and trowelling, suitable for vehicles with small, hard wheels
    - Often a shiny polished floor for the ease of cleaning
    - Too slippery for outdoor applications



Outdoor vs. indoor

- Surface regularity
  - Internal floors: often very strict requirements because of operational requirements of materials handling equipment used in high racking systems

Outdoor vs. indoor

- Conclusion:
  - **an internal concrete floor is not the same as an external concrete pavement**

OIHD-CP compared to concrete roads

Similarities & differences

Shape and dimensions

Concrete roads

- Long & linear

OIHD-CP

- Local – all directions
- Often large rectangular surfaces

Design aspects - loadings

Concrete roads

- Traffic = dynamic
- Heavy vehicles are determining thickness

OIHD-CP

- Vehicles –forklifts
- Static loadings
- Airplanes

Design aspects - loadings

- HD-CP: static loadings
  - Surface – Linear – Point contact
  - Not determining for contact pressure untill 1 N/mm²
  - Case of stacked containers
  - Positioning of loads depending on joint pattern
  - Risk for punching shear failure – contact pressures to be limited to 7 N/mm²

Design aspects - loadings

- HD-CP: dynamic loadings
  - HGV (up to around 130 kN axle load – tyre pressure 0,7 N/mm²)
  - Forklifts
  - Container handling equipment (reach stacker – straddle carrier - …)
  - Handling of breakgood: sometimes extreme loading (1100 kN of front axle)
- Shock or impact loading: higher dynamic coefficient

Design aspects – Service life

- No structural maintenance during the service life of a pavement. However, the necessary (preventative & curative) maintenance, even though limited, must be done.

Concrete roads

- Owner= Public Road Authority
- 30 to 40 years

OIHD-CP

- Owner = often private company
- 30 years
- For HD-CP, shorter lifetimes are possible (but minimum 15y)

Pavement type

Concrete roads

- Mainly JPCP
- CRCP, mostly for heavily trafficked roadways
- RCC pavements, mostly for secondary roads

OIHD-CP

- (Almost) Always JPCP
- Exceptional cases in CRCP
  - See further the presentation of J. de Vrieze
- Increasing use of RCC
  - See further the presentation of H. Ceylan

Pavement structure

1. Concrete slab
2. Sandwich layer - profiling layer - geotextile
3. Base layer
4. Subbase layer
5. Geotextile
6. Subgrade

Pavement structure

- OI-CP
  - in commercial areas, the traffic loading (intensity & frequency) are lower than on highways
  - Initial price also plays a role
  - Less strict requirements on base and subbase layer, e.g. the use of unbound mixed (concrete + brick) granular layer
  - No sandwich layer or geotextile
  - Conventional concrete thickness (18-25 cm)

Pavement structure

- HD-CP
  - Very high intensity of the loading but mostly low frequency
    - No calculation on fatigue resistance but use of safety factors on loading and material characteristics + dynamic coefficient
  - Importance of base layer + concrete thickness (up to 40 cm)
  - The use of a sandwich layer is to be considered

Pavement structure

- Sandwich layer
  - Levelling the base layer with a material that doesn't resist wash out or erosion (e.g. sand layer) is not allowed
  - Asphalt layer
    - Prevents erosion of the base layer and reflective cracking
    - Creates bond between the layers
    - Creates an even and comfortable working platform
  - Plastic sheet
    - Prevents loss of water on the bottom of the concrete
    - Reduces stresses in the concrete
    - But creates a sliding plane; joints will be too wide open
  - Geotextile (non-woven)
    - Prevents erosion and reflective cracking

Construction techniques

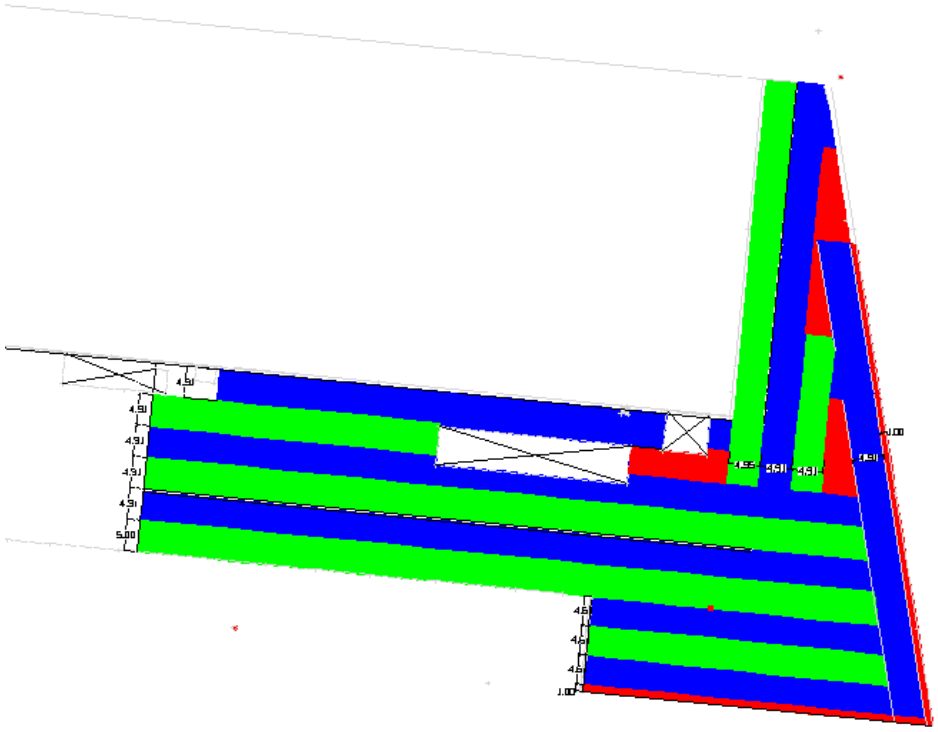
- Slipform paving
  - Roads & OIHD-CP: long enough sections;
  - Efficiency – strong compaction – best quality concrete
  - Alternating strips: attention to the concrete quality (consistency-water content) of the even strips

Construction techniques

- Slipform paving
  - HD-CP: very thick concrete slab
  - Attention to the edge slump
  - Sometimes: use of (slipform) paver combined with fixed formwork

Construction techniques

- Slipform paving : even for smaller jobs if the will and the skills are there



Construction techniques

- Slipform paving : even for smaller jobs if the will and the skills are there

Construction techniques

- Manual paving
  - Fixed formwork: small areas, both for roads and OIHD-CP
  - Compaction by poker vibrators and/or vibrating screed (light or heavy)

Construction techniques

- OI-CP: pouring large areas
  - Often pumped concrete
  - Sometimes limited to no compaction
  - Trowelled surface
  - High efficiency and low costs
  - Problem of uncovered and unprotected surface between pouring and compaction and the finishing

Construction techniques

- OI-CP: pouring large areas
  - Also possible with stiffer concrete (S2-S3)
  - Can be compacted, levelled and protected immediately
  - See further the presentation by Myron Hillock from Somero Enterprises

Concrete mix

- Concrete roads and OIHD-CP have same exposure, leading to the same durability requirements
- Strength requirements are also similar, except for light-duty pavements (low traffic, no exceptional loading). The difference is made in the CP thickness!
- Materials (sand- coarse aggregates – cement – water – admixtures) are mostly the same
  - Possible difference: no requirement on Polished Stone Value for coarse aggregates for OI-CP, in case of low speed traffic
- Basic principles are the same
  - Well-graded aggregates – low w/c – water content low for given workability – low sand content

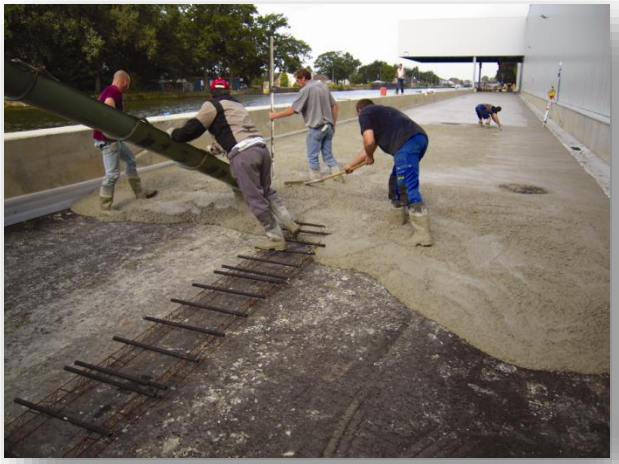
Concrete mix

- Slipform paving
  - Dry mix S1-S2
  - Highest quality
  - Air entrainment
- Manual paving – fixed formworks
  - Workable mix S2-S3:
  - No air entrainment (compatibility with superplasticizer!)
  - Use of sealers to protect surface against scaling from de-icing salts

Manual pouring: too dry concrete – limited compaction

Concrete mix

- Large areas – pumped concrete
  - Fluid concrete (S4-S5)
  - High dosage of superplasticizer: risk of entrapped air
  - Higher sand content
  - No air entrainer
  - Higher shrinkage
  - More sensitive to bleeding
  - Lower quality



Concrete mix

- Large areas – pumped concrete
  - The good, the bad…

Concrete mix

- Large areas – pumped concrete
  - …and the ugly

Concrete mix

- Influence of compaction on concrete strength (and durability)

	Vibrated concrete			Non-vibrated concrete		
Consis-tency (slump)	Density fresh concrete	Entrapped air	Compressive strength at 7d	Density fresh concrete	Entrapped air	Compressive strength at 7d
70 mm (S2)	2390 kg/m³	0,9 %	33,7 N/mm²	2305 kg/m³	3,7 %	27,3 N/mm² (-19 %)
120 mm (S3)	2390 kg/m³	1,2 %	33,7 N/mm²	2340 kg/m³	3,0 %	26,9 N/mm² (-20 %)
170 mm (S4)	2395 kg/m³	1,0 %	31,2 N/mm²	2355 kg/m³	2,3 %	26,9 N/mm² (-14 %)
210 mm (S4)	2400 kg/m³	0,7 %	32,4 N/mm²	2350 kg/m³	2,0 %	27,8 N/mm² (-14 %)

Joints

- Mostly the same for roads and OIHD-CP

Joints

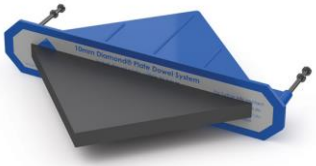
- Dowelled transverse joints
  - Load transfer: for heavily trafficked roads and HD-CP
  - On baskets
  - Inserted with DBI (dowel bar inserter)

Joints

- Dowelled transverse joints
  - HD-CP: possibility of two-lift concrete, using the same or a different concrete mix. Dowels are positioned in longitudinal grooves.

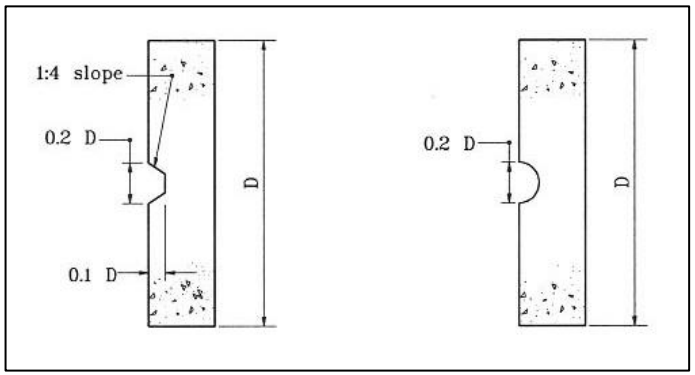
Joints

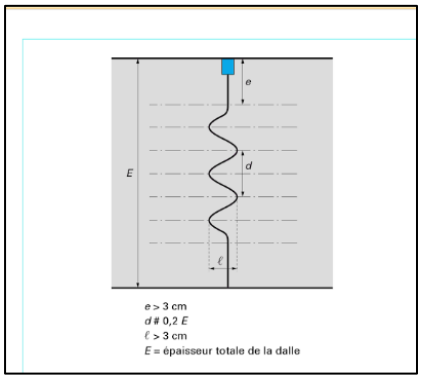
- Dowelled joints in both directions
  - Interesting solution for large rectangular surfaces



Joints

- Longitudinal joints
  - Use of tie bars
    - Prevent drifting away of concrete strip
    - Load transfer between adjacent lanes
  - HD-C: sometimes use of
    - Keyway joint (tongue and groove)
    - Sinus joint

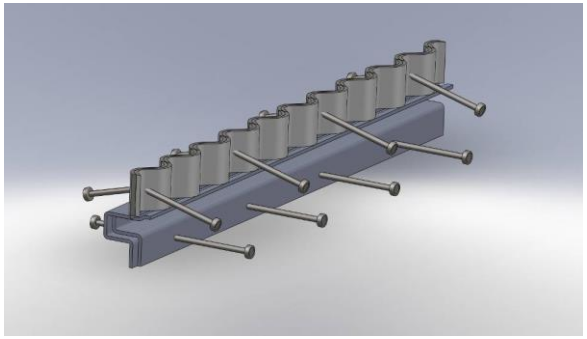


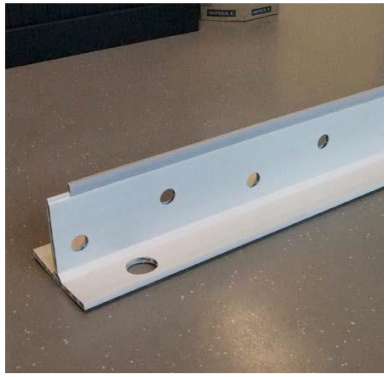


Joints

- Other types of joints
  - Some of them coming from the internal concrete floors

Omega-profile, mainly used for internal concrete floors (photo: Hengelhoef Concrete Joints)





Recycled T-shaped PVC used as a construction and contraction joint

Surface finishing

- Depending on the requirements of surface characteristics
  - Evenness
    - Also depending on construction technique
    - Roads: driving comfort, fuel consumption,…
    - OIHD-CP: sometimes specific requirements, mostly comparable to roads
  - Skid resistance – Friction
    - Roads: high speeds, importance of safety
    - Airfields: important or runway: braking operation after landing!, less for taxiway or apron
    - OI-CP: slip resistance for pedestrians
  - Rolling noise
    - Roads: very important, increases with speed
    - OIHD-CP: not really an issue
  - Rolling resistance
    - Rarely required, only for roads, related to fuel consumption

Surface finishing

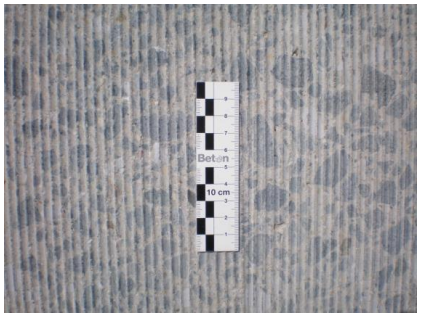
Concrete roads

- Exposed aggregate concrete
- Transverse or longitudinal tining
- Transverse brooming
- Grinding - NGCS

OIHD-CP

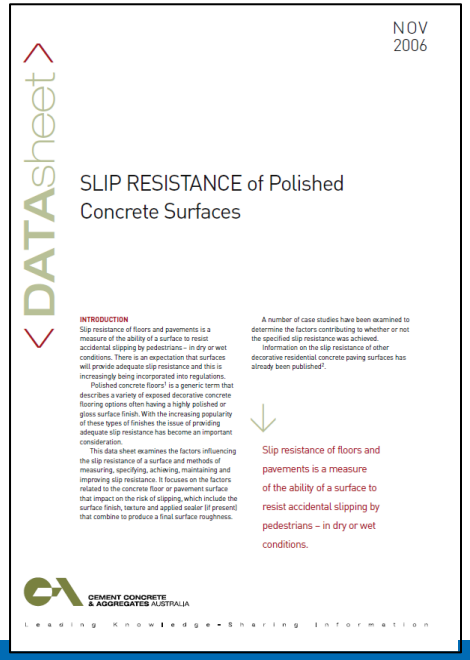
- Brooming
- Trowelling (sometimes followed by brooming)






Surface finishing

- Slip resistance of concrete surfaces
  - EN13036-4 Method for measurement of slip/skid resistance of a surface: The pendulum test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DATAsheet

SLIP RESISTANCE of Polished Concrete Surfaces

INTRODUCTION

Slip resistance of floors and pavements is a measure of the ability of a surface to resist accidental slipping by pedestrians – in dry or wet conditions. There is an expectation that surfaces will provide adequate slip resistance and this is increasingly being incorporated into regulations.

Polished concrete floors[1] is a generic term that describes a variety of exposed decorative concrete flooring options often having a highly polished or gloss surface finish. With the increasing popularity of these types of finishes the issue of providing adequate slip resistance has become an important consideration.

This data sheet examines the factors influencing the slip resistance of a surface and methods of measuring, specifying, achieving, maintaining and improving slip resistance. It focuses on the factors related to the concrete floor or pavement surface that impact on the risk of slipping, which include the surface finish, texture and applied sealer (if present) that combine to produce a final surface roughness.

A number of case studies have been examined to determine the factors contributing to whether or not the specified slip resistance was achieved.

Information on the slip resistance of other decorative residential concrete paving surfaces has already been published[2].

Slip resistance of floors and pavements is a measure of the ability of a surface to resist accidental slipping by pedestrians – in dry or wet conditions.

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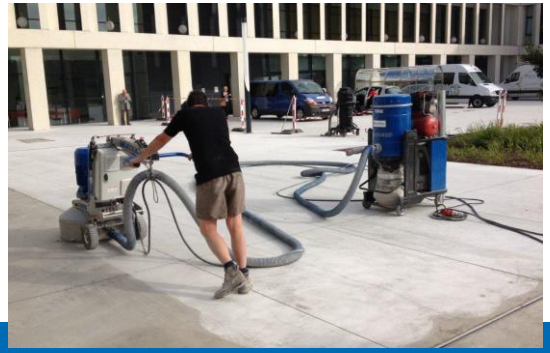
Leading Knowledge-Sharing Information

Surface finishing

- Slip resistance of concrete surfaces
  - Case BE, Kortrijk, Hospital AZ Groeninge
    - external pavement in trowelled white concrete
    - Too slippery, many accidents
    - Surface treatment required to roughen the surface



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