How to build durable heavy-duty pavements?

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Durable heavy-duty pavements

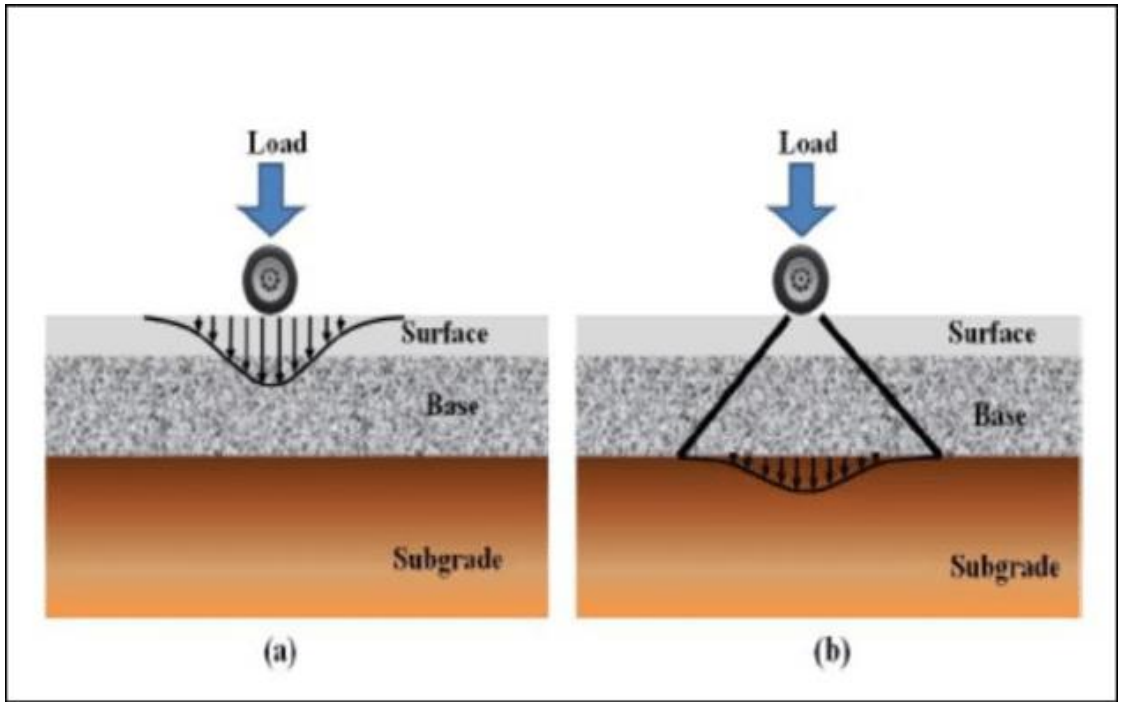
Design of heavy-duty pavements

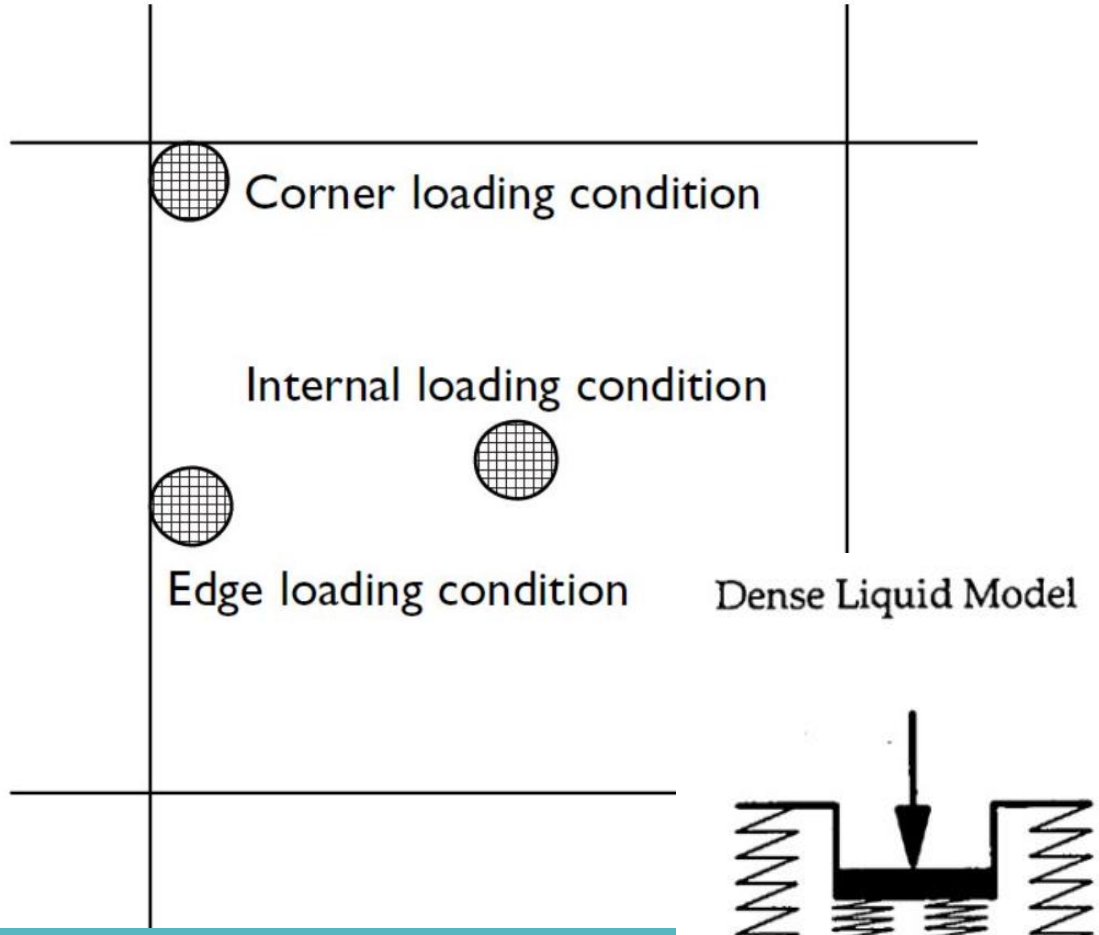
- Structural design: type and frequency of traffic, type of soil
- Choice of material
- Dowels, reinforcement
- Position of joints

Some case studies – eye for detail!

Design of rigid pavements by the Westergaard method

- full support





Determining the impact of the load

- Impact of adjacent wheel

Wheel Spacing		Proximity Factor For Effective Depth Of:		
(mm)	(in)	1,000 mm (39.4 in)	2,000 mm (78.7 in)	3,000 mm (118.1 in)
300	11.81	1.82	1.95	1.98
600	23.62	1.47	1.82	1.91
900	35.43	1.19	1.65	1.82
1,200	47.24	1.02	1.47	1.71
1,800	70.87	1.00	1.19	1.47
2,400	94.49	1.00	1.02	1.27
3,600	141.73	1.00	1.00	1.02
4,800	188.98	1.00	1.00	1.00
Note: Linear interpolation for intermediate values is acceptable				

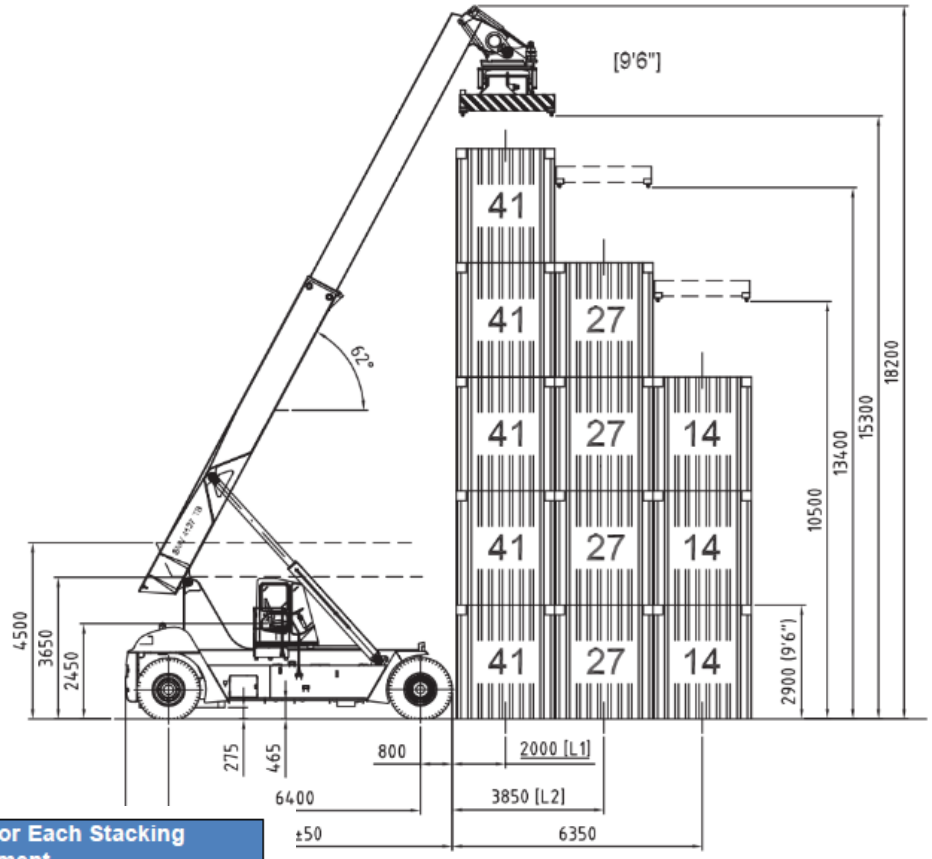
Table 1 – Proximity factor

@ Pianc

- dynamic factor: cornering, accelerating, braking and surface unevenness
- Channelisation and wander

Design of heavy-duty pavements: loads

Container Weight (kg)	Proportion of 40ft to 20ft Containers				
	100/0	60/40	50/50	40/60	0/100
0	0.00	0.00	0.00	0.00	0.00
1000	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.18	0.23	0.28	0.46
3000	0.00	0.60	0.74	0.89	1.49
4000	0.18	1.29	1.57	1.84	2.95
5000	0.53	1.90	2.25	2.59	3.96
6000	0.98	2.17	2.46	2.76	3.94
7000	1.37	2.41	2.67	2.93	3.97
8000	2.60	3.05	3.16	3.27	3.72
9000	2.82	3.05	3.11	3.17	3.41
10,000	3.30	3.44	3.48	3.52	3.66
11,000	4.43	4.28	4.24	4.20	4.04
12,000	5.73	5.24	5.12	4.99	4.50
13,000	5.12	4.83	4.76	4.69	4.41
14,000	5.85	5.38	5.26	5.14	4.67
15,000	4.78	5.12	5.21	5.29	5.63
16,000	5.22	5.58	5.67	5.76	6.13
17,000	5.45	5.75	5.83	5.91	6.21
18,000	5.55	5.91	6.00	6.10	6.46
19,000	6.08	6.68	6.83	6.98	7.58
20,000	7.67	8.28	8.43	8.58	9.19
21,000	10.40	8.93	8.56	8.18	6.72
22,000	9.95	7.60	7.02	6.43	4.08
23,000	5.53	4.31	4.00	3.69	2.47
24,000	2.75	1.75	1.50	1.25	0.24
25,000	0.95	0.63	0.55	0.47	0.15
26,000	0.67	0.40	0.33	0.27	0.00
27,000	0.72	0.43	0.36	0.29	0.00
28,000	0.53	0.32	0.27	0.21	0.00
29,000	0.43	0.26	0.22	0.17	0.00
30,000	0.28	0.17	0.14	0.11	0.00
31,000	0.03	0.02	0.02	0.01	0.00
32,000	0.03	0.02	0.02	0.01	0.00
33,000	0.00	0.00	0.00	0.00	0.00
34,000	0.05	0.03	0.02	0.02	0.00



Stacking Height	Reduction In Gross Weight	Contact Stress		Load on Pavement For Each Stacking Arrangement					
				Singly		Rows		Blocks	
		(N/mm²)	(lb./in²)	(kN)	(kips)	(kN)	(kips)	(kN)	(kips)
1	0	2.6	375.7	76.2	17.1	152.4	34.3	304.8	68.5
2	10 %	4.7	677.3	137.2	30.8	274.3	61.7	548.6	123.3
3	20 %	6.2	903.6	182.9	41.1	365.7	82.2	731.5	164.4
4	30 %	7.3	1,054.4	213.4	48.0	426.7	95.9	853.4	191.9
5	40 %	7.8	1,128.4	228.6	51.4	457.2	102.8	914.4	205.6
6	40 %	9.3	1,353.2	274.3	61.7	548.6	123.3	1,097.2	246.7
7	40 %	10.9	1,580.9	320.0	71.9	640.1	143.9	1,280.1	287.8
8	40 %	12.5	1,813.0	365.7	82.2	731.5	164.4	1,463.0	328.9
Note: Using 31,080 kg (68,520 lb.) container with equal distribution									

Table 2 – Container load

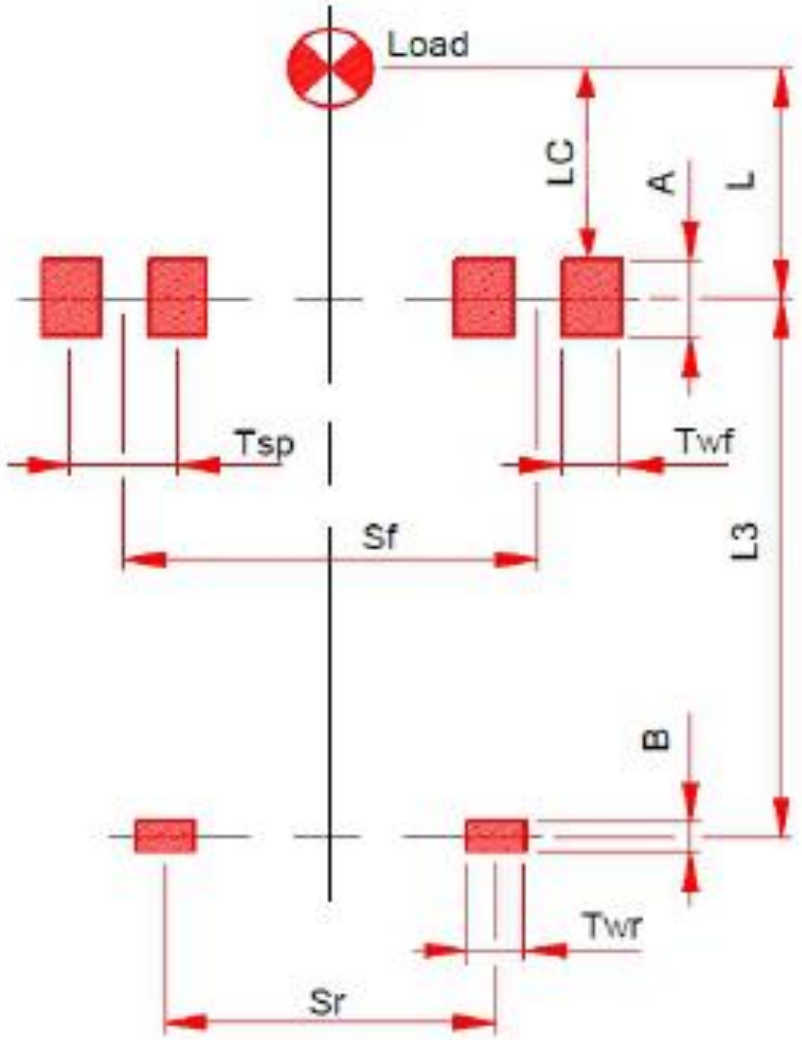
AXLE LOADINGS FOR DRG450-65S5

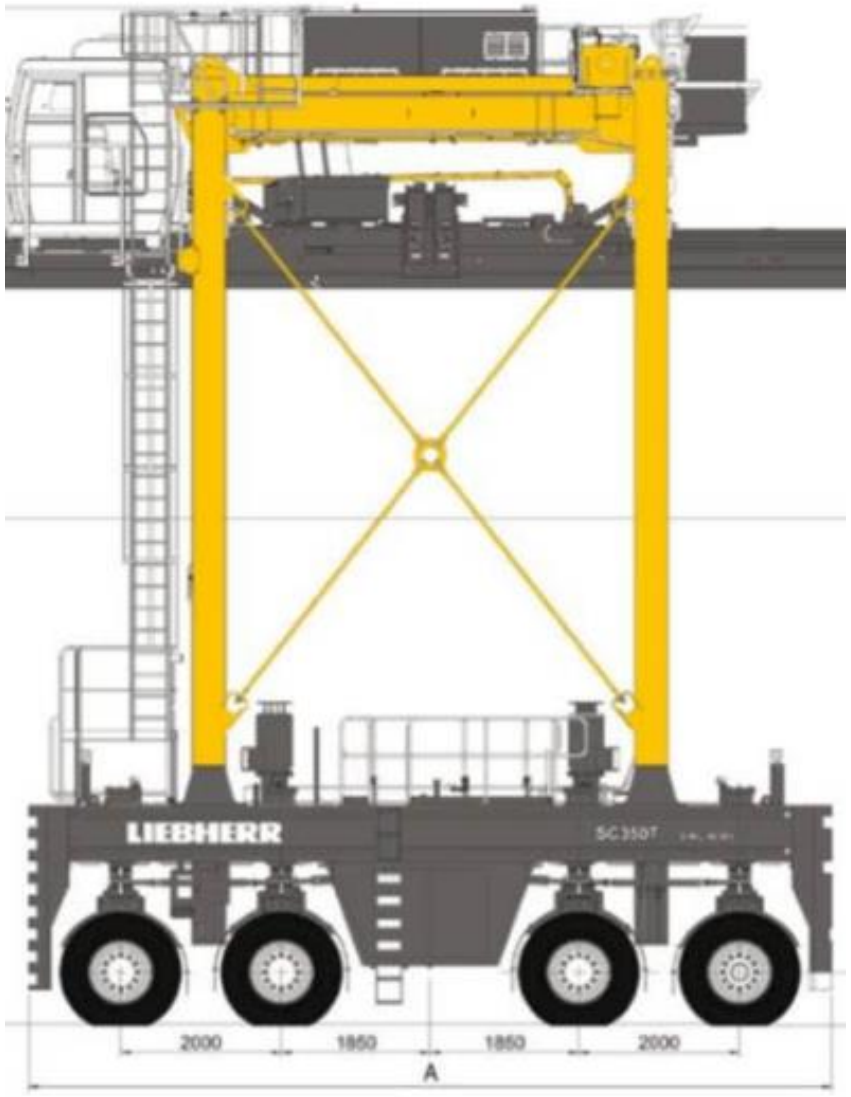
Wheelbase,L3=	6500	mm
Track front,Sf=	3030	mm
Track rear,Sr=	2600	mm
Tyre width front,Twf=	440	mm
Tyre width rear,Twr=	440	mm
Tyre spacing front,Tsp=	600	mm
Tyre radius,Tr=	835	mm

Weight of spreader =	7800	kg
Weight factor=	14,2	
Tyre pressure=	1,00	Mpa
Overload system:	Electrical	

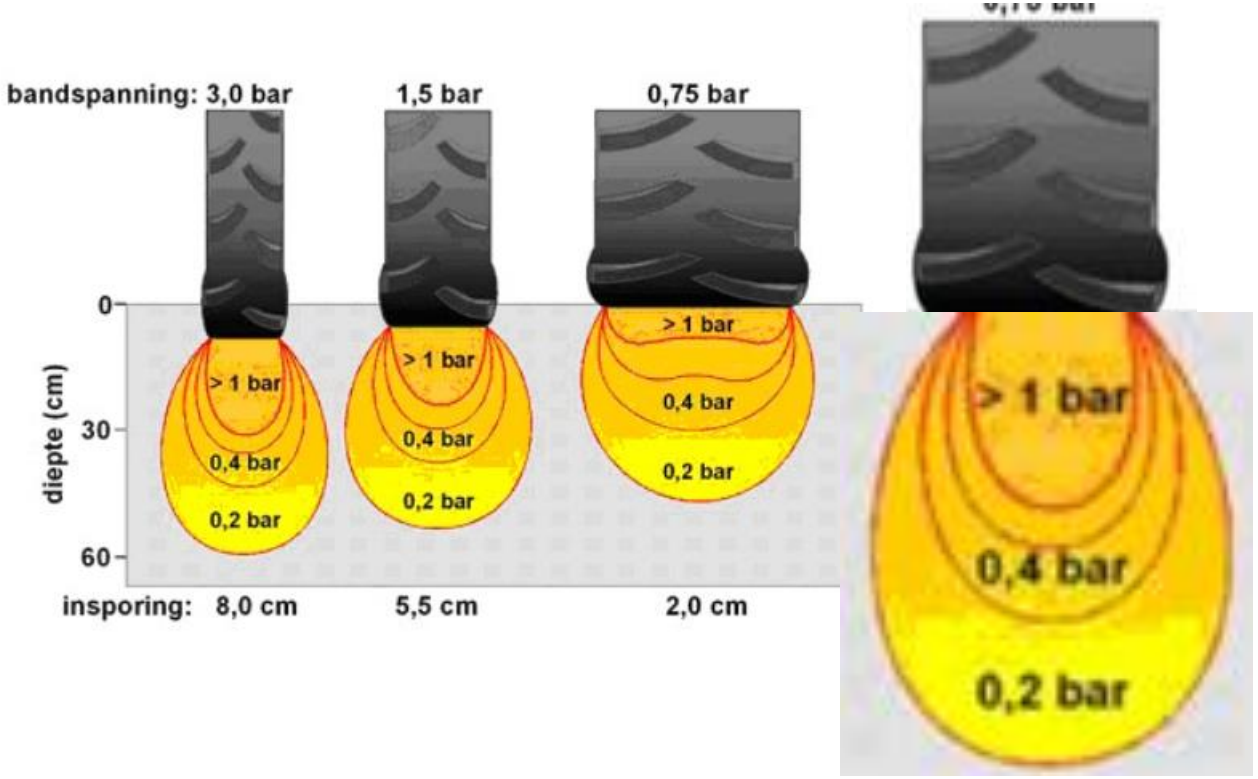
Load [ton]	LC [mm]	L [mm]	Steeraxle [ton]	Drivaxle [ton]	Stability [%]	Dim. A [mm]	Dim. B [mm]	
0	1965	2800	34,5	35		199	392	1 st row
45	1965	2800	15,1	99,4	78	565	172	1 st row
0	3815	4650	30,5	39		222	347	2nd row
32	3815	4650	7,6	93,9	33	534	86	2nd row
0	6315	7150	25	44,5		253	284	3rd row
16	6315	7150	7,4	78,1	42	444	84	3rd row
0	6500	7335	24,6	44,9		255	280	2nd rail
15	6500	7335	7,7	76,8	45	436	88	2nd rail
45	765	1600	26	88,5	235	503	295	Transport

PRINTAREA



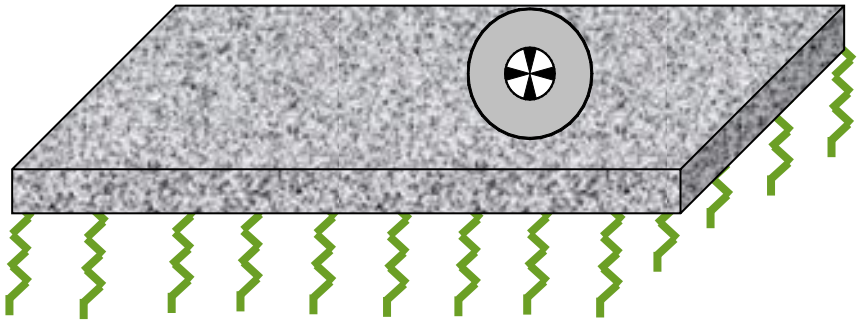


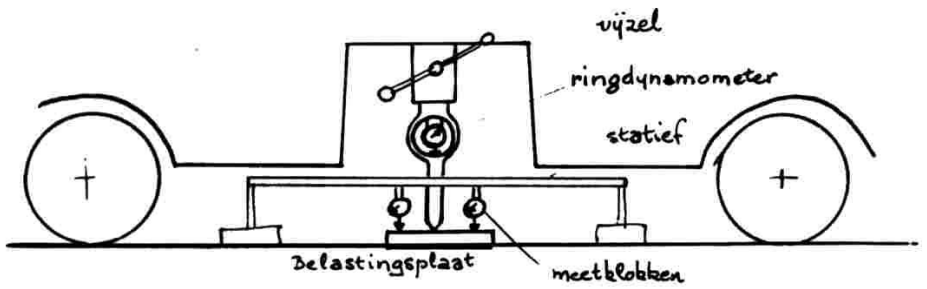
Tyre pressure and impact on soil

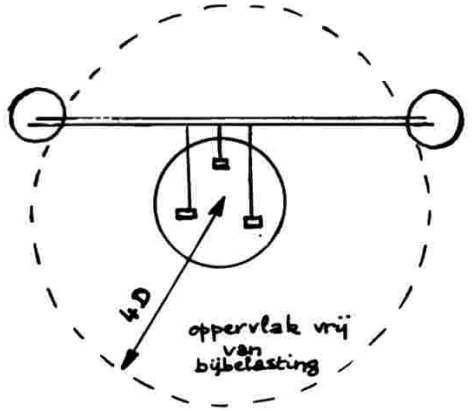


Soil resistance

q = k.w



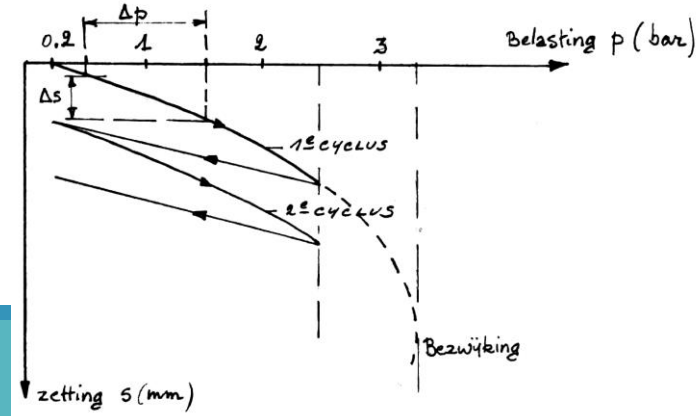




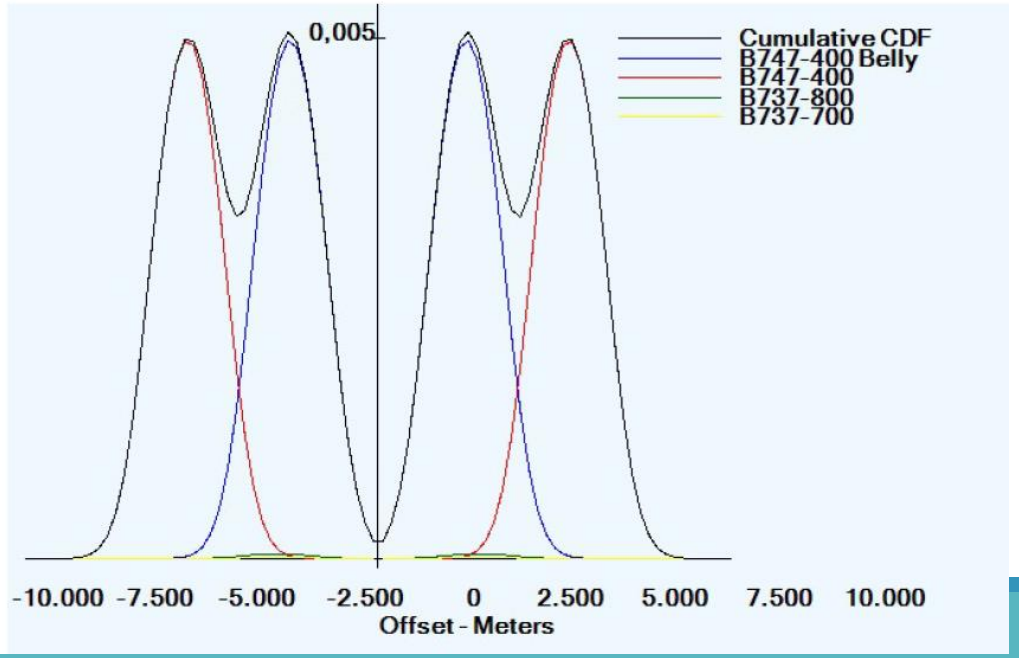
In practice, k (Westergaard) (in N/mm³) is determined by m of a plate test with a plate of diameter 760 mm.

Comparable with classic plate test (M1 in N/mm²):

- diameter 159.6 mm or area of 200 cm² for fine soils (clay, loam) and gravel up to 40 mm
- diameter 309.0 mm or area of 750 cm² for sand and crushed stone larger than 40 mm



Wandering or channeling



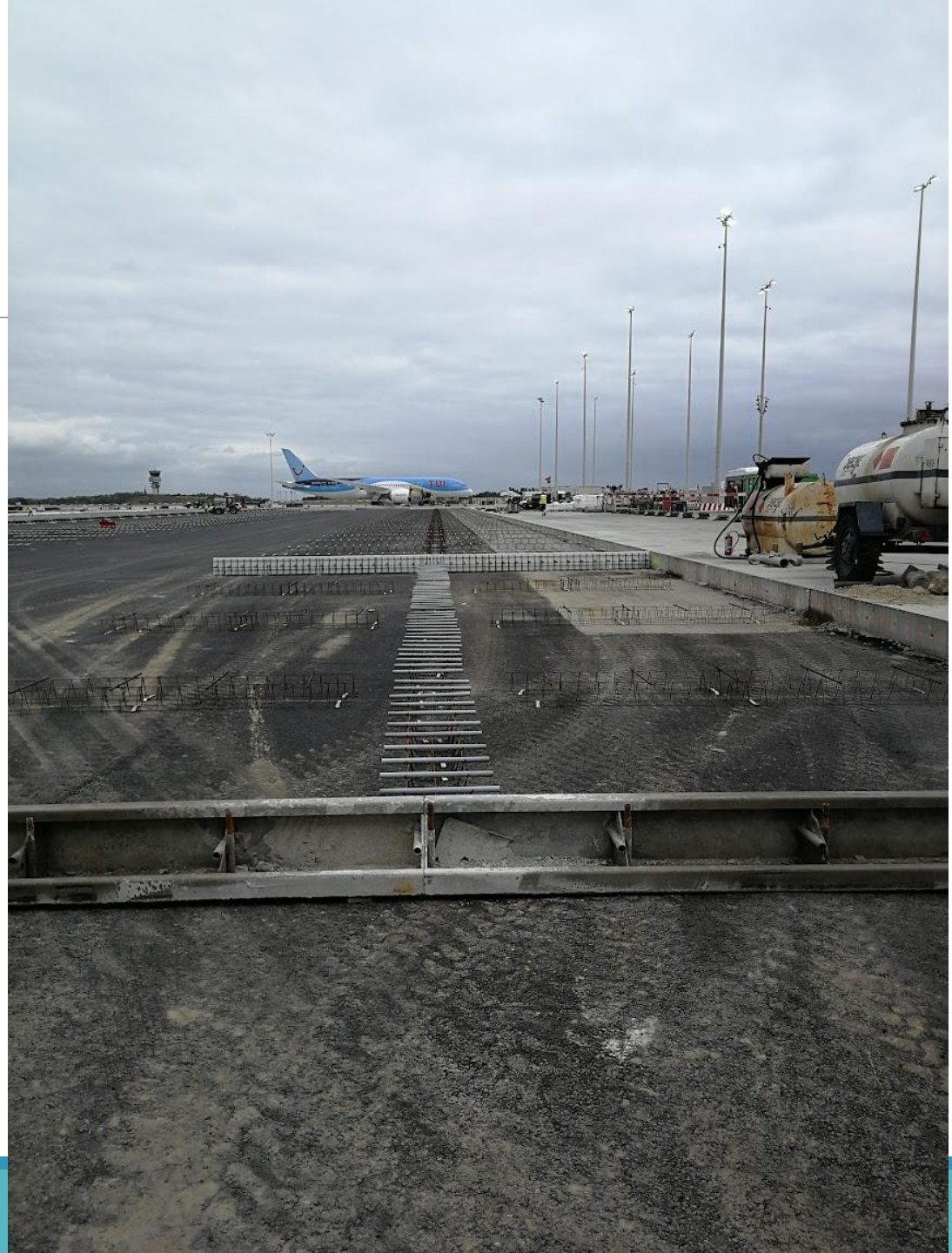
The airport of Zaventem - Apron

Doweled concrete pavement

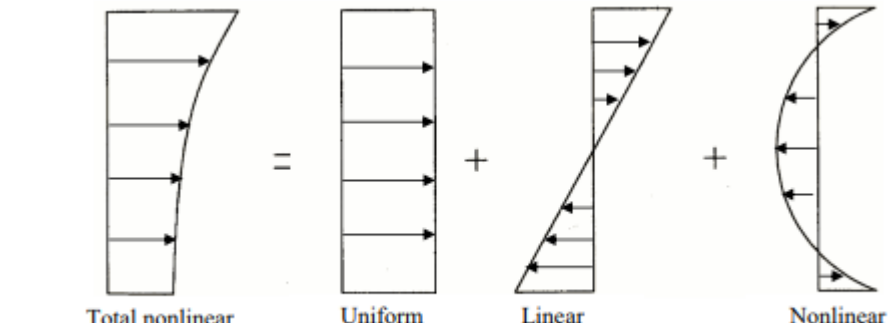
Asphalt interlayer

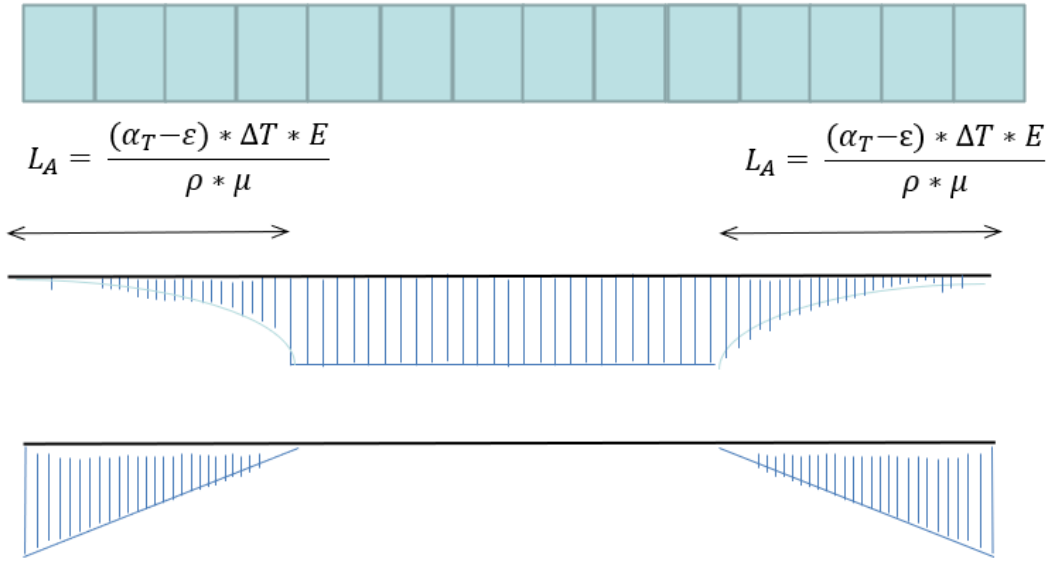
Lean concrete

Expansion joints



The need of expansion joints





$$L_A = \frac{(\alpha_T - \varepsilon) * \Delta T * E}{\rho * \mu}$$

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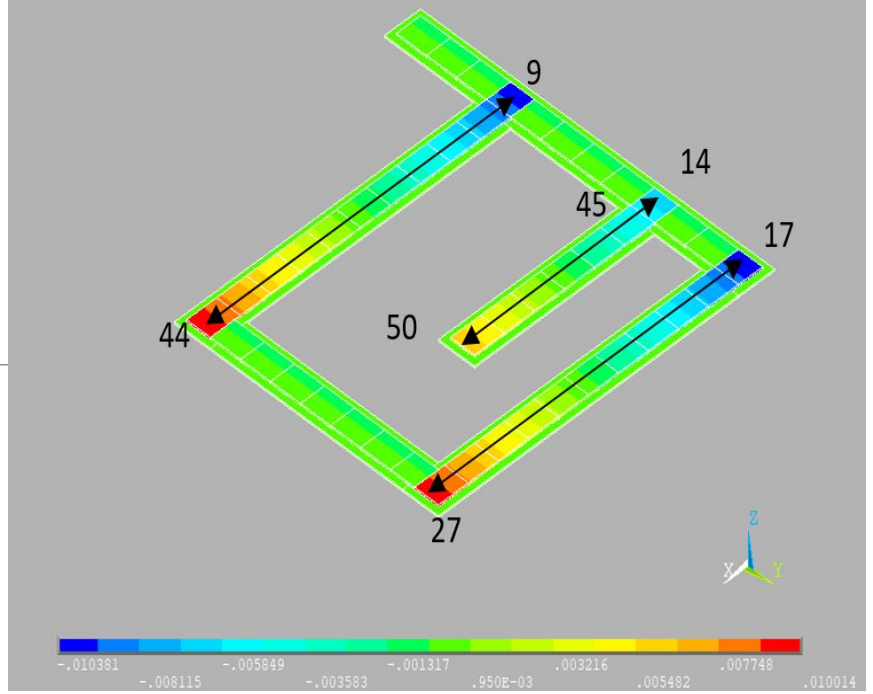
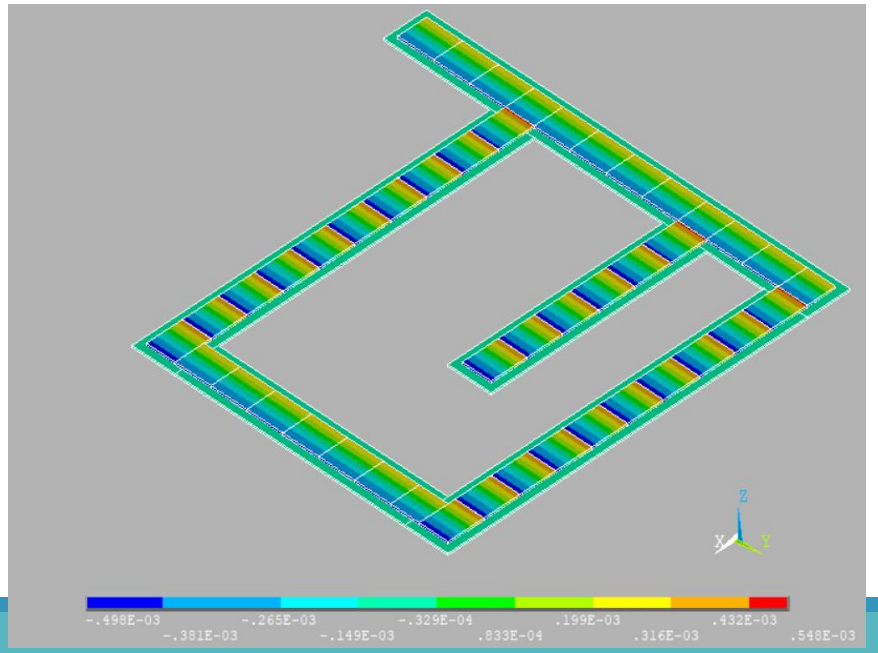
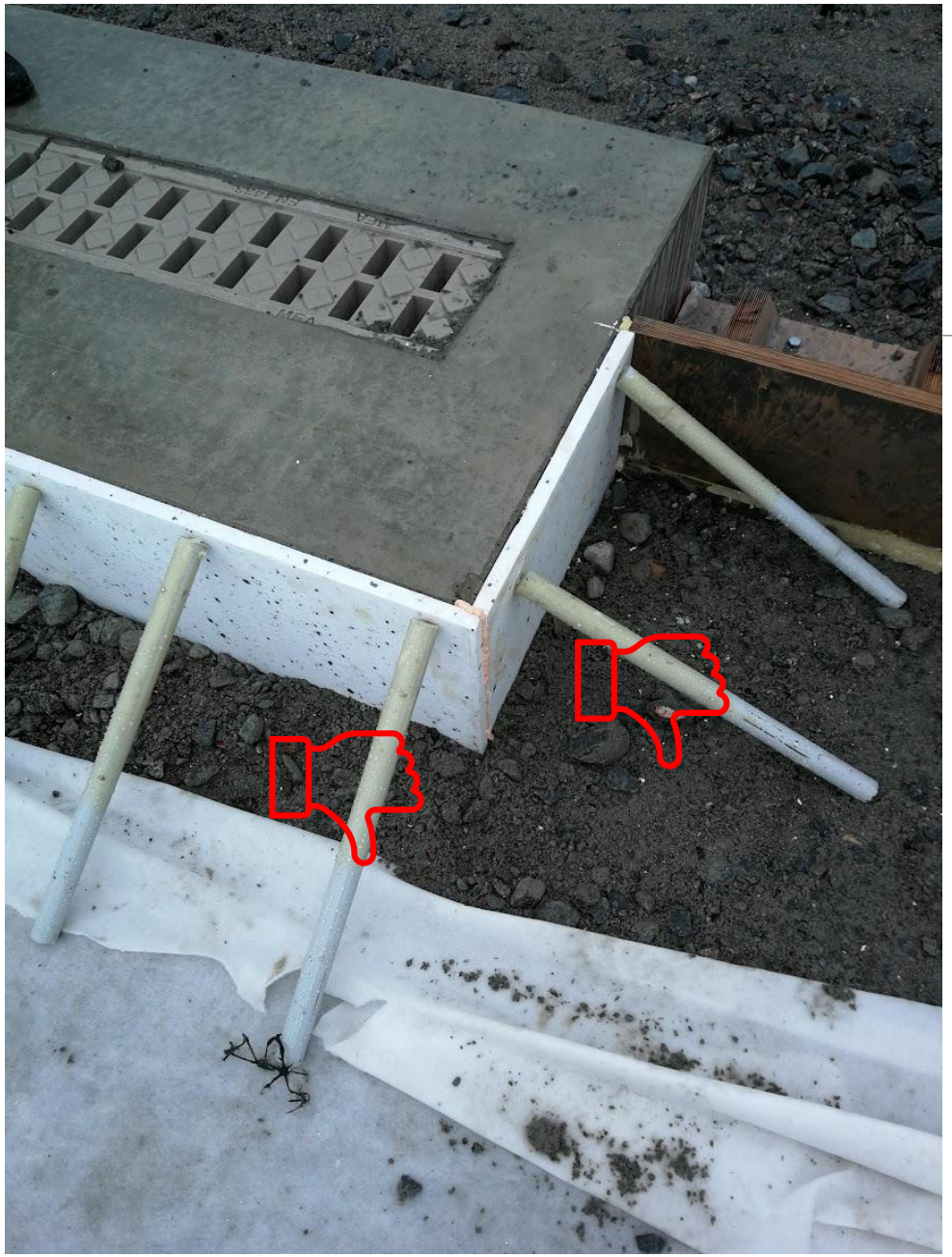
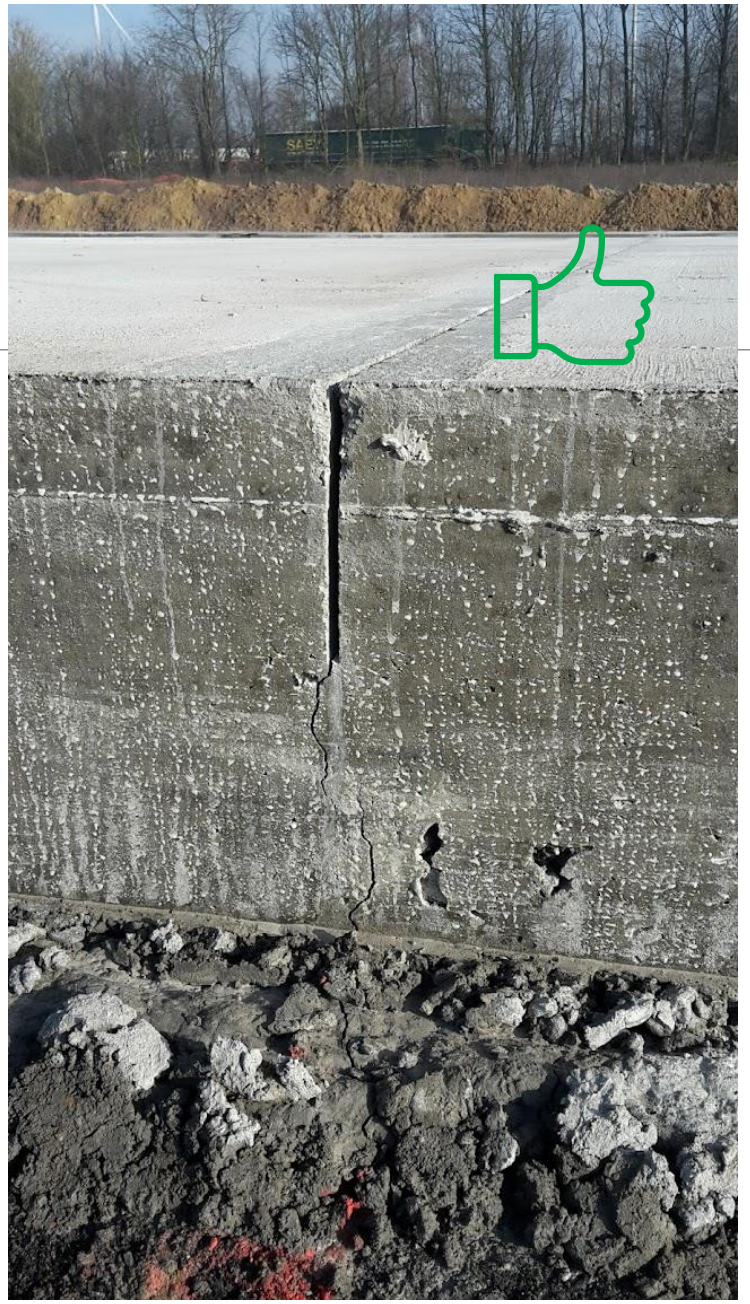





Riga airport
LIEBHERR
WIRTGEN
SP 641
Baltic
L126





Respect geometry!

Kristalpark Lommel – Belgium -
40 cm thick concrete, placed in two layers

But…
joints only cut over few cm

Depth of saw cut: at least 1/3 of total thickness

Joint filling material – to prevent water infiltration from the top

Quality of the base layer

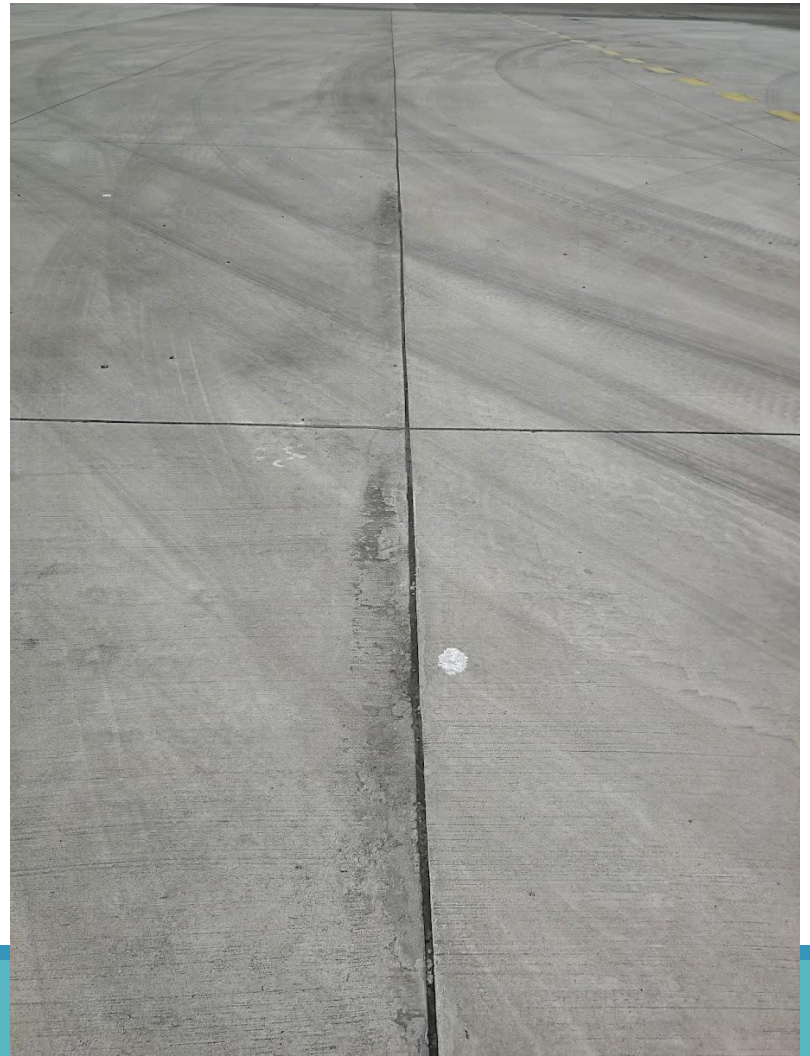
The advantage of a durable structure

Quality of base layer: by preference lean concrete

Placement of asphalt interlayer:

- protection of base layer
- placement of dowels/tie bars
- adherence between pavement and base layer
- lower risk of reflective cracking

Joint layout and execution



CRCP, Lanaken, Belgium

Lanaken, multimodal container platform 650m x 35m

- *Ring beam – together with gutter*
- *Advantages: high resistance to heavy traffic, no maintenance of transverse joints, no expansion joints*

Conclusions

Design of heavy duty concrete pavements:

- good load distribution: by preference rigid pavement with dowels on rigid base layer with asphalt interlayer

- higher impact than road pavements: higher axle loads, dynamic loads, impact of type of vehicle and traffic

- rules for classic concrete pavements need to be respected