FIBRE CONCRETE WITH FIBREX FIBRES MADE FROM SCRAP STEEL STRIPS

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Abstract

This contribution contains several examples of fibre-concrete structures which use fibre-concrete with atypical FIBREX A1 steel fibres, which are made of scrap steel strips of the strength of 350 ~ 450 MPa. The steel fibres with rectangular cross-section are 25 mm long. More effective anchoring in the cement matrix is provided by flattening of the fibre ends. The production of the mentioned steel fibres is supported by the characteristics of the produced fibre-concrete. Some of them are presented in this contribution.

Keywords: steel fibres, concrete, metal strips, strength, ductility, homogeneity

1. Introduction

The idea of producing steel fibres out of scrap steel strips occurred about 10 years ago in Adler company seated in Žďár nad Sázavou and was supported by the researchers of Department of Concrete and Masonry Structures, Faculty of Civil Engineering, CTU in Prague, who have been dealing with composites of cement matrix reinforced with dispersed fibres. The support for this type of fibres comes with the following reasons:

- strength of steel fibres is more than 10 times higher that the strength of commonly produced concrete and therefore it is logical that their uniform dispersion in the cement matrix must lead to an increase of mechanical properties as compared with concrete without fibres,
- production of fibres from scrap steel strips and their possible application in novel fibre-concrete structures is in accordance with the current trend to improve the environment, development of fibre-concrete and sustainability of construction.

Several experiments including mix design of fibre-concrete, production of fibre-concrete and testing of hardened fibre-concrete were conducted in the Experimental Centre of Faculty of Civil Engineering, CTU in Prague. Based on the results of all conducted tests, the tests were conducted according to:

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- ČSN EN 14845-1 „Testing methods for fibres for concrete“- Part 1: Reference concrete, Part 2: Influence of concrete,
- ČSN EN 14651 „Testing method for concrete with metal fibres“- Measurement of flexural tensile strength (proportionality limit, residual strength),

which proved that fibres made from scrap metal strips can be classified as fibres suitable for production of fibre-concrete.

The analysis of the test results also showed several differences in the positive and negative effects on characteristics of fibre-concrete when compared with characteristics of steel fibre-concrete produced with today’s steel fibres, e.g. Dramix or Harex. The following differences can be listed:

positive effects:

- Fibrex fibres tend to segregate from each other during production of fibre-concrete even when high mass concentrations are dosed,
- the effect of air-retaining in the aggregate mixture is less than when longer fibres are used, which allows higher dosage of coarse aggregate for production of fibre-concrete,
- Fibrex fibres stiffen the structure of cement matrix for common fibre-concrete (max. aggregate particle size of 16 mm or 22 mm), which leads to higher compressive strength characteristics of fibre-concrete than the strengths which are attained when longer fibres are used at the same mass dosages,
- fibres with rectangular cross-section are more suitable for shotcrete than the circular cross-section fibres,
- lower price of the weight unit of Fibrex fibres than the price of the commonly available steel fibres,

negative effects:

- low ductility of hardened fibre-concrete after crack initiation,
- hardened fibre-concrete tends to crack suddenly in brittle manner.

Both these negative effects of fibre-concrete with Fibrex steel fibres can be reduced by higher weight dosages of the fibres per unit volume. Relatively good knowledge of the characteristic properties of fibre-concrete with Fibrex fibres and its behaviour in structures gives an opportunity to identify practically applicable structures which will utilized the characteristics of these steel fibres effectively. All the up-to-date applications of fibre-concrete with the fibres made of scrap metal strip offered by Adler company are described in detail in the proceedings of the FC2011 conference. The detailed comments on these fibre-concrete structures which deal, besides the technological aspects, also with the behaviour, functionality and possible also their durability are very valuable. The locations of these applications were selected with respect to the size of the concrete areas and the volume of the fresh fibre-concrete.

2. Applications of fibre-concrete with FIBREX® - A1 steel fibres

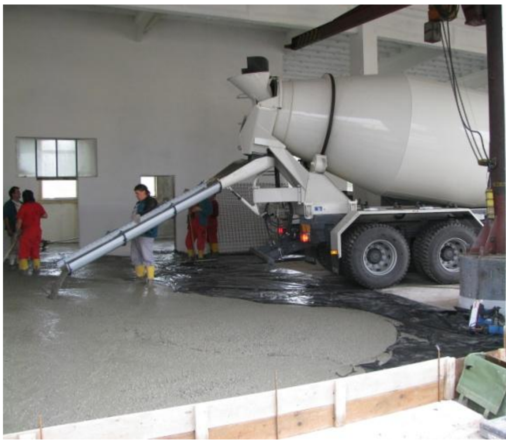
Application of fibre-concrete with FIBREX® steel fibres is without problems from the production point of view. The FIBREX® fibres in small dosages do not affect the amount of pores trapped in concrete and therefore the fibres can be placed in commonly used concrete mixtures without any alteration of their mix proportions. Even in the case of small dosages of these fibres, which does not correspond strictly to production of structural fibre-concrete – e.g. with the minimum dosage of 0.5 vol.% (about 40 kg/m^3), a large amount of fibres enters concrete which affects the strength characteristics (especially tensile strength at crack initiation) of such fibre-concrete positively. This effect of increased strength characteristics can be utilized in certain types of structures, some of which are presented below.

2.1 Service hall for trucks – 320 m^2, with required load bearing capacity of 5.5 t/m^2

In this case, the thickness of the floor slab was limited by the height of the existing floor because the fibre-concrete slab was only added on the existing concrete floor. The production was performed with respect to the limiting thickness and the condition of the existing floor. The reinforcement was decided as welded meshes (6x6/100x100 mm) and dispersed FIBREX® fibres (25 kg/m^3). The concrete class was decided as C25/30 and the Dober MFC Dober 120 admixture was selected in order to increase the resistance to abrasion. The expansion joints were saw-cut with the periodicity of 6x6 metres and the depth of 30% of the slab thickness.

Discussion: No destruction or defects sustained by the floor were found after one year of service even though the floor was subjected to heavy truck loads and machinery of the weight of 10 ~ 15 tons.

Figures 1 to 4 show this application.



Figs.1 and 2: Casting of concrete

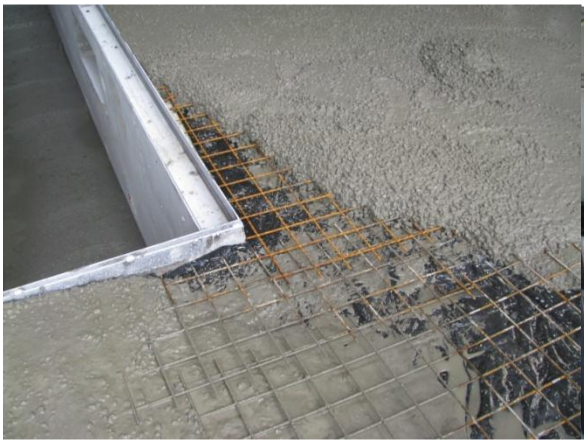


Fig. 3: Detail of floor slab

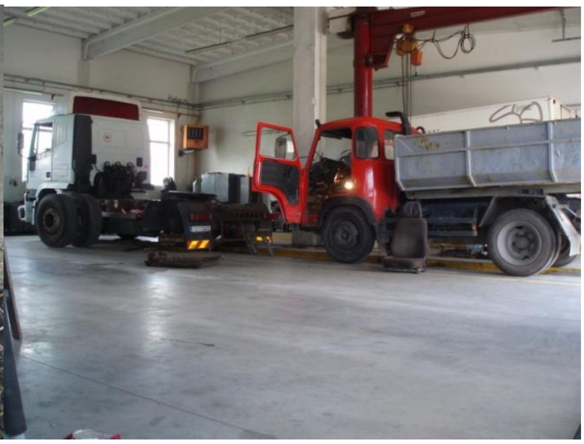


Fig. 4: Hall in service

2.2 Production hall – 620 m^2, with required load bearing capacity of 6.5 t/m^2

The thickness of the slab was designed as 250 mm and the concrete class was C25/30 with FIBREX® fibres (35 kg/m^3). The sub-base was compacted at 90 MPa. The hall is used for processing of coiled steel sheets. The sheet-separating machine is fixed directly to the floor. The distribution and movement is performed by forklifts of the weight of 10 tons (the weight of a coil).

Discussion: No deformation or defect was found in the floor after two years of service.

Figures 5 to 8 show this application.

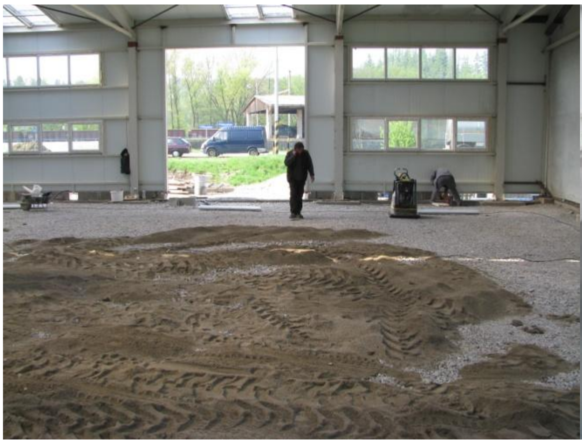


Fig. 5: Preparation of sub-base

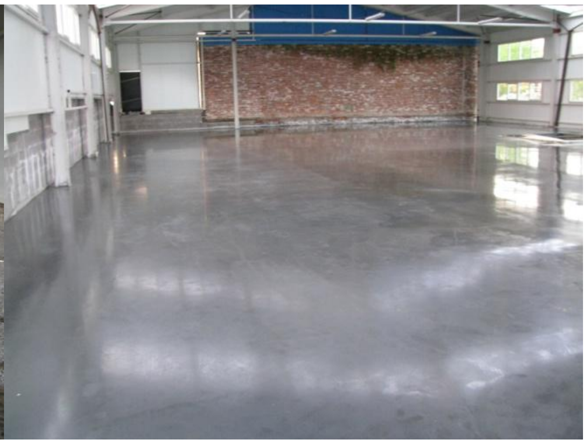
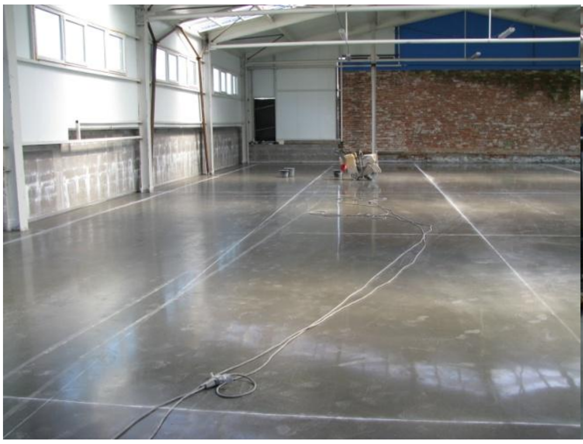


Fig. 6: View of slab surface



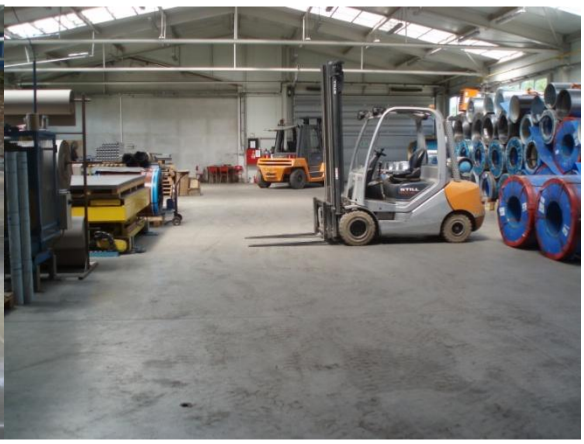


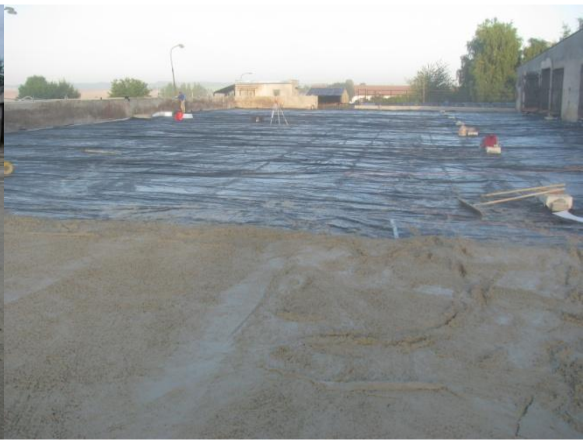
Fig. 7: Finishing of slab – cutting of joints *Fig. 8:* View of hall in service

2.3 Storage of manure – 3200 m2, with required load bearing capacity of 4.5 t/m2

This application was performed as an alternative to the originally designed slab with the thickness of 200 mm and two layers of welded meshes. The alternative design of the fibre-concrete of the class of C30/37 with FIBREX® fibres (25 kg/m^3) was by 20 % more economical. The floor slab is loaded statically and also dynamically by the moving blade, which is used for loading and moving of the manure. Beside this load, the floor slab is subjected to aggressive environment.

Discussion: No defects leading to limitation of service were detected after two years of service. This positive result is attributed to the selected concrete class and the increased tensile strength at crack initiation of the fibre-concrete which uses FIBREX® fibres.

Figures 9 to 12 show this application.



Figs. 9 and 10: Preparation of sub-base

Fig. 11: View of completed slab *Fig.12:* View of slab in service

3. Conclusions

As was stated in the previous section, the hypothesis that the FIBREX® steel fibres provided by Adler trade s.r.o. are suitable for production of fibre-concrete is correct. These fibres give the fibre-concrete certain characteristics which have a positive effect in realized structures. However, it should be emphasized that the FIBREX® steel fibres have only a minor effect on ductility of fibre-concrete and thus the suitability of a structure for application of these fibres should be considered.

Acknowledgement

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4. References

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