ConCribe

sTruc

Fiber reinforced concrete design

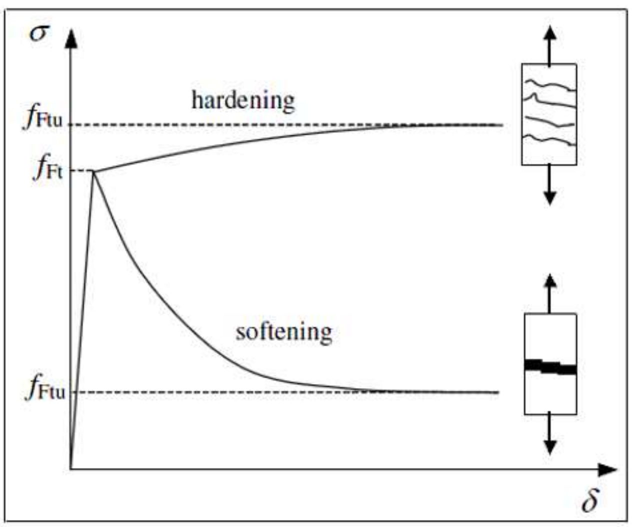
For concrete elements

Reference standard of the design

This design is done against NB 38 – 2019 / EN 1992-1-1-2004

Design method

Fibre reinforced concrete (FRC) is a concrete mix containing water, cement, aggregate and discontinuous fibres of various shapes and sizes.
The behaviour of fibre reinforced concrete, varies with composition and can have a softening or hardening behaviour. Post crack hardening allows multiple cracks before failure while in post crack softening there is a reduction of strength after the first crack allowing no further cracks.



Concept

According to FIB model code, the strength of fibres is measured as a residual flexural tensile strength.

This can be done by performing crack mouth opening displacement (CMOD) tests. A CMOD test is a deformation controlled loading test, where the crack opening is measured as a horizontal deflection. The test setup requires a beam, notched to prevent horizontal cracking, and devices for recording the applied load and the crack opening, which is referred to as CMOD.
The FIB model code proposes that it is to be done in accordance with EN 14651 (2005). The CMOD.

Concrete specifications

This design is based on the assumptions that concrete mix follows EN 206. To increase the performance of the fibre reinforced concrete slab, ConCribe recommends to keep aggregate size below 22 mm in any case. Water cement ration should also be kept as low as possible, with maximum of 0.5. To prevent drying shrinkage, filler content should be maximum 400 kg/m3 or mix should not content fly ash nor microsilica. Slab thickness should not be below 80 mm, in which case ConCribe´s screed specifications should be used.

Fiber reinforced concrete

Steel fibres and macro-synthetic fibres, in accordance with EN 14889 Fibres for concrete, provide post-cracking or residual moment capacity – see Section 6.3.3.For CE marking, the fibre supplier is required to declare the quantity of fibres to achieve residual (post-cracking) flexural strength fR of 1.5N/mm2 at a crack mouth opening displacement (CMOD) of 0.5mm (0.47mm central deflection) and of 1.0N/mm2 at a CMOD of 3.5mm (3.02mm central deflection). This requirement equates to a ratio of cracked to uncracked moment resistance of 30–35%, which is less than the requirements for the design in accordance with this guidance. As with conventional steel reinforcement, fibres do not generally* increase the flexural tensile strength of plain concrete, as the concrete must crack before any reinforcement can have effect.
*Unless FRC shows hardening effect (see FIB Model code 2010 § 56)

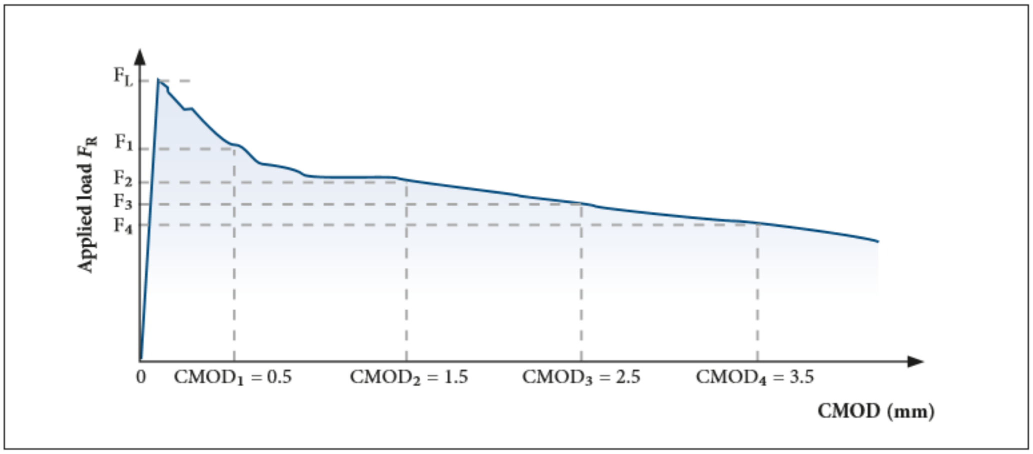
Micro-synthetic fibres

Micro-synthetic fibres do not provide any post-crack ductility. They do not control cracking of the hardened concrete and therefore cannot be used in lieu of other reinforcement. They are not considered in the design process.

Performance of FRC

EN 14889-1 and 2 Fibres for concrete, Part 1 and 2: Steel fibres and synthetic fibres requires the effect of the fibre on the strength of the concrete to be determined in accordance with EN 14845 using a standard notched beam test in EN 14651 Test method for metallic fibre concrete. Measuring the flexural tensile strength. Specimens 150mm wide × 150mm deep are tested under central point loading on a span of 500mm. The specimens are notched with a saw cut 25mm deep in a side face as cast, and then tested with the notch in the tension face.
Either the crack mouth opening displacement (CMOD) (i.e. the increase in width of the notch) or the central deflection is measured, and the load f recorded at CMODs of 0.5, 1.5, 2.5 and 3.5mm (or deflections of 0.47, 1.32, 2.17 and 3.02mm). A test set should consist of at least 12 samples. A typical graph of applied load FR against CMOD is shown below.

This graph indicates the behaviour of a typical fibre reinforced concrete, exhibiting strain softening. Peak load (FL) is achieved at the point the concrete section cracks, and thereafter the capacity of the section reduces as strain / crack width increases. F1 is lower than FL and F4 is lower than F1. Certain combinations of fibre type and dosage can exhibit strain hardening behaviour. Strain hardening is identified in a notched beam test where F1 is equal to or greater than FL and F4 is greater than F1.



Fibre reinforcement moment resistance

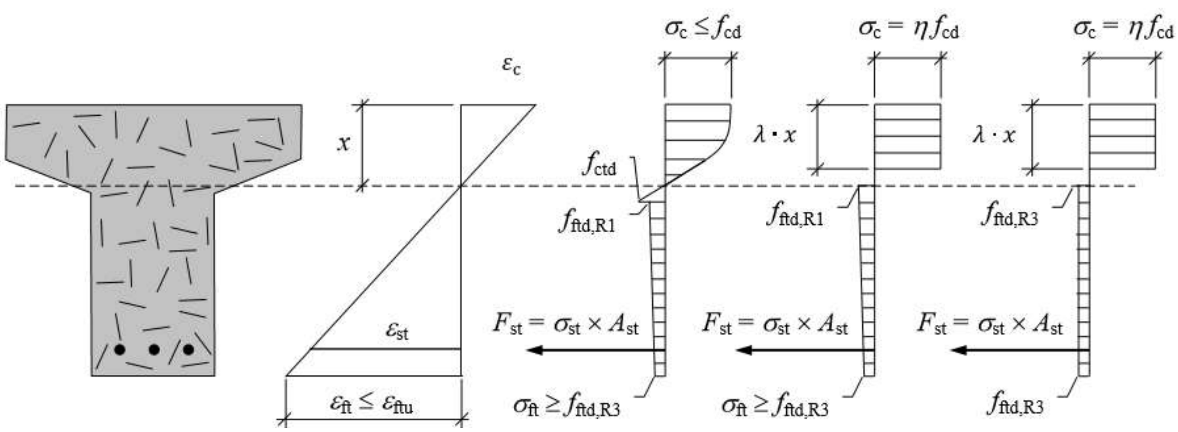
The residual flexural tensile strength of the fibres is added as a stress block as seen in figure below.

For bending moment and axial force in the ultimate limit state, a simplified stress/strain relationship is given by the FIB model code. The simplified stress distributions can be seen in Figure below where the linear post cracking stress distribution is to the left and the rigid plastic stress distribution is to the right, with η = 1 and λ = 0.8 for concrete with compressive strength below or equal to 50MPa.

Shear on the critical perimeter

RILEM suggests that the increase in shear capacity is 0.12 times the residual flexural strength, where the mean flexural strength is taken from a load deflection plot up to a deflection of 3mm. This deflection is equivalent to the CMOD of 3.5mm of the notched beams as determined from EN 14651. For this report, only 50% of this value is taken and this is applied to the mean of fr1 to fr4. Thus, the increase in shear strength is given by:

υf = [0.12 (fr1 + fr2 + fr3 + fr4)/4]/2 = 0.015(fr1 + fr2 + fr3 + fr4)



Partial safety factors

The partial safety factors used in ground-supported floors are as follows.

Materials Concrete	1.5
Concrete with fibre	1.5
Reinforcement (bar or fabric)	1.15
Loads Defined racking	1.2
Other	1.5
Dynamic loads	1.6

Shrinkage and movement

Shrinkage is a reduction in size or volume; for concrete floors, several generic types of shrinkage are of concern.
These are:
Drying shrinkage
Early thermal contraction
Crazing
Plastic shrinkage.
All forms of shrinkage can lead to cracking, although drying shrinkage is the most relevant to concrete floor slabs.

Curing

It is mandatory to apply appropriate curing techniques as soon as practical after finishing is completed.

Liability

ConCribe is unable to have insight in the correctness of the data which the design is based on. This design is therefore only valid for the given data, and covered by ConCribe professional indemnity for design and personal damages due to failed design. As ConCribe obviously does not have insight in or control over execution of the slab, liability declines for all losses and/or damages consequently.

Disclaimer

Performance data given in this document is provided as a guide for the user to determining suitability. This document is property of ConCribe and is protected by copyright law. All rights reserved, including translations rights. No part of this document may be reproduced or transmitted in any form or by means, electronic, mechanical, photocopying or otherwise, without our written consent. The information in this document has been carefully checked and is believed to be accurate, however, no responsibility is assumed unless final validation by ConCribe. All data are subject to change without notice.

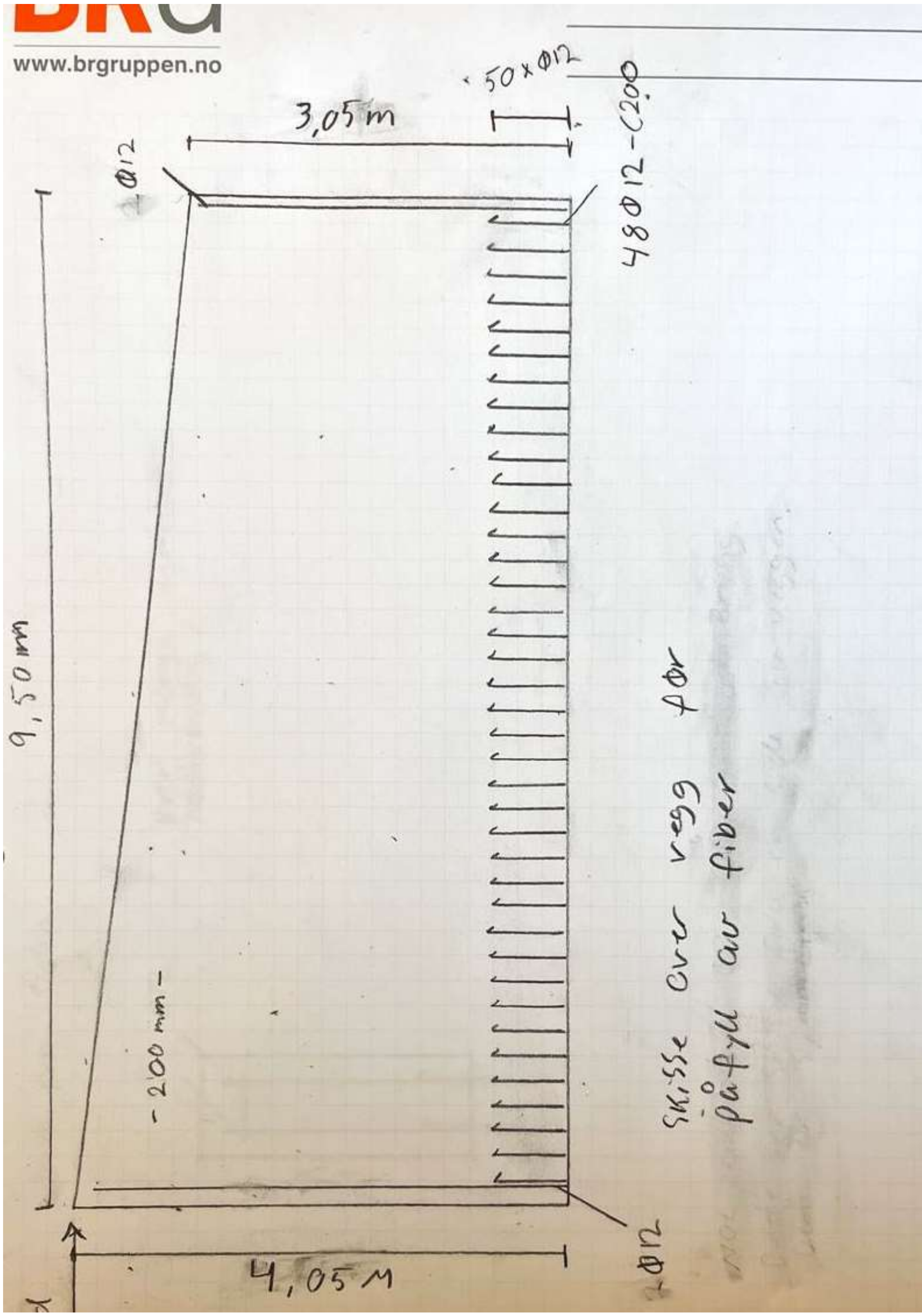
Reference	RT20220421
Project name	**Moy Terrasse**
Designed by	ABO
Verified by	LLA
Customer name	REFORCETECH

CONCRETE WALL

Input data

Concrete grade	C30/37
Fibertype	MiniBars 43 BF
Thickness	200 mm

Drawings


www.brgruppen.no
50 x Ø12
3,05 m
Ø12
48Ø12-C200
9,50 m
~200 mm~
4,05 M
Ø12
Skisse over vegg før påfyll av fiber

EC2 min reinforcement

Asminv = 2470 mm2 => Tv= 1235 kN for verticla reinforcement

Aslinh = 1053 mm2 => Th = 526 kN for horizontal reinforcement

With fyk = 500 Mpa
E= 200 mm
L= 9500 mm
H = 4050

Equivalence for MBRC to NB38

for vertical and horizontal sections:

fFtsv = 1235/1900= 0.65 Mpa
fFtsh= 526/810 = 0.649 Mpa

With 6 kg/m3 of MB 43 in a c30/37,
=> ffts= 0.67 Mpa

CONCLUSION

Concrete grade	C35/45
Fiber type	MiniBars 43 BF
Dosage rate	6 kg/m3