Flooring With BarChip Inc.

Flooring With BarChip Macro Synthetic Fibre Concrete Reinforcement

www.barchip.com

BarChip Inc.
The Synthetic Fibre Experts

Introduction

Industrial flooring, both internal and external, is typically constructed using reinforced concrete. In Australia, minimal codes and guidelines exist which govern the design and construction of these concrete slabs. Typically, Australian designers can refer to the CCAA T48 document which provides guidance on the design of reinforced concrete industrial slabs, however other guidelines exist such as the UK Concrete Society's Technical Report 34 (TR34). This document provides best practice guidelines on the design and construction of industrial ground floors, including the use of fibre reinforced concrete to replace traditional steel mesh reinforcement.

Fibre reinforced concrete has been used commercially in slabs on grade since the late 70's. However, structural design was still based on elastic theory using Westergaard's formulas, i.e. not taking into account the post-crack performance provided by the reinforcement. Only the adoption of the Yield Line theory for fibre reinforced concrete slabs in the Mid 90's, developed by Meyerhof and Losberg, takes advantage of the ductility provided by the fibres, which also led to more economic designs.

Partial safety factors are used at the ultimate limit state (ULS) design to calculate the capacity at the hogging (negative moment) region and residual post crack load-bearing capacity at the sagging (positive moment) region.

The design of punching shear is based on the approach in Eurocode 2 for suspended slabs with allowance for loads to be transferred directly through the slab to the ground.

From economic and social perspectives, traditional steel reinforcement (bars or welded mesh) is expensive to purchase, transport and store. Steel fixing requires significant time and costs as it is particularly labour intensive. It is a potentially risky exercise at difficult and dangerous locations. Additionally, steel is highly corrosive in nature. The high alkalinity of concrete (pH>12) can passivate steel reinforcement depending on the amount of intact concrete cover. However, chloride ions and other chemicals can diffuse through the concrete to further corrode steel over time.

Industrial concrete slabs often experience cracking, mainly due to plastic shrinkage at earlier stages in the design life, and due to temperature, drying shrinkage or settlements at the later stage of the element's design life. This significantly reduces the effectiveness of steel passivation and in conjunction with carbonation of the concrete cover can significantly reduce the design life of reinforced concrete structures Due to these reasons, there has been a growing interest in ways to reduce the quantity of steel in concrete works, whilst maintaining or optimizing the structural performance of traditional steel reinforced concrete.

To counteract corrosion problems, macro synthetic fibres made of high strength polymers, such as BarChip

fibre, can be specified to replace steel in concrete.

There are numerous applications of synthetic fibres. Examples include slabs on ground, precast elements and sprayed concrete. Macro synthetic fibres are typically 30 to 65 mm long and are used for structural performance. In contrast, micro synthetic fibres, with diameters between 18 and 34 microns, are typically 6 to 20 mm long and are used mainly for crack control in young concrete (plastic shrinkage).

The design guidance provided in this document is in accordance with the UK Concrete Society's Technical Report 34 (TR34) 4th Edition. For a copy of BarChip's complete guidance on the design and construction of BarChip macro synthetic fibre reinforced concrete floors, contact your local BarChip representative, or download a copy at **www.barchip.com.**


Advantages BarChip Macro Synthetic Fibre

Increases concrete ductility / toughness

- Provides post crack flexural capacity equivalent to SL82 mesh at regular dose rates

Eliminates corrosion

- Removing the risk of concrete cancer and ensuring long term durability

70% reduction in carbon footprint compared to steel alternatives

Reduces crack propagation

Eliminates set-up of steel mesh

- Increased construction speeds
- Lower labour cost
- Reduction in workplace health and safety risks

Reduced maintenance costs

Safer and lighter to handle than traditional steel reinforcement

Improves shrinkage and temperature crack control

Retains performance with age

Designing Industrial Concrete Floors with BarChip fibres

Determining Fibre Reinforced Concrete Properties

In accordance with TR34, the residual flexural strength provided by the fibres is determined using a three-point notched beam test with a notch at mid span as per the European harmonised standard EN 14651:2005 (refer to Image 1).

The beams are tested in a servo controlled machine, which applies load to the beam in order to achieve a constant rate of crack mouth opening displacement (CMOD). The load applied and displacement measured are recorded and used to provide a *Load vs. CMOD* plot, an example of which can be seen below:

Image 1: *EN 14651 Notched Beam Test*

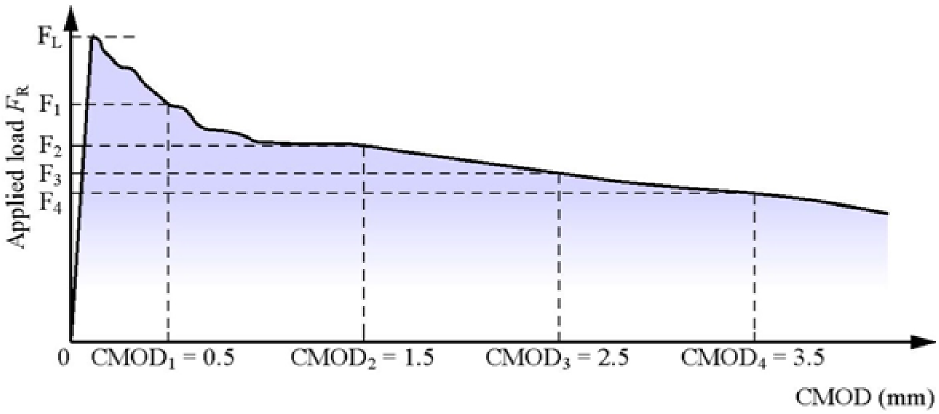


Figure 1: *Example of Load vs. CMOD plot derived from EN14651 beam test (European Committee for Standardisation (CEN), 2005)*

Each load is used to derive a residual flexural tensile strength f_R

$$f_R = 3\,F_R\,l\,/\,(2\,b\,h_{sp}^{\,2})$$

Where: F_R = applied load at stage R

l = the loading span (500 mm)

b = the beam width (150 mm nominal)

h_{sp} = depth of the section to the tip of the notch (125 ± 1 mm)

Four values f_{Ri} are reported at $CMOD_1$ to $CMOD_4$.

Calculation of Residual Moment Capacity from Notched Beam Tests

With reference to RILEM TC 162-TDF (RILEM TC 162-TDF, 2003), the moment capacity can be calculated by first calculating the direct axial tensile strength from the residual flexural strength at each of the CMOD's. These are σ_{r1} and σ_{r4} which correspond to a CMOD of 0.5 mm and 3.5 mm respectively in the notched beam test. The crack depths herein are assumed to be 0.66 and 0.9 of the beam depth.

The following formulae are then derived:

$$\sigma_{r1} = 0.45\, f_{R1}$$

$$\sigma_{r4} = 0.37\, f_{R4}$$

Where: f_{R1} = the residual flexural strength at CMOD 0.5 mm

f_{R4} = the residual flexural strength at CMOD 3.5 mm

In the floor cross section, at Ultimate Limit State (ULS), it is assumed that the axial tensile stress at the tip of the crack is equivalent to σ_{r1}, and at the extreme tensile face it is assumed to be σ_{r4}, with a triangular distribution in between as shown in Figure 2.

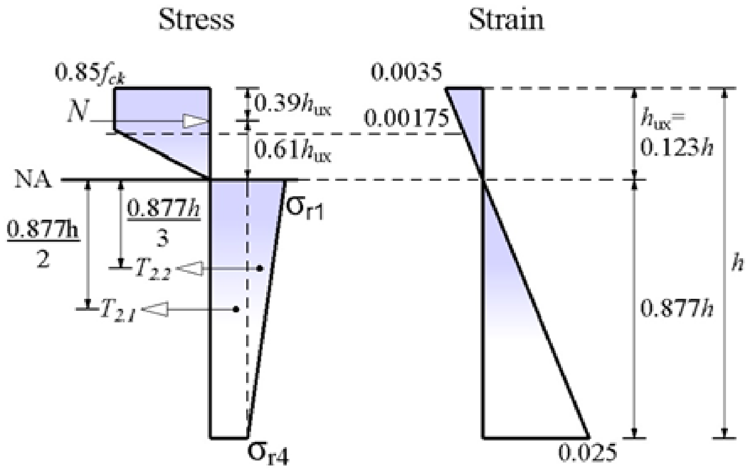


Figure 2: *Stress block for fibre reinforced concrete*

Using the partial material safety factor γ_m the ultimate sagging (positive) moment capacity of a fibre reinforced concrete section can then be calculated using the simplified formula below:

$$M_{up} = h^2 / \gamma_m \times (0.29\,\sigma_{r4} + 0.16\,\sigma_{r1})$$

Cost Comparison of BarChip FRC vs. Conventionally Reinforced Concrete Industrial Floor

The comparison below has been obtained from an Australian pavement construction project. This particular project was originally designed to incorporate SL81 mesh in the top third of a 200mm thick concrete slab. This was replaced with a BarChip fibre reinforced concrete slab in order to complete construction within a shorter time frame and to save costs.

Slab Area	10,000	m^2
Concrete Strength	32	MPa

Traditional Mesh Reinforced Concrete			**BarChip Fibre Reinforced Concrete**		
Slab Thickness	200	mm	Slab Thickness	200	mm
Volume	2,000	m^3	Volume	2,000	m^3
\$ / m^3 Concrete	220		\$ / m^3 Concrete	270	
Concrete Cost	440,000	\$	Concrete Cost	540,000	\$
\$ / m^2 for Concrete	44	\$ / m^2	\$ / m^2 for Concrete	54	\$ / m^2
Mesh / Chairs / Labour / Waste	29.5	\$ / m^2	Mesh / Chairs / Labour / Waste	0	\$ / m^2
Concrete Placement Labour	35	\$ / m^2	Concrete Placement Labour	28	\$ / m^2
Pump	7	\$ / m^2	Pump	7	\$ / m^2
Concrete & Mesh Cost per m^2	**115.5**	**\$ / m^2**	**BarChip Fibre Reinforced Concrete Cost per m^2**	89	\$ / m^2

Saving per m^2	**\$ 26.5**
Total Saving on Project	**\$ 265,000**
Percentage Saving	**23 %**

BarChip
Synthetic Reinforcing Fibre

References

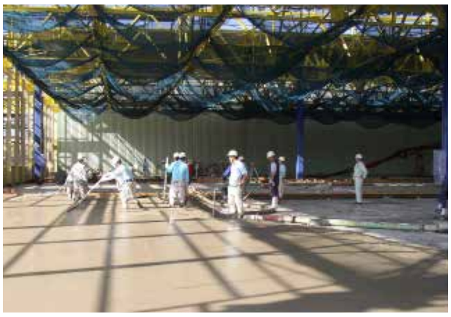
REINFORCED WITH BarChip

Alekon Cargo - is a state of the art provider of forwarding services, storage and warehousing services and handling of all types of cargo. Built in 2007 the Alekon Cargo Logistics Hub, located in Tallinn, Estonia, is a state of the art logistics centre incorporating road, rail and port services over a 12.5 hectare site.

The complex includes 106,000 m^2 of warehousing space, 22,000 m^2 of parking, a 3,500 m^2 container yard and 3 railway branches with 1.3 km of total frontage. The cargo handling machinery fleet on site included;

- 30 tonne capacity gantry crane
- 45 tonne capacity reach stacker for containers and equipment
- 9 lift trucks with up to 16 tonne capacity
- Fork lift trucks with lifting capacities of 1.5 to 4.5 tonnes
- Electric stacker
- Special electric lift truck with side grippers for handling tyres, paper drums, pulp etc.

BMW Manufacturing Plant



Toyota Manufacturing Plant

Westfield Shopping Centre Carpark

HABOM - in Turkey is a multi-story aircraft maintenance and repair facility. When completed it will be one of the largest in the region. BarChip 48 synthetic fibre reinforcement was chosen as the primary crack control reinforcement for 155,000 m^2 of floor area. BarChip48 offered superior durability, simplified site processes and offered significant time and cost advantages, as outlined in the right hand column.

Initially construction began with steel mesh reinforcement. Construction delays resulted in the designer and contractor switching to BarChip 48 reinforcement. Prior to the switch to BarChip synthetic fibre, 12 man crews were completing approximately 800 m^2 per day using welded wire mesh reinforcement. After switching to BarChip synthetic fibres, ***12 man crews were completing between 1200 m^2 and 1600 m^2 per day.*** As BarChip reinforcement is delivered mixed with the concrete the set up time for welded wire mesh was completely eliminated.

In all the contractor was able to make an approximate time saving of 35%, or two full months for the entire flooring project.

BarChip Inc.

OUR VISION

BarChip has a simple vision - revolutionise the world of concrete reinforcement. For over 100 years the technology of concrete reinforcement has barely changed. We set out to create a new reinforcement for the 21st century. We created BarChip synthetic fibre reinforcement.

OUR PROCESS

We believe that long term business relationships can only be sustained by a commitment to provide the highest quality products and services. We make sure to understand your concrete, know the performance requirements and work with you to get the right design and the right performance outcomes.

YOUR PRODUCT

When you work with BarChip, you know that your concrete asset has been reinforced to the latest engineering standards. It will never suffer from corrosion. It will be cheaper and quicker to build. It will be safer and it will keep performing throughout its entire design life.

BarChip Inc.
info@barchip.com
Australia: +61 1300 131 158
N. America: +1 704 843 8401

EMEA: +353 (0) 1 469 3197
Asia: +65 6835 7716
S. America: +56 2 2703 1563
Brazil: +55 19 3722 2199

BarChip Inc.
The Synthetic Fibre Experts

Distributors are located in other regions. For contact details visit www.barchip.com.

www.barchip.com