THE APPLICATION OF FIBRECONCRETE IN THE PRODUCTION OF PREFABRICATED PARTS

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Abstract

Current knowledge of fibreconcretes already allows for the application of fibres not only in the execution of classic industrial floors but as well as for more sophisticated tasks of production of precasts and prestressed prefabricated parts.

1. Fibre application pre-requisites

Since the year 2008 a file of standards prescribing not only experimental methodology but as well as conditions for assessment of interactions inbetween fibres themselves has been valid for concretes containing fibres. The most relevant standards are the standard EN 14 889-1-steel fibres and EN 14 889-2- polymer fibres.Only group 1 fibres are suitable for the above mentioned application i.e.fibres showing a property of stability. For polymer application this fact must be verified and proven. Unfortunately from the longterm point of view the application of polymer fibres as a reinforcement for stability appears to be problematic for flow whereby the bonds between fibres and the matrixes go loose and in loaded prefabricated parts cracks get developed. For all other types of monofilament polymer fibres without structural properties, it is strongly recommended to install these fibres mainly for fireresistant ability in high temperatures associated with fire-breakout and for improving resistance of prefabricated parts to deformation during shipping and assembly(installation) and with all other positive properties of these fibres inclusive. Eventually both steel and polymer fibres could be applied simultaneously as a mix.

2. Steel fibres for prefabricated parts production

are subject to the above-mentioned criterion of stability role which must be verified and proven in accordance with relevant EN standards. This property predominantly relates to fibres manufactured cold-drawn with circular cross-section and with anchorage ending..

When selecting the individual type of fibres for application, it is necessary to bear in mind

their core shape characteristics i.e. l/d which represents the ratio of length to diameter. The diagrams illustrated hereunder reflect individual fibres according to batching/dosage of fibres, their type, length and the l/d ratio or the shape and it is quite obvious that the

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resulting graph of the behaviour of fibre-concrete can be significantly affected by these properties.

The graph of residual strength of fibres with anchorage endings and wavy fibres. And as the last characteristic I deem it important to mention longterm-capacity of fibres to transfer load across cracks. This is one of the negligible parameters of fibres, the role of which was not emphasized but for prefabricated parts it is however an entirely significant parameter. Here we make a comparison between steel fibres with anchorage endings and polymer fibres. In principle the test is about the performance of experiment on beams according to the following course of loading.

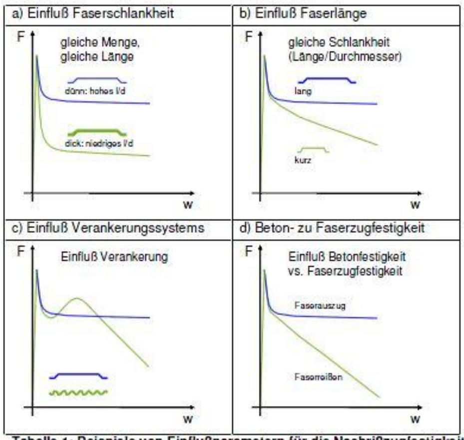
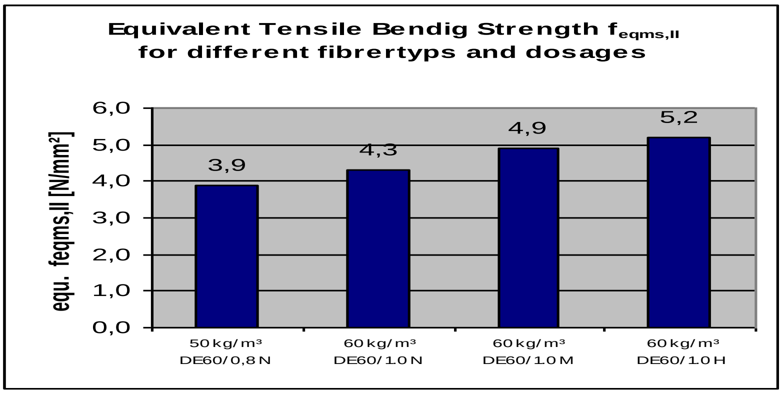
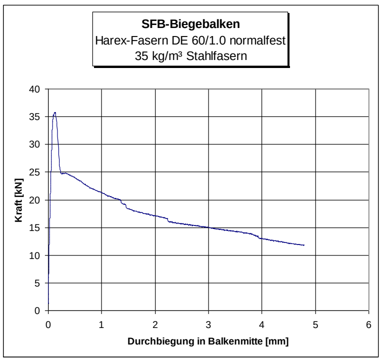
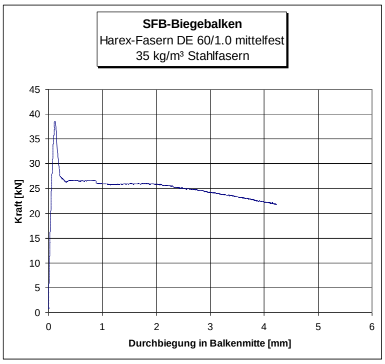


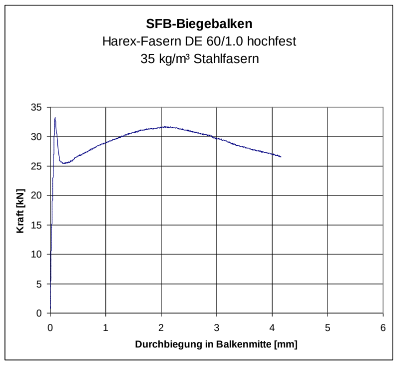
Tabelle 1: Beispiele von Einflußparametern für die Nachrißzugfestigkeit

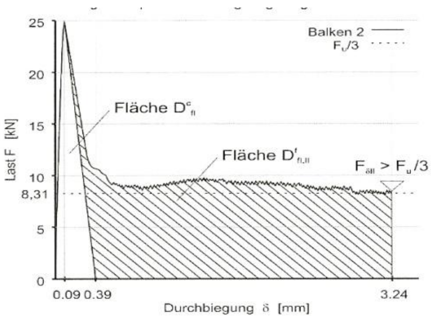
The beams are subsequently exposed to longterm loading with the same force and their relevant deflections are monitored . The following graphs (curves) as a result are compared to the decline in deflection of the beams.The comparison shows that steel fibre is the most suitable regarding longterm transmission (transfer) of forces across a crack contrary to polymer fibre which in the course of time breaks loose in the matrix or gets distorted leading to subsequent failure of beams.

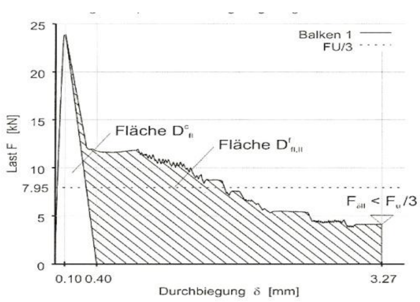


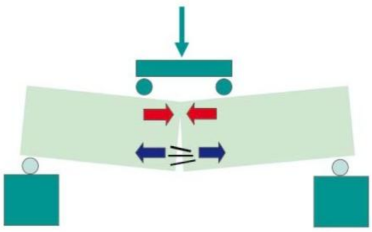


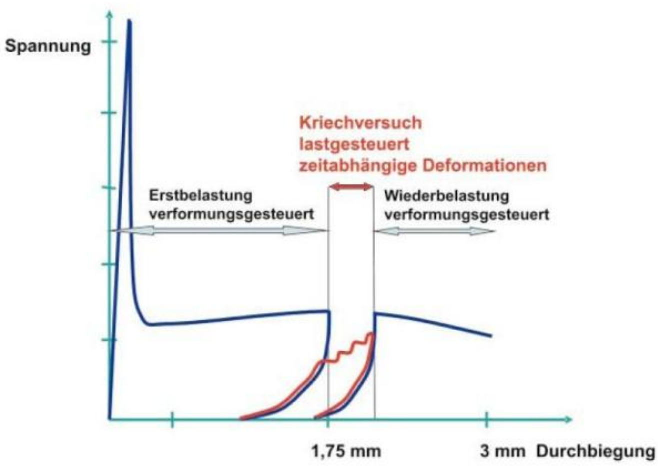












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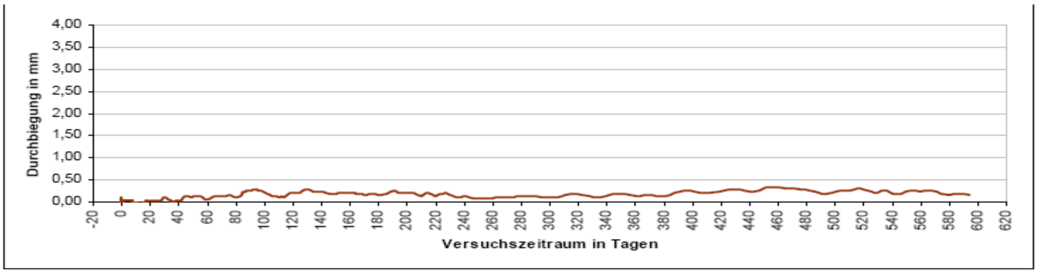
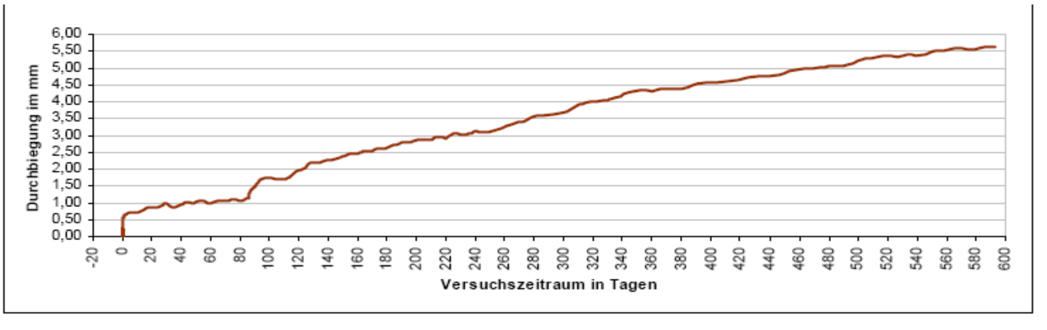
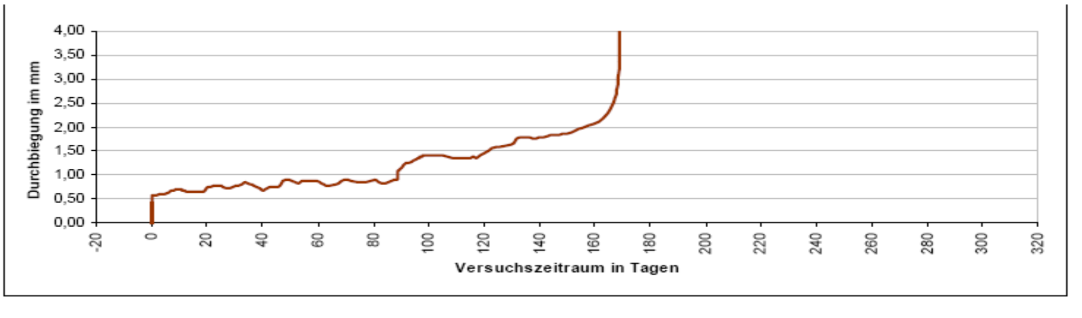


steel fibre



polymer fibre without failure of beam



polymer fibre with failure of beam

Steel fibres used on the basis of the above-mentioned criteria and regulations of fibres having a structural effect as the reinforcement of element on the basis of a proven test should therefore show a residual strength greater than 1 N/mm2 according to the requirement of the standard EN 14 889.

Action of individual types of fibres is then dependent on technical values of the fibre such as slenderness ratio, its strength , anchorage in the matrix and in principle it holds that the longer and more slender a fibre the more significant are the results.However with respect to the restriction resulting from the usage of these slender fibres such as the uniform distribution of the fibres and workability of fibre-conrete.

When the right ratio of both building materials of fibre-conrete i.e. of concrete and fibres is chosen, a creation of corresponding ratio which is best evaluated according to working diagram (stress-strain curve) will develop.

When the combination is wrongly chosen, fluctuations and wrong interpretations of the effect of fibres itself or even a pull out of fibres from the matrix can happen.

Thus later the fulfilment of expected statically/structurally considered strain-stress curve of the fibre concrete and its deformation including the residual strength can not happen related to incorrect calculation of the element.

To conclude it is also necessary to touch on the fact that presently for evaluation of fibre concretes we apply several standards or reagulations and as such EN standard, German Richtlinie, American ASTm and Japanese JSCE.

Therefore it is necessary to pay greater attention to strength characteristics because individual methods mutually differ and misinterpretation of tests results can happen and hence unsuitable usage of resulting values can also happen leading to miscalculation of the element.

Out of this reason I am hereby mentioning the fact that all the above-mentioned graphs and tests have been performed on the basis of procedures and evaluations according to the German Richtlinie.

3. Laying of foundations

The laying of foundations on monolithic fibre-concrete slabs has become popular lately not only when building family houses but as well as in construction of structures of large dimensions. The principle of this method is about jointless monolithic slab laid on a loadbearing soil layer. In areas of adequate loadbearing soils it is even possible to lay these slabs as prefabricated directly on a modified plain of footing bottom. In areas of soils with lower load-bearing capacities there is already the need to prepare a soil slab which will transfer load into the mother soil and subsequently the monolithic fibre concrete slab itself. In the present day a functional method for complex designs of monolithic fibreconcrete slab already exists whereby both the category of concrete and batching/dosage and type of fibres and in the result as well as the case of requested thickness of conrete slab are taken into consideration

4. Industrial structures

The laying of foundation for indsutrial structures on monolothic slabs leads especially to significant savings and facilitations . It is not necessary to prepare individual footings under the structure and at the same time somehow insignificantly not disrupt the original underlayer. Another saving and facilitation is accelerating the assembly of the structure in the sense of facilitating the handling of building prefabs and machines on the surface of the structure during its construction. The fibre concrete foundation slab as a result will transfer into the underlayer all considered dead and live loads posed by the structure and its operation.

When laying the foundations of industrial structures on monolithic fibre concrete slabs, it is therefore important to take into consideration geotechnical relations on the construction site because for industrial structures it is often required an extremely higher load bearing capacity of the floors themselves in view of the dead or live loads given by the fabric of the structures themselves and their subsequent operations inside. Out of this reason it is necessary to correctly overdimension them as well as the underlayer of the foundation slab, occasionally it is essential to artificially improve the foundations ratios of underlying layers for example by using soil columns and the like.

When performing structural analysis calculation of monolithic foundation slabs it is therefore necessary to proceed by the method of finite elements and of course with correct input values for fibreconcrete whereby we simultaneously avoid casual imbalances and mistakes in calculation, which can reach upto 30 % of difference in the final values- in the case of incorrect selection of input values

5. Underground structures

Another important area , where steel fibres are used as reinforcement is underground construction where fibres find their implementation not only in production of various bottom prefabricated parts, adjoining (key) pieces and pipes but as well as in structures of solid tracks in railway tunnels and in concrete carriageways in road/highway tunnels.

Adjoining prefabricates are entirely specific for quality and durability requirements, e.g. when stripping,shipping to construction site or when handling during installation. For these prefabs there are often damages on corners or edges when stripping or even more often in the laying in tunnel pipe itself whereby there is often a part split off or a split-off of the whole edge of the adjoining piece-see picture below.

In case of requirement for higher resistance (durebility) of tunnel walls against fire, steel fibres can be simultaneously used as reinforcement with stability effect and polypropylene fibres which can essentially increase the fire-resistance of the prefabricated part. Now it is possible to say that this is how composite conrete with steel and polypropylene fibres develop. In the next picture can be seen the photo of a prefabricated bottom part of a pioneer adit. There are already dowels in the prefab for fixing the rails and the middle part of the prefab serves the purpsose of drainage of water from the adit-even during manufacture of this part, steel fibres were used.

6. Prestressed beams

The application of steel fibres, hence fibre-concrete in prestressed concrete prefabricated parts belongs to the most complicated procedures (approaches). Therefore a highly demanding certification of the method for designing and production of prestressed concrete prefabs was performed , because this new method of applying steel fibres as reinforcement is galloping. As an example it is possible to mention prestressed girders by the firm Rekers Betonwerk GmbH & Co. KG Spelle, in which normal reinforcement was replaced by the addition of KrampeHarex steel fibres. These girders were manufactured and used in the construction of the IKEA central warehouse in Dortmund.

A total of 780 prefabricated girders have been manufactured, each of them of length 20m and for each girder 40 kg of KrampeHarex 60/08M steel fibres were used which were for this purpose certificated.

The result therefore was especially the shortening of the preparation time of the prefab, saving of material used for reinforcement, excellent results of girders when loaded and overall costs-saving for the whole structure.

Another parameter is the tensile strength of the fibres itself. Currently the fibres are manufactured in three strength characteristics and for that matter as fibres in execution of N normal strength, M medium strength and H highstrength fibres. In the graph are displayed results of residual strength of fibres of all three strength categories for the same batching of fibres and class (category) of concrete. It is more or less obvious that we can by choosing correctly the fibres, significantly influence the statical (structural) characteristics of the prefab part.

The graph of tensile bending strength test itself is afterwards also significantly influenced by this parameter of fibre strength. As an illustration I am presenting the following three graphs with batching (dosage) 35 kg of fibre DE 60/ 10 in the execution N,M and H.

Another interesting parameter is the influence of fibre-shape on the character of shape of graph of residual strength.For comparison we herewith compare two types of fibre and for that matter wavy fibre and fibre with anchorage endings .

7. References

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picture: archives of KrampeHarex