

Dramix® 5D: Concrete reinforcement for pile supported floors

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Ultimate safety and serviceability

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Choosing your floor type

Choosing the right floor is an important aspect of assuring the continuity of operations in your building. If the ground conditions are too unstable for a regular industrial floor on grade, the floor can be, for instance, constructed on piles. The safety and serviceability of your pile supported floor is influenced by two important aspects:

Geotechnical conditions

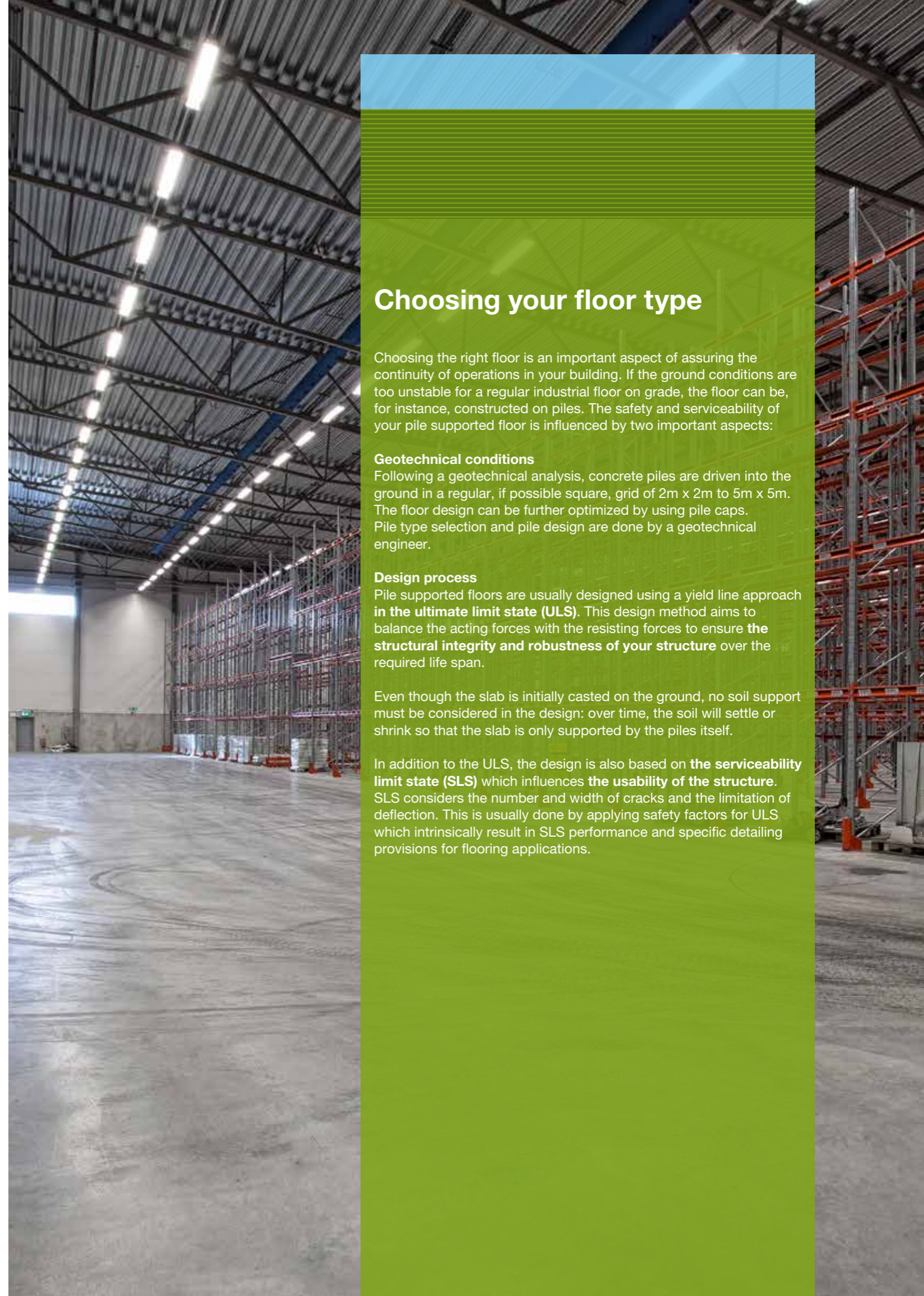
Following a geotechnical analysis, concrete piles are driven into the ground in a regular, if possible square, grid of 2m x 2m to 5m x 5m. The floor design can be further optimized by using pile caps. Pile type selection and pile design are done by a geotechnical engineer.

Design process

Pile supported floors are usually designed using a yield line approach **in the ultimate limit state (ULS)**. This design method aims to balance the acting forces with the resisting forces to ensure **the structural integrity and robustness of your structure** over the required life span.

Even though the slab is initially casted on the ground, no soil support must be considered in the design: over time, the soil will settle or shrink so that the slab is only supported by the piles itself.

In addition to the ULS, the design is also based on **the serviceability limit state (SLS)** which influences **the usability of the structure**. SLS considers the number and width of cracks and the limitation of deflection. This is usually done by applying safety factors for ULS which intrinsically result in SLS performance and specific detailing provisions for flooring applications.



Reinforcing floors on piles

To provide the required strength and stability, pile-supported floors can be either reinforced with conventional rebar or steel fibre reinforcement or a combination of both.

The major advantage of working with steel fibres is that the reinforcement is directly integrated into the concrete mix. This benefit has a major impact on your installation process and the quality of your floors on several levels.

Easy logistics

Imagine how much your logistics would improve by not having to cast a lean concrete base or compacted gravel bed to support your double layer of rebar or mesh. You will also be able to eliminate the extra work with spacers, rebar or mesh.

Fast and easy to handle

Imagine finishing your 40 000 m² floor one month earlier than planned. Steel fibres aren't only cost-efficient in terms of reducing labour and transportation; they will also significantly reduce your project completion time, allowing you to start your industrial activities sooner.

Ergonomic and safe handling

Imagine a safer work environment and better ergonomics. Using steel fibres eliminates the labour intensive process of installing rebar or meshes; this means less bending and heavy lifting.

User-friendly solution

Imagine the peace of mind you will receive by creating less room for error: no rebar or mesh that can be mislaid; no mounting and dismantling concrete pipes that can clog; no need for a concrete pump that can breakdown. Steel fibres also allow the use of modern placing technologies such as laser screeds, resulting in outstanding, ultra-flat concrete surfaces.



Using steel fibre reinforcement allows a fast, easy and safe installation process.

Dramix® 5D steel fibre reinforcement for safe and reliable floors

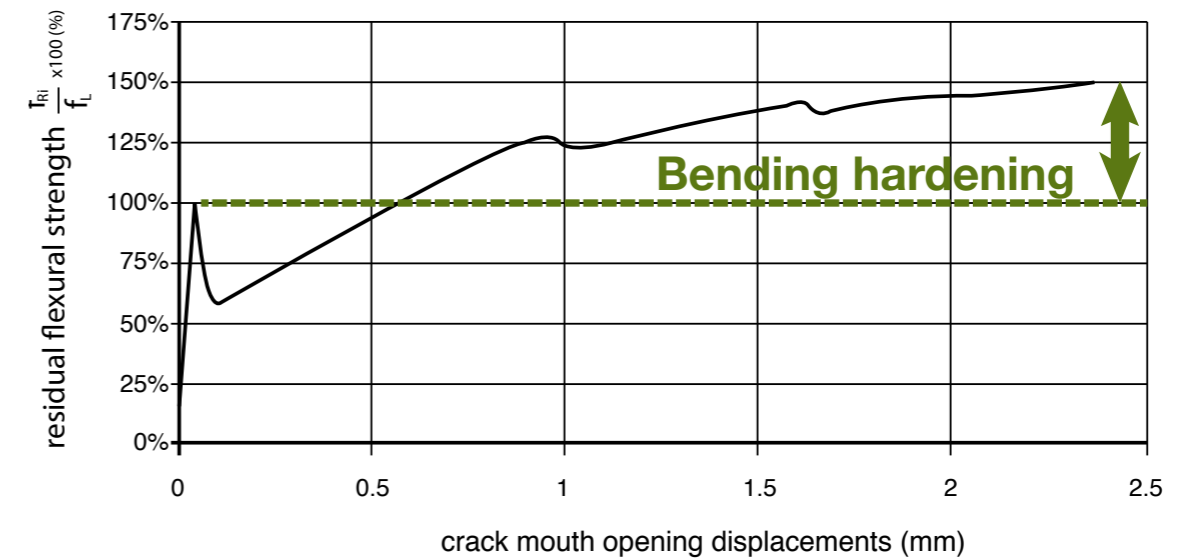
Floors are a critical element to ensure safe and efficient operation. To meet the specific demands for reinforcing concrete structural floors, Bekaert developed a steel fibre with a unique shape and capabilities: Dramix® 5D.

Features

- perfect anchoring properties
- ultra-high tensile strength of more than 2200 N/mm³
- high-ductility steel wire with more than 6% elongation capacity

Result

These unique features result in a high performing building material: a bending hardening steel fibre concrete at workable dosage rates.



Structural advantages with Dramix® 5D

Homogenous reinforcement

Dramix® 5D steel fibres are glued into bundles to ensure a homogeneous distribution through the concrete, creating a stronger, safer and more durable floor.

The complete reinforcement solution

Dramix® 5D steel fibres enable the construction of pile supported concrete floors without the use of mesh or any other traditional reinforcement other than detailing steel at column locations.



Using Dramix® 5D reinforced concrete enables a smooth finish of your structural floor in no time.

Dramix® 5D in practice - Project ELON

“This was the first time we used Dramix® 5D steel fibres. We were soon convinced of its benefits.

Since we didn't need to place rebar or additional reinforcement, we had more space to move around. We needed fewer men to get the work done and we reduced the estimated project period by 15%.

The Dramix® 5D steel fibres were spread homogeneously through the concrete. The ultra-high performance of the fibres allowed us to reduce the dosage. This improved the workability compared to very high dosages of traditional steel fibres, making the concrete easier to pump.

We were also very pleased with the technical support we received from Bekaert. We'll definitely be working with them again for future projects.”



Conny Gustafsson, Business Area Manager Linotol



25 000m² warehouse floor in Örebro, Sweden, 2014

Proven performance

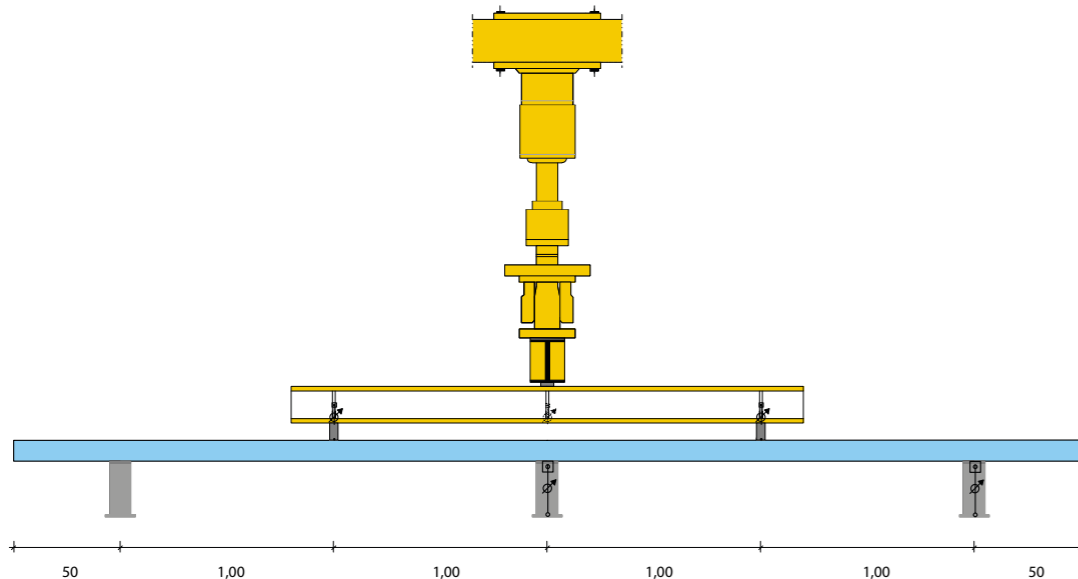
At Bekaert, we subject our products to rigorous testing to measure their performance and safety. These tests are not only performed in house, but by independent laboratories including renowned universities.

KIBKON and the Institute of Concrete Structures Faculty of Civil and Environmental Engineering performed three large scale tests at the Ruhr-University Bochum (Germany) to measure the performance of Dramix® 5D reinforced floors on piles.¹

The purpose of the tests was to measure the load-deflection and load-crack opening performance as well as crack patterns and crack propagation.

Test set-up

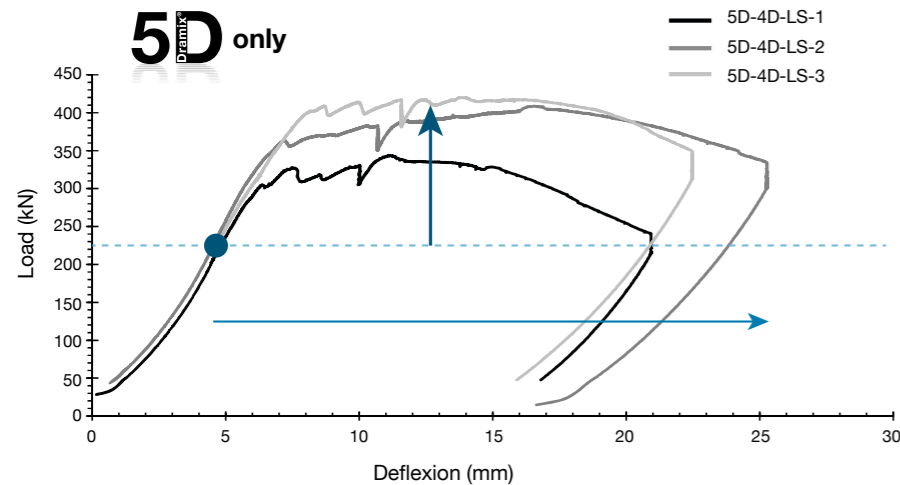
The tests were performed on 5000mm x 5000mm x 150mm concrete slabs that consisted of C30/37 concrete reinforced with 40 kg/m³ Dramix® 5D 65/60BG. Each slab was supported by 9 columns and loaded at 4 point.



Layout of test setup in east-western direction

Result

- a distinct bending hardening behaviour that meets the structural requirements of the floor
- a very high ductility of the structure
- an improved crack pattern - tight cracks + crack pattern much more spread out
- a high stiffness during yield line formation - less deformations in the initial phase (SLS)



Tests performed according corresponding to DIN EN 14651 showed that all structural requirements are met, proving that Dramix® 5D reinforced floors are robust, reliable and safe

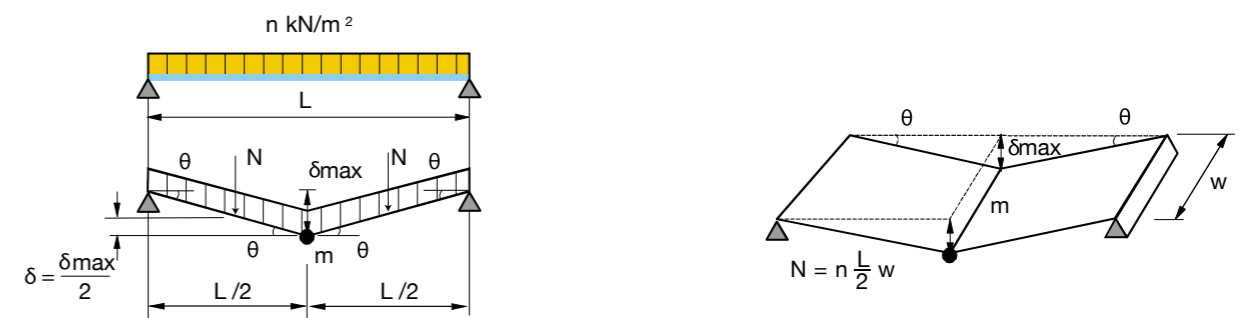
¹(Prof. Dr.-Ing. habil. Mark P. and Heek P., M. Sc., Large scale tests of fibre reinforced concrete slabs on pile support: Dramix® 5D 65/60-40 kg/m³, Ruhr-University Bochum, 2014)

Design philosophy

Our structural engineering team is guided by the philosophy that structurally sound designs are the key to safe, robust and long-lasting structures. For this, we rely on well-established design guidelines.

- The required bending moment capacity is determined according the yield line theory (cf. publication by Kennedy and Goodchild, 2004).

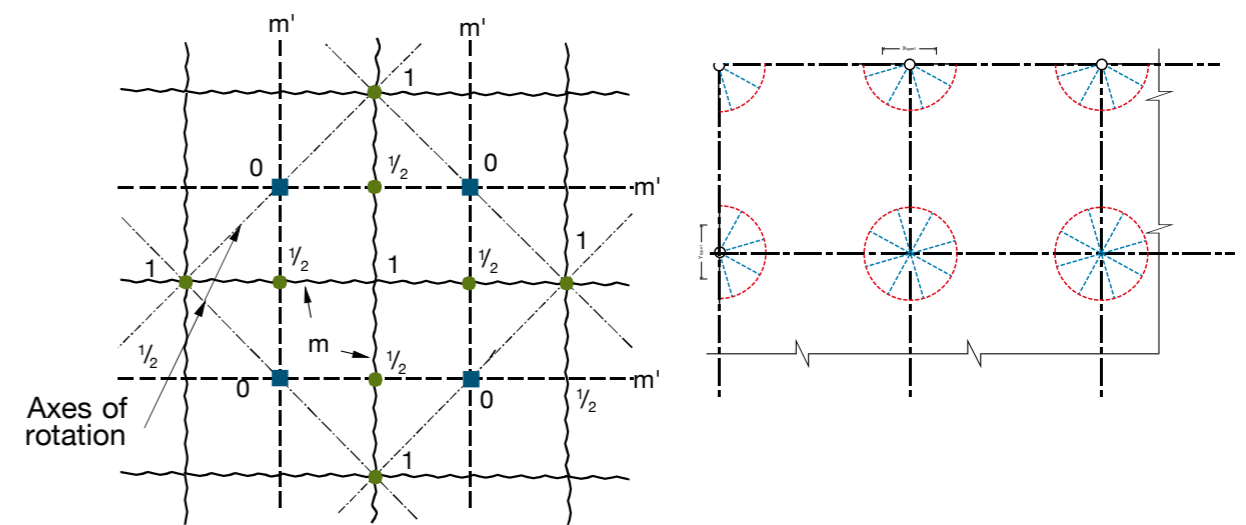
The yield line theory is a design approach that analyses and establishes the loading capacity or ultimate limit state of a structure. The easiest and most popular way of applying the yield line theory is the virtual work method. Yield line analysis is based on the equilibrium of the work performed by an external force moving through a distance and the rotations about plastic hinges resisting that external force.



A simple, supported, one-way slab illustrating a basic yield line pattern according to the virtual work theory

According to the yield line theory two main mechanisms affect the bending moment of pile supported slabs: the folded plate and the fan pattern. While the first cause is a general effect, the other is considered to be a more local phenomenon.

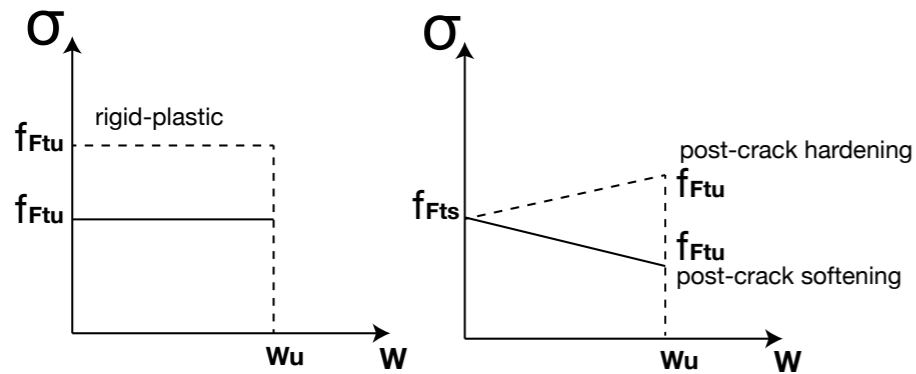
The fan pattern must not be confused with punching. Punching resistance has to be verified in an additional step. Steel fibres do also add to the punching capacity.



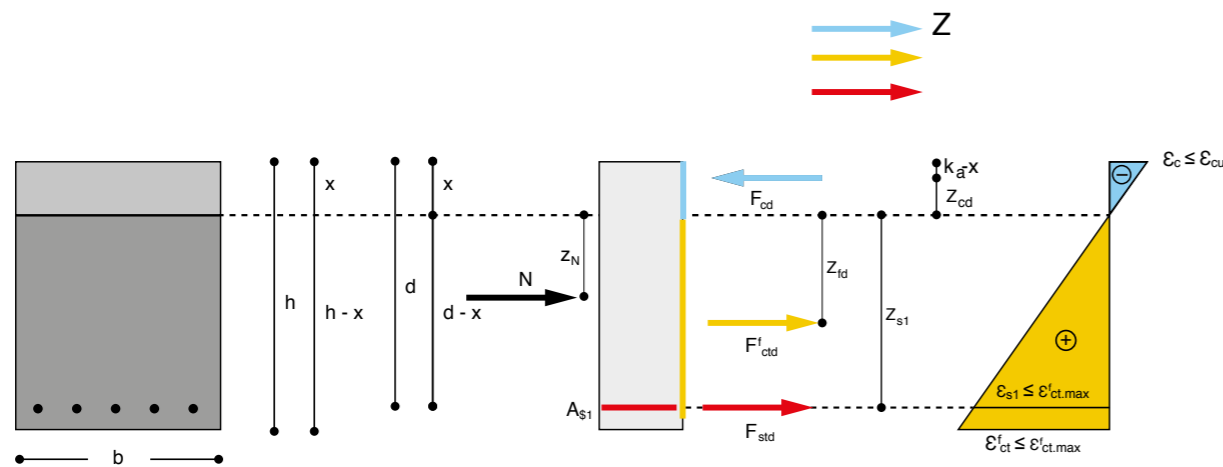
Combined folded plate collapse mode

Conical collapse mode

- The design of the **resisting forces** is based on internationally accepted guidelines and standards such as Modelcode 2010 and the DAfStb guideline for steel fibre concrete.



The constitutive laws according to FIB model code 2010



Calculating the bending moment capacity: Forces and lever arms in a combined reinforced cross section (steel bars in combination with steel fibre reinforced concrete)

- The **load and material safety factors** that are chosen depend on the local building codes.

Your partner in concrete reinforcement solutions

Reinforcing concrete structural floors is a challenging task. This is why our team is readily available to assist you at each step of your project; from concept design to financial analysis. Whatever your project, our knowledge and expertise is only a click or a phone call away.

Our services include:

- slab design
- construction detailing
- concrete optimization
- automatic total quality control procedures for the contractor

Reinforcing your world

Bekaert Building Products has production plants and sales offices all over the world. This means you can always count on fast delivery, extensive support, and professional advice. Anytime, anywhere.
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