Regarding the Formation and Design of Joints in Industrial Flooring

Dimension of Usability by Joint Geometry

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Summary

Modern production and logistics companies require functional industrial floors for an economic and timely operation. Industrial flooring is functional if it can safely absorb the loads applied to it, for example by shelving, goods, machinery and traffic. This is considered as part of the stability verification. Furthermore, the industrial flooring must be fit for use. This is achieved by a flat, wear-resistant base having a small number of cracks and defects, and an optimized number of systematic weak points, e.g. in the joint area. With that, a low-maintenance and functional operation of the floor is ensured, which provides supports of the industrial flooring and a service life of industrial forklift trucks and their tyres. Therefore, most of this industrial flooring is implemented in concrete design, as it offers many advantages for this application. One problem is the design of the joints between the fields. Due to structural raptures, damages can be frequently detected here, which subsequently reduces the usability of the industrial flooring.

It is possible to summarize the impacts on the industrial flooring and to dimension the flooring, with technical regulations and a comprehensive state of the art. This includes both, the load-free impacts, such as shrinkage, creep and restraint stresses from discharged hydration heat, and load-controlled impacts, such as point loads of shelving, area loads from the use and dynamic loads of industrial forklift trucks. This leads to choosing a reinforcement type, a concrete strength class, and component strength and component size. The rules do not explicitly address the joint formation. Two problems emerge here:

I) Description of the shock event

The DIN EN 1991-1-1 "Euro code 1: Impacts on structures - Part 1-1: General actions on load-bearing structures - Densities, self-weight and imposed loads for buildings, German version EN 1991-1-1:2002 + AC: 2009" knows truck categories that take the forklift weight into account. These include calculated contact surfaces, which then create defined pressures (or contact pressures) on the base slab. The standard implies a contact area of 20 cm x 20 cm, reflecting pneumatic tyres. However, in reality vehicles with synthetic tyres with smaller contact areas are used. As a result, the contact pressure immediately increases significantly. Figure 1 shows the impact of the contact area of the industrial forklift truck on the base slab's contact pressure and its difference, on the one hand, how it is captured arithmetically and, on the other, how it occurs in reality. If the mass is moved, an impact stress is created on the joint edge, during regular crossing with a linear joint. It is dependent on the size and hardness of the wheels, the mass of the truck and its load, the joint gap width and the speed of the mass. The impact is greater, the smaller and harder the wheels are, the higher the mass of the forklift and its load, the greater the crossed joint gap and the faster the mass passes over the joint. Figure 2 shows the impact of the tyres and the speed of the shock stress of a joint, when assuming a joint gap of 15 mm. This implies that the shock stress increases exponentially, with a decreasing wheel diameter and increased speed with the same mass. Figure 3 illustrates this effect again. These factors and the resulting increase in activity on the industrial flooring and the joint area are not taking into account by the existing load.

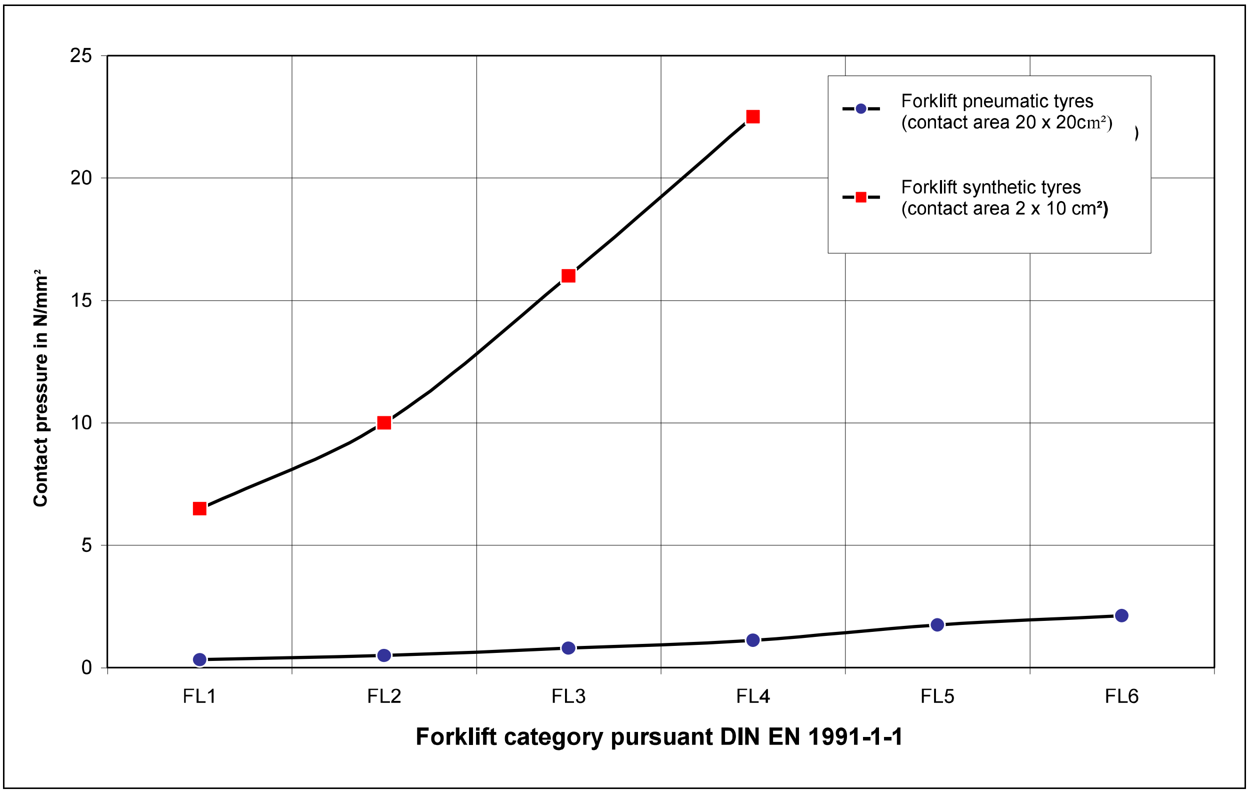

Fig. 1: Tyres effect on the contact pressure of the floor slab with different forklift categories

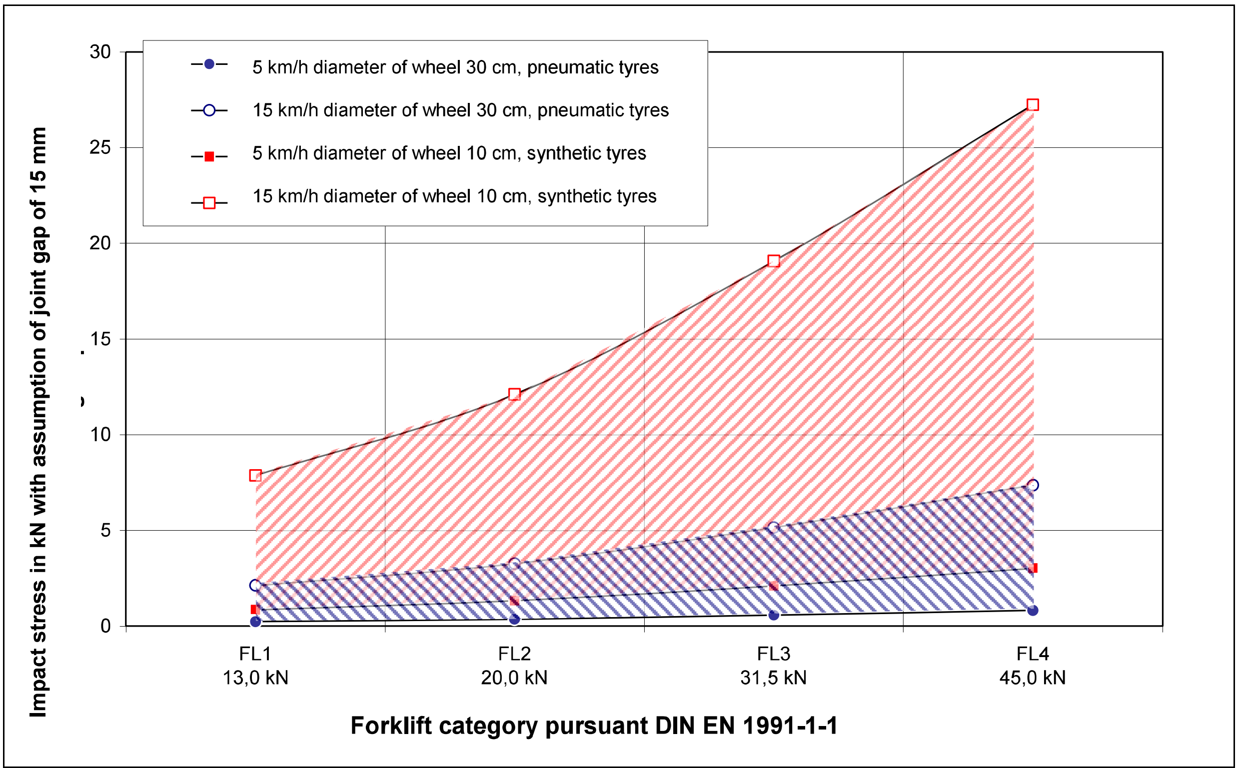

Fig. 2: Impact effect on the linear joint profile edges contingent on the diameter of the wheel and speed

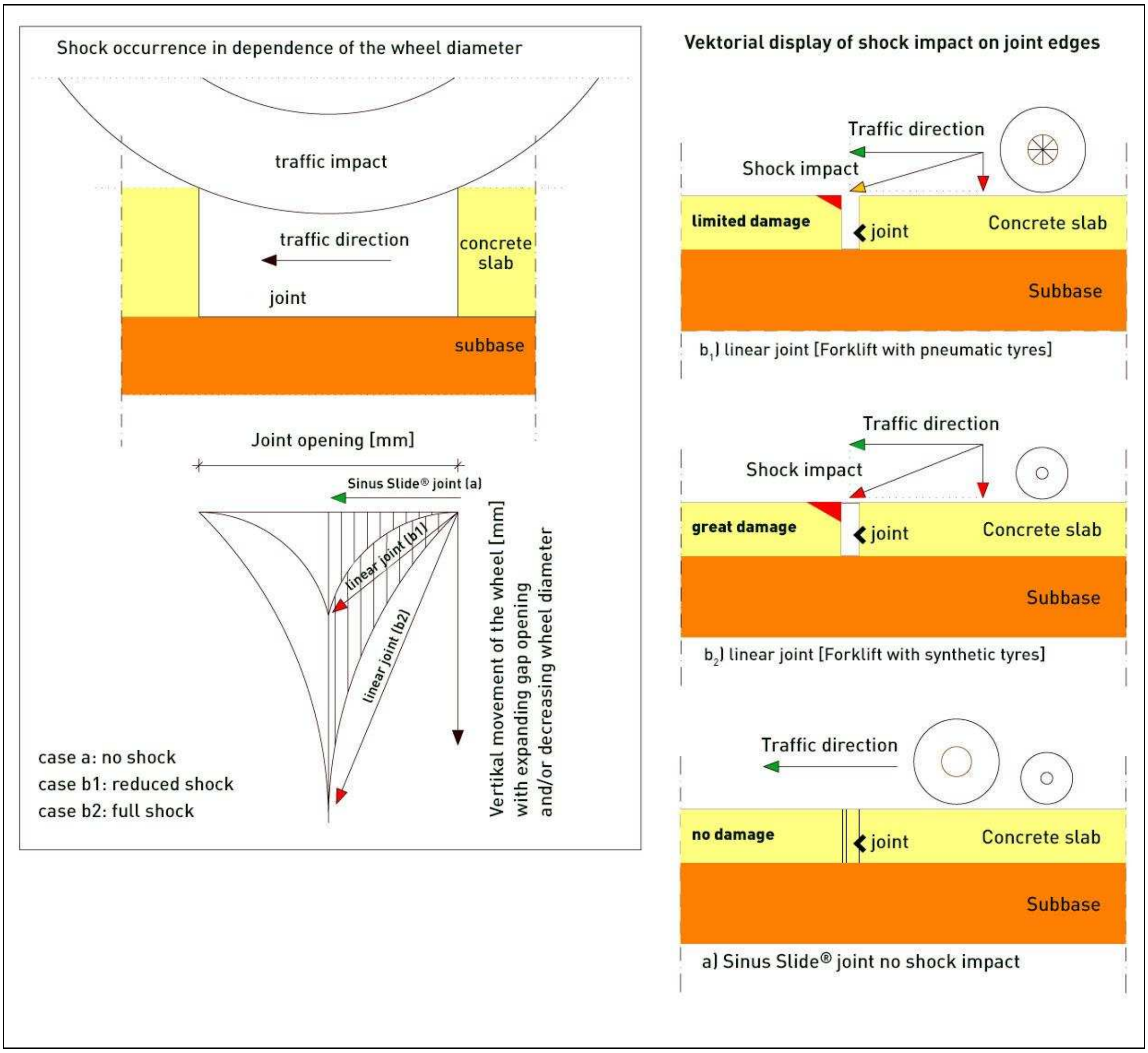

Fig. 3: Vector representation shock event on the joint face contingent on the diameter of the wheel

II) Lack of resistance against a shock event

It is noted that the predictable impacts cannot withstand any resistance through the dimensions of the joint. Therefore it is not possible, to protect the joint sides, for example by suitable sheet thickness or additional reinforcement. Hence, depending on the use of the floor (forklift, wheels, speed, number of crossings, concrete quality) break-outs and spallings of the concrete along the joints will occur, which is generally associated with a significant reduction of usability.

Finally, this leaves only three ways to maintain the usability of industrial flooring in the joint area. These are:

- Reduction of the shock by using forklifts with pneumatic tyres.
- Reducing the impact by reducing the speed of industrial trucks with synthetic tyres.
- Complete elimination of the shock by the use of a sinusoidal joint profile with slide effect.

When using a sinusoidal joint profile with slide effect, due to the joint geometry, there is a possibility that shock stress is not likely to occur at all, see case a) in figure 3. The specific shape allows for a continuous shock-free when crossing the joint. Hence, no shock load is created, when the joint is crossed with industrial forklift trucks, as observed with conventional, straight joint profiles, see case b_1) and b_2) in figure 3. Instead, the wheels glide with a strike angle of a field to another, and from the aspect of performance capability, a joint-free concrete floor slab is ensured. In terms of durability design of the industrial flooring, in the joint area resistance can be set against the shock stress.

In summary, it can be concluded that in order to improve the usability of industrial flooring and in view of later changes regarding the use of industrial forklift trucks with different tyres, the use of a sinusoidal joint profile with slide effect, is generally the most useful option.