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Stålfiberarmeret SCC

Resultater og erfaringer fra en bundpladestøbning på Eternitgrunden i Aalborg

Lars Nyholm Thrane
lnth@teknologisk.dk

Stålfiberbeton-konsortiet (2010-2013)
www.steelfibreconcrete.com

Dansk Betondag 2011
Middelfart

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Project partners

Companies
COWI A/S
MT Højgaard A/S
Unicon A/S
Aalborg Portland A/S
Bekaert A/S
Convi ApS
Hi-Con A/S
Betonelement-Foreningen
CRH Concrete A/S

Knowledge transfer party
Danish Technological Institute, Concrete Centre

Research Institutution
Technical University of Denmark (DTU), department of civil engineering

Other parties
Danish Road Directorate

Associated parties
The Danish Construction Association
Confederation of Danish Industry (DI)
Femern A/S
Rail Net Denmark (Banedanmark)

Document Info
Document ID: 29096
Document Type: Subject
Approved: 2011-06-07
Revision of content: 2010-06-30

Sustainable concrete structures with steel fibres

The SFRC Consortium is an innovation consortium which was initiated in January 2010 and is set to run for 3½ years. The project is funded by the participating partners and the Danish Agency for Science, Technology and Innovation.

The partners are COWI, MT Højgaard, Unicon, Aalborg Portland, Bekaert, Convi, Hi-Con, CRH Concrete, The Danish Precast Concrete Association, DTU Byg and Danish Technological Institute.

The main purpose of the project is to enhance the sustainability of concrete structures by improving working environment, productivity and aesthetics through increased usage of steel fiber reinforced concrete.

This purpose is fulfilled by carrying out the necessary research activities needed to form the basis for the preparation of a pre-normative document containing guidelines for design, production and execution of steel fiber reinforced concrete structures. A more specific goal is to develop well documented and applicable solutions for 2-3 selected load bearing structural elements.

Document Info
Document ID: 29000
Document Type: Front page

Approved: 2011-06-08
Revision of content: 2010-06-18

http://www.steelfibreconcrete.com/

SFRC-Consortium

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Print Search

You are here: SFRC-Consortium

- Frontpage
- Contact
- Dissemination
- Project partners
- WP1_Simulation of design and execution
- WP2_Development and testing of materials
- WP3_Design basis
- WP4_Execution check and methods
- WP5_Demonstration and knowledge transfer

Sustainable concrete structures with steel fibres

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Approved: 2011-06-08
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Document type: Front page

Udvalgte konstruktionsdele

Fundamenter

Vægge

Prefabrikerede bjælker

Indhold

DANISH TECHNOLOGICAL INSTITUTE

Design

Indledende undersøgelser

Prøvestøbning hos MT Højgaard i Aalborg

Fuldskala på Eternitgrunden

Konklusion

Hva så nu?

Design

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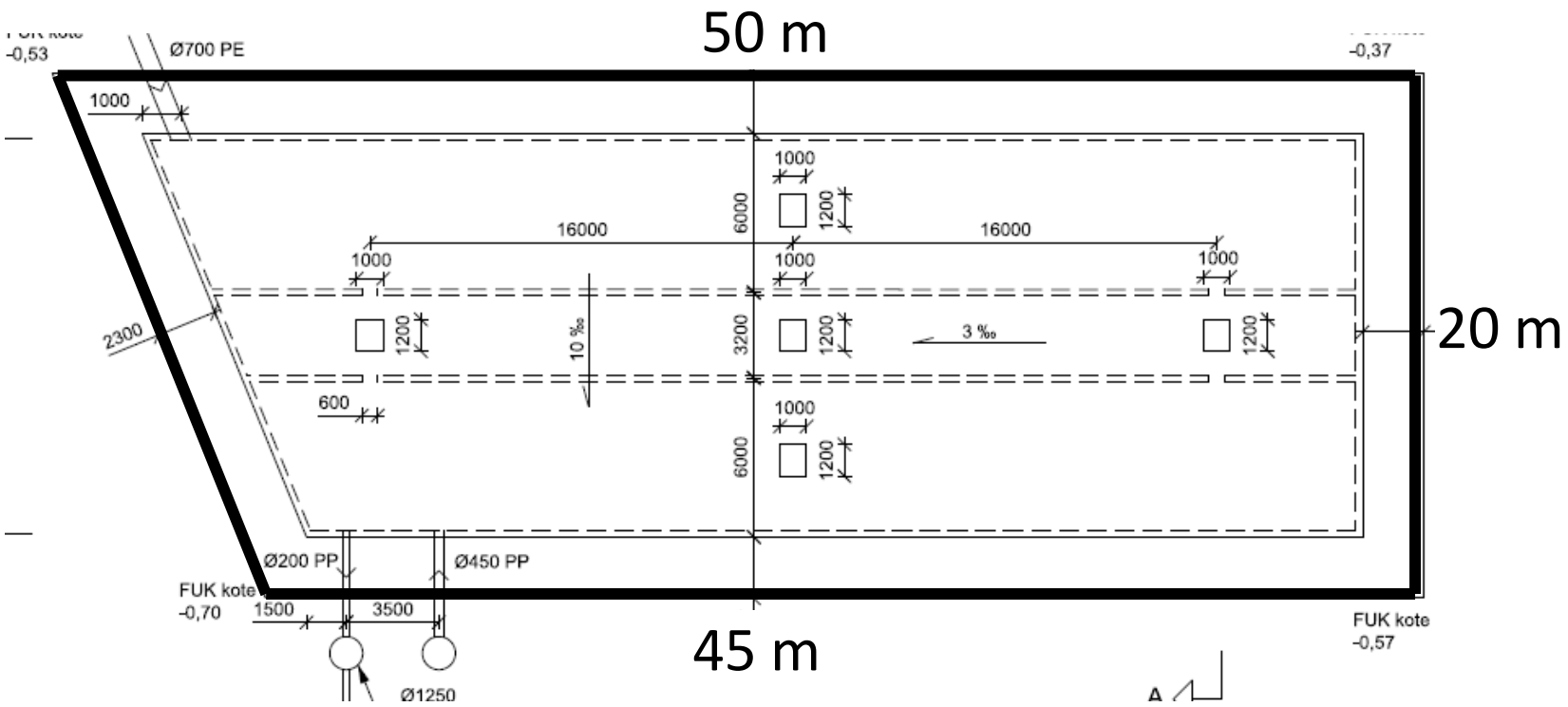

Design

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Bekaert Combi Slab design - godkendt af COWI

Revneviddekrav	: 0.2 mm
Pladetykkelse / dæklag	: 400 mm / 35 mm
Armering uden brug af stålfibre	: Y16 per 100 i top og bund
Armering med stålfibre	: Y10 per 100 i top og bund
Ståltype og mængde	: 30 kg/m^3 RN-80/60-BN

Økonomisk besparelse på ca. 30 %

Design

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Beton	: E40

Design

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Beton	: E40		
f_{ctm} (28 dage)	: 3,5	[N/mm²]	
$f_{ctR,S}$ (28 dage)	: 1,5	[N/mm²]	
$f_{R,1}$ (28 dage)	**: 4,0**	**[N/mm²]**	3-pkt bøjning - OK!

$f_{R,1}$ = den residuelle (tilbageværende) bøjetrækstyrke, der svarer til $f_{ctR,S}$ i rent træk (altså når bjælken lige nøjagtig kan optage en trækspænding på 1,5 N/mm², kan den samtidig lige nøjagtig optage en bøjetrækspænding på 4,0 N/mm²).

EN 14651:2005
(Aalborg Portland)

Indledende undersøgelser

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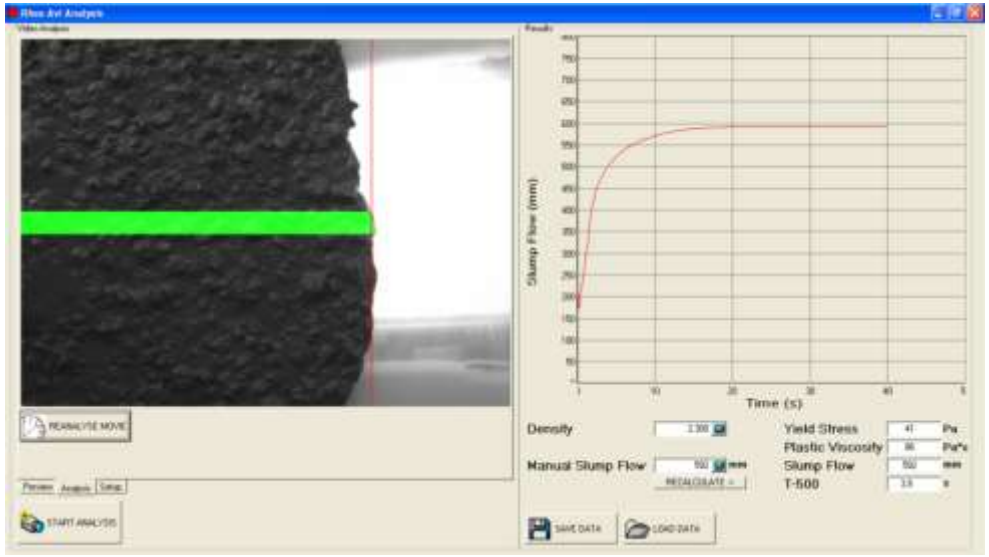
Unicon undersøgelser i Aalborg

- receptudvikling
- flydegenskaber (flydesætmål og t500)

Alle materialer fragtet til Teknologisk Institut i Taastrup

- pakningsanalyser
- rheologiske egenskaber med 4C-Rheometer (flydespænding, plastisk viskositet, flydesætmål og t500)



Prøvestøbning

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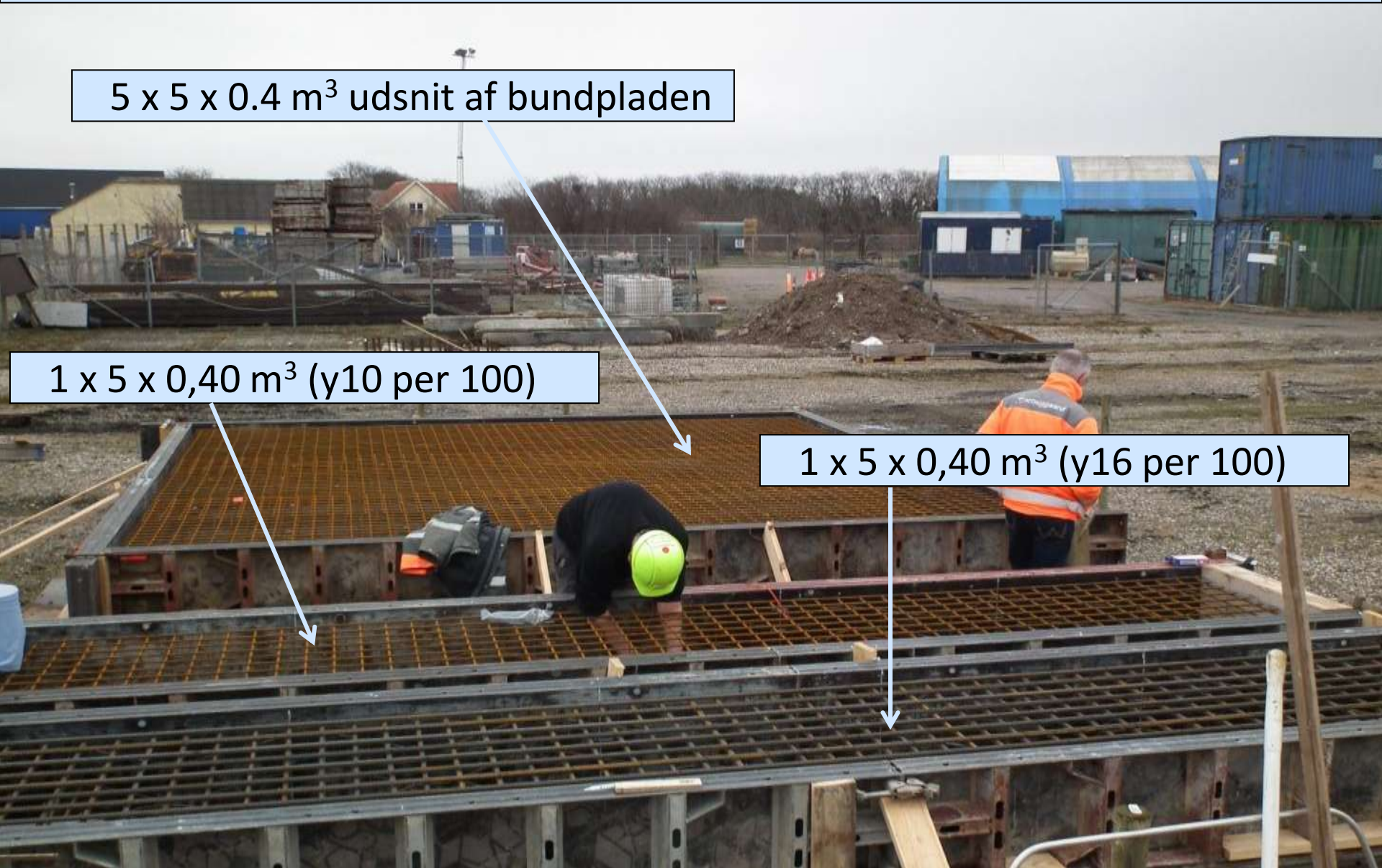

Prøvestøbning

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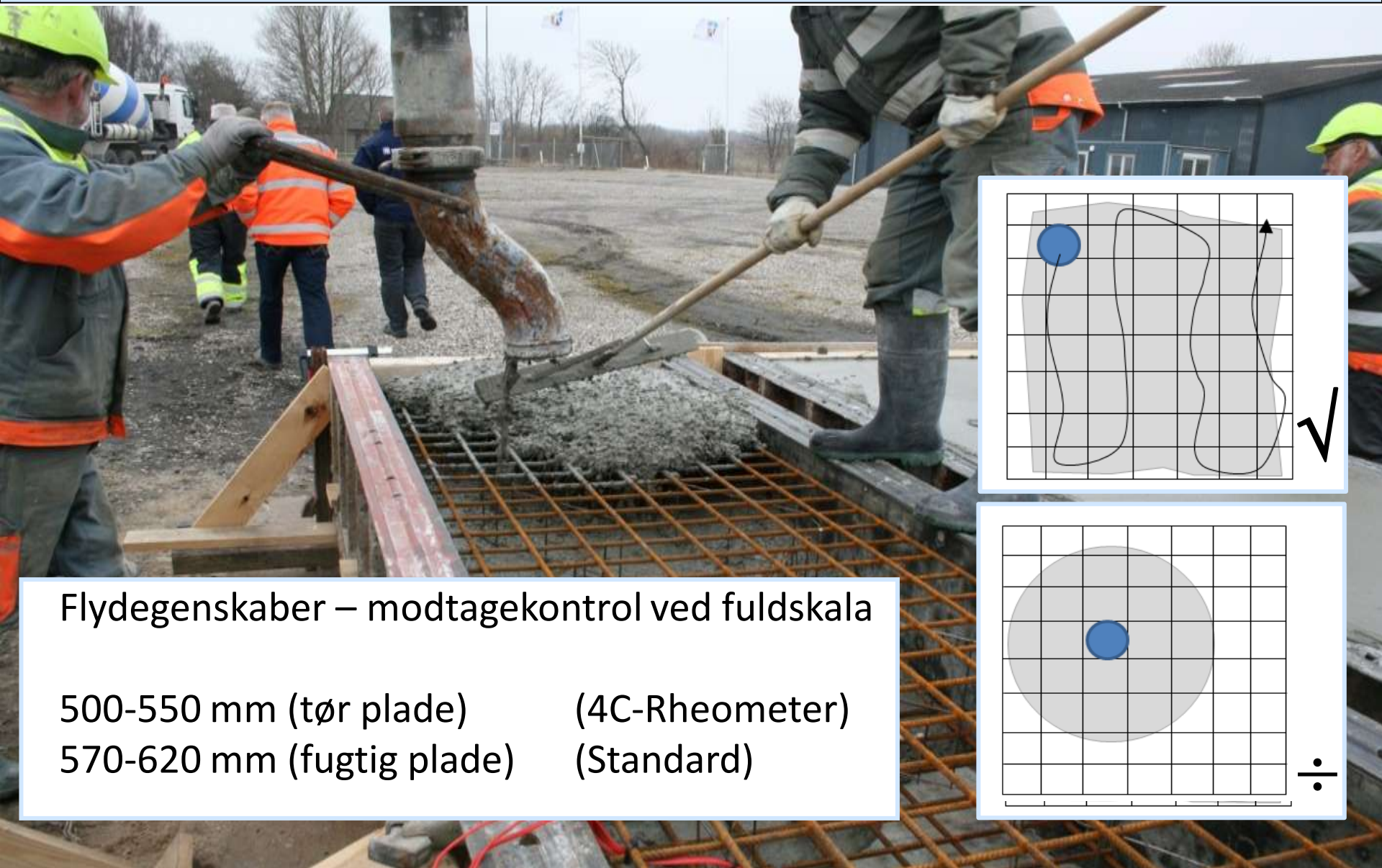

Flydegenskaber – modtagekontrol ved fuldskala

500-550 mm (tør plade)	(4C-Rheometer)
570-620 mm (fugtig plade)	(Standard)

Prøvestøbning

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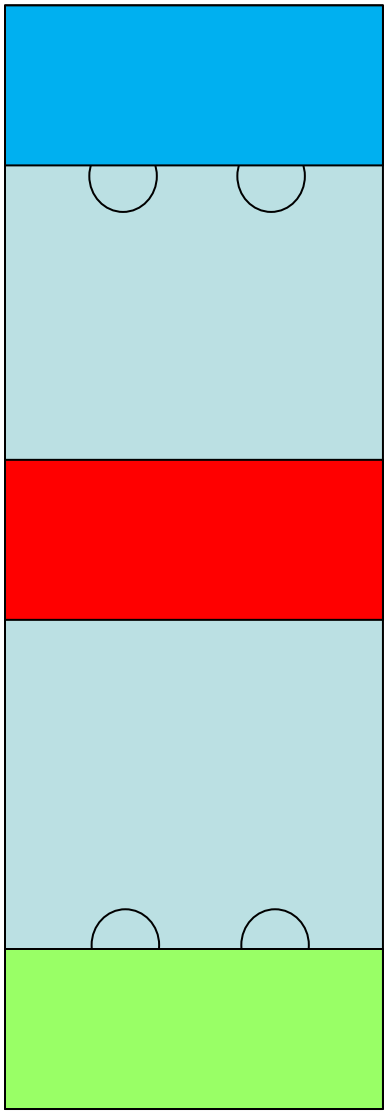

5 borekerner (Ø150)

Prøvestøbning

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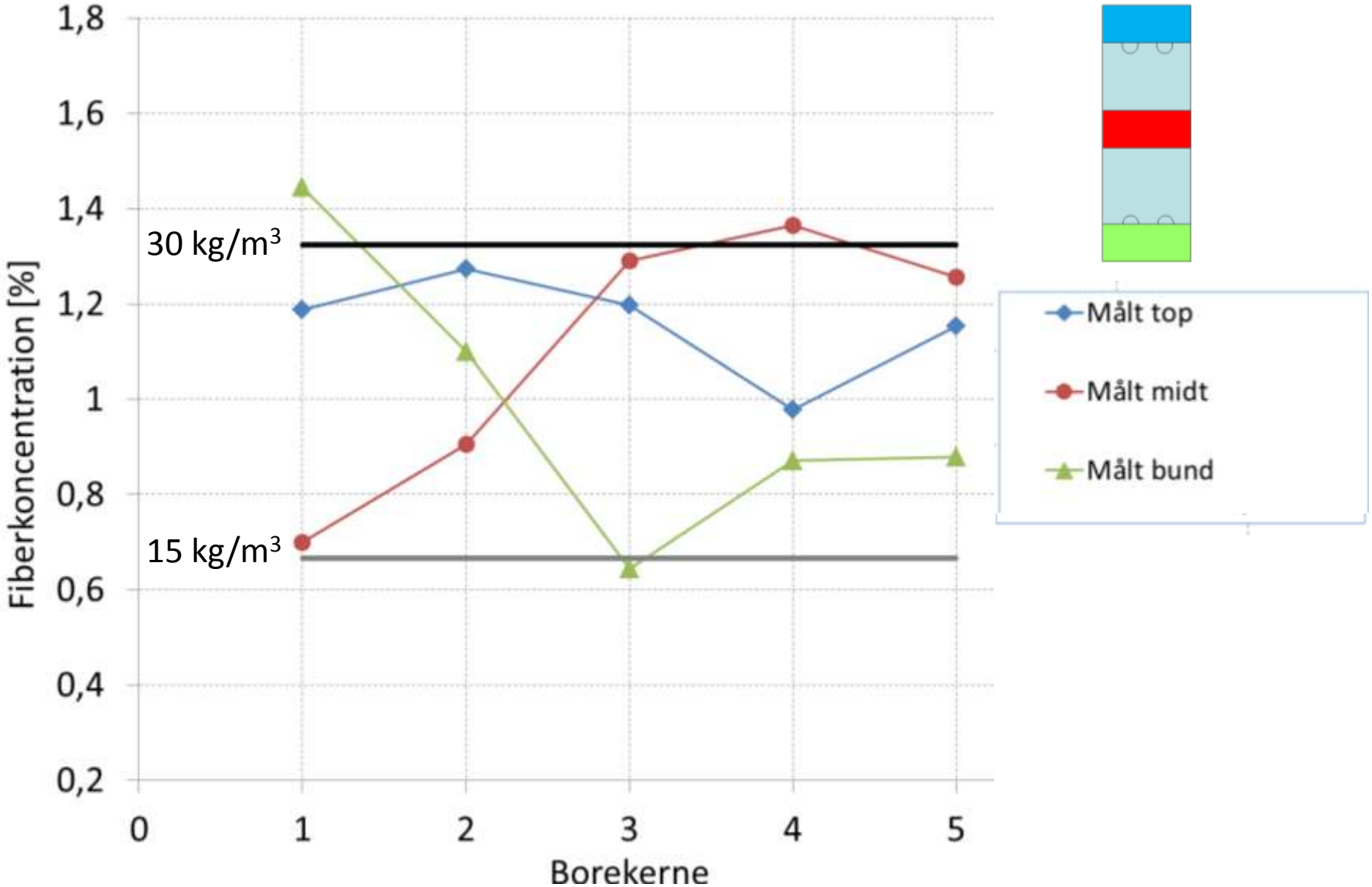

Prøvestøbning

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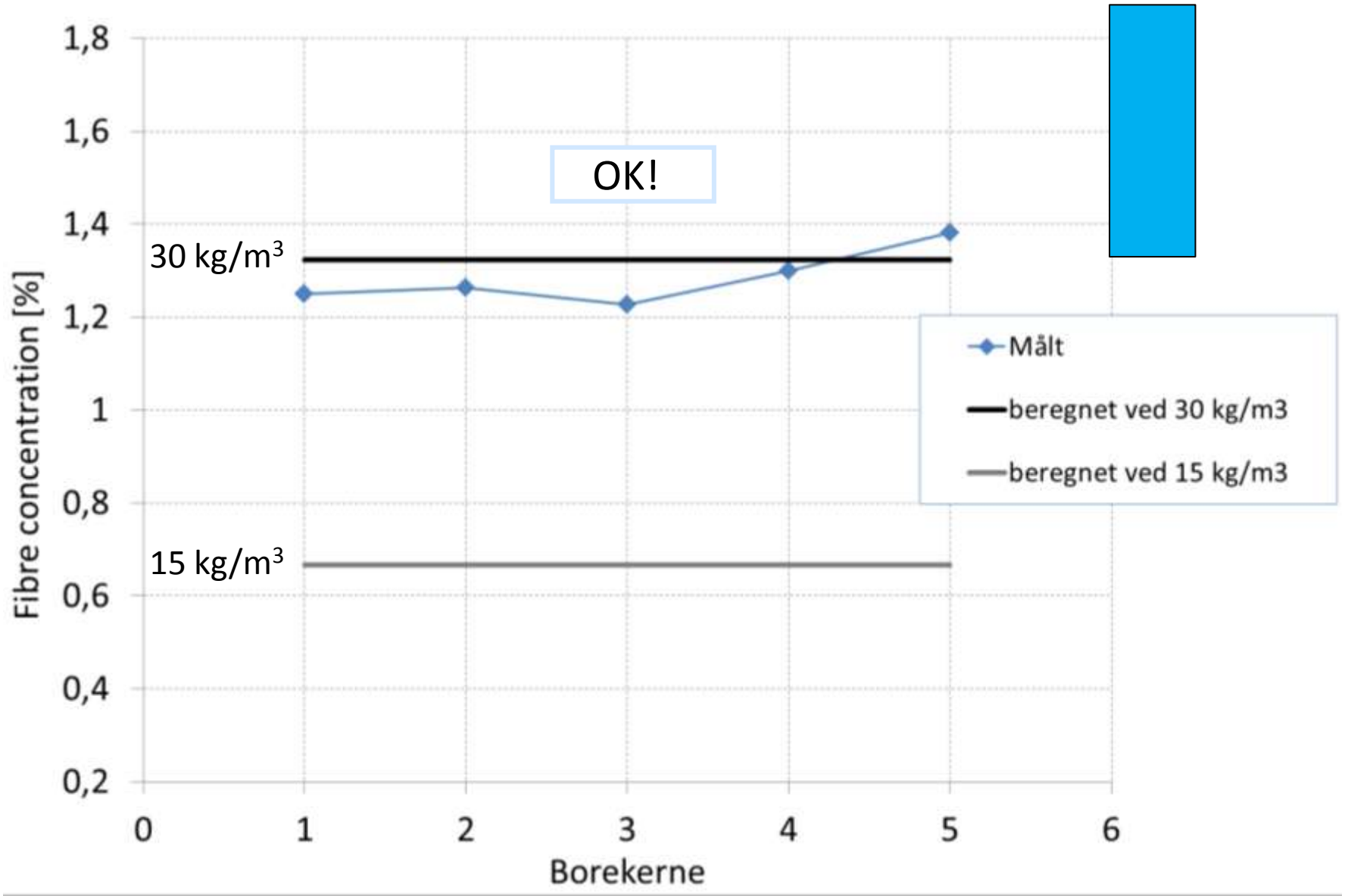

Fuldskala

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Fuldskala

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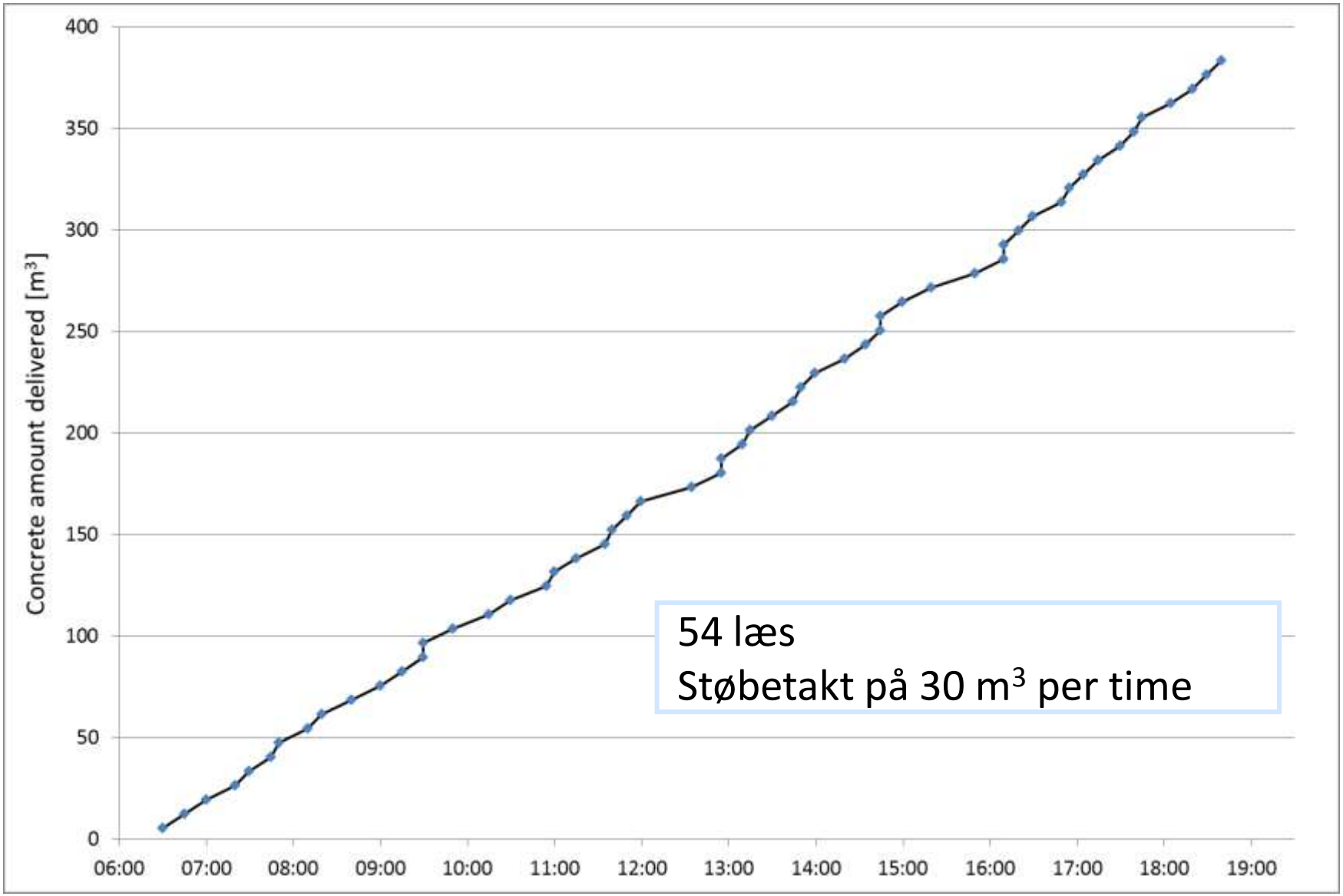

Fuldskala

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Prøver før pumpe

Prøver efter pumpe

Fuldskala

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4C-Rheometer

Unicon kontrol

Fuldskala

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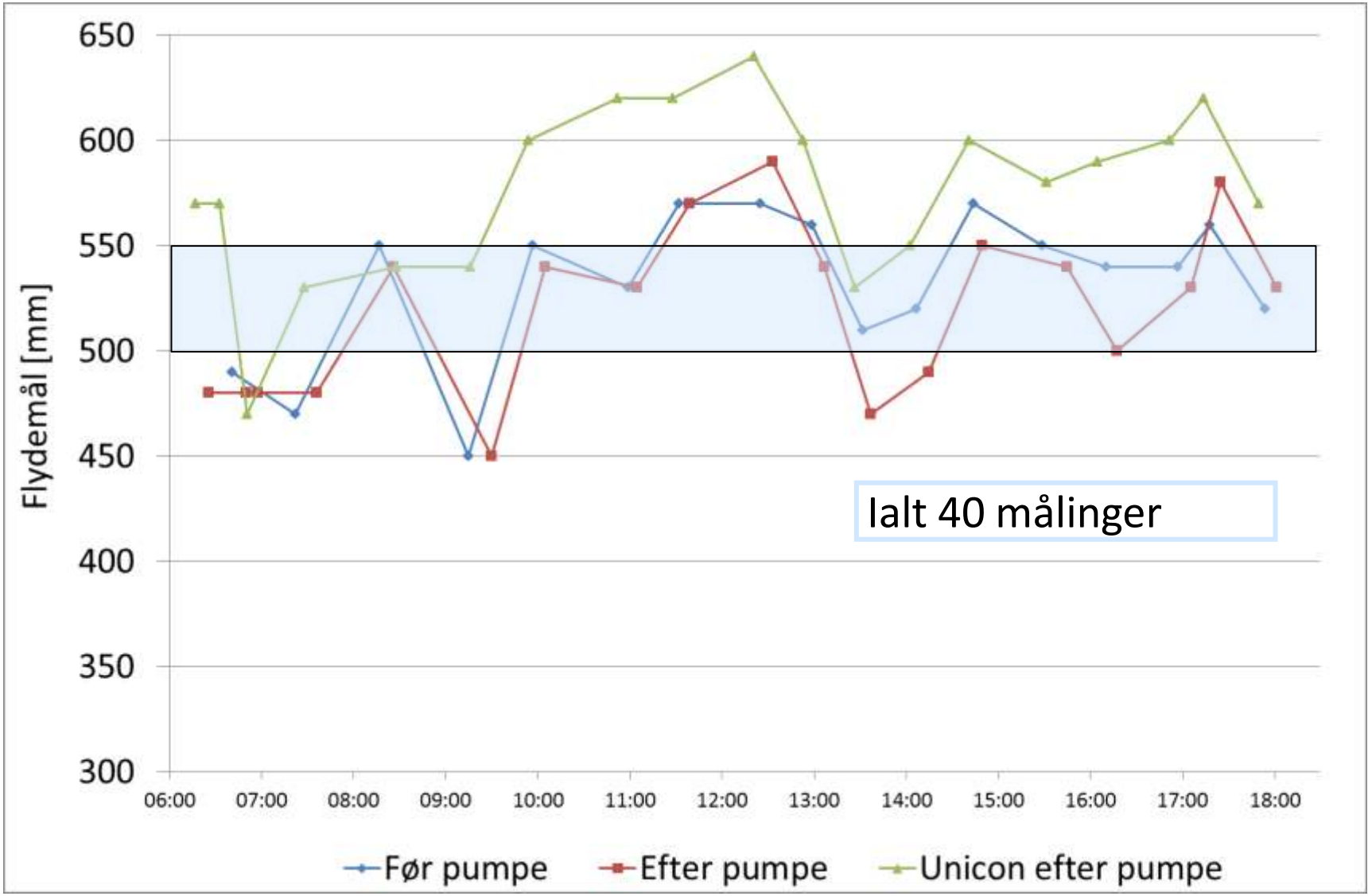

Fuldskala

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	4C Rheometer (DTI)		Flydemål (Unicon)	
	Før pumpe	Efter pumpe	Fabrik	Efter pumpe
Flydemål [mm]				
Gennemsnit	532	521	546	575
Spredning	34	38	41	40
T500 [sec]				
Gennemsnit	4,5	4,64	5,25	2,6
Spredning	1,0	1,8	2,1	0,9
Plastisk viskositet [Pa·s]				
Gennemsnit	79	68		
Spredning	16	30		
Flydespænding [Pa]				
Gennemsnit	72	80		
Spredning	27	29		
Luft [%]				
Gennemsnit			6,4	5,9
Spredning			1,2	0,9

Fuldskala

DANISH TECHNOLOGICAL INSTITUTE

	4C Rheometer (DTI)		Flydemål (Unicon)	
	Før pumpe	Efter pumpe	Fabrik	Efter pumpe
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T500 [sec]				
Gennemsnit	4,5	4,64	5,25	2,6
Spredning	1,0	1,8	2,1	0,9
Plastisk viskositet [Pa·s]				
Gennemsnit	79	68	Middel viskositet	
Spredning	16	30		
Flydespænding [Pa]				
Gennemsnit	72	80		
Spredning	27	29		
Luft [%]				
Gennemsnit			6,4	5,9
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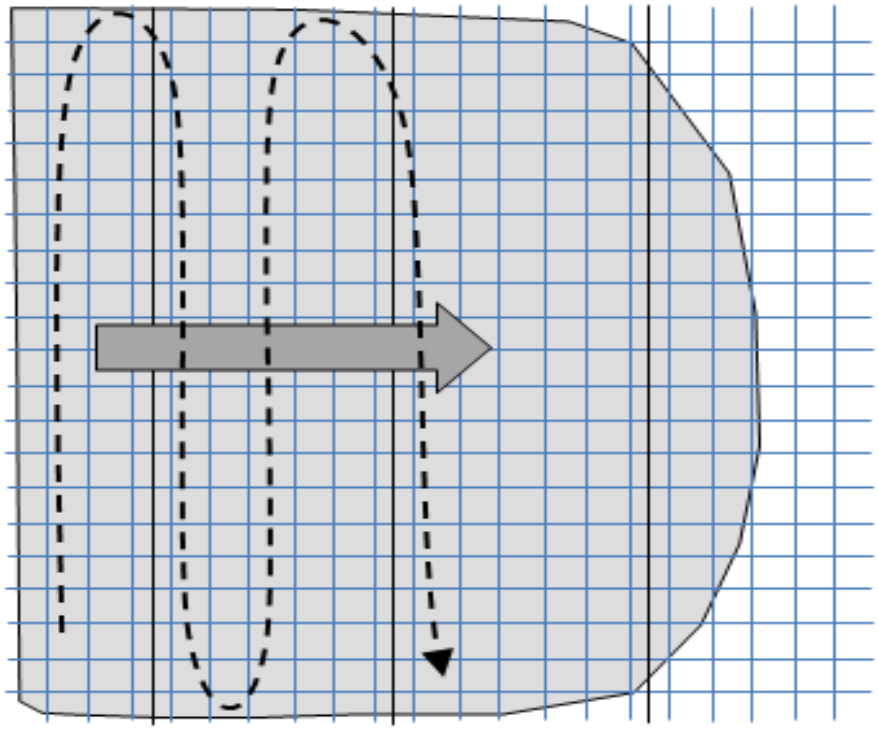
Fuldskala

DANISH TECHNOLOGICAL INSTITUTE



Fuldskala

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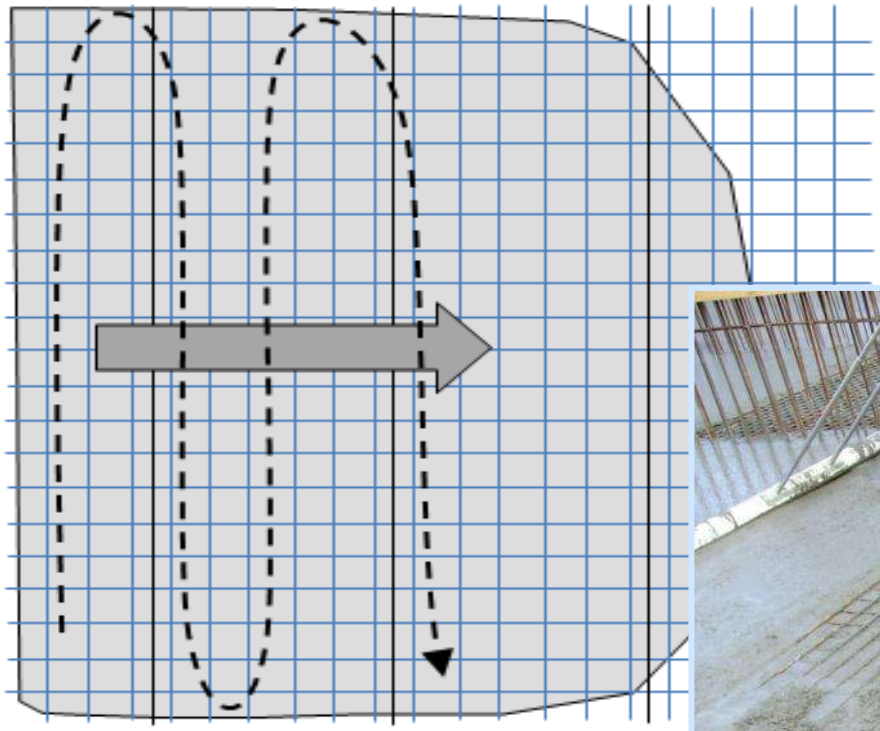

Fuldskala

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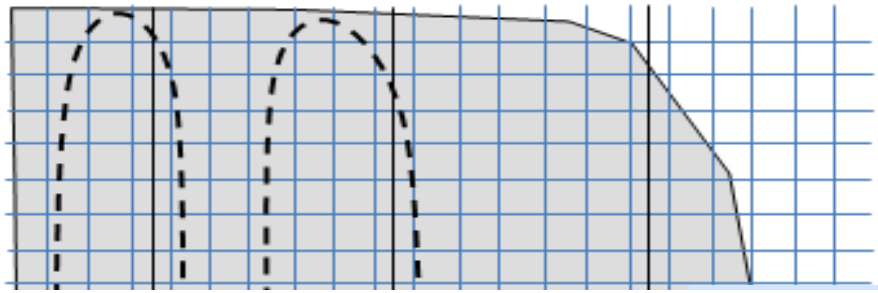

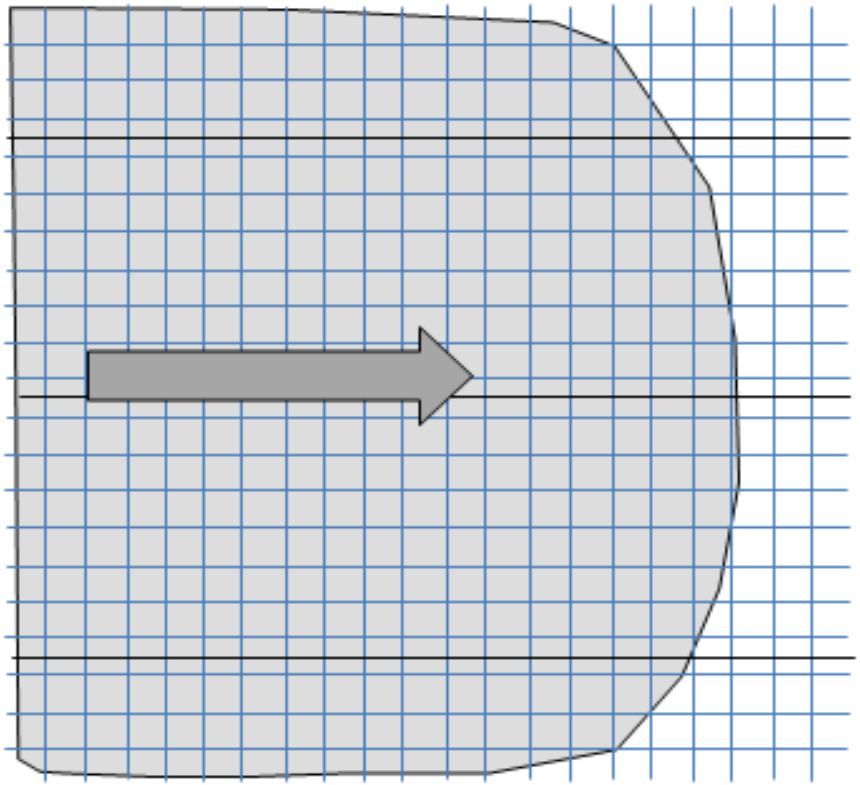

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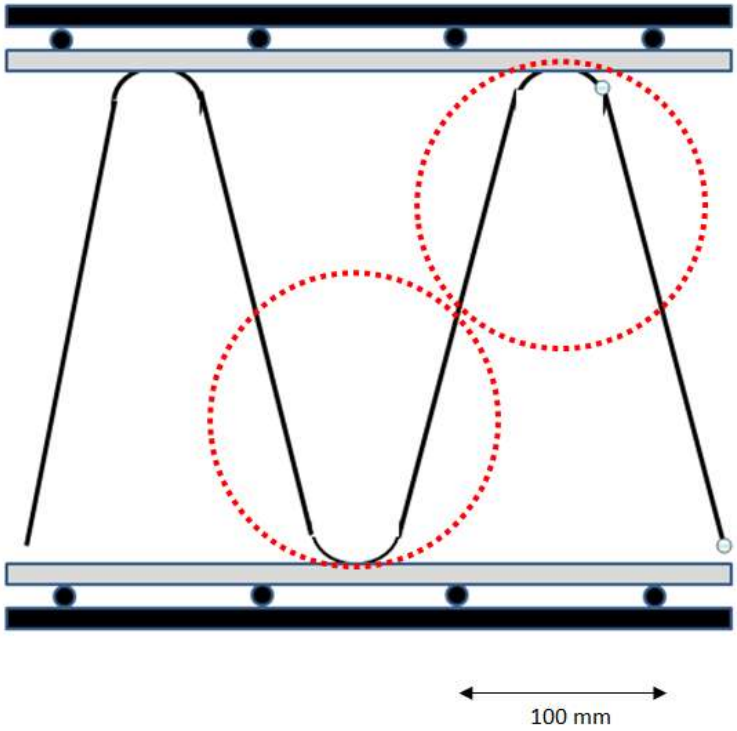

Trekantformede afstandsholdere ÷

Fuldskala

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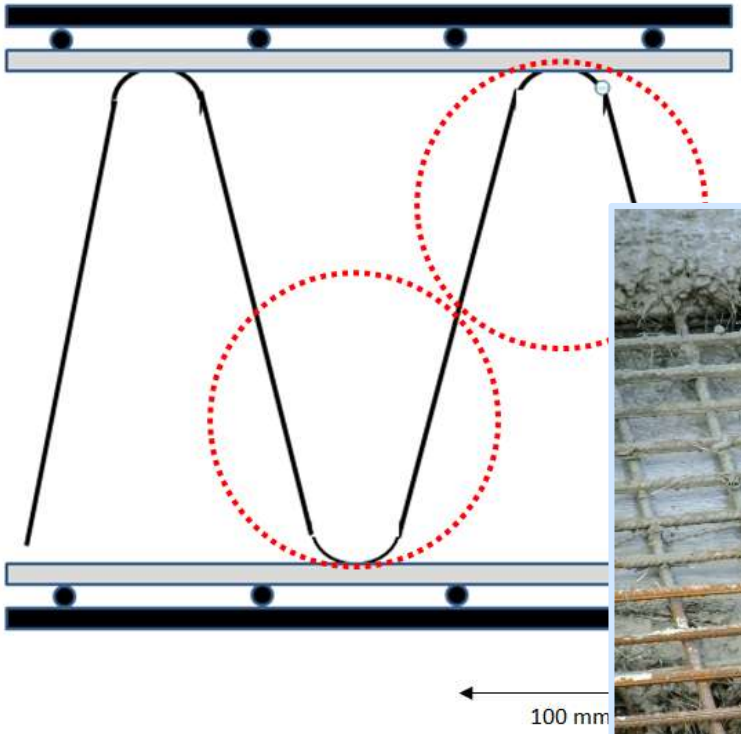

Trekantformede afstandsholdere ÷

Fuldskala

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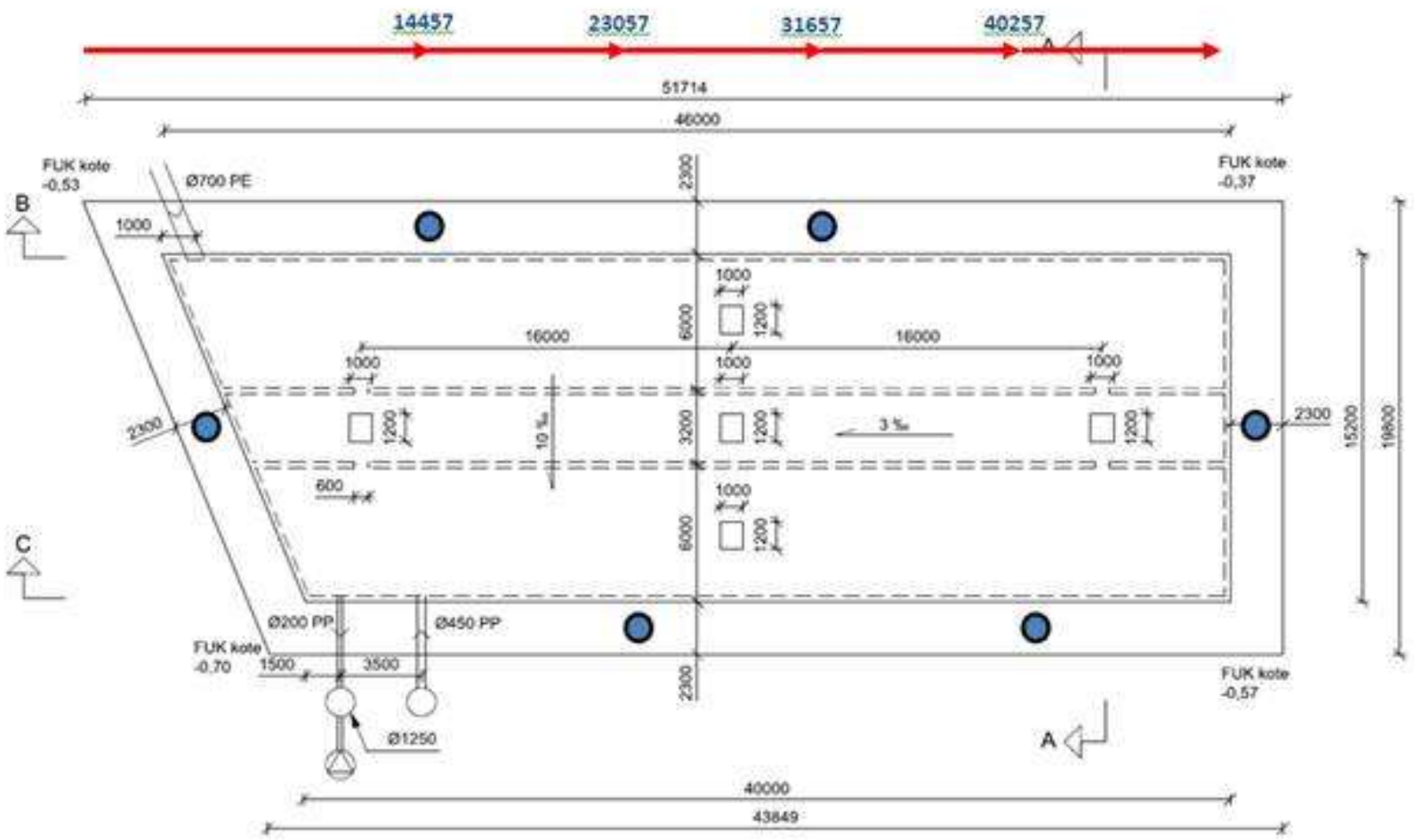
6 borekerner (Ø150)



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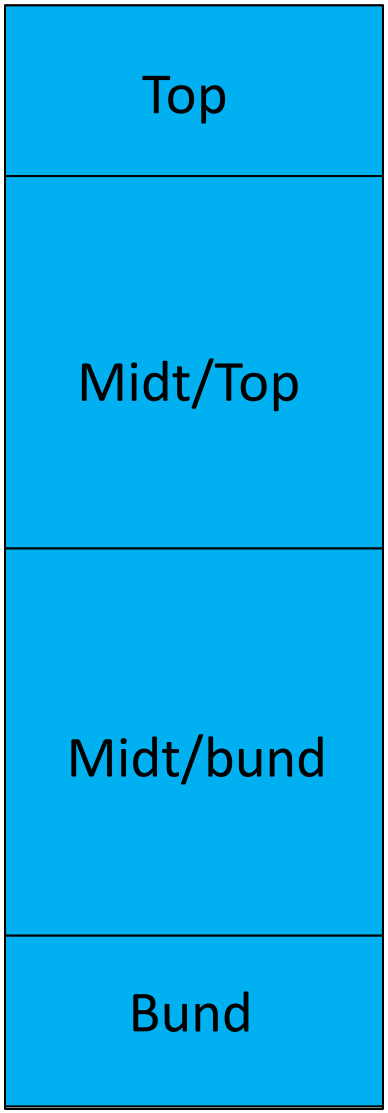

6 borekerner (Ø150)

Fuldskala

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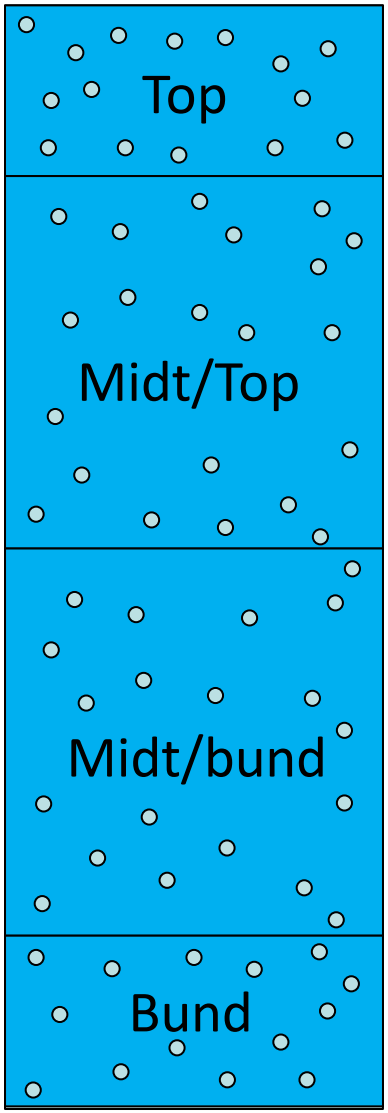
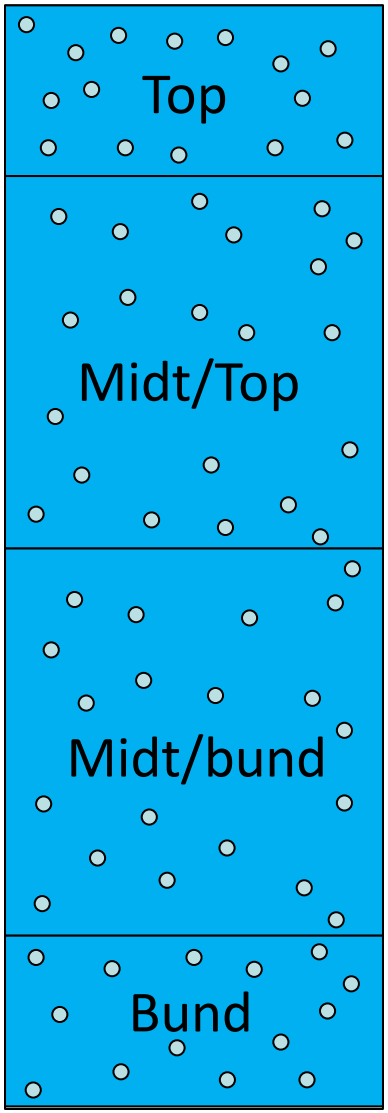


6 borekerner (Ø150)

Fuldskala



6 borekerner (Ø150)

$$n_f = \eta_\theta \frac{V_f}{A_f}$$

n_f = Antal fibre per m^2

V_f = Fiber vol. fraktion

A_f = Tværsn. areal fiber

η_θ = Orienteringsfaktor

Fuldskala

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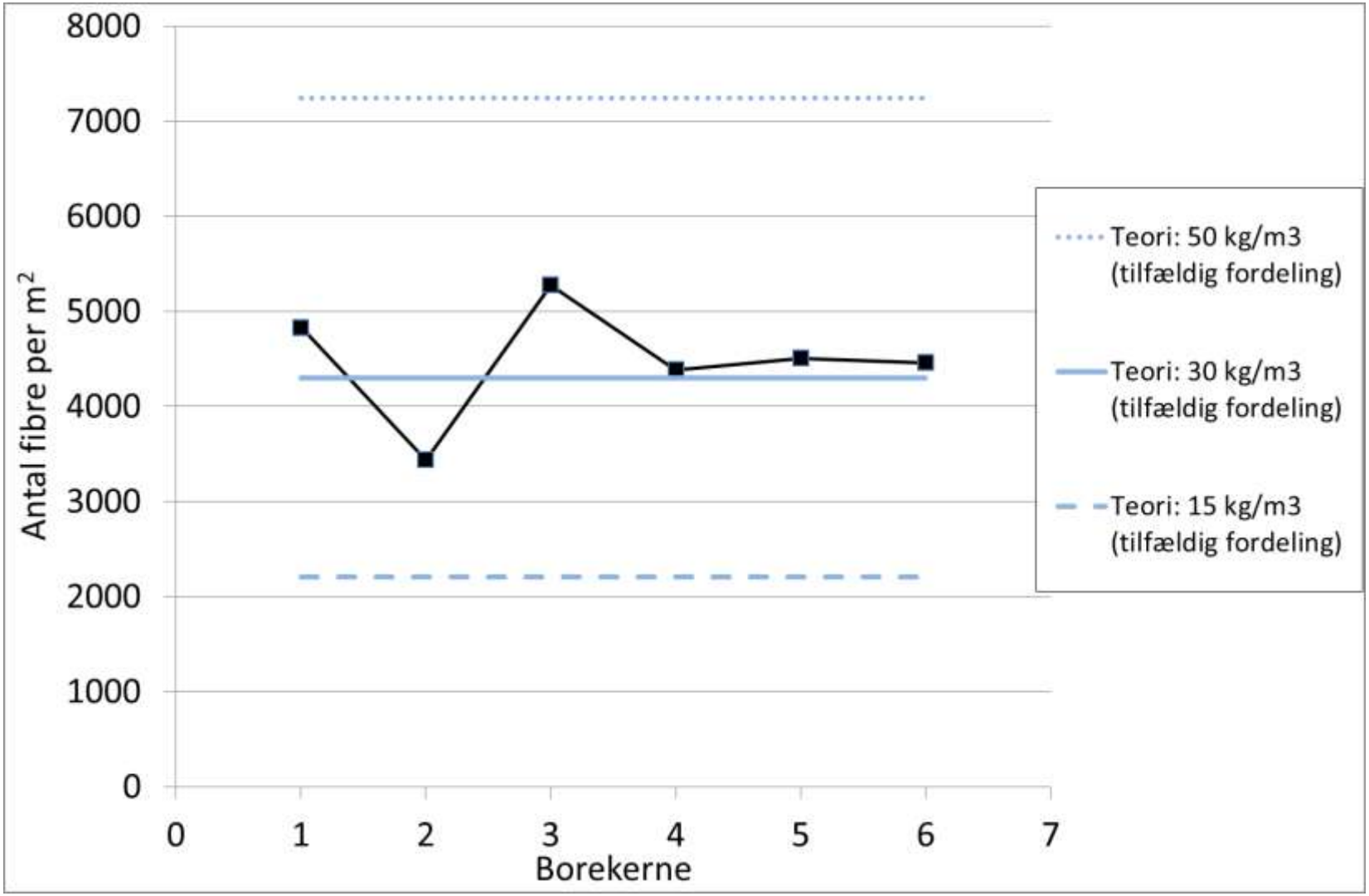

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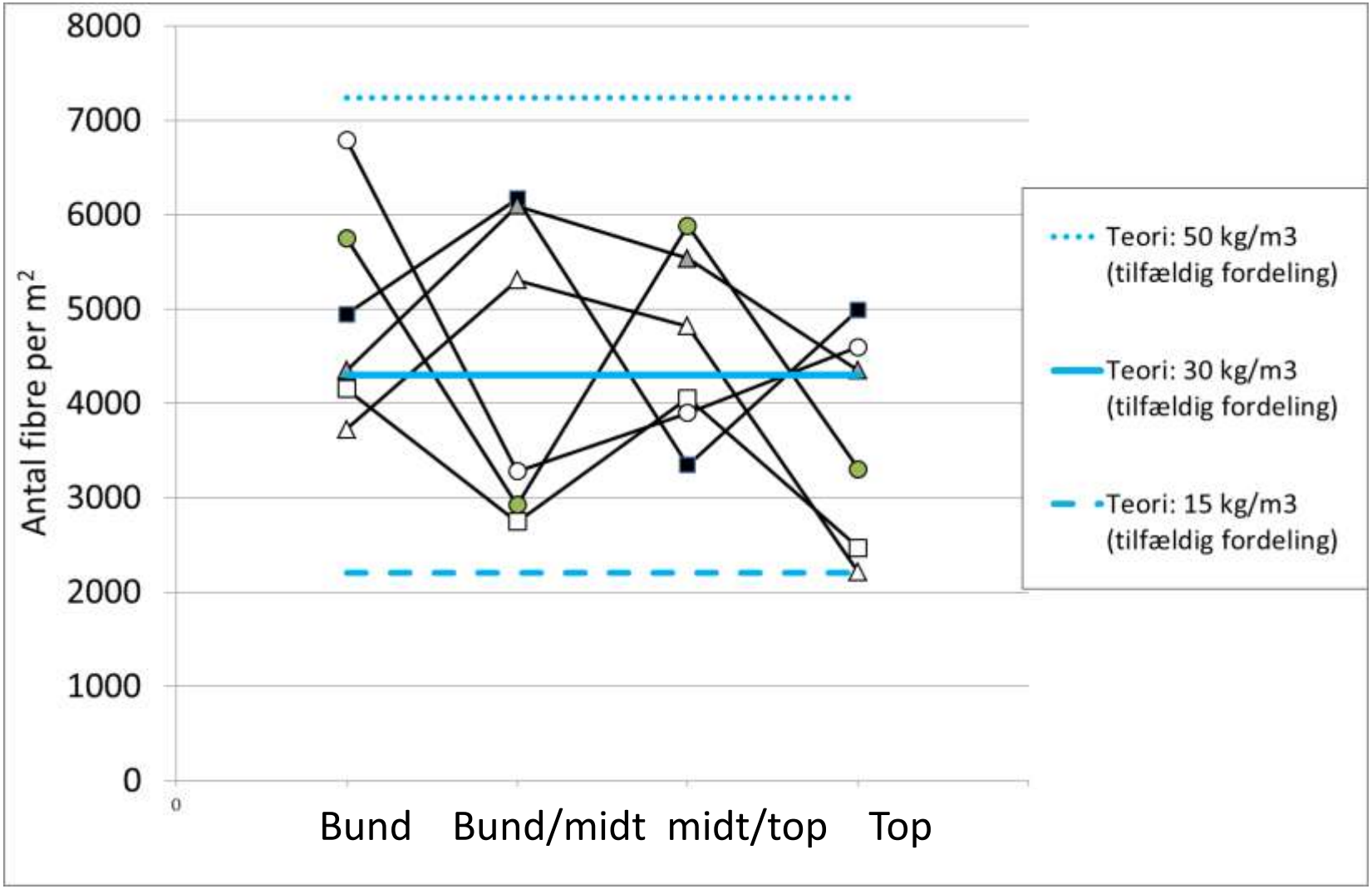

Konklusion

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- Ved bundplader af denne type har det vist sig muligt at reducere mængden af traditionel armering og opnå en økonomisk besparelse på ca. 30 % ved anvendelse af stålfiberarmeret beton.
- Det er muligt at støbe betonen som SCC og undgå opslidende vibreringsarbejde.
- Vigtigt med de rigtige flydeegenskaber. Hvis for stiv, var det nødvendigt med vibrator. Hvis for flydende, svært at styre betonen.
- Vigtigt at bevæge pumpeslangen kontinuerligt for at undgå ophobning. 100 x 100 maskevidde. Skal ikke være mindre!
- Vælg afstandsholdere med samme minimums maskevidde. Om muligt placer dem i retningen af støbefronten og ikke på tværs.

Hva så nu?

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Hva så nu?

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Simuleringer af flow (fiberorientering og fordeling) og mekaniske egenskaber

Hva så nu?

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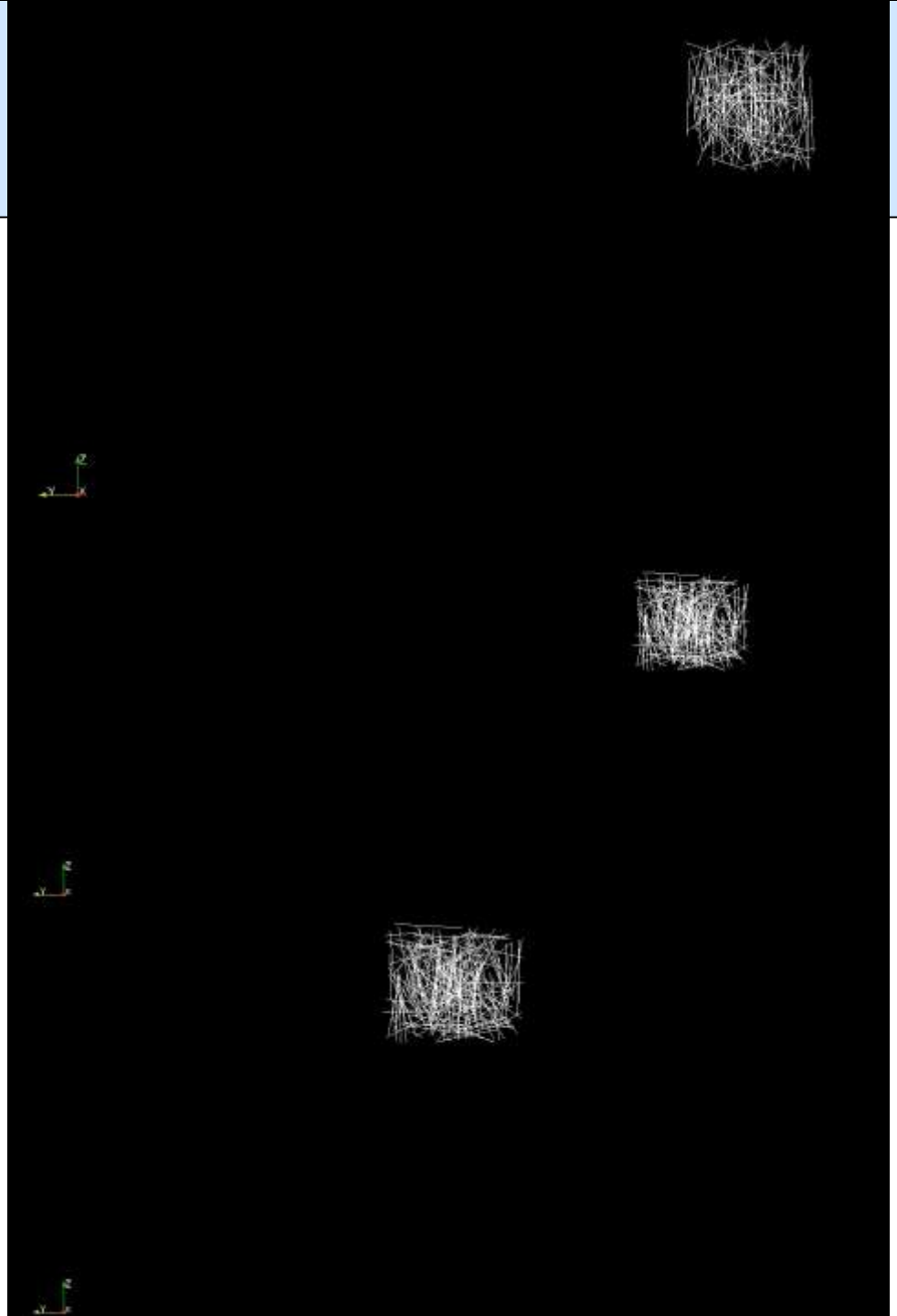
Simuleringer af flow (fiberorientering og fordeling) og mekaniske egenskaber

PhD studerende: **Oldřich Švec**

Vejledere:
John Forbes Olesen, DTU
Henrik Stang, DTU
Peter Noe Poulsen, DTU
Lars Nyholm Thrane, DTI

Švec, O., Skoček, J., Stang, H., Olesen, J. F., & Poulsen, P. N. (2011). *Fully coupled Lattice Boltzmann simulation of fiber reinforced self compacting concrete flow.* Proceedings of 19th International Conference on Computer Methods in Mechanics, Warsaw, Poland 2011

Švec, O., Skoček, J., Stang, H., Olesen, J. F., & Poulsen, P. N. (2011). *Flow simulation of fiber reinforced self compacting concrete using Lattice Boltzmann method.* Proceedings of ICCC



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Hva så nu?

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Simuleringer af flow (fiberorientering og fordeling) og mekaniske egenskaber

Verificering ved CT Scanning

Hva så nu?

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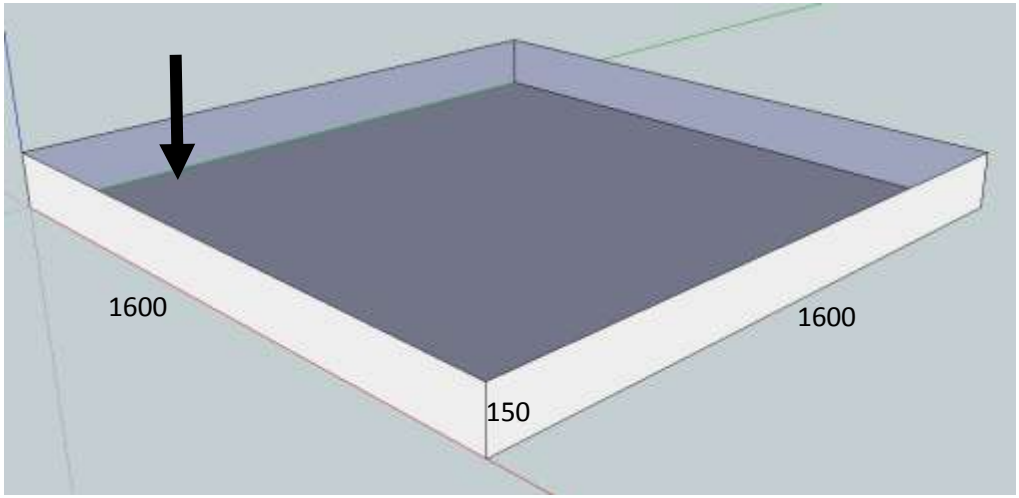

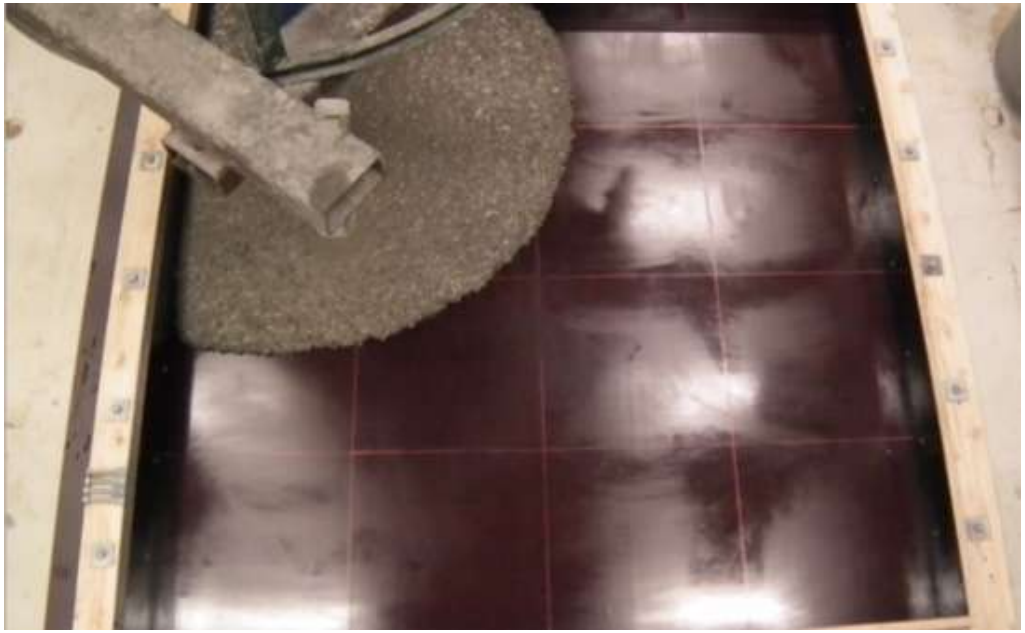

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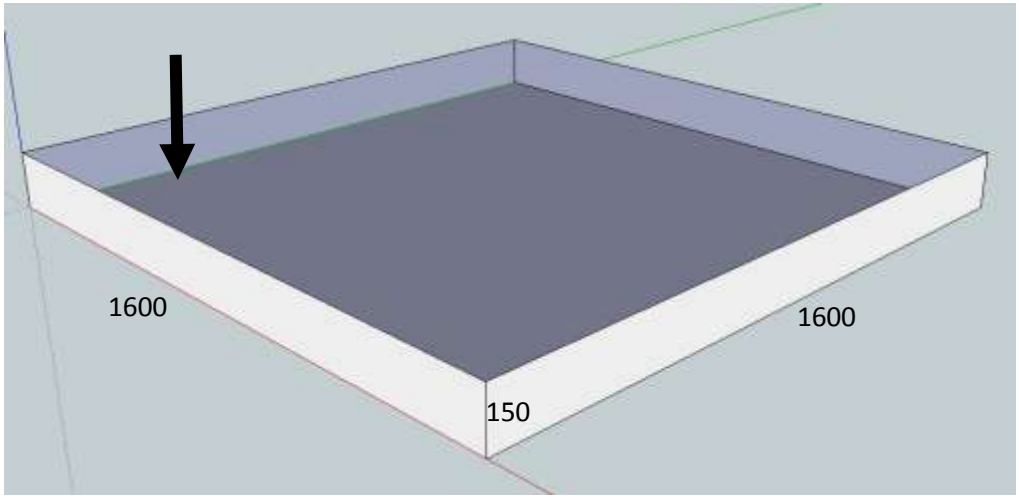

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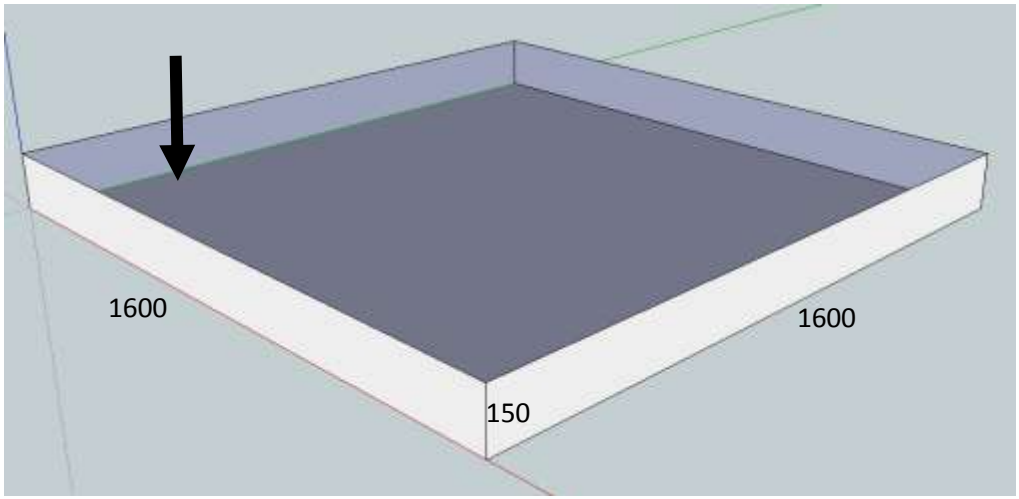

Grisescanner

Hva så nu?

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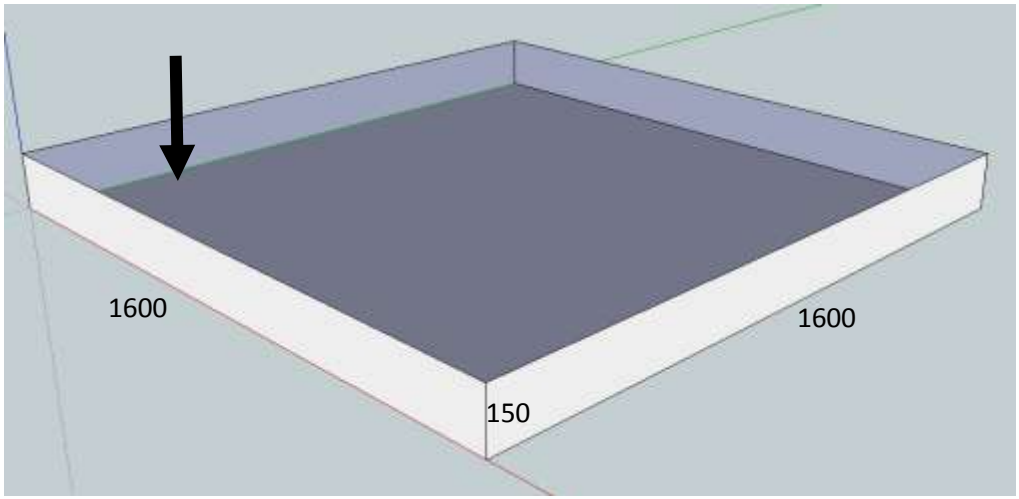

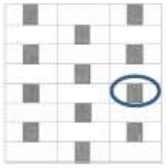

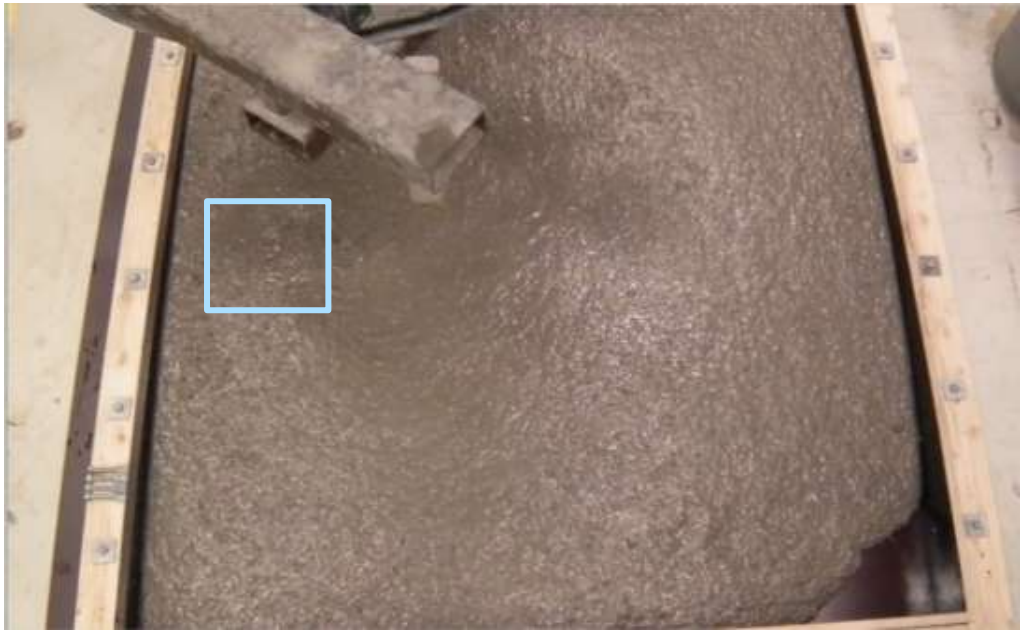

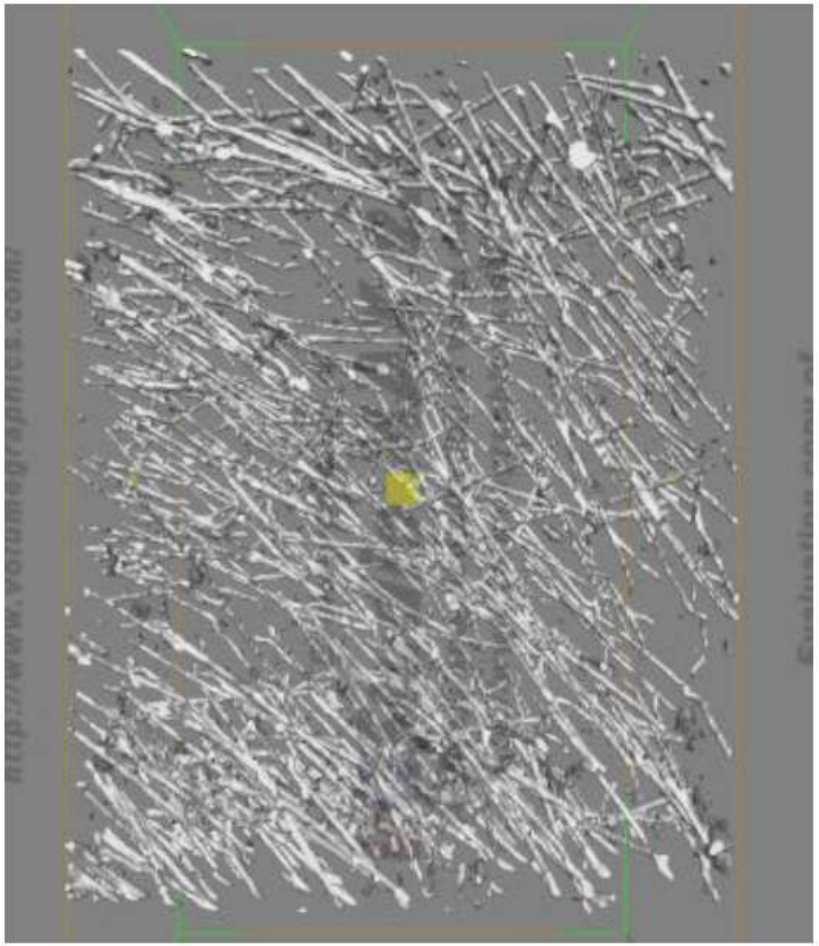

Hva så nu?

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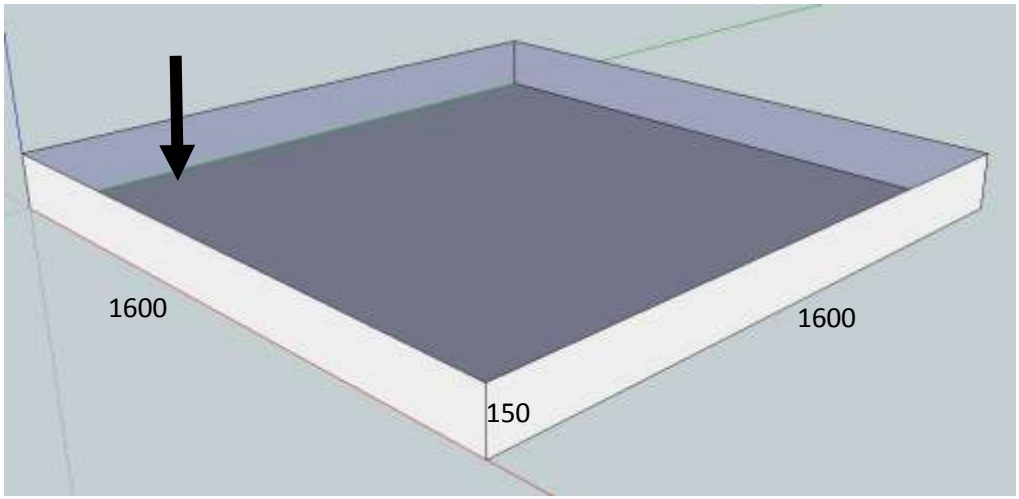

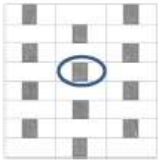

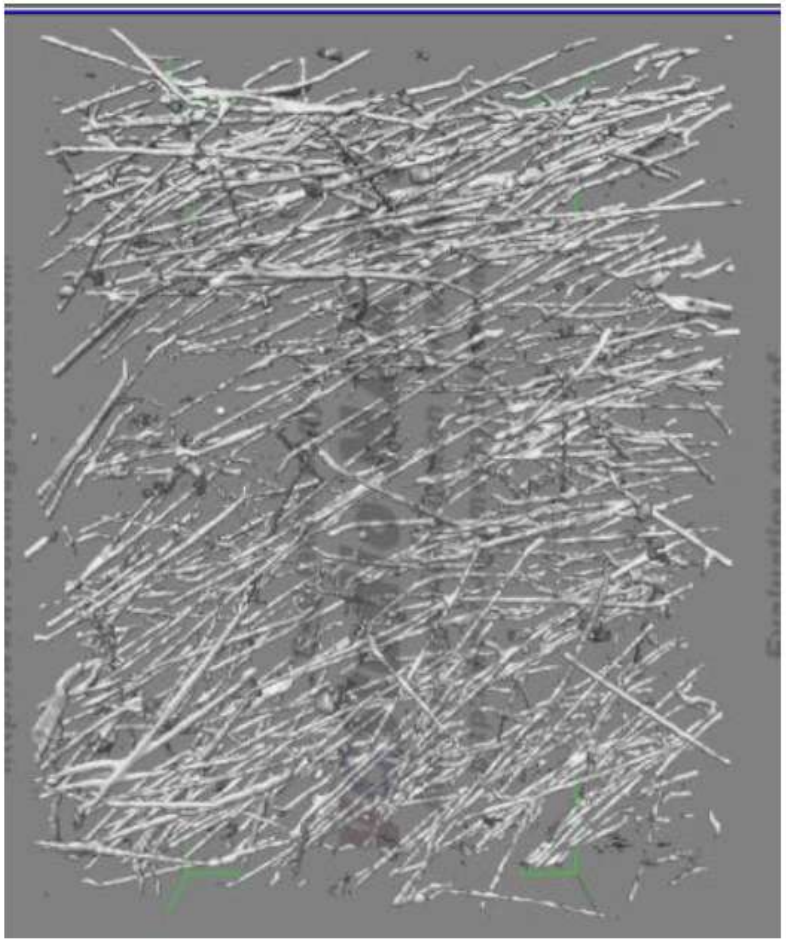

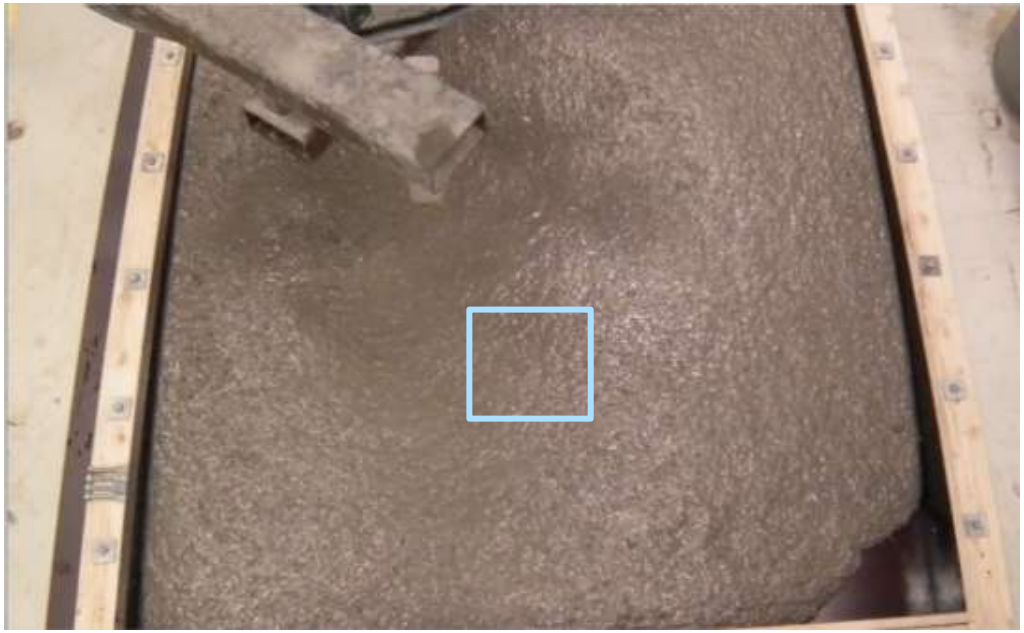

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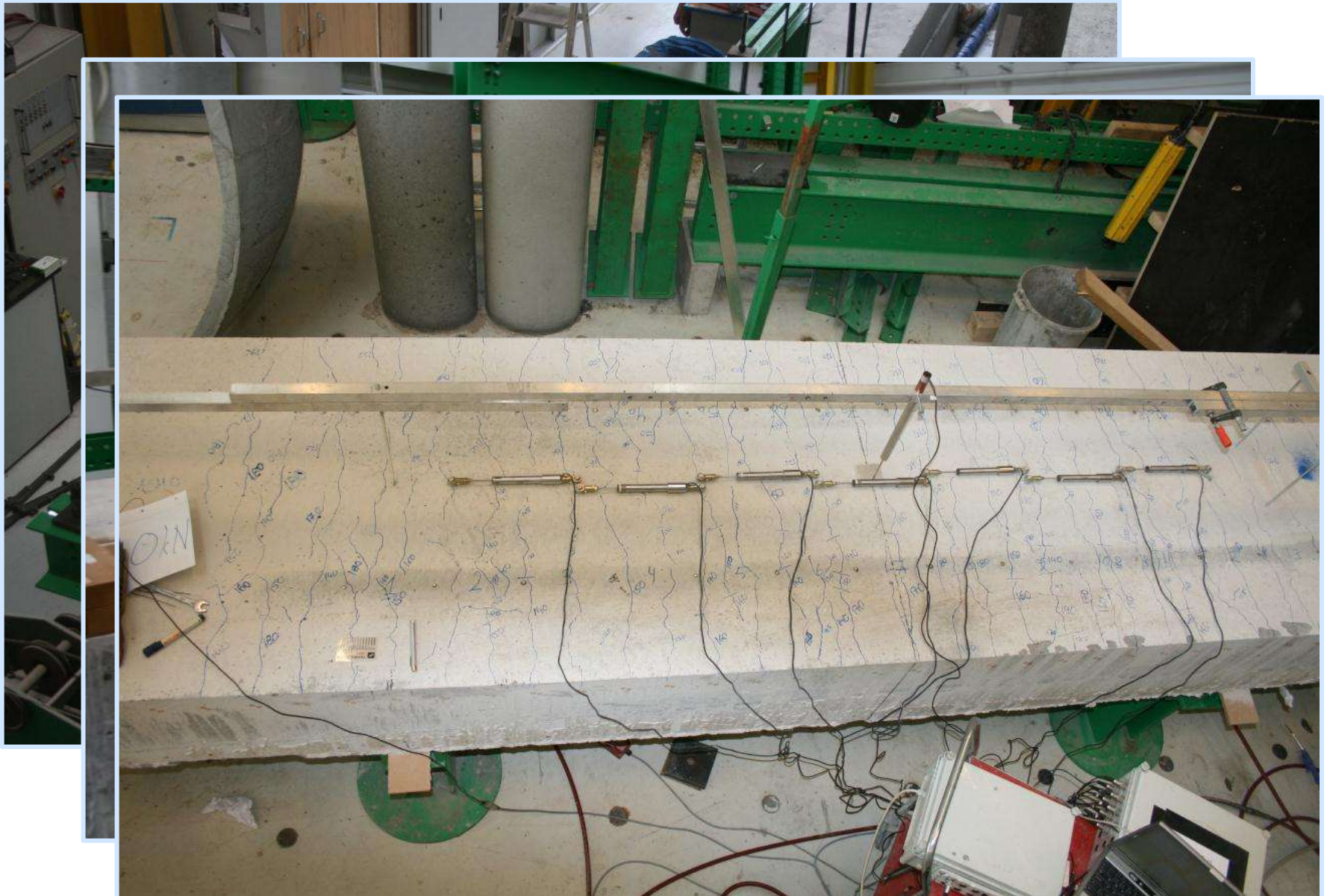

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