Test report

PROJECT NUMBER:
2008487

DANISH TECHNOLOGICAL INSTITUTE

Teknologiparken
Kongsvang Allé 29
DK-8000 Aarhus C
+45 72 20 20 00
Info@teknologisk.dk
www.teknologisk.dk

Init.: AREH/MIDJ
Order no.: 929072
Appendices: 4

Customer:

Company: Grundejernes Investeringsfond
Address: Ny Kongensgade 15
City: DK-1472 København

Material:

- 10 red soft-moulded bricks.
- 45 mortar samples according to EN 1015-11: 160x40x40mm (Length x Width x Height).
- 15 samples, each sample consisting of two bricks bonded with mortar
- 12 masonry wall specimens according to EN 1052-1: 588x108x594mm (Length x Width x Height).

See page 2 for details about brick and mortar types.

Sampling: The test material was acquired by the Danish Technological Institute. The preparation dates for the test samples are shown on page 2.

Period: The testing was carried out on the following days of curing of the mortar: 90, 145, 230, 300 and 370 days.

Method:

DS/EN 772-1:2011+A1:2015	Methods of test for masonry units – Part 1: Determination of compressive strength
DS/EN 772-11:2011	Methods of test for masonry units – Part 11: Determination of water absorption of aggregate concrete, autoclaved aerated concrete, manufactured stone and natural stone masonry units due to capillary action and the initial rate of water absorption of clay masonry units
DS/EN 772-21:2011	Methods of test for masonry units – Part 21: Determination of water absorption of clay and calcium silicate masonry units by cold water absorption
DS/EN 1015-11:2019	Methods of test for mortar for masonry – Part 11: Determination of flexural and compressive strength of hardened mortar.
DS/EN 1052-1:1999	Methods of test for masonry – Part 1: Determination of compressive strength

Result: The results of the test are given on page 5-6.

Terms: This analysis/test was conducted in accordance with international requirements (ISO/IEC 17025:2017) and in accordance with the General Terms and Conditions of Danish Technological Institute. The test results solely apply to the tested item. This analysis report/test report may be quoted in extract only if Danish Technological Institute has granted its written consent.

Place: 2022-08-29, Danish Technological Institute, Building and Construction, Aarhus

Signatures:

Arash Ehtesham
Business manager, M.Sc. Eng.

Telephone: +45 7220 1396
E-mail: areh@teknologisk.dk

Mikkel Daniel Vahle Johnsen
Consultant

Telephone.: +45 7220 3532
E-mail: midj@teknologisk.dk

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Test Specimens

Bricks

10 "Red, soft-moulded – 2.2.07" from Vesterled Teglværk were tested to determine the water absorption, initial rate of water absorption and normalized compressive strength.

Mortar

Applied mortar: Three types of lime mortars from Vejle Kalk- og Mørtelværk was used:

- Bakkemørtel (lime mortar) 5.1% 0.4mm
- Bakkemørtel (lime mortar) 6.6% 0.4mm
- Bakkemørtel (lime mortar) 9.0% 0.4mm

A test was conducted initially to verify the amount lime and to determine the water content in the fresh mortars. The results of these tests are given in the table below.

Sample marking	Content of lime: Weight% $Ca(OH)_2$	Water content Weight%
18-01-2021	5.1	12.1
26-01-2021	6.3	10.0
02-02-2021	9.1	13.5

Table 1. Determination of lime and water content in weight% according to MUC Method 7.12.

For each type of mortar, three mortar prism samples were produced, to be tested for flexural and compressive strength after 90, 145, 230, 300 and 370 days of curing.

Hence the amount of mortar prism samples was: 3 x 3 x 5 = 45.

Mixing of mortar and fresh mortar properties

5.1%:

Lime mortar 5.1%: 72.8kg.

Water: 6.1 L.

Mixing time: 15 min.

Fresh mixed mortar consistency acc. to EN 1015-3: 172 mm

Fresh mixed mortar air content acc. to EN 1015-7: 4%

Fresh mixed mortar water content: 17.2%

6.6%:

Lime mortar 5.1%: 69.3kg.

Water: 7.0 L.

Mixing time: 15 min.

Fresh mixed mortar consistency acc. to EN 1015-3: 173 mm

Fresh mixed mortar air content acc. to EN 1015-7: 9 %

Fresh mixed mortar water content: 17.5%

9.0%:

Lime mortar 5.1%: 75.0 kg.

Water: 5.9 L.

Mixing time: 15 min.

Fresh mixed mortar consistency acc. to EN 1015-3: 174 mm

Fresh mixed mortar air content acc. to EN 1015-7: 3 %

Fresh mixed mortar water content: 19.3%

Masonry

15 samples consisting of two bricks bonded with mortar. The brick and mortar were of the type mentioned above. Hence 5 samples were prepared for each mortar type. These samples were used to determine the depth of carbonization and curing, for each day of testing.

Four wall specimens were produced for each of the above-mentioned lime mortars, summing up to a total of 12 wall specimens. The geometry of the wall specimens was according to EN 1052-1: 588x108x594mm (Length x Width x Height). The wall specimens were used to determine the modulus of elasticity and the compressive strength of the masonry walls. A description of the test procedure is given in the section Test procedure.

Samples series

Three sample series were defined:

Series A: 15 mortar prisms, 5 samples of two bricks and 4 wall specimens (5,1% lime mortar) prepared 2021-01-15.

Series B: 15 mortar prisms, 5 samples of two bricks and 4 wall specimens (6,6% lime mortar) prepared 2021-01-22.

Series C: 15 mortar prisms, 5 samples of two bricks and 4 wall specimens (9,0% lime mortar) prepared 2021-01-29.

Test procedure

As mentioned earlier there were 5 test days for each mortar type: 90, 145, 230, 300 and 370 days of curing. The test procedure for each test day had the following steps:

1. Determination of flexural and compressive strength of mortar samples according to DS/EN 1015-11.
2. Determination of carbonization depth and curing of mortar, by Phenolphthalein. These were photo documented.
3. Determination of modulus of elasticity by testing 3 wall specimens according to the principles of DS/EN1052-1:1999. Tests were performed non-destructive with a maximum load of approximately 9,000kg, equivalent to 50% of the estimated load capacity of the walls. The test setup is shown on Photo 1.
4. Determination of the mortar compressive strength by testing 1 wall specimen according to the X-drill method. The X-drill method is described in the appendices.

On test day 370, a final and fifth step was added:

5. Determination of compressive strength by testing all 4 wall specimens to failure, without measuring axial deformations, as this was already done in step 3 for day 370.

Photo 1: Test of wall specimens. Axial deformations were recorded on front and back of the wall along with the applied load.

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Test Results

Bricks

The test result for the bricks are as follows:

Normalized compressive strength: **14.2 MPa**.

Average initial rate of water absorption: **2.8 kg/m²/min**

Total water absorption: **12%**

Detailed results of individual values are given in the appendices.

Mortar compressive strength f_m

Test results for the mortar compressive strength according to EN 1015-11 are given in Table 2.

Lime mortar	Mortar compressive strength f_m days of curing				
	90	145	230	300	370
5.1%	0.40	0.47	0.39	0.40	0.40
6.6%	0.45	0.45	0.45	0.50	0.47
9.0%	0.54	0.52	0.47	0.51	0.54

Table 2: Test results for f_m [MPa] tested according to EN 1015-11.

Detailed results of individual values are given in the appendices. Note that a few samples for the testing of 5.1% at 300 days were damaged, so only 2 flexural tests and 5 compressive tests were conducted.

Test results for the mortar compressive strength according to the X-drill method are given in Table 3 below.

	Days of curing				
	90	145	230	300	370
A-4	0.58	0.51	0.37	0.37	0.91
B-4	0.56	0.46	0.40	0.45	0.63
C-4	0.25	0.58	0.68	0.87	0.72

Table 3: Test results for f_m [MPa] tested according to the X-drill method.

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Masonry wall specimens

Test results for the modulus of elasticity, E, are given in Table 4.

	Days of curing				
	90	145	230	300	370
A-1 (5.1%)	1386	1201	1134	1134	1077
A-2 (5.1%)	1282	1043	1037	1023	1066
A-3 (5.1%)	1219	1153	1071	1100	1024
Mean	**1296**	**1132**	**1081**	**1086**	**1056**
B-1 (6.6%)	1210	1237	1140	1060	1049
B-2 (6.6%)	1288	1151	1108	1019	1027
B-3 (6.6%)	1240	1262	1088	1082	1008
Mean	**1246**	**1217**	**1112**	**1054**	**1028**
C-1 (9.0%)	1234	1201	814	924	931
C-2 (9.0%)	1228	1240	1185	1090	790
C-3 (9.0%)	1235	1094	1032	1024	979
Mean	**1232**	**1178**	**1010**	**1013**	**900**

Table 4: Test results for E [MPa] tested according to EN 1052-1.

Results for the final tests, where all 12 walls specimens were tested to failure, are given in Table 5.

	Cross S. Area [mm^2]	F_{crack} ton	σ_{crack} MPa	F_{max} ton	σ_{max} MPa	Time of failure min
A-1 (5.1%)	63504	33,1	5,1	33,1	5,1	25,0
A-2 (5.1%)	63504	28,5	4,4	31,2	4,8	17,0
A-3 (5.1%)	63504	28,2	4,4	33,3	5,1	15,0
A-4 (5.1%)	63504	29,4	4,5	32,4	5,0	16,0
Mean	63504	29,8	4,6	32,5	**5,0**	18,3
B-1 (6.6%)	63504	30,3	4,7	33,2	5,1	18,0
B-2 (6.6%)	63504	29,5	4,6	33,1	5,1	18,0
B-3 (6.6%)	63504	28,9	4,5	32,4	5,0	17,0
B-4 (6.6%)	63504	28,3	4,4	29,7	4,6	16,0
Mean	63504	29,3	4,5	32,1	**5,0**	17,3
C-1 (9.0%)	63504	29,9	4,6	33,9	5,2	17,0
C-2 (9.0%)	63504	0,0	0,0	31,2	4,8	15,0
C-3 (9.0%)	63504	29,8	4,6	32,3	5,0	18,0
C-4 (9.0%)	63504	30,1	4,7	32,7	5,1	17,0
Mean	63504	29,9	4,6	32,5	**5,0**	16,8

Table 5. Results for the compressive strength after 370 days of curing, tested according to EN 1052-1.

Appendices

Appendix 1 – X-drill method
Appendix 2 – Compressive strength, water absorption and initial rate of water absorption of bricks
Appendix 3 – Flexural and compressive strength of mortar prisms
Appendix 4 – Stress/strain relations

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Appendix 1. X-drill method

The X-drill is used for experimental determination of the mortar compressive strength (fm) for masonry consisting of bricks in normal format and with mortar joints with a nominal thickness of 12 mm. The calculations of f_k are integrated with SBi instruction 248 "Strength properties of older masonry".

Procedure

1. Initially, the mortar type (L, LC, C) is estimated. This is important for determining f_m and E_{0k}.
   In case of doubt, typically in the case of an assessment between L and LC, a mortar sample is examined in the laboratory. Thus, at the customer's request, a mortar test can be carried out, where the cement content is determined. The mortar is categorized as:

Mortar type	Content of Cement	Examples of mortar type
L	<40%	L 100/1200
LC	40-50%	LC60/40/850 og LC 50/50/700
C	>50%	LC 35/65/650 and pure C-mortars

2. The brick type is indicated through the K-factor. Note: If ordinary hollow bricks are used, K=0.45 is specified, even if the hollow area is ≤25%. For hollow bricks, an estimated β-value is also indicated. See point 13.
3. It is indicated whether the current wall is at least a 1/1 brick wall (for determining minimum mortar compressive strengths).
4. It is stated whether the coefficient of variation for fb is at least 25% (for determining minimum mortar compressive strengths). Determined from individual values in terms of measurement of fb or by estimation.
5. A number of T-junctions are selected between the bed and head joints on the wall where the joint strength is desired to be determined (typically 10 positions).
   Areas where the load increases must be selected, and the points must be representative (for example in height).
   The points are marked, if necessary, with chalk, so that the holes can easily be found according to grouting the holes. The lower part of the head joint is used.
6. If 10% or 20% of the joint is estimated to be broken in full depth, set 1 or 2 of the 10 values for M_v = 0, so that these areas are included when determining f_m for the masonry.
7. Drill a hole in the selected T-junctions: Ø6, length: approx. 70 mm. Afterwards: Ø 10, length: 10 mm. See figures 2 and 3.
8. The distance is measured with a ruler from the edge of the wall to, for example, the starting nut. The cross drill is placed in the position where it meets resistance (where the Ø6 hole meets the cross). The distance is measured before and after the X-drill has been inserted and hammered in. The embedment length (Li) is the difference. See figure 4.
   The cross drill is usually embedded 20-30 mm. See figure 5.
   • It can be knocked in shorter, but this increases the uncertainty of Li. Minimum embedment should be 10 mm.
   • In weak mortars, a longer distance may be relevant. Maximum 50 mm.
   • For very strong mortars, where maximum torque (=50 Nm) is achieved, Li must be ≤20 mm. (This is to protect the flanges of the cross drill, as otherwise yielding would occur in the steel).
   Here, X-drills made of black high-strength steel are chosen.
9. The torque wrench is selected according to the expected strength of the mortar.
10. The torque wrench is turned slowly with one hand at the same time that the cross drill is held with the other hand so that the effect of force is as much as possible a pure twisting torque.

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11. Maximum achievable torque (M_v) and embedment length (Li) are recorded for each test.
12. Possibly extremely high values, which are considered to be due to the cross drill being stuck are omitted. Extremely low values are not omitted.
13. β is the fraction of the area made up by the holes in the critical section. See the following figure:

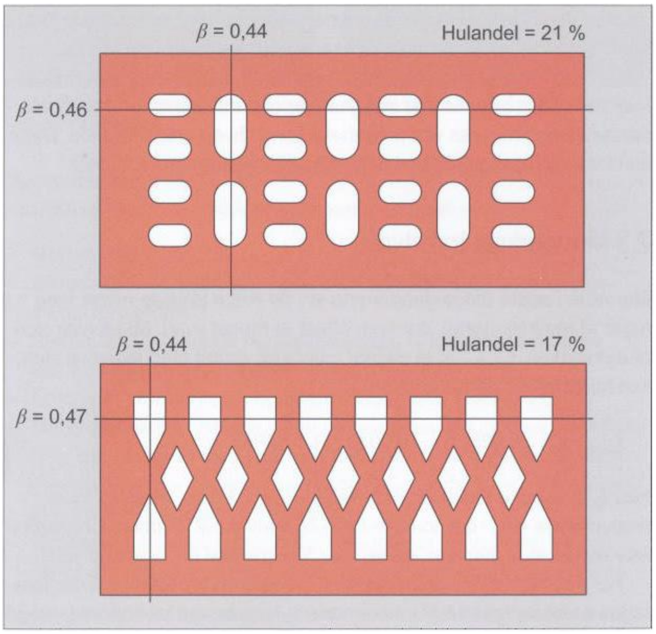

Figure 1. Reduction factors in critical sections.

Calculation is done in a spreadsheet. Main points in the spreadsheet:

1. m_v is calculated as Mv/Li.

2. Mean value for all measurements of m_v is determined. This is called $m_{v,m}$

3. The mortar compressive strength is determined as = 3.2 × $m_{v,m}$

Here, the units [MPa] are assumed for the mortar compressive strength and [Nm/mm] for $m_{v,m}$

4. The compressive strength of the masonry is determined according to Eurocode 6:

$$f_k = K \times f_b^{0,7} \times f_m^{0,3}$$

with sizes as specified in EN 1996-1-1.

Note for:

Lime-rich* mortars (L and LC): f_m = ½ × Mortar compressive strength

cement-rich* mortars (C): f_m = Mortar compressive strength

* lime-rich mortars are defined as mortars with a lime content of 50% or more of the binder quantity. Cement-rich mortars are defined as mortars with a cement content of more than 50% of the binder quantity. If the term for cement-rich mortars is used, the current cement content must be verified by qualified assessment, testing, information about the mortar or equivalent.

Note for:

pure lime mortars (L) are $E_{od} = 150 f_m f_d$

other mortars (LC and C) are $E_{od} = \min(400 f_m; 20 f_b; 1000) f_d$

For solid bricks (group I with K-factor = 0.55) and hollow bricks (group II with K-factor = 0.45), the minimum value for fm is calculated. This minimum value is dependent on the thickness of the wall, the coefficient of variation of fb and β. See method in "strength properties of older masonry", SBi instruction 248.

5. The friction coefficient of the masonry is determined based on the type of mortar.

For L-mortars: $\mu_d = 0.6/1.3$

For LC and C mortars: $\mu_d = 1.0/1.3$

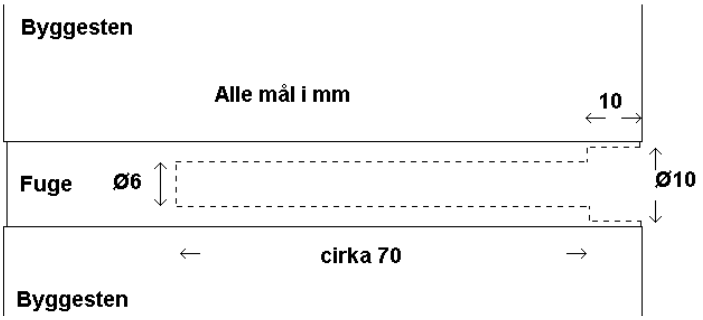

Figure 2. Sketch of holes in the joint before inserting the X-drill.

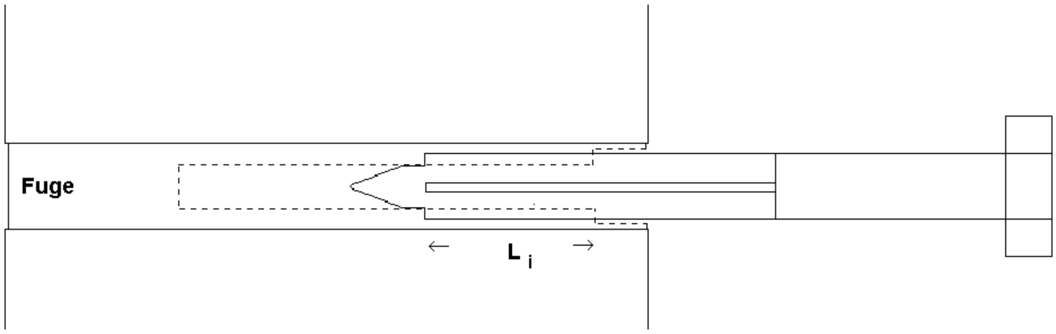

Figure 3. Sketch of joint after inserting the X-drill.

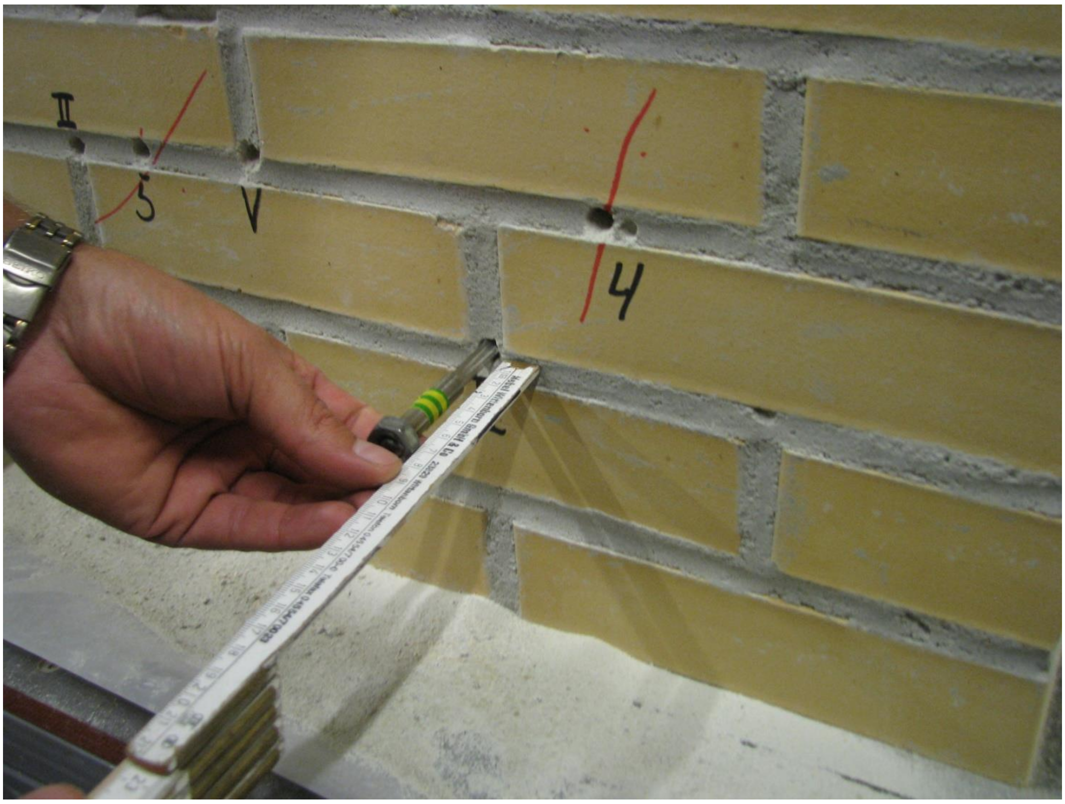

Figure 4. Determining the distance L_i. The distance is measured before and after the X-drill has been knocked in.

Figure 5. The X-drill is usually embedded 20-30mm in the joint.

Figure 6. Torque wrench is used to determine M_v. The torque wrench is turned slowly with one hand at the same time the X-drill is held with the other hand so that the effect of force is as much as possible a pure twisting torque.

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Appendix 2. Compressive strength, water absorption and initial rate of water absorption of bricks

Brick no.	Gross area [mm²]	Height [mm]	Failure load [N]	Compression strength [MPa]	Normalized compression strength [MPa]
1	25223	50.3	496386	19.7	14.6
2	25356	50.3	450279	17.8	13.2
3	25455	50.3	444393	17.5	13.0
4	25608	50.4	446355	17.4	12.9
5	25476	50.3	461070	18.1	13.4
6	25307	49.0	527778	20.9	15.4
7	25282	50.3	462051	18.3	13.6
8	25306	49.0	541512	21.4	15.8
9	25558	50.4	501291	19.6	14.6
10	25352	49.0	553284	21.8	16.1
Mean				19.2	**14.2**
Standard variation				1.7	1.2
Coefficient of variation %				8.7	8.3

Table 6. Normalized compression strength of bricks according to EN 772-1.

Brick no.	Length [mm]	Width [mm]	Dry mass Measurement 1 [g]	Dry mass Measurement 2 [g]	Change in dry mass %	Wet mass after 1 minute of soaking [g]	Initial rate of water ab-sorption [kg/m²]
1	231.6	107.8	2480	2478	0.081	2548	2.8
2	231.4	107.9	2477	2476	0.040	2542	2.6
3	231.6	107.2	2479	2477	0.081	2548	2.9
4	230.6	107.5	2481	2479	0.081	2552	2.9
5	231.8	107.6	2493	2492	0.040	2559	2.7
6	230.9	107.6	2479	2478	0.040	2547	2.8
7	231.6	107.6	2457	2456	0.041	2526	2.8
8	230.8	107.8	2439	2437	0.082	2508	2.9
9	231.5	107.5	2490	2489	0.040	2557	2.7
10	230.9	107.9	2486	2486	0.000	2552	2.7
Mean							**2.8**
Standard deviation							0.10
Coefficient of variation							3.6

Table 7. Initial rate of water absorption according to EN 772-11.

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Brick no.	Dry mass [g]	Wet mass [g]	Water absorption [%]
1	2478	2767	12
2	2476	2765	12
3	2477	2765	12
4	2479	2768	12
5	2492	2778	11
6	2478	2765	12
7	2456	2740	12
8	2437	2724	12
9	2489	2774	11
10	2486	2776	12
Mean			12
Standard deviation			0,10
Coefficient of variation			0,84

Table 8. Water absorption according to EN 772-21.

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Appendix 3. Flexural and compressive strength of mortar prisms

5.1%. 90 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,22	39,0	40,1	0,53
2	0,25	39,0	40,0	0,60
3	0,26	39,1	40,1	0,62
Mean				**0,6**

Table 9. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,3	39,3	0,82
1b	1,2	39,2	0,79
2a	1,3	39,3	0,81
2b	1,2	39,3	0,78
3a	1,2	39,1	0,79
3b	1,2	39,1	0,77
Mean (ML)			**0,8**
MC Strength:			**0,40**

Table 10. Compressive strength

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6.6%. 90 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,30	39,4	39,8	0,72
2	0,27	39,8	40,3	0,61
3	0,30	39,7	40,1	0,71
Mean				**0,7**

Table 11. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,5	39,4	0,96
1b	1,5	39,4	0,93
2a	1,4	40,0	0,87
2b	1,5	39,5	0,92
3a	1,3	39,6	0,82
3b	1,5	39,4	0,94
Mean (ML)			**0,91**

MC Strength: **0,45**

Table 12. Compressive strength

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9.0%. 90 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,31	38,5	40,0	0,76
2	0,27	38,8	39,8	0,66
3	0,31	38,5	39,8	0,77
Mean				**0,7**

Table 13. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,7	38,4	1,12
1b	1,7	38,4	1,09
2a	1,7	38,7	1,07
2b	1,5	38,5	0,98
3a	1,7	38,7	1,10
3b	1,7	38,5	1,08
Mean (ML)			**1,07**
MC Strength:			**0,54**

Table 14. Compressive strength

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5.1%. 145 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,24	39,3	40,1	0,57
2	0,26	39,4	40,1	0,61
3	0,25	39,4	40,1	0,59
Mean				**0,6**

Table 15. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,5	39,2	0,96
1b	1,5	39,5	0,92
2a	1,5	39,6	0,94
2b	1,5	39,5	0,92
3a	1,5	39,5	0,94
3b	1,5	39,5	0,96
Mean (ML)			**0,9**
MC Strength:			**0,47**

Table 16. Compressive strength

6.6%. 145 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,27	39,5	39,7	0,66
2	0,26	39,6	39,9	0,62
3	0,29	39,3	40,0	0,68
Mean				**0,7**

Table 17. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,39	39,8	0,87
1b	1,47	39,1	0,94
2a	1,38	39,7	0,87
2b	1,44	39,2	0,92
3a	1,37	39,3	0,87
3b	1,50	38,9	0,97
Mean (ML)			**0,91**
MC Strength:			**0,45**

Table 18. Compressive strength

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9.0%. 145 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,32	38,5	39,9	0,77
2	0,33	38,5	39,9	0,80
3	0,31	38,7	39,7	0,76
Mean				**0,8**

Table 19. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,6	38,6	1,04
1b	1,4	38,3	0,91
2a	1,6	38,5	1,05
2b	1,7	38,6	1,07
3a	1,6	38,7	1,06
3b	1,7	38,5	1,13
Mean (ML)			**1,04**
MC Strength:			**0,52**

Table 20. Compressive strength

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5.1%. 230 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,27	39,2	40,0	0,64
2	0,28	39,4	40,0	0,68
3	0,26	39,4	40,0	0,61
Mean				**0,6**

Table 21. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,4	39,4	0,86
1b	1,2	39,7	0,78
2a	1,1	39,2	0,73
2b	1,3	39,5	0,83
3a	1,2	39,4	0,74
3b	1,1	39,3	0,70
Mean (ML)			**0,8**
MC Strength:			**0,39**

Table 22. Compressive strength

TEKNOLOGISK INSTITUT

6.6%. 230 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,24	38,9	40,0	0,59
2	0,26	38,2	40,3	0,63
3	0,28	38,8	40,0	0,68
Mean				**0,6**

Table 23. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,32	39,0	0,85
1b	1,42	38,4	0,92
2a	1,46	38,9	0,94
2b	1,44	39,5	0,91
3a	1,40	39,2	0,89
3b	1,47	39,1	0,94
Mean (ML)			**0,91**
MC Strength:			**0,45**

Table 24. Compressive strength

TEKNOLOGISK INSTITUT

9.0%. 230 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,28	38,7	39,8	0,69
2	0,29	39,1	39,9	0,70
3	0,29	38,7	39,6	0,73
Mean				**0,7**

Table 25. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,5	38,8	0,97
1b	1,4	38,9	0,89
2a	1,6	39,1	0,99
2b	1,4	38,6	0,89
3a	1,6	39,1	1,01
3b	1,4	38,5	0,88
Mean (ML)			**0,94**
MC Strength:			**0,47**

Table 26. Compressive strength

TEKNOLOGISK INSTITUT

5.1%. 300 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,25	39,3	39,9	0,61
2	0,25	39,5	40,1	0,58
Mean				**0,6**

Table 27. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,4	39,0	0,87
1b	1,2	39,3	0,76
2a	1,4	39,0	0,88
2b	1,2	39,5	0,75
3a	1,2	38,9	0,78
Mean (ML)			**0,8**
MC Strength:			**0,40**

Table 28. Compressive strength

TEKNOLOGISK INSTITUT

6.6%. 300 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,22	39,2	40,0	0,52
2	0,20	39,3	40,0	0,46
3	0,19	39,4	41,0	0,43
Mean				**0,5**

Table 29. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,60	39,3	1,02
1b	1,59	39,3	1,01
2a	1,56	39,2	0,99
2b	1,45	39,5	0,92
3a	1,62	39,2	1,03
3b	1,66	39,3	1,05
Mean (ML)			**1,01**
MC Strength:			**0,50**

Table 30. Compressive strength

TEKNOLOGISK INSTITUT

9.0%. 300 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,22	38,6	39,7	0,54
2	0,21	38,7	40,0	0,51
3	0,23	38,2	39,8	0,57
Mean				**0,5**

Table 31. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,7	38,8	1,10
1b	1,6	38,6	1,02
2a	1,7	38,8	1,09
2b	1,5	38,9	0,98
3a	1,5	38,6	0,95
3b	1,5	38,8	0,99
Mean (ML)			**1,02**
MC Strength:			**0,51**

Table 32. Compressive strength

TEKNOLOGISK
INSTITUT

5.1%. 370 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,19	39,1	40,1	0,44
2	0,17	39,3	40,0	0,41
3	0,20	39,4	40,0	0,48
Mean				**0,4**

Table 33. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,3	39,1	0,85
1b	1,4	39,1	0,86
2a	1,2	39,2	0,79
2b	1,2	39,4	0,75
3a	1,2	39,2	0,79
3b	1,3	39,2	0,85
Mean (ML)			**0,8**
MC Strength:			**0,40**

Table 34. Compressive strength

TEKNOLOGISK INSTITUT

6.6%. 370 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,21	39,0	40,0	0,50
2	0,20	39,1	40,3	0,46
3	0,21	39,2	40,0	0,51
Mean				**0,5**

Table 35. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,49	39,0	0,95
1b	1,57	39,1	1,01
2a	1,52	39,1	0,97
2b	1,55	39,1	0,99
3a	1,42	39,3	0,90
3b	1,33	39,2	0,85
Mean (ML)			**0,95**
MC Strength:			**0,47**

Table 36. Compressive strength

TEKNOLOGISK INSTITUT

9.0%. 370 days.

Sample	Failure load (kN)	b (mm)	h (mm)	Strength (MPa)
1	0,27	38,6	39,7	0,66
2	0,26	38,8	39,8	0,64
3	0,25	39,0	39,7	0,60
Mean				**0,6**

Table 37. Flexural strength

Sample	Failure load (kN)	b (mm)	Strength (MPa)
1a	1,8	38,5	1,19
1b	1,6	38,9	1,06
2a	1,6	38,5	1,01
2b	1,6	39,1	0,99
3a	1,6	38,4	1,05
3b	1,7	38,5	1,13
Mean (ML)			**1,07**
MC Strength:			**0,54**

Table 38. Compressive strength

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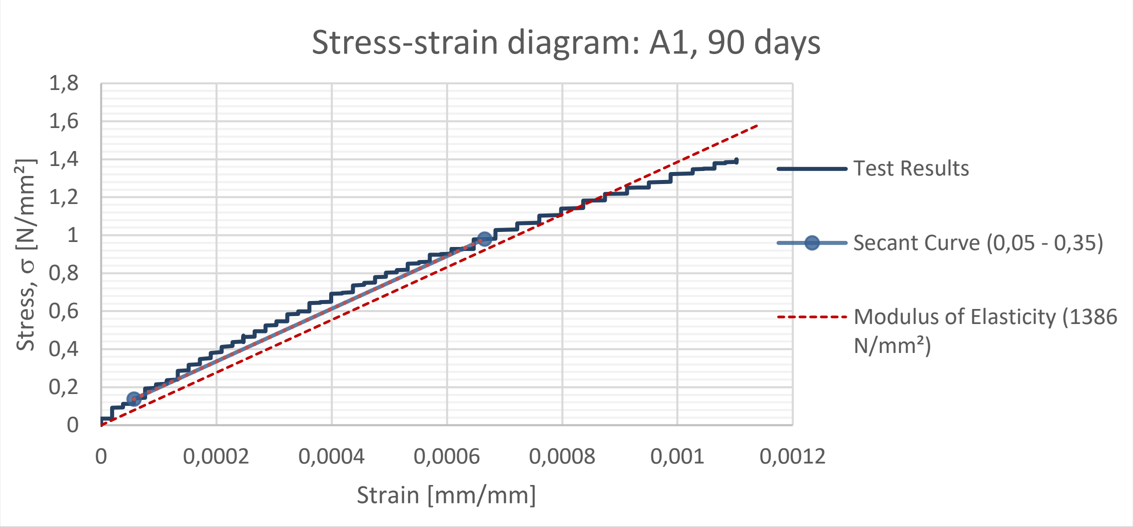
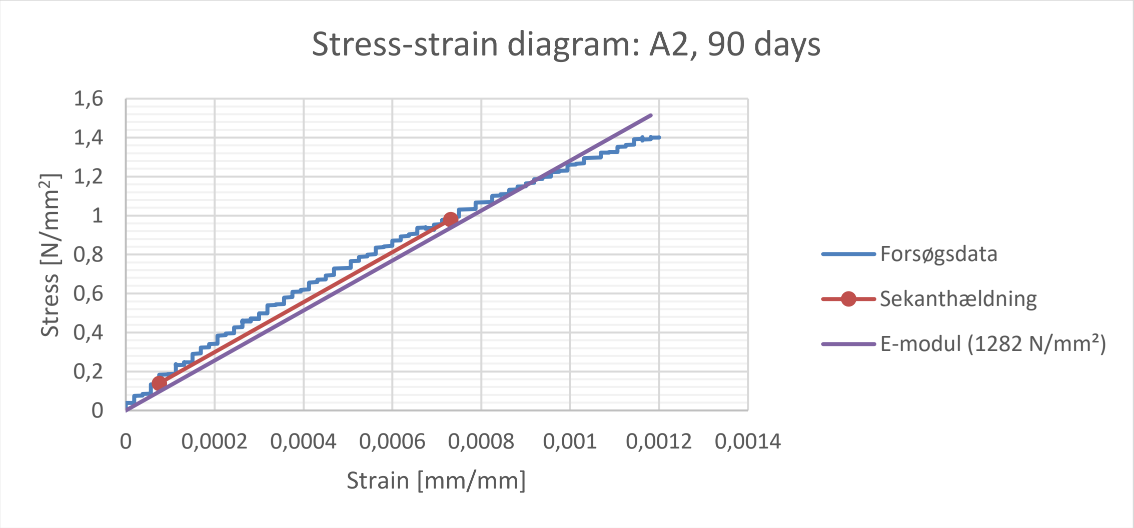
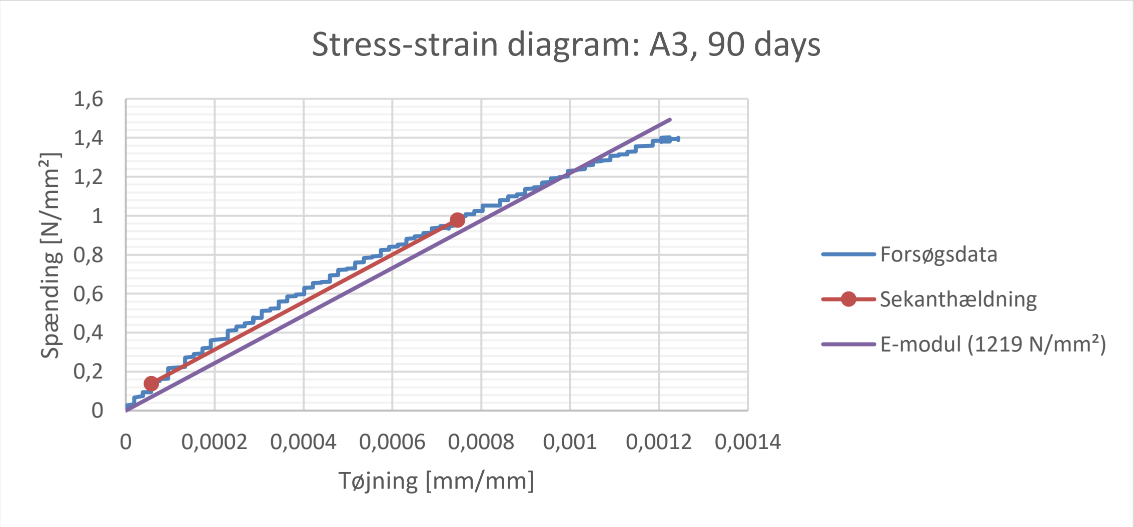
Appendix 4. Stress-strain-diagrams







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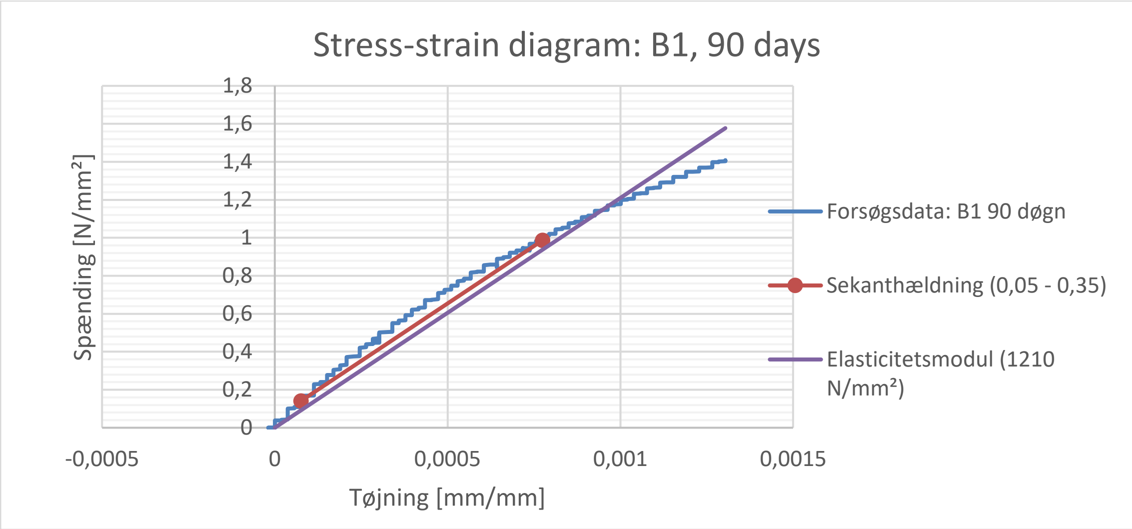
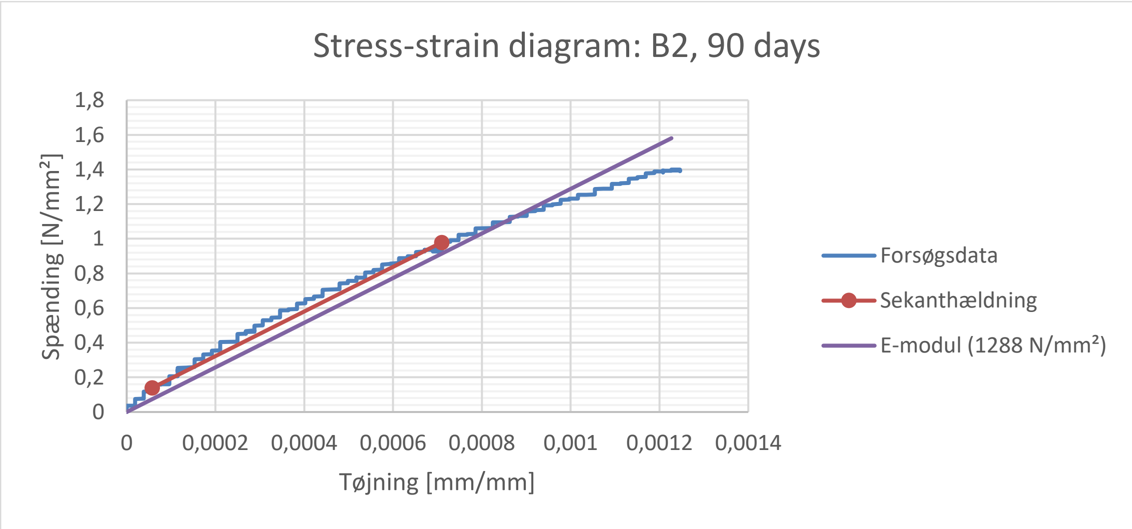
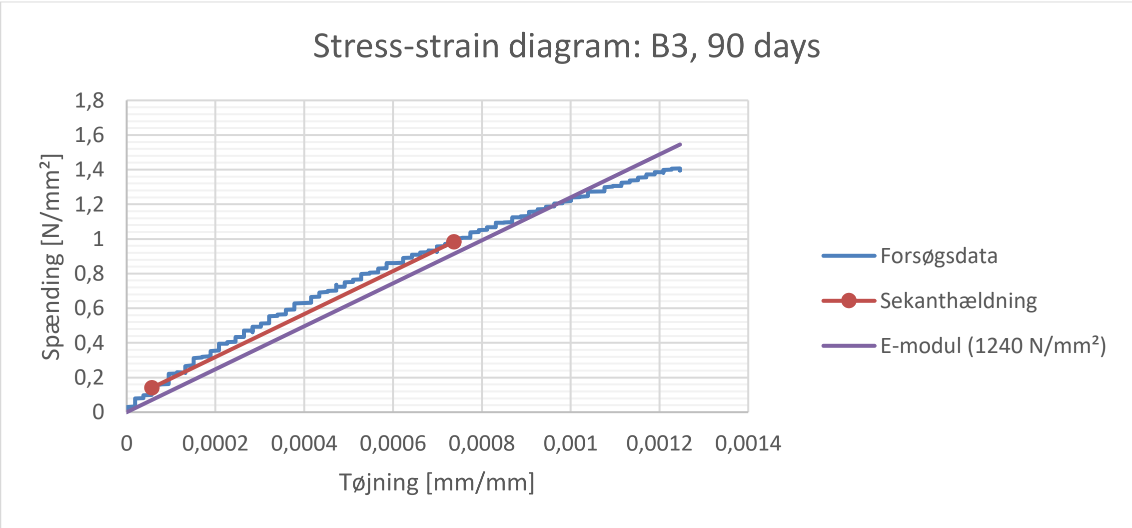
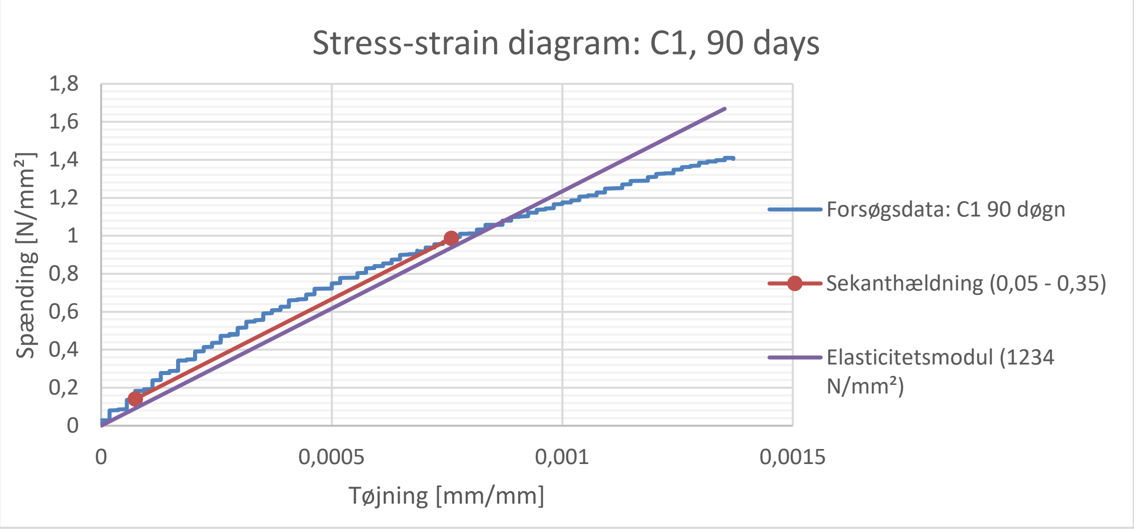
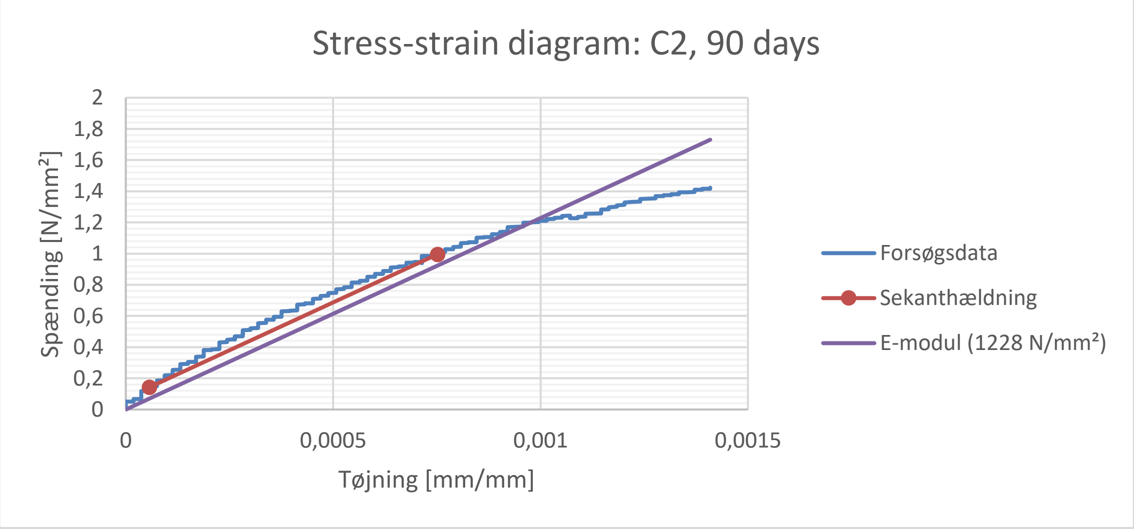
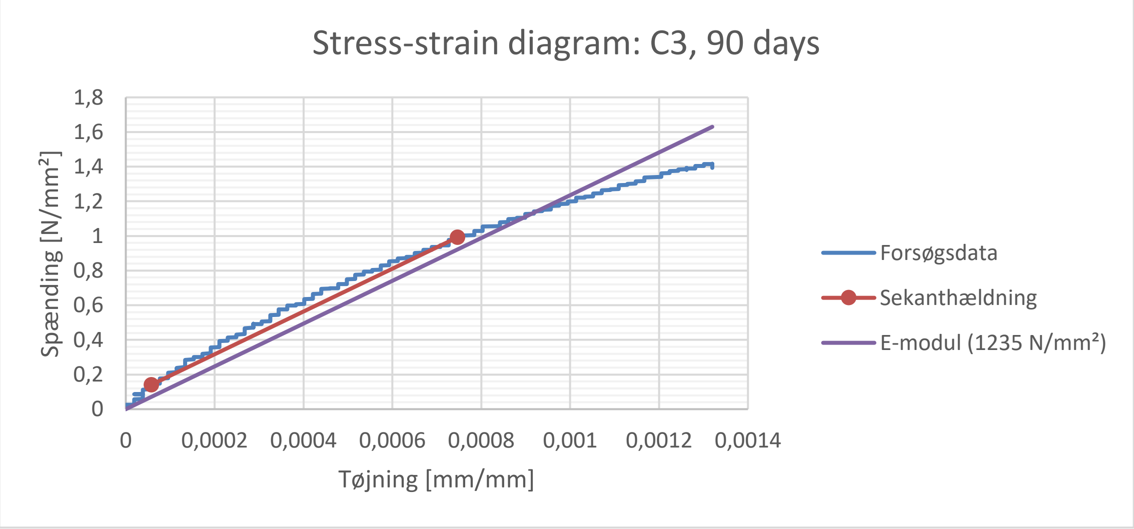







Stress-strain diagram: C1, 90 days
Spænding [N/mm²]
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
0
0,0005
0,001
0,0015
Tøjning [mm/mm]
Forsøgsdata: C1 90 døgn
Sekanthældning (0,05 - 0,35)
Elasticitetsmodul (1234 N/mm²)


Stress-strain diagram: C2, 90 days
Spænding [N/mm²]
2
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
0
0,0005
0,001
0,0015
Tøjning [mm/mm]
Forsøgsdata
Sekanthældning
E-modul (1228 N/mm²)


Stress-strain diagram: C3, 90 days
Spænding [N/mm²]
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
0
0,0002
0,0004
0,0006
0,0008
0,001
0,0012
0,0014
Tøjning [mm/mm]
Forsøgsdata
Sekanthældning
E-modul (1235 N/mm²)

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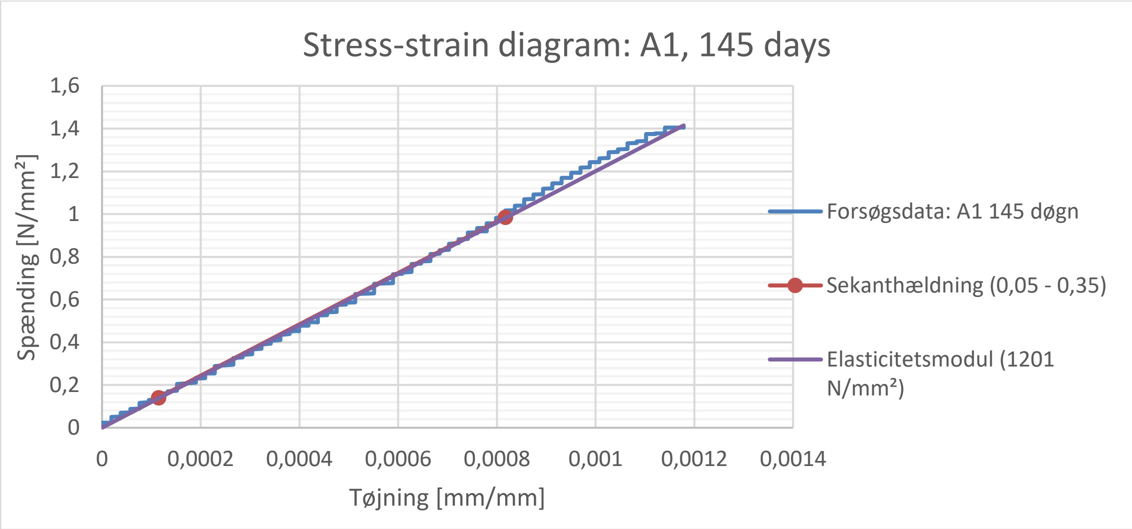

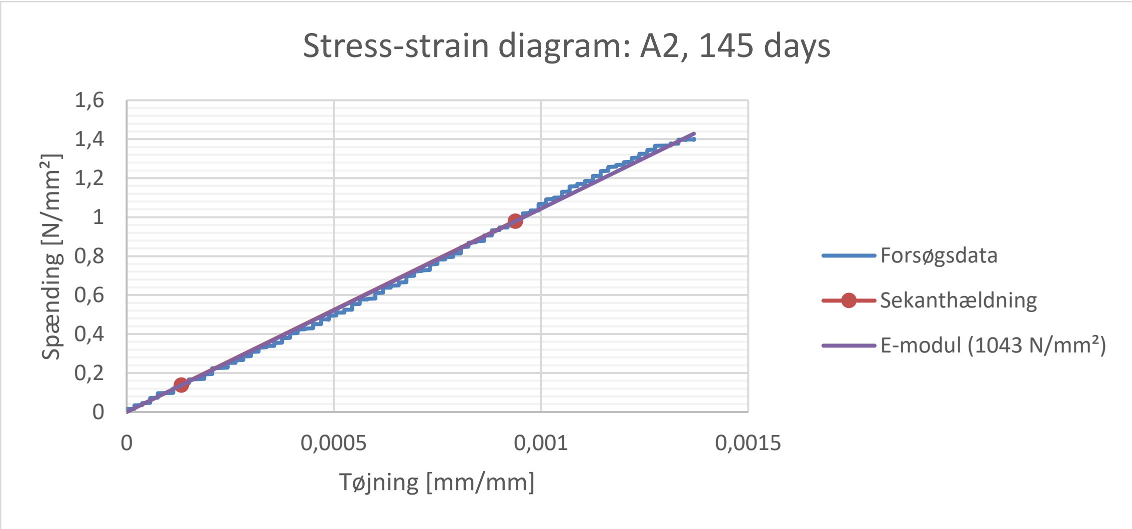

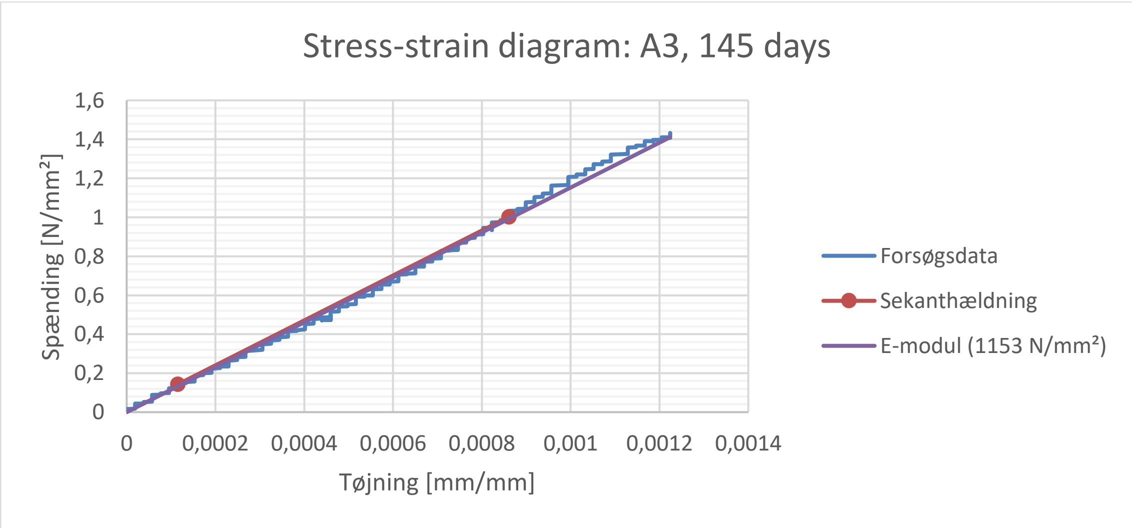

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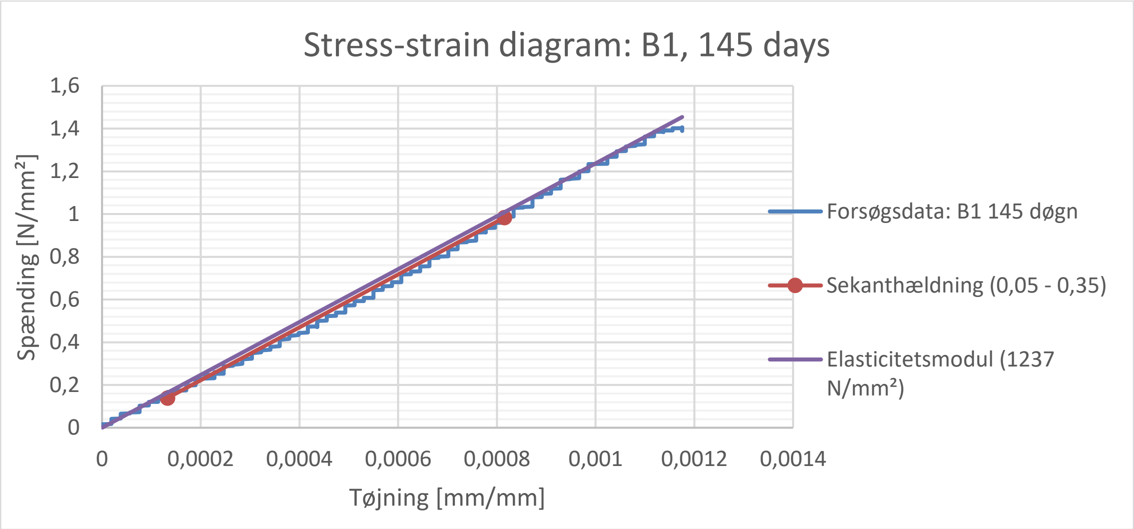

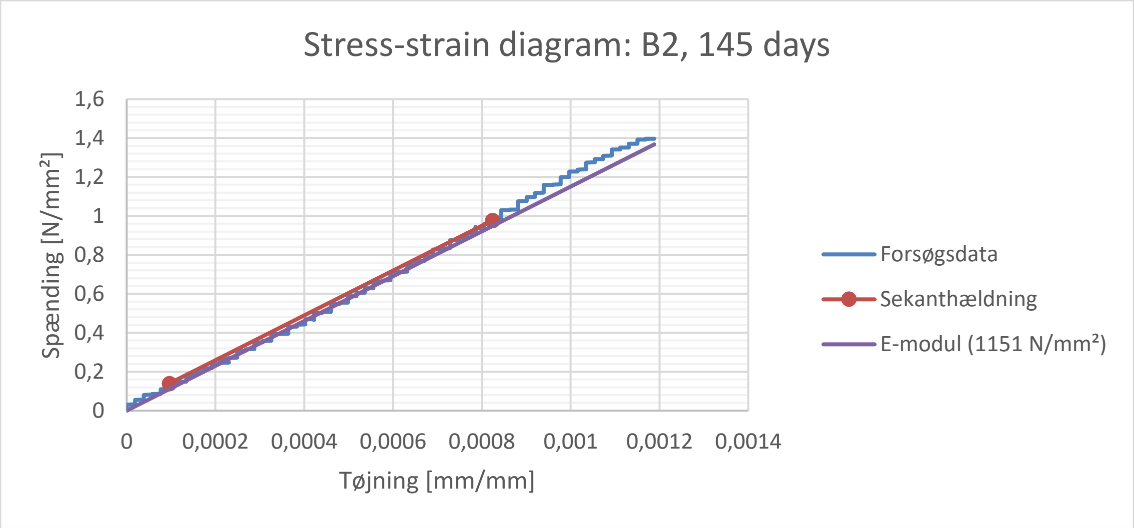

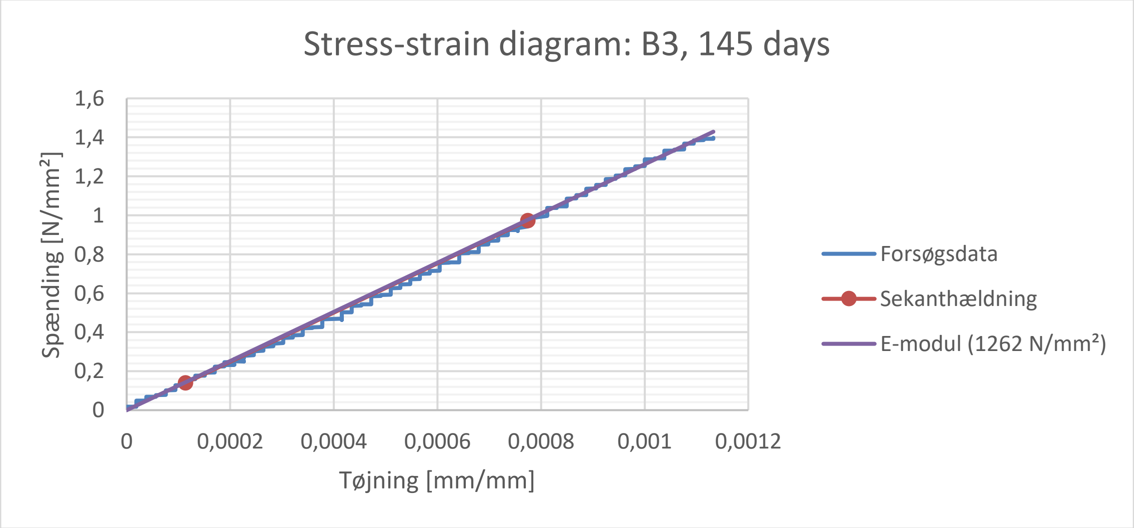

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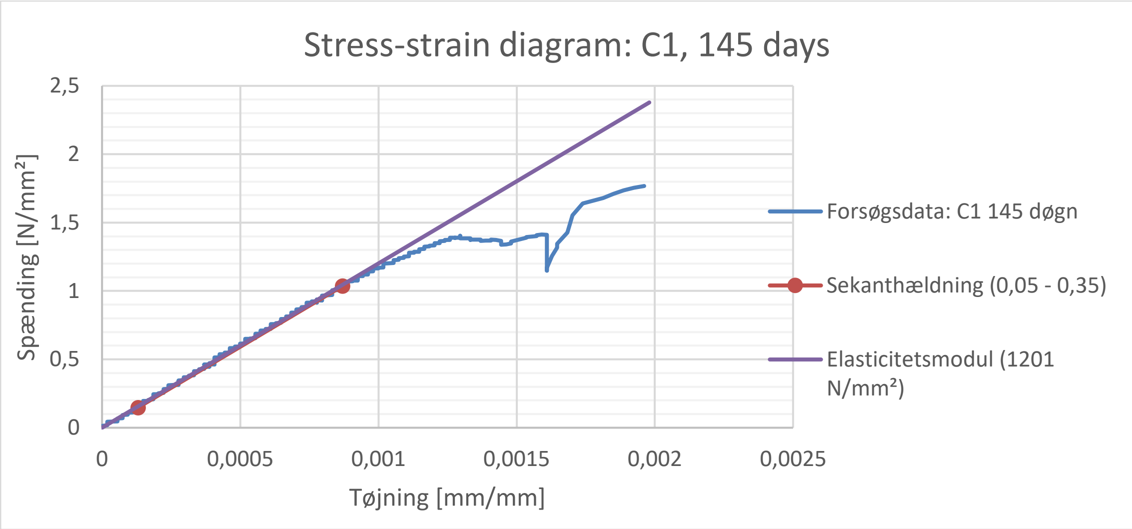

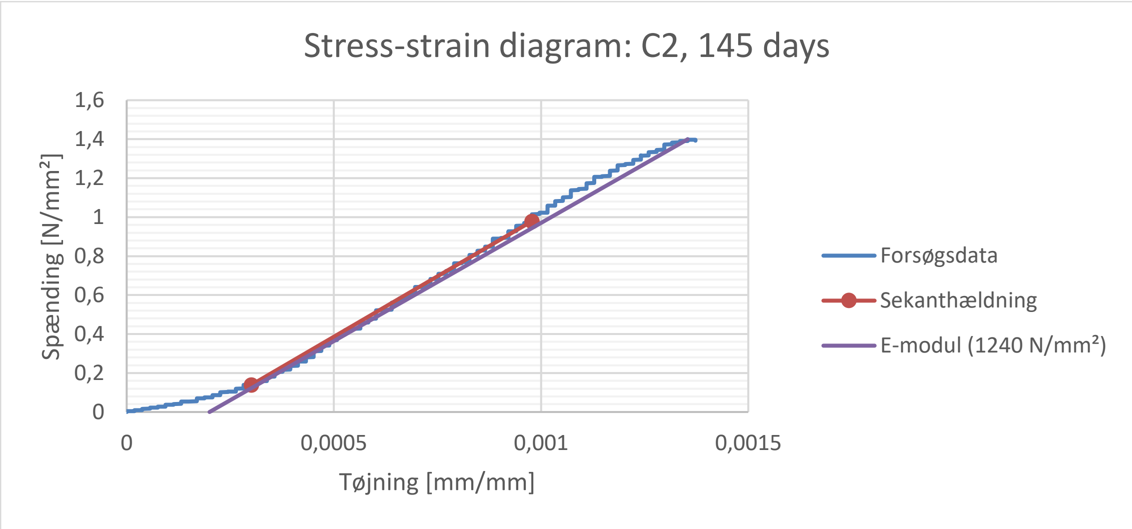

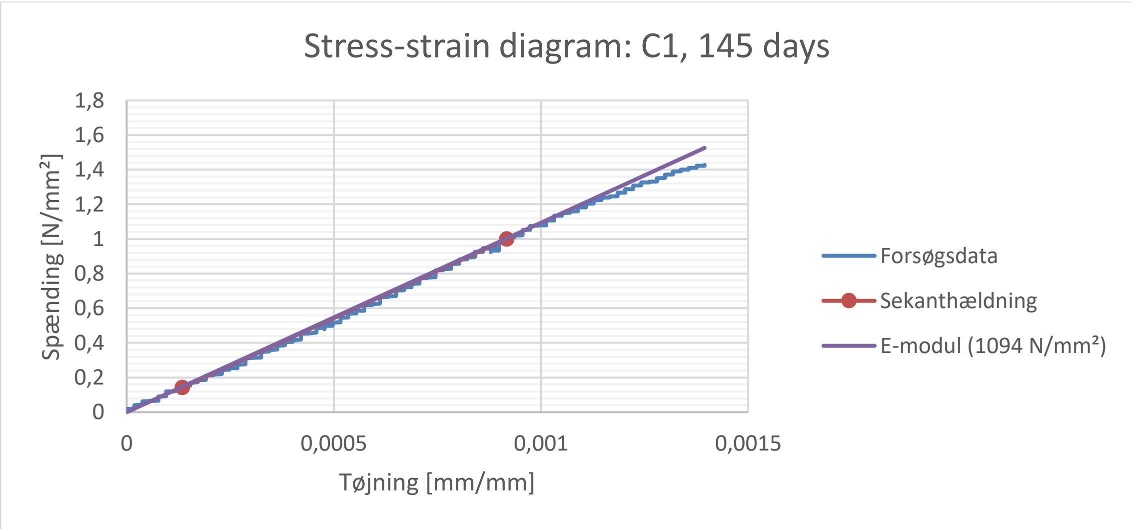

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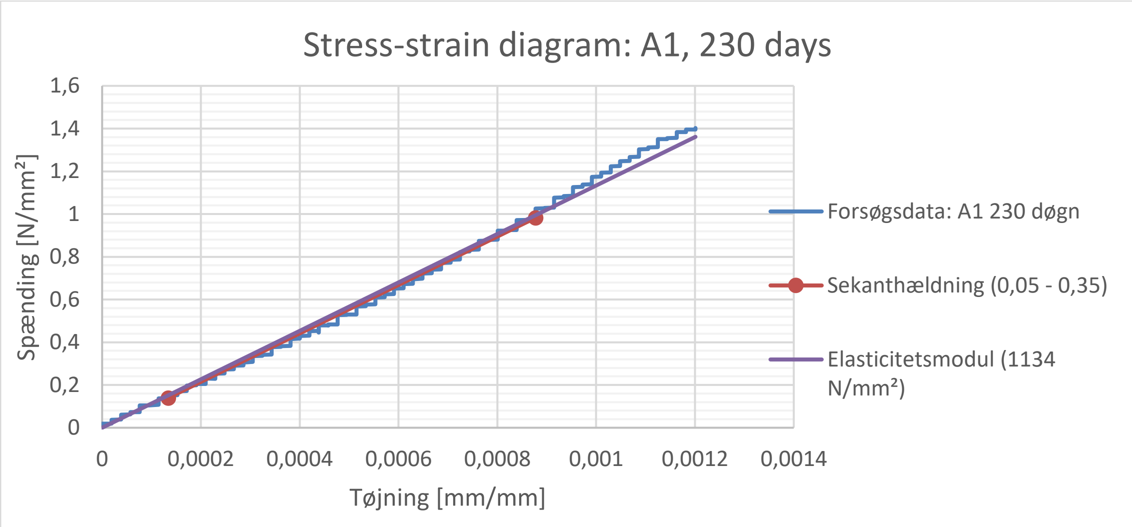

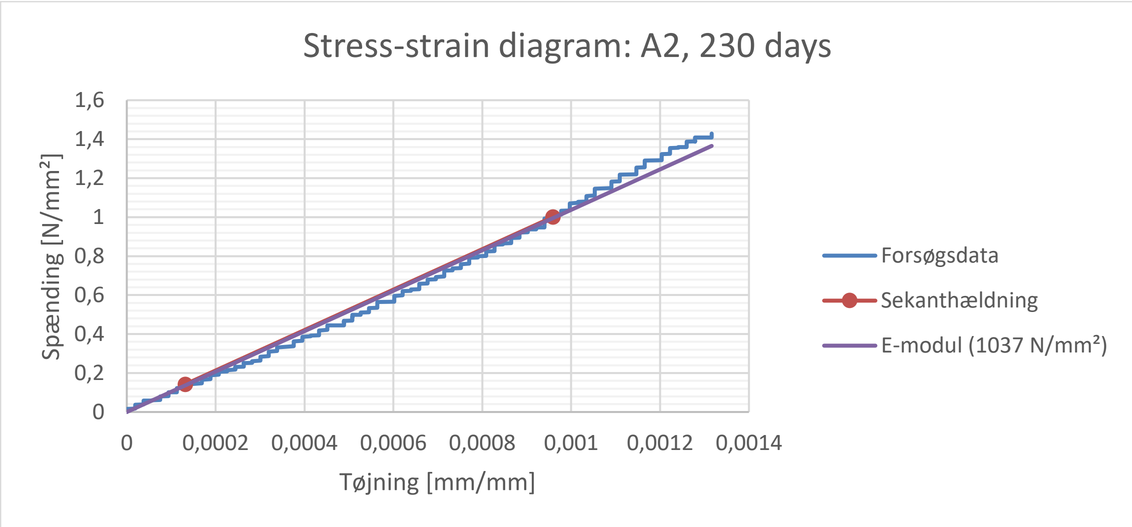

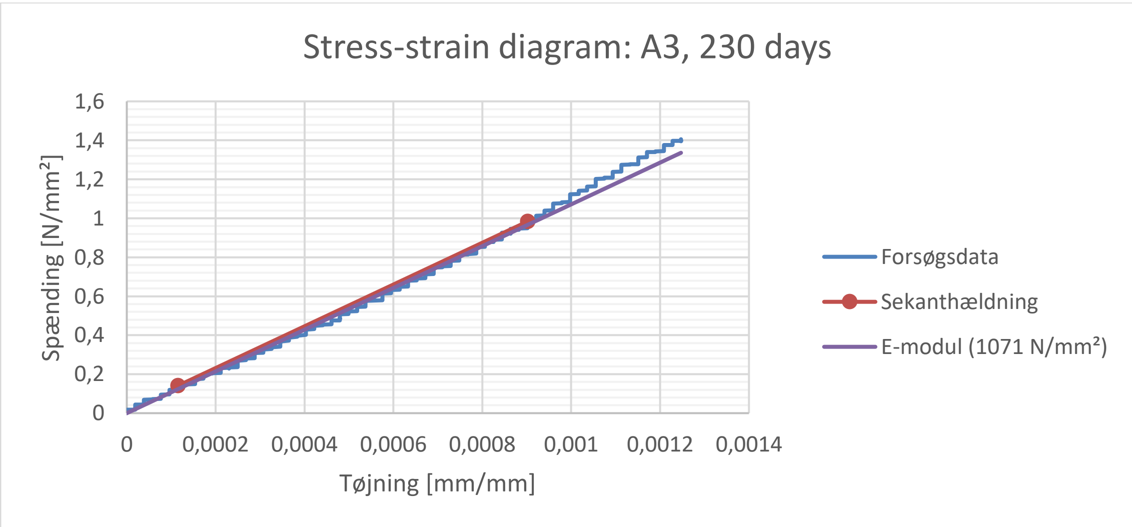

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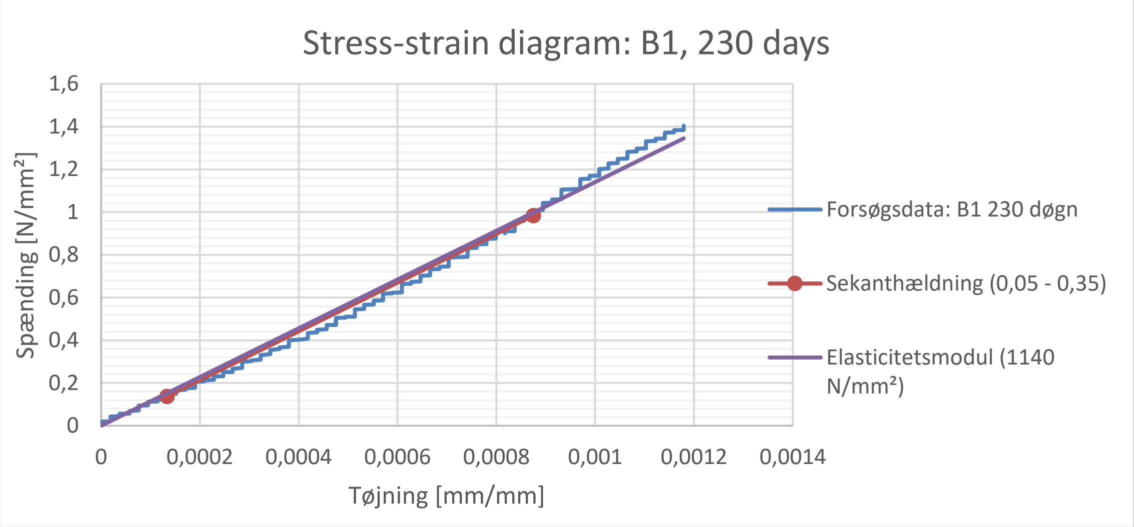
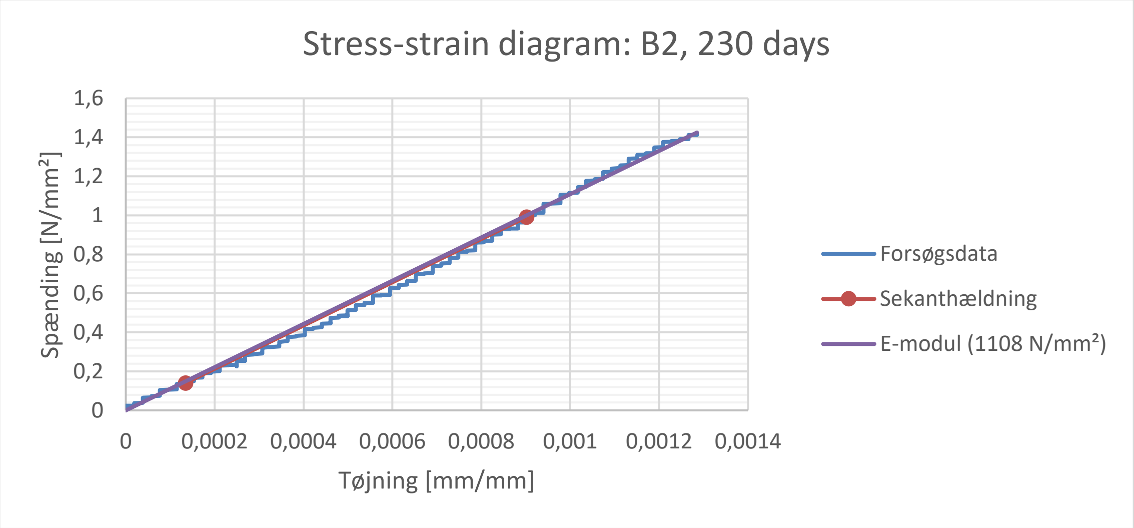
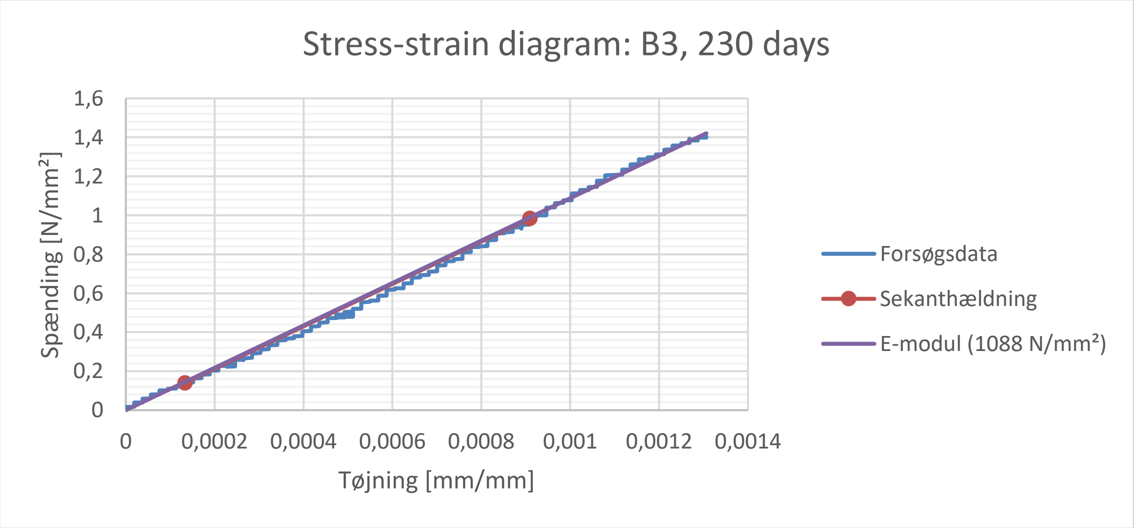
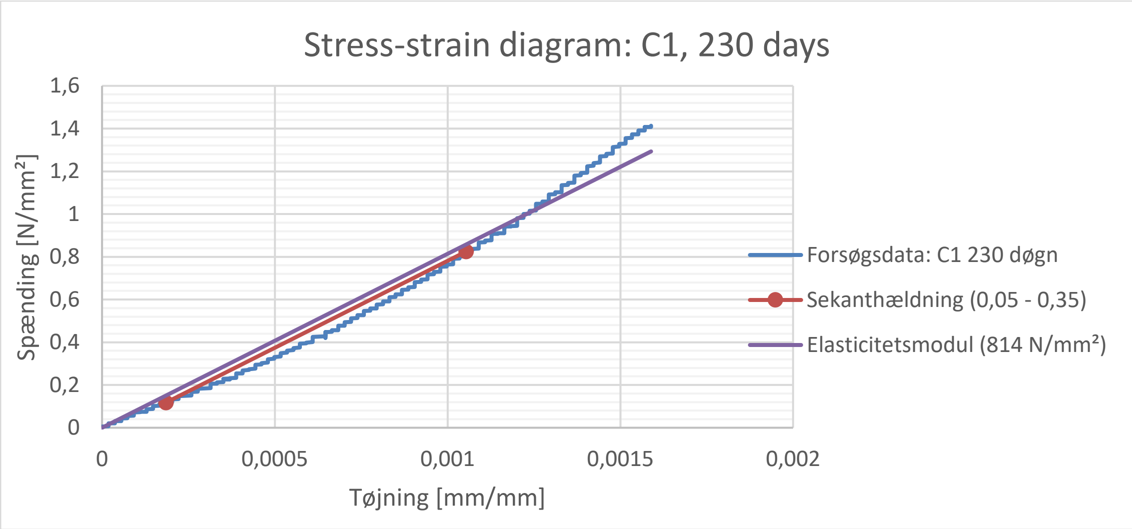
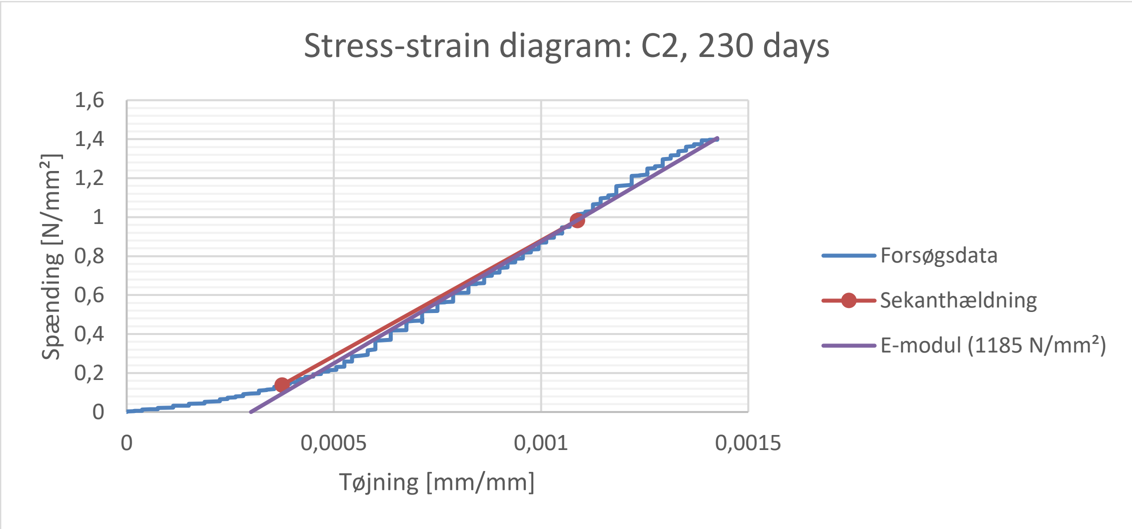
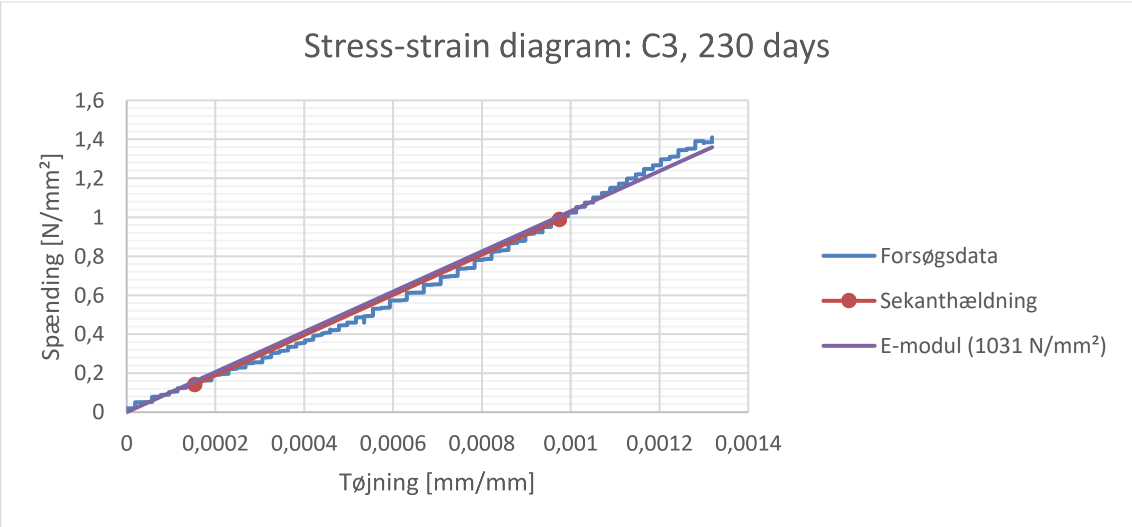




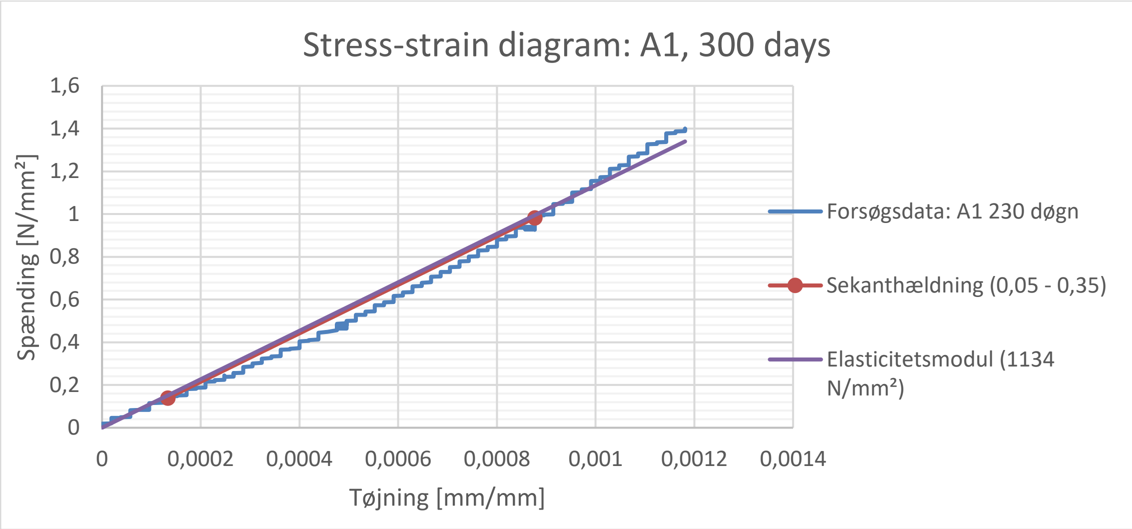


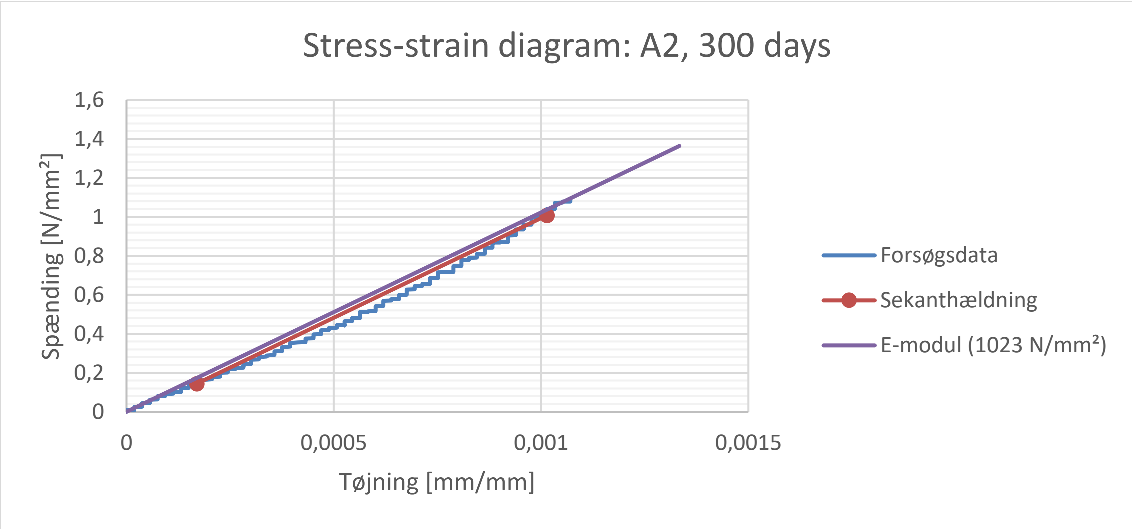

Stress-strain diagram: C1, 230 days
Spænding [N/mm²]
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
0
0,0005
0,001
0,0015
0,002
Tøjning [mm/mm]
Forsøgsdata: C1 230 døgn
Sekanthældning (0,05 - 0,35)
Elasticitetsmodul (814 N/mm²)

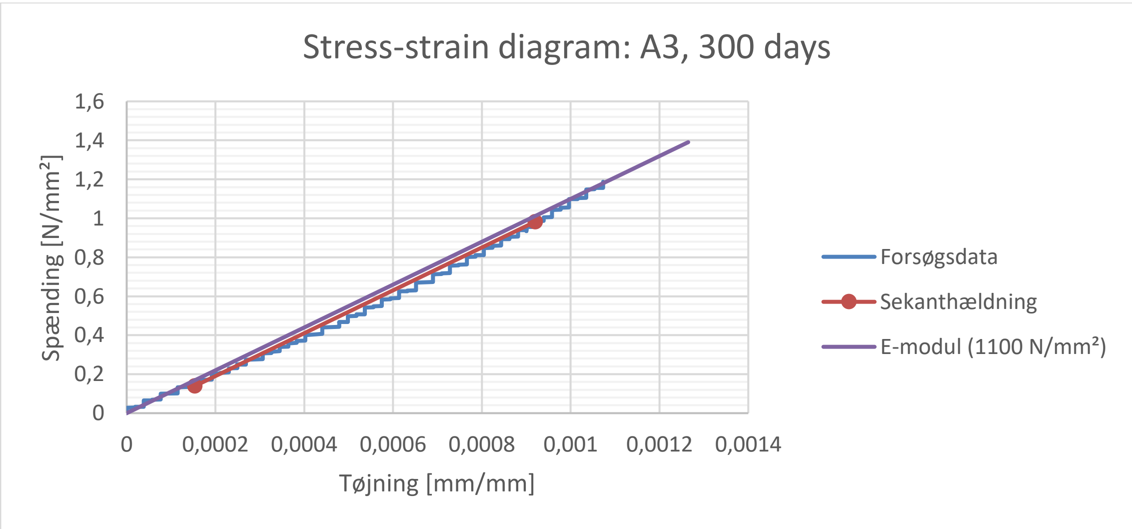

Stress-strain diagram: C2, 230 days
Spænding [N/mm²]
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
0
0,0005
0,001
0,0015
Tøjning [mm/mm]
Forsøgsdata
Sekanthældning
E-modul (1185 N/mm²)


Stress-strain diagram: C3, 230 days
Spænding [N/mm²]
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
0
0,0002
0,0004
0,0006
0,0008
0,001
0,0012
0,0014
Tøjning [mm/mm]
Forsøgsdata
Sekanthældning
E-modul (1031 N/mm²)

TEKNOLOGISK INSTITUT







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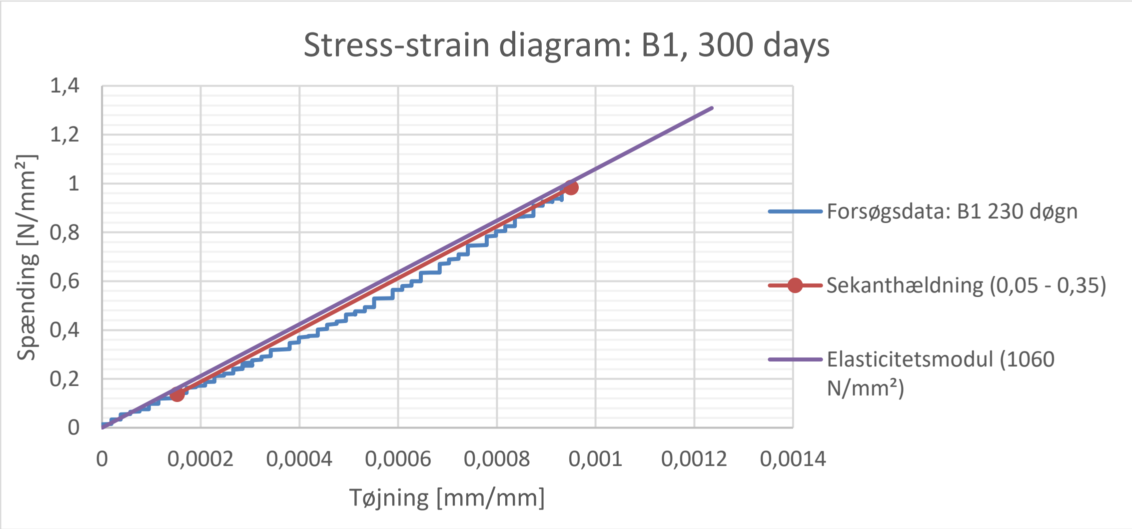
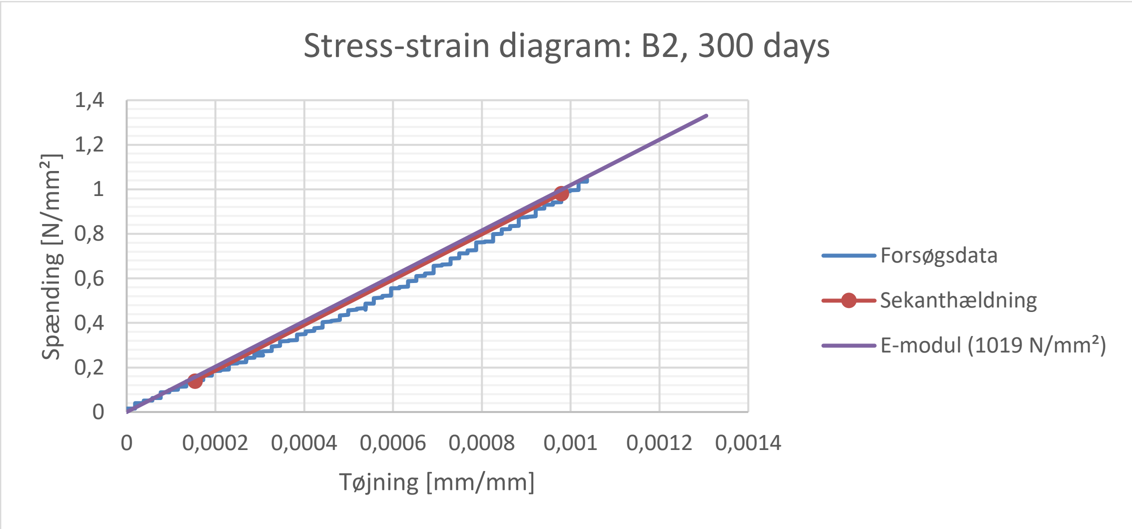
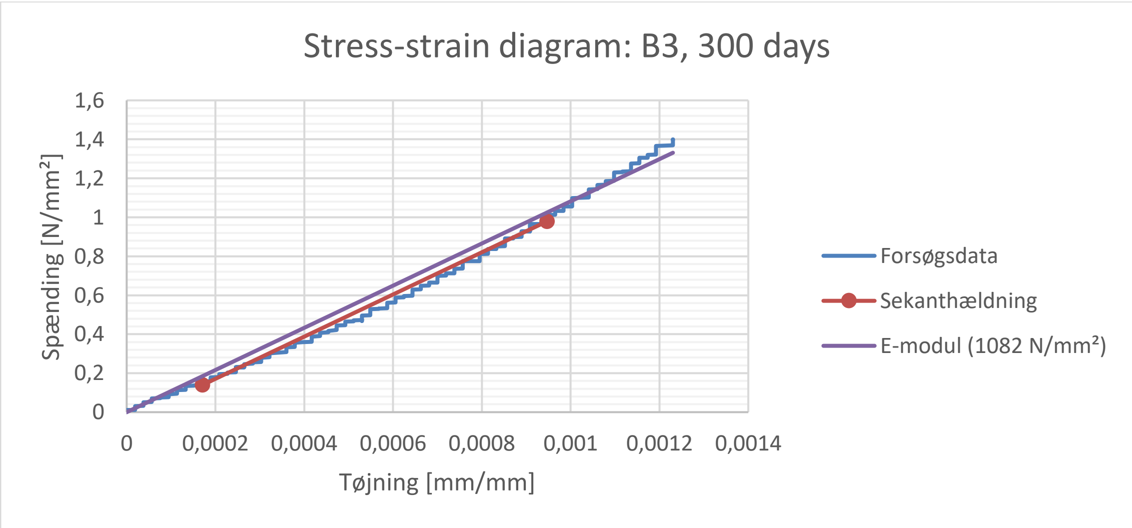
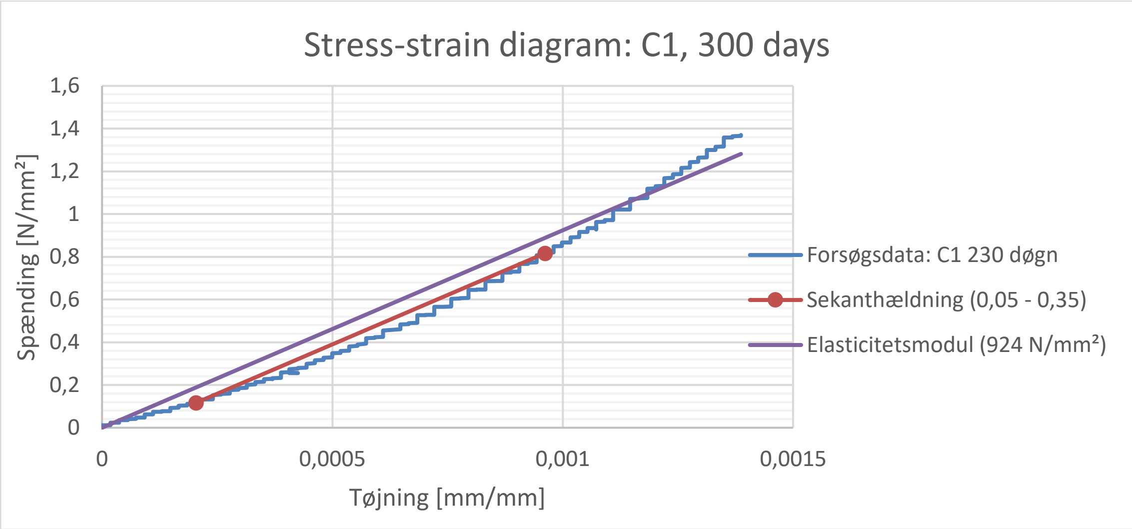
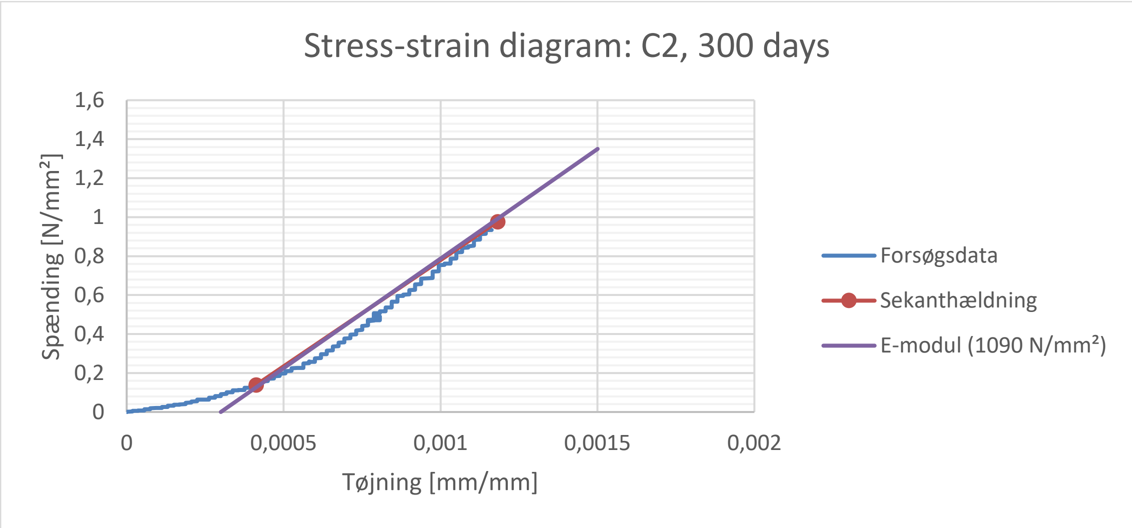







Stress-strain diagram: C1, 300 days
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
Spænding [N/mm²]
0
0,0005
0,001
0,0015
Tøjning [mm/mm]
Forsøgsdata: C1 230 døgn
Sekanthældning (0,05 - 0,35)
Elasticitetsmodul (924 N/mm²)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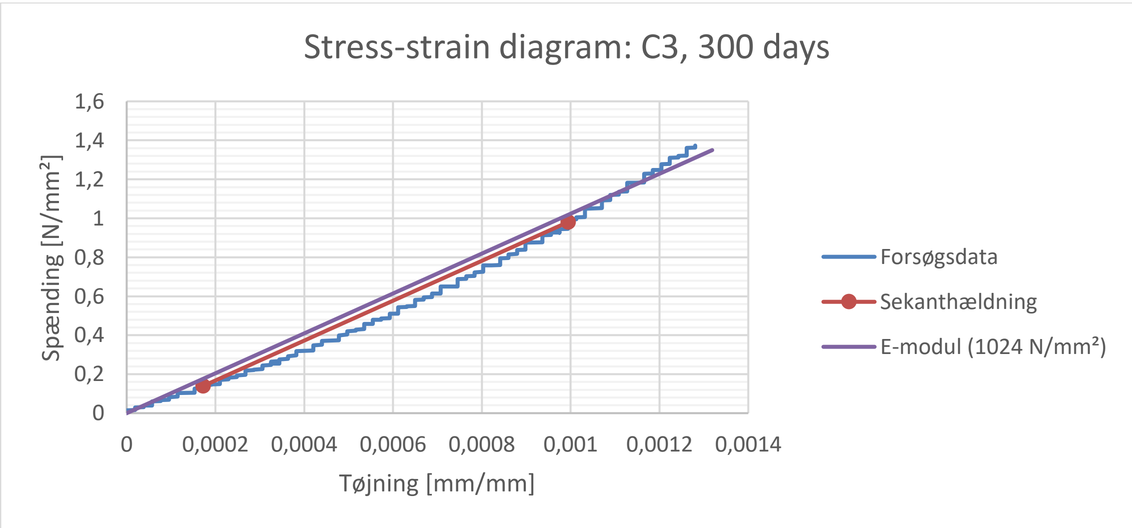
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
Spænding [N/mm²]
0
0,0005
0,001
0,0015
0,002
Tøjning [mm/mm]
Forsøgsdata
Sekanthældning
E-modul (1090 N/mm²)


Stress-strain diagram: C3, 300 days
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
Spænding [N/mm²]
0
0,0002
0,0004
0,0006
0,0008
0,001
0,0012
0,0014
Tøjning [mm/mm]
Forsøgsdata
Sekanthældning
E-modul (1024 N/mm²)

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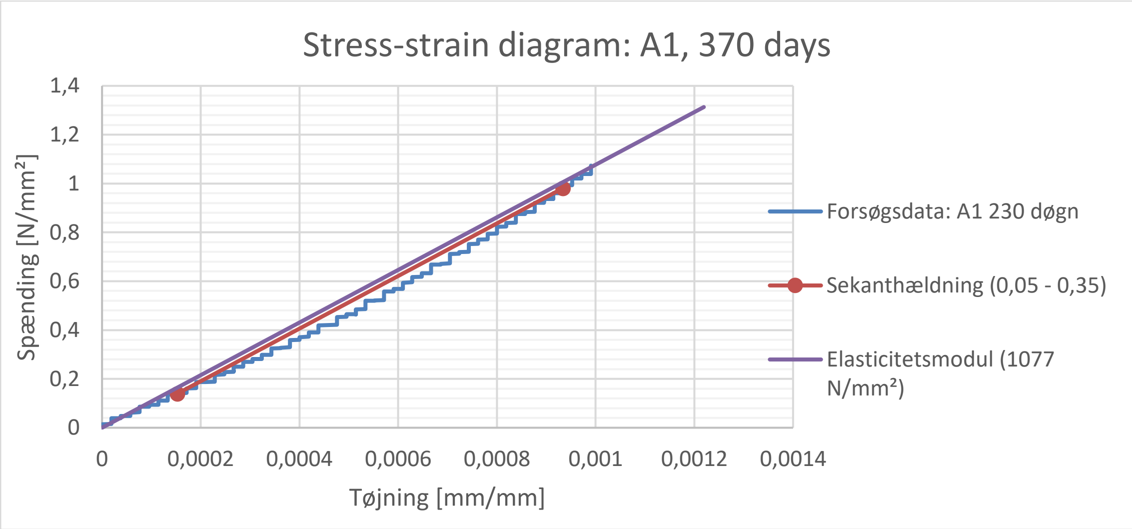

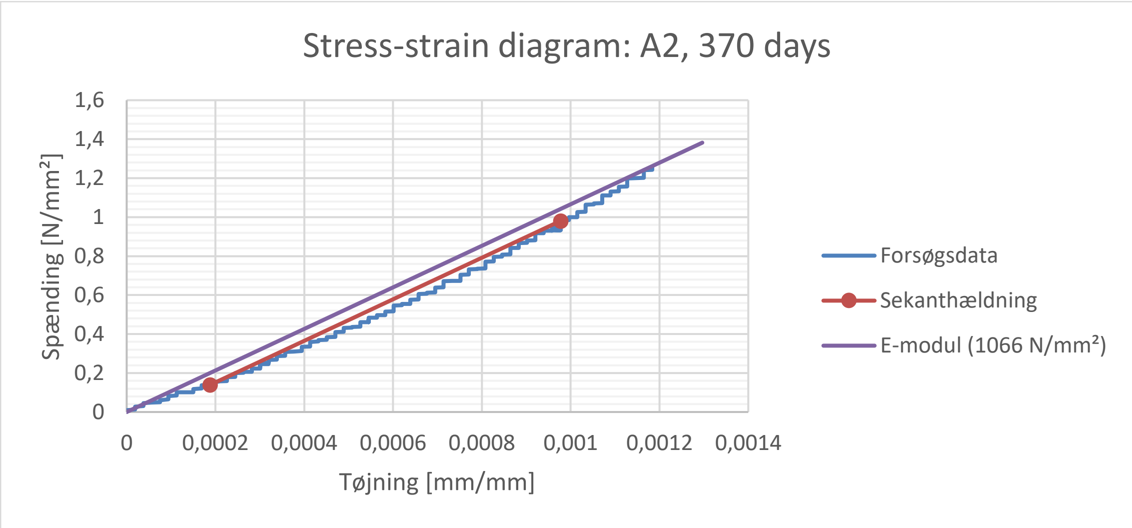

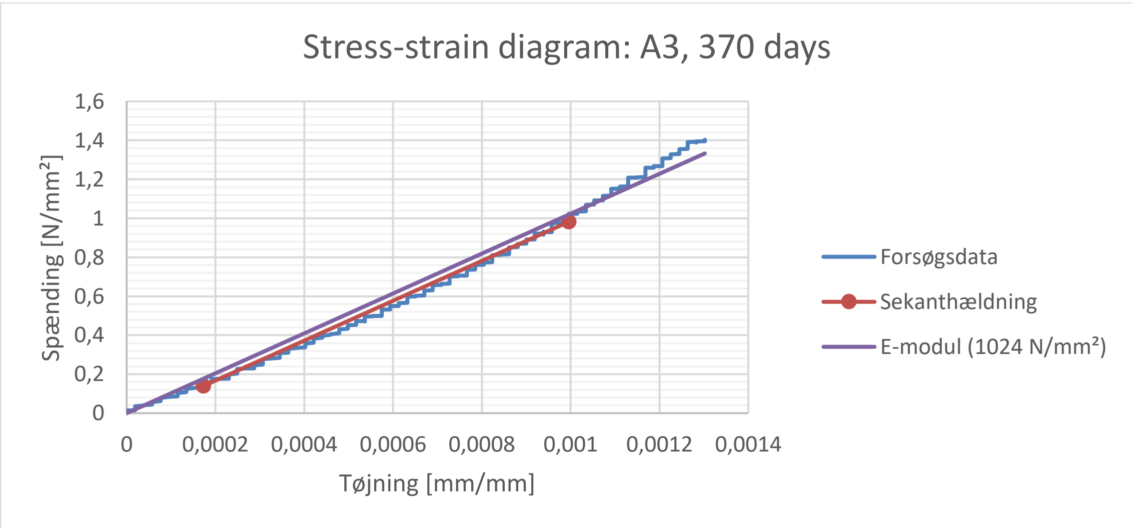

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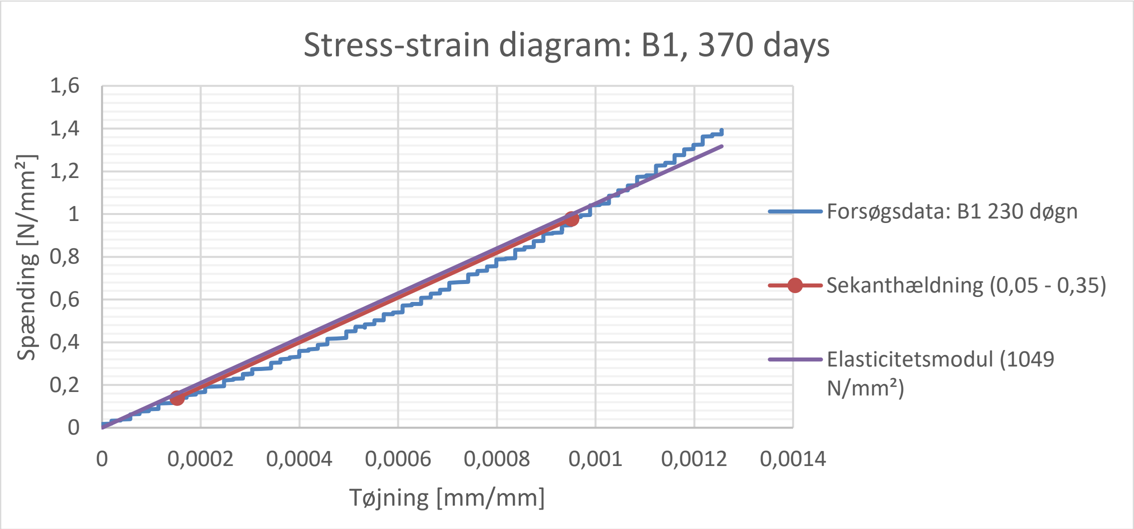

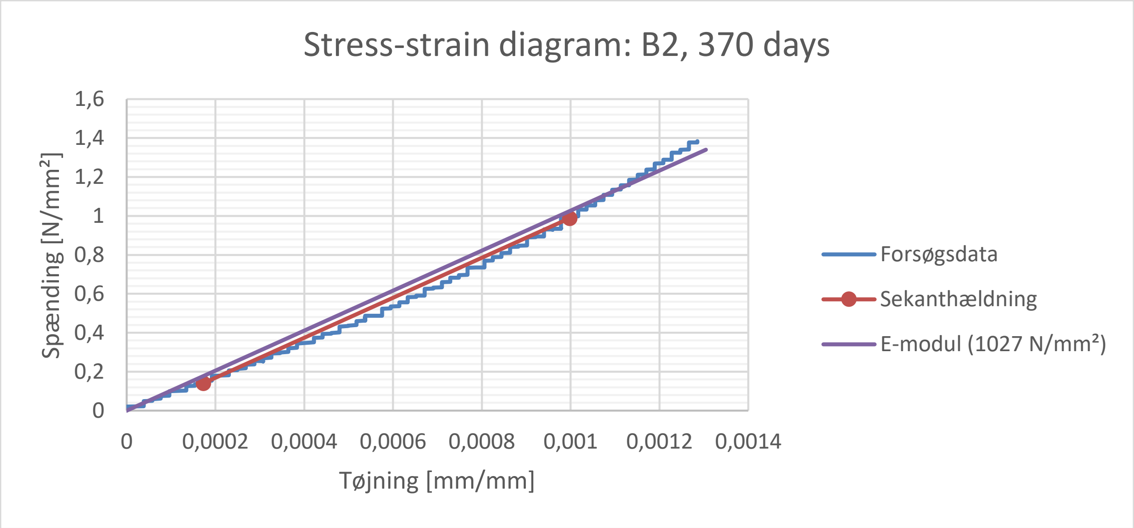

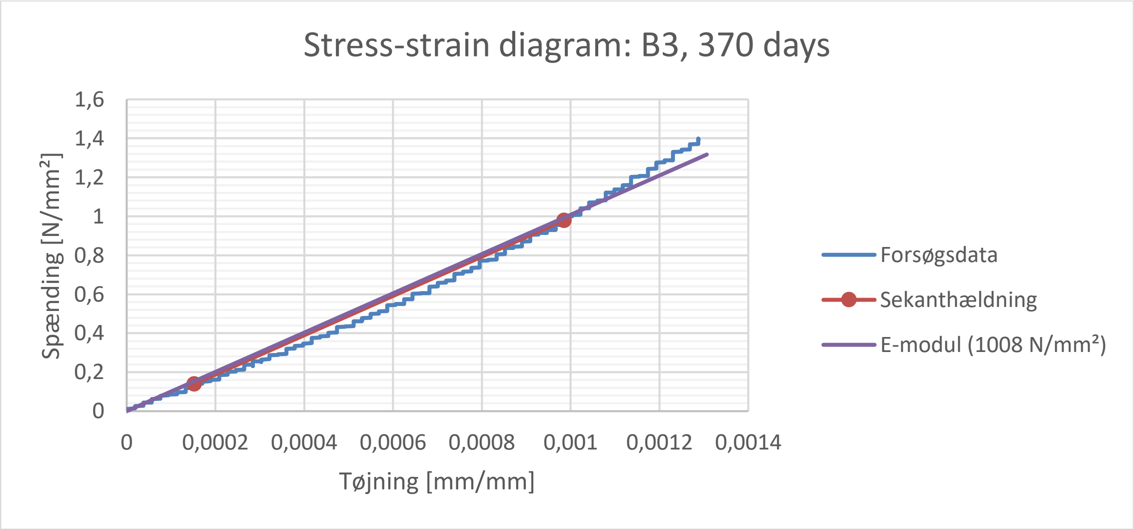

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