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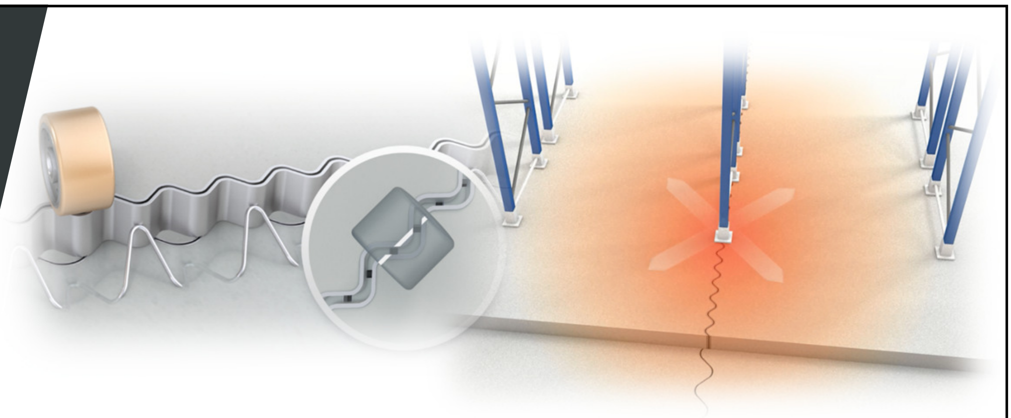

State of the Art for joints in industrial floors

September 2016

International Joint Tech Engineering s.a. ▪ Hauptstrooss 1 ▪ L-9753 Heinerscheid

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Overview

- Review / history of joints
- Problem „shock“
- Sinus Slide® Joint
- Cosinus Slide® Joint
- Structural design
- Execution – How not to do
- References
- Resume

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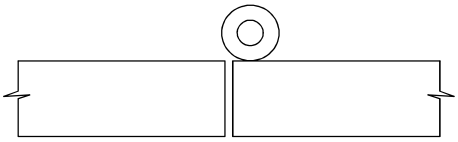
Review / history of joints

Some facts:

- Joints in concrete construction are nearly not to avoid
- Each joint in a concrete construction is a possible point of failure
- Joints a generally a weak point in terms of design
- Joints are limiting the use of a construction
- Joints usually require an intensive maintenance during the lifetime of the whole construction

Review / history of joints

No connection at all:



saw cut joints:

Review / history of joints

Shrinkage stresses compensated by saw cut joints

Review / history of joints

The problems can be various…

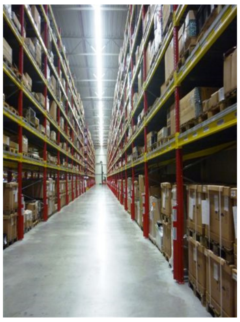
Review / history of joints

The problems can be various…

note:
Over the life time period of an industrial floor, saw cut joints have regularly to be maintained.

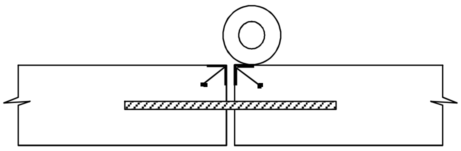
Review / history of joints

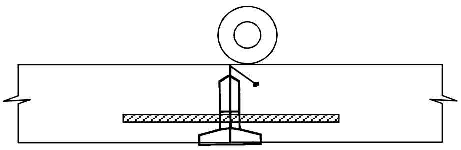
Flooring technology since +/- 1980:
Jointless floors are constructed
Potential joint problems reduced by about 80 %



Review / history of joints

Different construction principles were used:



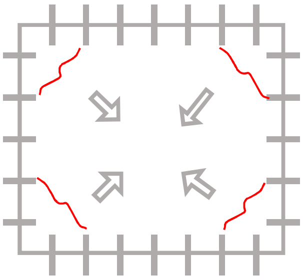


double angle
with dowel system

Review / history of joints

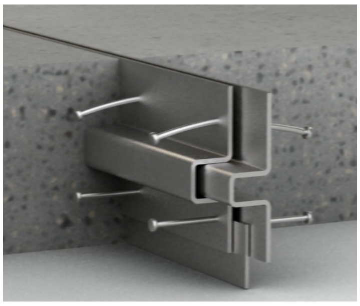
Different construction principles were used:

Disadvantage: No movements possible parallel to the joint

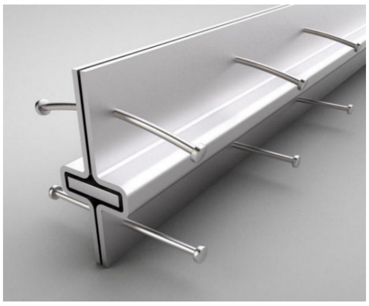


Review / history of joints

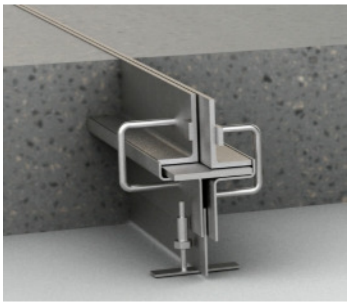
Different construction principles were used:
Types that allow longitudinal movements with
<u>continued load transfer</u>:



Omega



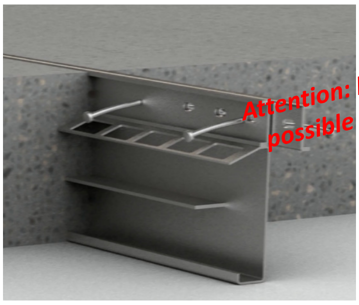
Delta



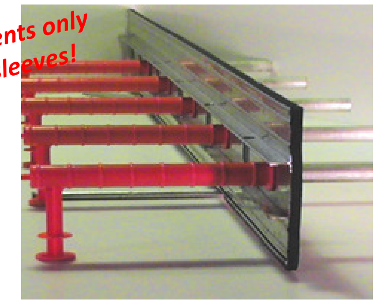
so called „Schwerlastprofil"

Review / history of joints

Different construction principles were used:
Types that allow longitudinal movements with
discontinued load transfer:



Attention: longitudinal movements only possible with corresponding sleeves!



Profile with plate dowels **Profile with round or square dowels**

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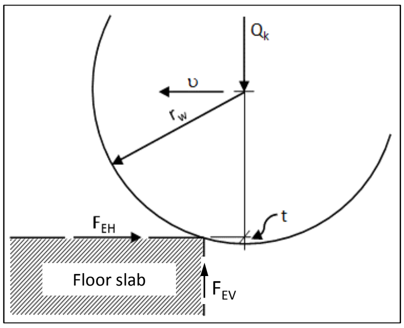
Problem „shock“

All traditional jointing systems have the same principal problem:

Problem „shock“

All traditional jointing systems have the same principal problem:

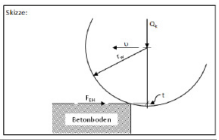
When crossing an open joint: horizontal an vertical impact!
In function of the chosen joint, forces are introduced systematically!



Problem „shock“

Qualitative overview of horizontal impact – exact calculation practically not possible

joint opening ö = 15 mm
dynamic safety factor φ = 1,20 [-]
static safety factor γ_Q = 1,00 [-] (SLS problem)
hypotheses: - Base time factor for the impact of tA = 0.5 s (assumption on the safe side)
- assumed reduction of impact duration in function of the tire material with $t_{A,red} = t_A \cdot (1 - p / 140)$
- assumed shock absorption in function of tire material with $red_p = 1{,}05 \cdot (1/p)$



covered by DIN EN 1991-1-1 (pneumatic, super elastic) / not covered by DIN EN 1991-1-1 / practical cases

tire material:		pneumatic						super elastic					
contact pressure p:		1 bis 1,5 N/mm²						1,5 bis 4 N/mm²					
wheel radius r_w:		325 mm						275 mm					
sinking depth t:		0,09 mm						0,10 mm					
forklift category	wheel Q_k [kN]	speed v [km/h] 5		10		15		5		10		15	
FL 1	13,0	1	1	1	1	1	2	1	1	1	2	2	3
FL2	20,0	1	1	1	2	1	2	1	2	2	3	3	5
FL 3	31,5	1	1	1	2	1	3	2	3	3	5	4	8
FL 4	45,0	1	2	1	3	1	5	2	4	4	7	5	11
FL 5	70,0	1	3	1	5	1	7	3	6	5	11	8	16
FL 6	85,0	1	3	1	6	1	8	3	7	6	13	9	20

tire material:		rubber						Vulkollan					
contact pressure p:		3 bis 8 N/mm²						5 bis 12 N/mm²					
wheel radius r_w:		225 mm						150 mm					
sinking depth t:		0,13 mm						0,19 mm					
forklift category	wheel Q_k [kN]	speed v [km/h] 5		10		15		5		10		15	
FL 1	13,0	2	2	3	3	4	5	2	3	4	5	6	7
FL2	20,0	2	3	4	5	5	7	3	4	6	8	9	11
FL 3	31,5	3	4	6	7	8	11	5	6	10	12	14	17
FL 4	45,0	4	5	8	10	11	15	7	8	14	16	20	24
FL 5	70,0	6	8	12	16	18	23	11	13	21	25	31	38
FL 6	85,0	7	10	14	19	21	28	13	15	25	30	38	45

tire material:		hard plastic / polyamide						steel or similar					
contact pressure p:		8 bis 30 N/mm²						20 bis 100 N/mm²					
wheel radius r_w:		100 mm						50 mm					
sinking depth t:		0,28 mm						0,57 mm					
forklift category	wheel Q_k [kN]	speed v [km/h] 5		10		15		5		10		15	
FL 1	13,0	4	5	7	9	10	13	8	24	16	48	23	71
FL2	20,0	5	7	10	13	15	20	12	37	24	73	35	110
FL 3	31,5	8	11	16	21	24	31	19	58	37	115	56	172
FL 4	45,0	12	15	23	30	34	44	27	82	53	164	79	246
FL 5	70,0	18	23	35	46	52	68	41	128	82	255	123	383
FL 6	85,0	21	28	42	55	63	83	50	155	100	310	149	465

xx (hatched) rare or improbable combination of wheel load and contact pressure / tire material
xx common occurring combination

Problem „shock“

Horizontal impact – jobsite reality:

Problem „shock“

Horizontal impact – jobsite reality:
Significantly increased wear of stacker wheels and increased electrical / electronic issues



Problem „shock“

Horizontal impact – jobsite reality:

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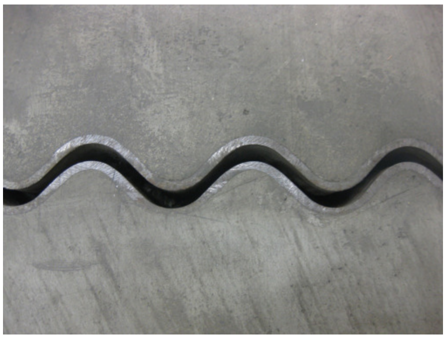
Sinus Slide® Joint

Question from the industry: IS IT POSSIBLE TO ELIMINATE THE REASON OF DAMAGES?

Answer: YES!

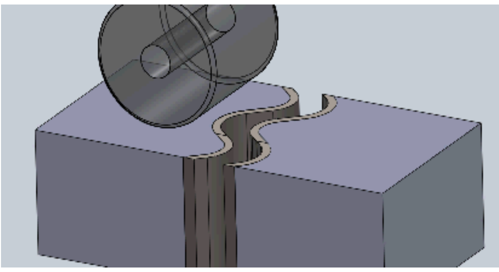


Sinus Slide® Joint

Question from the industry: IS IT POSSIBLE TO ELIMINATE THE REASON OF DAMAGES?

Answer: YES!

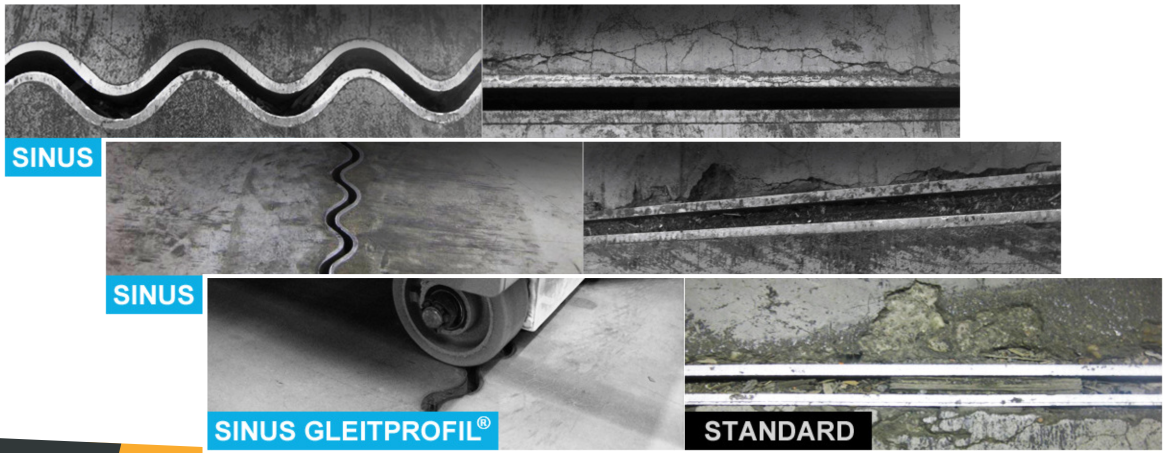
Due to the sinusoidal shape of the Cosinus Slide® Joint the wheels of forklift trucks remain permanently in contact with the concrete.



This permanent contact between wheel and concrete floor creates a sliding and silent crossing, so that drivers experience a feeling of a jointfree floor slab.

Sinus Slide® Joint

The initial concept: avoid damage, ensure durability



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Cosinus Slide® Joint

Development of Cosinus Slide® joints

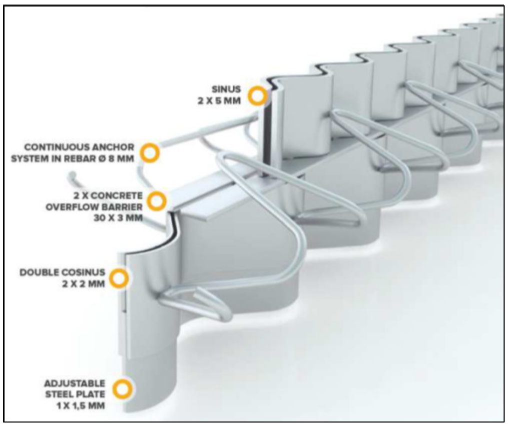
INITIAL SITUATION:

- Sinus Slide ® joints leading to durable solutions, but need a lot of steel and are relatively heavy.
- Existing systems often offer only moderate load transmission
- Bearing capacity always has been achieved through an additional component (dowel)
- Load transfer from the joint system into the floor usually only punctually
  - partially only single dowels or plate dowels approximately in the center of the concrete section
  - depending on the joint opening different failure mechanisms

Cosinus Slide® Joint

Development of Cosinus Slide® joints

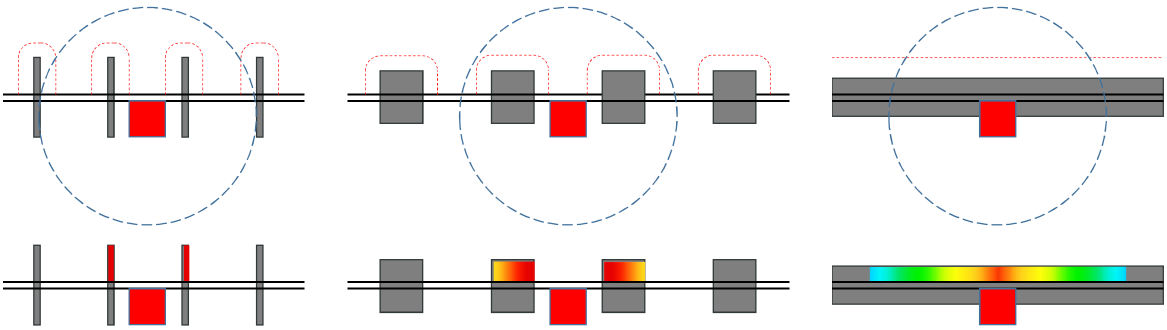
INITIAL SITUATION:
Combining all these facts in further R&D projects lead the new solution of
Cosinus Slide® joint
solving all the prementioned problems.



Cosinus Slide® Joint

Other system-related advantages:

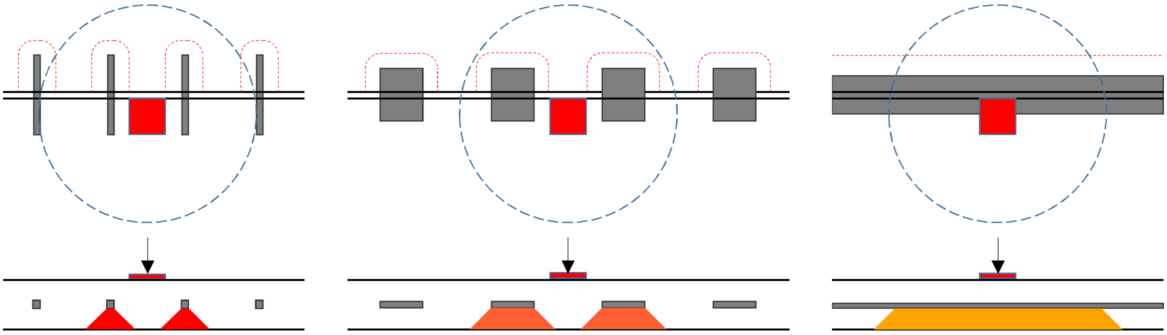
CAPACITY: **Discontinuous vs. continuous**



Cosinus Slide® Joint

Other system-related advantages:

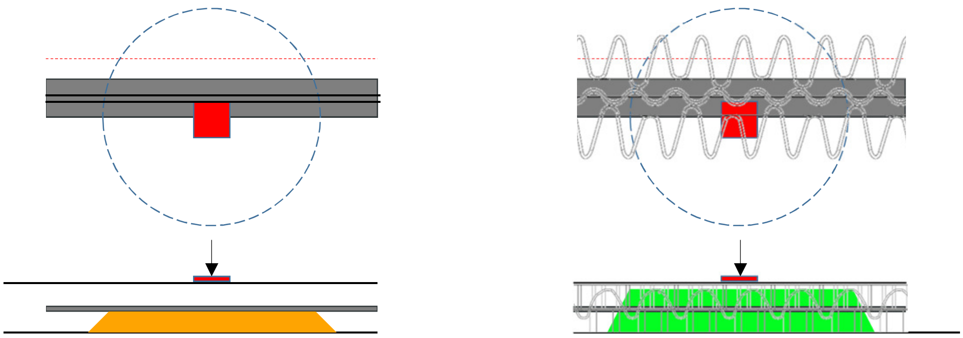
CAPACITY: **Discontinuous vs. continuous**



Cosinus Slide® Joint

Other system-related advantages:

CAPACITY: **Continuous vs. Cosinus Slide®**



Cosinus Slide® Joint

Other system-related advantages:

WHOLE BODY VIBRATIONS

Problem: Through work on/with forklift trucks, operators are exposed to whole-body vibration.

Legal Terms: EU Directive 2002/44/EC: Europe formulated limits for exposure of drivers.

Consequence: operators/owners of forklift trucks obligated to carry out a risk assessment.

Solution: Simple construction action eliminates trouble spots when driving over floor joints and provides legal certainty.

Cosinus Slide® Joint

Other system-related advantages:

WHOLE BODY VIBRATIONS

Solution: Simple construction action eliminates trouble spots when driving over floor joints and provides legal certainty.

Result: A jointless floor, joint free in its sensation

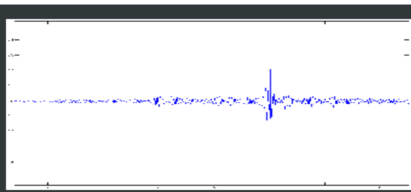
Cosinus Slide® Joint

Other system-related advantages:

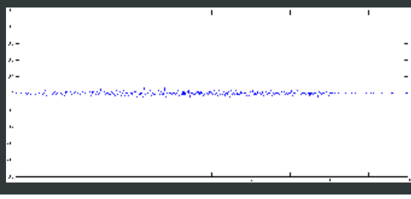
WHOLE BODY VIBRATIONS

Scientifically proven:

Forklift crossing a linear joint.



Forklift crossing a Cosinus Slide® Joint



Cosinus Slide® Joint

Other system-related advantages:

Economy / Ecology:

Fact 1: In average 66% of all damages of forklift trucks affect electric and wheels (source: InnoRad)

Fact 2: A major cause of failure of electric and wheels are shocks and vibrations (source : InnoRad)

Fact 3: Joint profiles in industrial floors are crossed 140 times per day on average (source : InnoRad)

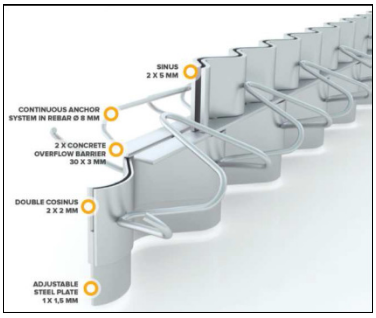
Fact 4: Only by changing damaged wheels in Europe costs arise amounting to € 550 million per year. The average cost per forklift and year is € 755. The Europe-wide quantity of waste is nearly 17,000 tons per year (source: Linde)

Cosinus Slide® Joint

Other system-related advantages:

Economy / Ecology:

By using Sinus Slide® Joints: minimize consequential costs and waste, both in floor as well as forklift trucks.
Savings between 25 and 50% depending on the forklift type, joint opening, operation time, speed, etc ..



Example: Logistic company operates at a site 50 forklift trucks
Average costs for wheel change € 755 x 50 = € 37,750 / year
Savings 25 - 50%: about 9,400-18,800 € / year

The investment costs pay off very quickly.

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Structural design

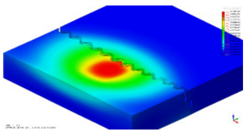
Initual situation:

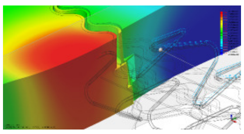
- The capacity of used jointing systems is often not calculated nor proven but simply assumed.
- Partial statements about load bearing capacity: „steel is strong enough, you have to take care for concrete…“
- Designs for industrial floors are – if considered at all – based on assumption for joint capacities. Often this design check is not done at all and forklift trucks are simply declared as „not decisive“
- The tire material of dynamic loads has not been considered!

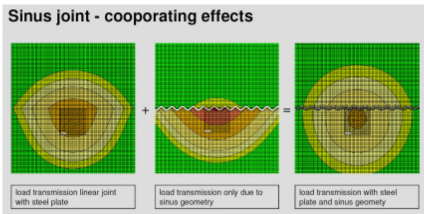
Structural design

With Cosinus Slide® Joint:

- The impact is exluded by geometrical shape. This is the precondition for a complete structural analysis:
  Due to exclusion of impact, all forces are known for ULS design
  SLS is secured
- By sinusoidal formation of the surface the load introduction and transmission is positively influenced.



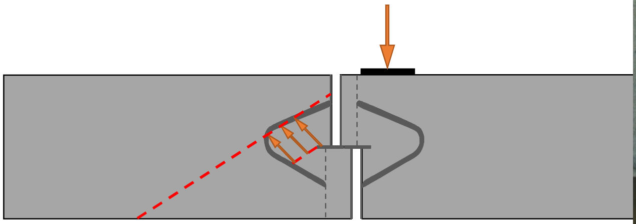




Structural design

With Cosinus Slide® Joint:

Illustration of the load bearing principle

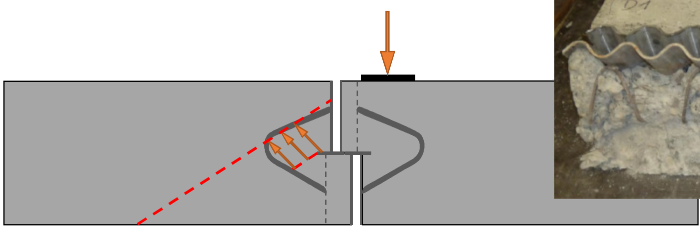


Displacement of the failure area into the upper stirrup level

Structural design

With Cosinus Slide® Joint:

Illustration of the load bearing principle



Due to the special shape of the sinusoidal consoles and their opposite arrangement, the introduced forces can be distributed very uniformly in the length direction of the profile.

Structural design

Determination of actions:

- Design of the floor (eg by steel fiber manufacturer) is based on an assumption of load transfer at the joint (usually betw. 30 & 50 %)
- Until now a check of this assumption was not possible:
  - Impact effect of vehicles not defined (many unknown parameters)
  - Designer has mostly no information about the bearing capacity of the joint
  - Real percentage of load to be transferred is not exactly known
- How loads are distributed along the joint?

Structural design

Determination of actions:

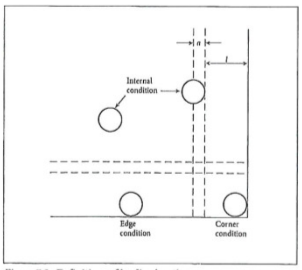


Figure 7.3: Definitions of loading locations.

Technical Report 34 (TR34),
The Concrete Society
Definition of loading locations

What loads have to be considered for a design check at the joint profile?

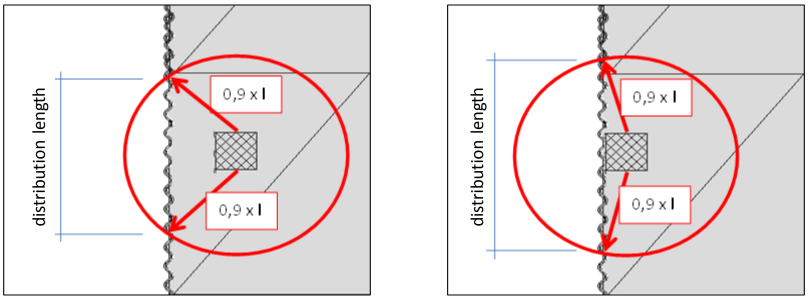
According Westergaard influence defined by radius of stiffness
f (modulus concrete, thickness, soil characteristics, Poisson's ratio)

All loads within this distance, have an impact on the joints!

Structural design

Determination of actions:

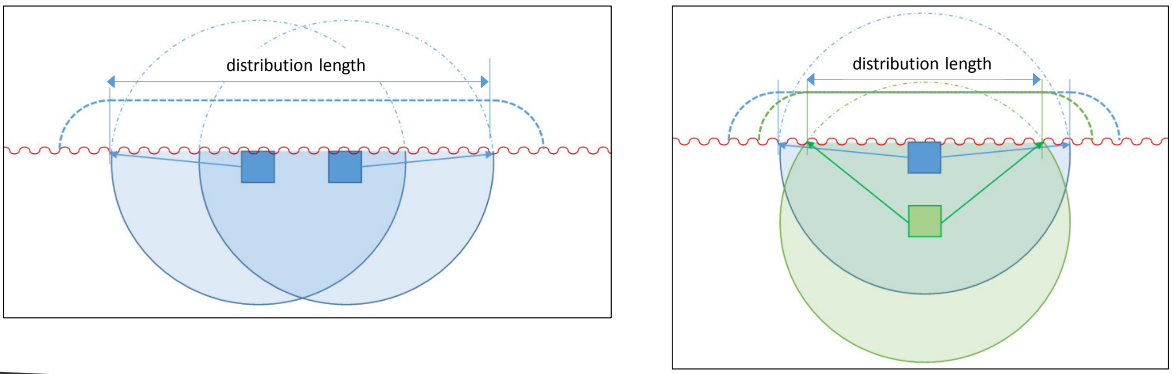
Acc. Technical Report 34 (TR34): load distribution up to 1,8 x l bothsides of load, but decreasing
Simplification: 0,9 x l with full loading



Structural design

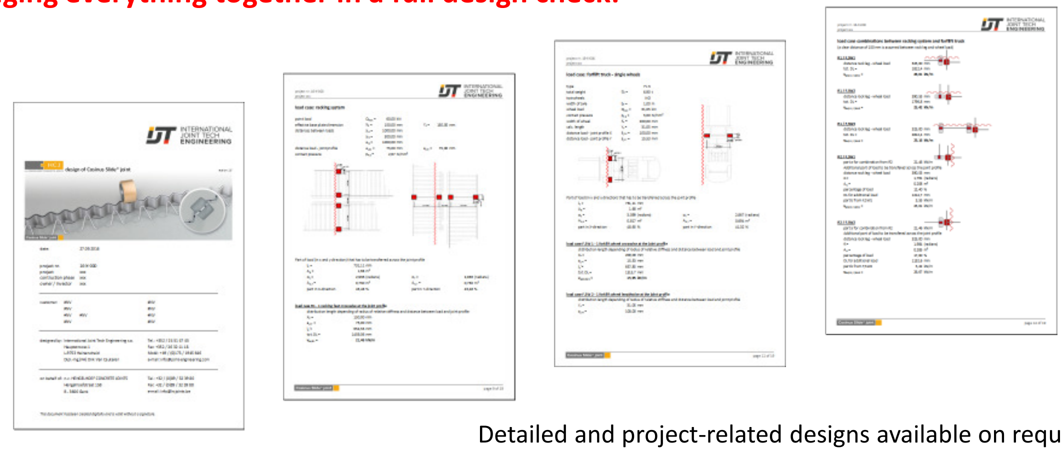
Determination of actions:

Development of the model: superposition of actions



Structural design

Bringing everything together in a full design check:



Detailed and project-related designs available on request

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Execution – How not to do

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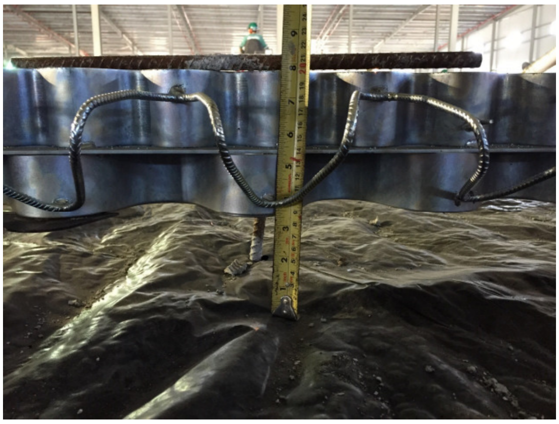

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Toyota Parts Center
Diest (Belgium)

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Volkswagen Braunschweig (Germany)

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References

REWE Neu-Isenburg (Germany)

State of the Art for joints in industrial floors

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References

Shoprite Distribution Centre Cilmor, Brackenfell, Cape Town, (RSA)

INTERNATIONAL JOINT TECH ENGINEERING

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Overview

- Review / history of joints
- Problem „shock“
- Sinus Slide® Joint
- Cosinus Slide® Joint
- Structural design
- Execution – How not to do
- References
- **Resume**

Resume

- The **requirements** for industrial floors and by consequence for joints have **increased significantly**.
- **Straight profiles are not anymore State of the Art** in case of presence of forklift trucks with hard tires.
- **Cosinus Slide® Joints** allow to **ensure and prove the bearing capacity and long term serviceability**. Additionally, **significant cost savings** over the life time period can be achieved.
- Responsibility of designers: **inform and advice the building owner.** He has then to make the choice whether or not a durable solution at the State of the Art is required, or if he – being aware of all facts – tends to another solution that might be cheaper in short term view.
- Although as it should be known from other areas and as it is obvious: The **execution is the key** to a **high quality and durable industrial floor**.

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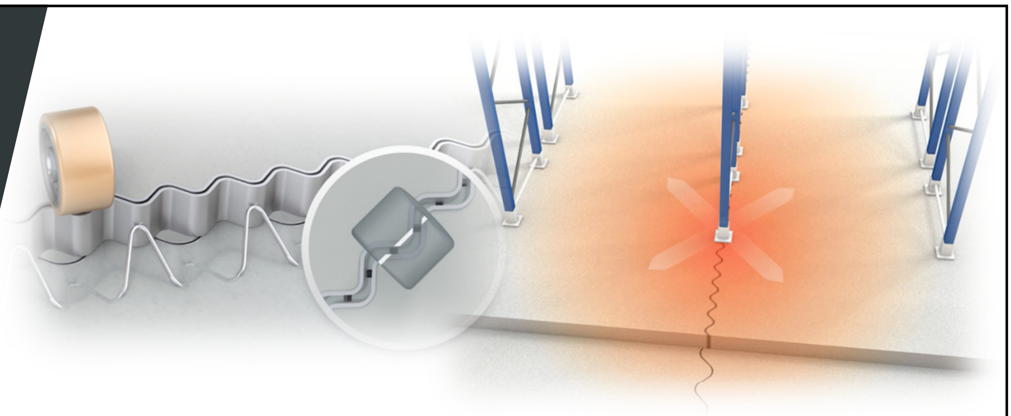

Thank you for your attention

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