Measurement Report on the Transition between Flexural and Shear Failure on RC Beams without Shear Reinforcement

Koekkoek, R.T.; Yang, Y.

Publication date
2016

Citation (APA)
Koekkoek, R. T., & Yang, Y. (2016). *Measurement Report on the Transition between Flexural and Shear Failure on RC Beams without Shear Reinforcement*. Delft University of Technology.

Delft University of Technology
Faculty of Civil Engineering and Geosciences
Department of Design and Construction
Section of Structural and Building Engineering
Concrete Structures

Report	25.5-16-04
Project	C33B89
Date	November 2016
Status	Draft
Version	0.01

Measurement Report on the Transition between Flexural and Shear Failure of RC Beams without Shear Reinforcement

Ir. R.T. Koekkoek
Dr.ir Y. Yang

PO Box 5048
2600GA Delft
The Netherlands
yuguang.yang@tudelft.nl

RELEASE NOTES

Version	Date	Detail
	25/10/2016	A121B1, A123B2, A601B2, C751B2, C451A3, R802A1, P301B1, P501B2 failure mode C901A2, C451A4, C451B2, C451B4, adjustment of comments C451B4 value changed in general table
1.00	05/11/16	Table 2.1.1 and Table 2.1.2 mistakes corrected. Fig. 2.2.20, was added with explanations. Fig. 3.3.1 was corrected. Still have to check R501B1 lvdt12.

CONTENTS

SUMMARY

This is a measurement report of the test series on reinforced concrete beams withouth shear reinforced carried out in Delft University of Technology from April 08, 2015 till Auguest 23, 2016. The target of the research is to investigate the transision of shear failure and bending failure. In this report, the detailed information of the experimental program is given. In addition to that, the main results of each experiment, including the description of each test, a selection of the measurement results are summarized. This report is used as an accompany to support the conclusions and the analysis of the report on the determination of the minimum shear strength before flexural failure, and other researches related to this shear – bending test series.

NOTATION LIST

a	Distance from centre of support to centre of loading point
a/d	Shear slenderness ratio. Also expressed as M/Vd.
AE	Acoustic Emission. A measurement technique to monitor the acoustic signals emited during the loading process.
c	Concrete cover applied on outer reinforcement bars
d	Effective heigt of the tested specimen, calculated as $h - c - 0.5Ø_{mean}$
Displacement	Vertical displacement of specimen, measured at the loading position and corrected for vertical displacements measured at supports
DIC	Digital Image Correlation, a photogrammetry measurement approach to track the deformation of a surface.
$f_{c,cube}$	Concrete compressive cube strength determined by testing concrete cubes with dimensions 150×150×150 mm^3, casted during casting of the specimens
$f_{ct,split}$	Concrete tensile strength, determined by splitting concrete cubes with dimensions 150×150×150 mm^3, casted during casting of the specimens
h	Total height of the tested specimen
Laser	Abreviation of laser triangulation displacement sensor, it measures deflections in a single direction.
Load	Total applied load on tested specimen measured by the calibrated loadcell
LVDT	Linear Variable Differential Transformer, sensor used to measure deformations and deflections in a single direction
$Ø_{cal}$	Calculated rebar diameter based on weight, length and specific weight of steel
$Ø_{mean}$	Nominal rebar diameter of reinforcement
P	Applied load, see Load
P_u	Maximum load for yielding or shear failure, when only one failure mechanism is observed
P_y	Load level at which yielding of the reinforcement is observed. It equals to P_u when no other failure occurred after further increase of the deflection.
$x_{c,b}$	Distance between the the shear crack at the bottom reinforcement level and the centre of the support.
$x_{c,m}$	Distance between the shear crack at the centre line of the specimen and the centre of the support.
ρ	Reinforcement ratio of tested specimen. Calculated by using the effective depth d of the specimen.

1. INTRODUCTION

This is a measurement report of the test series on reinforced concrete beams withouth shear reinforced carried out in Delft University of Technology from April 08, 2015 till July 01, 2016. The target of the research is to investigate the transision of shear failure and bending failure. In this report, the dteiled information of the experimental program is given. In addition to that, the main results of each experiment, including the description of each test, a selection of the measurement results are summarized.

In paralelle to the investigation of the v_{min}, several other researches have been carried out with the help the experimental data presented in this report. For that reason, it was decided to prepare a seperate measurement report, which is used as a companion to support the conclusions and the analysis of the other researches related to this shear – bending test series, including the determination of the minimum shear strength before flexural failure.

2. TEST SPECIMENS

2.1. INTRODUCTION

In general the research program is composed of three stages. In the first stage, the focues of the research is on experimentally finding the transition point between shear failure and bending failure with the variable of reinforcement ratio, concrete strength, and beam depth. In the first stage, three test series can be distinguished. Test series A is the references: h = 300 mm, higher strength concrete (C65). In test series B, the beam height is increased to 500 mm. while test series C has lower strength concrete (C30). The numbering of the specimens in the test series is indicated in Fig. 2.1.1, where the major difference between the three series are marked by the starting letter.

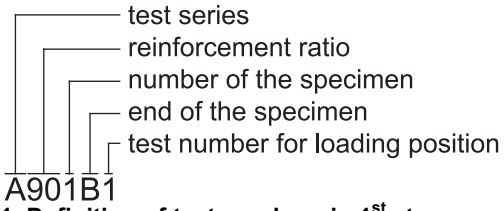


Fig. 2.1.1. Definition of test numbers in 1st stage.

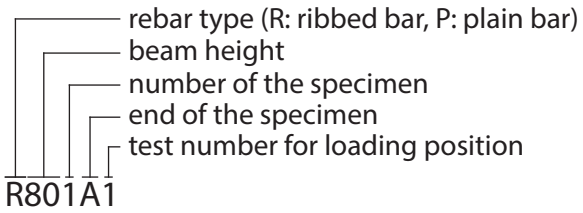


Fig. 2.1.2. Definition of test numbers in 2nd stage.

In the second stage, the research question was to investigate the influence of plain bar to the shear capacity of reinforced concrete members without shear reinforcement. Thus the test specimens during this test series are subdived into two groups, beams reinforced with plain bar and ribbed bars. The numbering system during this stage is changed accordingly, see Fig. 2.1.2. As a general conclusion, the study showed that other than the lower yielding strength of the tensile reinforcement, no clear difference was observed between the specimens with different reinforcement type. Based on that observation, in the third phase of the research, it was decided to merge the two test series into one. The specimens are regrouped by the major variables such as the specimen height, concrete type, yielding strength of tensile reinforcement. Considering that in the research on the effect of plain bars, the specimens were numberd differently. It was decided that during the tests stage 3, that numbering system was kept. Therefore, in the main text of this report, the test numbers in the test stage 2 and 3 uses the test definition given in Fig. 2.1.2. In order to make the comparison consistent, a conversion table is given to make all the number of all the tests consistent, see Table 2.1.2. In addition, the difference between the several test series are summerized in Table.2.1.1

Table.2.1.1. Variations amonst test series.

Test series	h [mm]	Concrete class	f_{yk} (rebar) [MPa]
Series A	300	C65	500
Series B	500	C65	500
Series C	300	C30	500
Series D	800	C65	500
Series E	300	C65	240
Series F	500	C65	240
Series G	800	C65	240

Table 2.1.2. Summary of tested specimens.

Specimen No. Unit	New No.	rebars config. [-]	Cast No. [-]	$f_{c,max}$ [Mpa]	h [mm]	d [mm]	ρ [%]
A121	same	3Ø20	1	64.36	304.5	269.5	1.17
A122	same	3Ø20	1	64.36	305.5	270.5	1.16
A123	same	3Ø20	4	64.36	305.0	270.0	1.16
A901	same	1Ø12+2Ø20	1	64.36	309.0	274.0	0.90
A902	same	1Ø12+2Ø20	1	64.36	311.0	276.0	0.90
A751	same	3Ø16	1	64.36	307.5	274.5	0.73
A752	same	3Ø16	1	64.36	306.0	273.0	0.74
A601	same	1Ø10+2Ø16	1	64.36	308.5	275.5	0.58
A602	same	1Ø10+2Ø16	1	64.36	305.5	272.5	0.59
B701	same	3Ø20	2	66.46	506.5	471.5	0.67
B702	same	3Ø20	2	66.46	506.5	471.5	0.67
B501	same	1Ø16+2Ø20	2	66.46	506.5	471.5	0.59
B502	same	1Ø16+2Ø20	2	66.46	507.5	472.5	0.59
C901	same	1Ø12+2Ø20	3	19.39	306.5	271.5	0.91
C751	same	3Ø16	3	19.39	303.0	270.0	0.74
C451	same	3Ø12	3	19.39	303.5	272.5	0.42
P801	**D651**	3Ø25	6	71.47	800	762.5	0.64
P802	**D851**	6Ø20 (2 layers)	5	62.13	800	755.0	0.83
P803	**D121**	2Ø20+4Ø25 (2 layers)	5	62.13	800	755.0	1.14
P804	**D852**	6Ø20 (2 layers)	8	63.51	800	755.0	0.83
R801	**E651**	3Ø25	6	71.47	800	762.5	0.64
R802	**E851**	6Ø20 (2 layers)	5	62.13	800	755.0	0.83
R803	**E852**	3Ø25	9	62.07	800	762.5	0.64
R804	**E652**	6Ø20 (2 layers)	8	63.51	800	755.0	0.83
P501	**G121**	5Ø20 (2 layers)	7	66.04	500	455.0	1.15
P502	**G701**	3Ø20	6	71.47	500	465.0	0.68
R501	**B121**	5Ø20 (2 layers)	7	66.04	500	455.0	1.15
R502	**B703**	3Ø20	9	62.07	500	465.0	0.68
P301	**F121**	3Ø20	7	66.04	300	265.0	1.19

2.2. MATERIAL

2.2.1. Concrete

In total 9 casts were made to cast all the specimens listed in Table 2.1.2. The mixures of all the casts were ordered from the same factory. Other than the lower strength concrete, all the other mixtures are supposed to be the same. Cubes were casted together with the specimens in order to follow the strength development of the concrete with time. The compressive strength and splitting tensile strength of the mixtures were tested at given ages. Based on which, the strength development curve of every casting are given in Table.2.2.1 and Fig. 2.2.1 to Fig. 2.2.16. It has to be remarked that cast 3 and 4 were done on the same date. Cast 4 was the high strength mixture. With that cast, only 1 specimen was casted with no cube accompanying. It was assumed that the cast has the same strength as the rest.

In some of the casts, the density of the mixture are measured from the cubes. The density of the mixture is employed in the calculation of the selfweight. As is shown in Table.2.2.1, other than the low strength concrete, the variation of the density is very limited. In general, 23.9 kN/m^3 is used to be on the conservative side. The density of the lower strength concrete is ρ_c = 22.9 kN/m^3.

Table.2.2.1. Cube test results for all casts used for specimens

Cast no.	cast date	$f_{c,cube}$ [MPa]	COV	$f_{ct,split}$ [MPa]	COV	Volumetric weight [kN/m^3]
1	18-02-2015	78.49	1.71%	5.64	5.10%	n.a.
2	02-04-2015	83.11	3.43%	5.86	4.64%	n.a.
3	15-07-2015	23.65	1.38%	2.47	6.70%	22.9
4	15-07-2015	n.a.	n.a.	n.a.	n.a.	n.a.
5	30-09-2015	75.77	1.56%	5.56	1.39%	23.8
6	08-10-2015	87.15	3.96%	6.01	3.81%	23.7
7	13-11-2015	80.54	3.27%	6.00	2.56%	n.a.
8	10-03-2016	77.45	5.92%	5.76	6.61%	23.9
9	17-03-2016	75.70	2.95%	5.71	3.56%	23.9

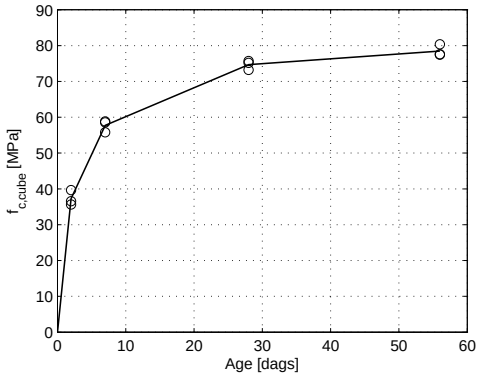


Fig. 2.2.1. $F_{c,cube}$ development for cast 1

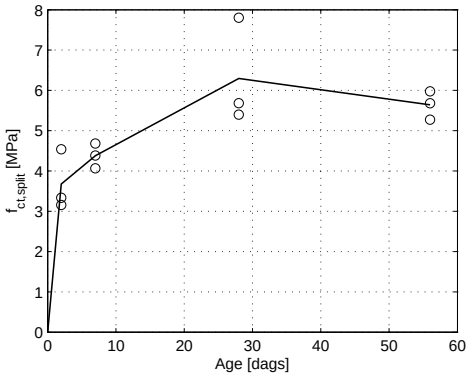


Fig. 2.2.2. $F_{ct,split}$ development for cast 1

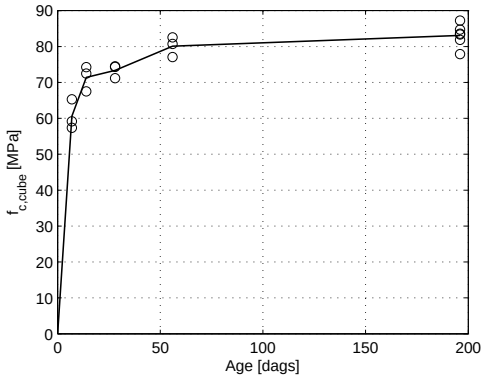


Fig. 2.2.3. $F_{c,cube}$ development for cast 2

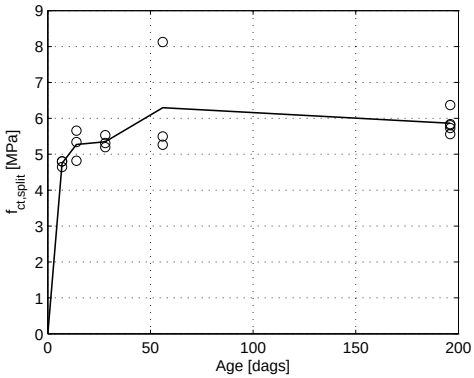


Fig. 2.2.4. $F_{ct,split}$ development for cast 2

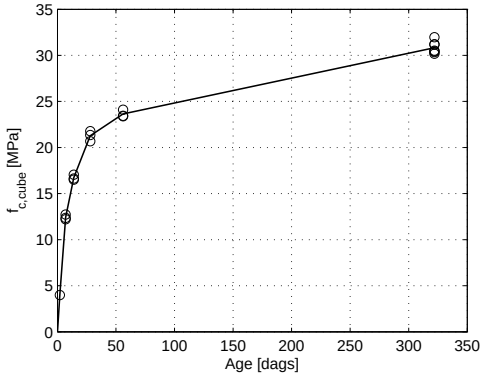


Fig. 2.2.5. $F_{c,cube}$ development for cast 3

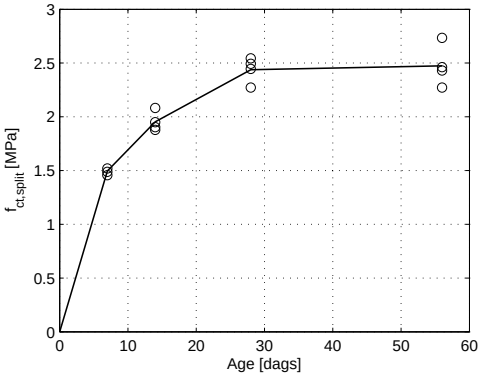


Fig. 2.2.6. $F_{ct,split}$ development for cast 3

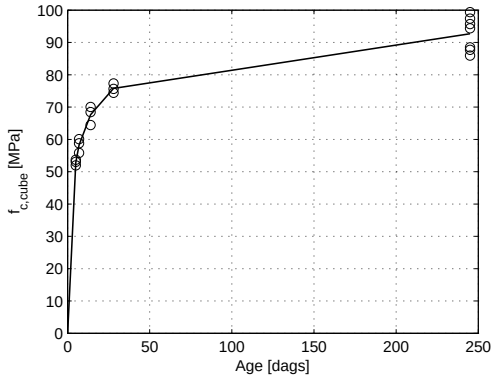


Fig. 2.2.7. $F_{c,cube}$ development for cast 5

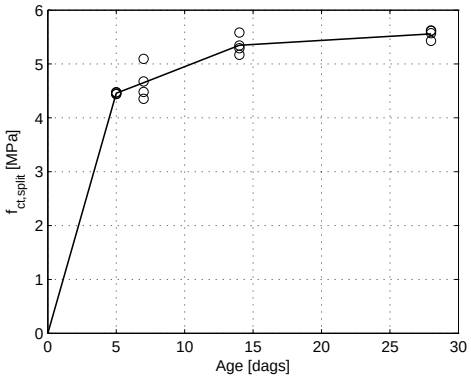


Fig. 2.2.8. $F_{ct,split}$ development for cast 5

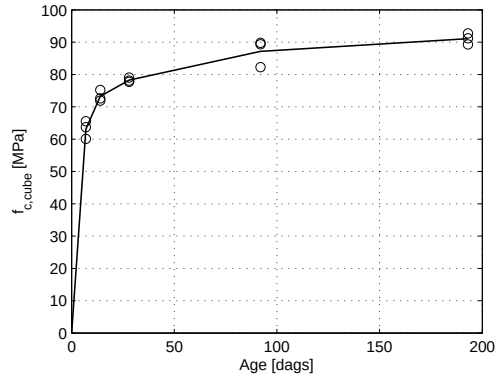


Fig. 2.2.9. $F_{c,cube}$ development for cast 6

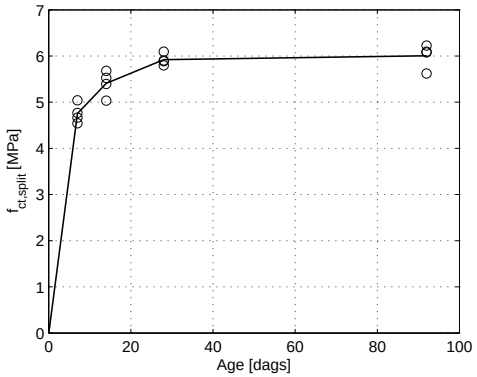


Fig. 2.2.10. $F_{ct,split}$ development for cast 6

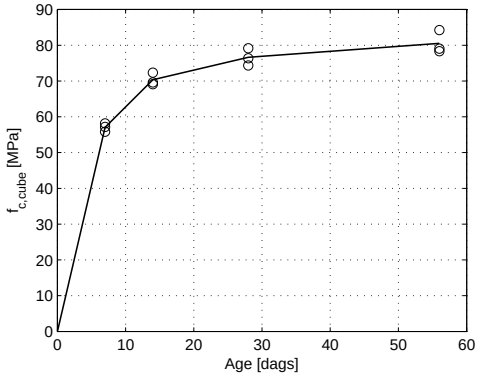


Fig. 2.2.11. $F_{c,cube}$ development for cast 7

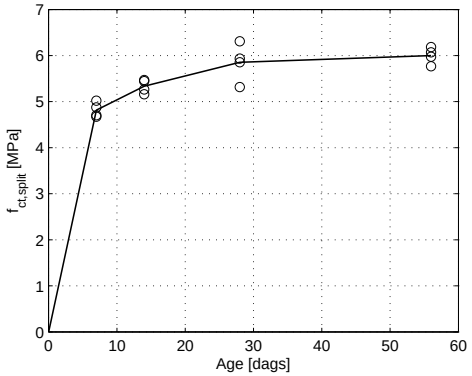


Fig. 2.2.12. $F_{ct,split}$ development for cast 7

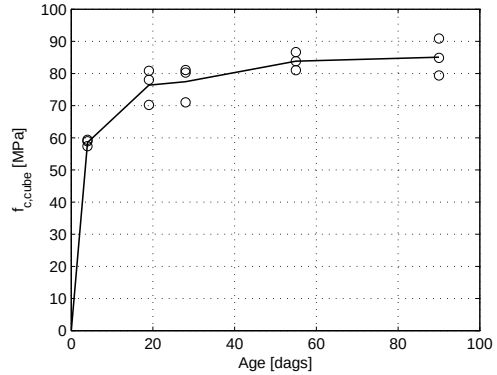


Fig. 2.2.13. $F_{c,cube}$ development for cast 8

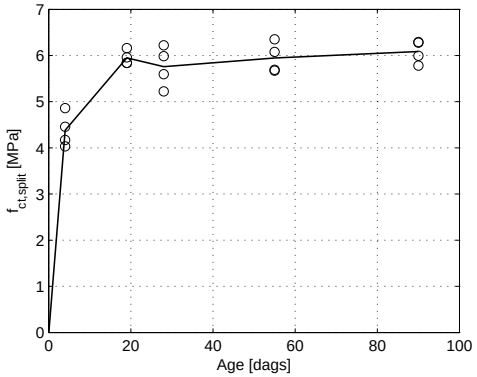


Fig. 2.2.14. $F_{ct,split}$ development for cast 8

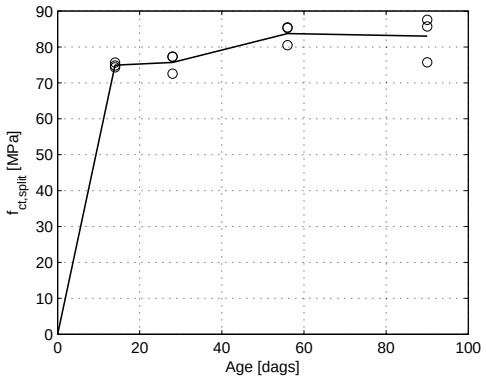


Fig. 2.2.15. $F_{c,cube}$ development for cast 9

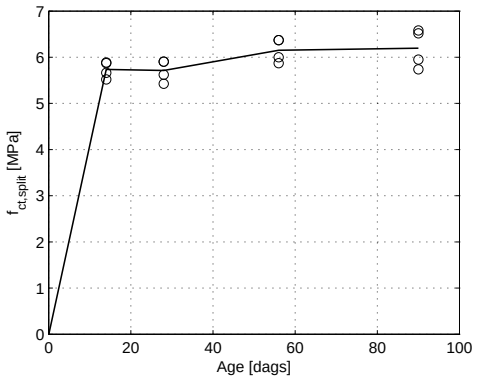


Fig. 2.2.16. $F_{ct,split}$ development for cast 9

2.2.2. Reinforcement

Two types of reinforcing bars are employed in the research. As explained before, the original motivation was to investigate the effect of smooth bars. Thus, other than the usually applied ribbed bar with steel grade of 500 MPa, plain bars with lower yielding strength were utilized as reinforceing bars. In order to confirm the mechanical propertied of the reinforcement, several pieces of extra steel bars were ordered together with the reinforcement cage. They were tested in the lab with relatively simple loading machine. Since the deformation of the steel bars were not accurately measured, no exact stress-strain relationship were able to be acquired. Nevertheless, the yielding strength and the ultimate stress of the steel were measured. The are listed in Table.2.2.2. Two typical examples of the stress – displacement relationship from the loading machine are given in Fig. 2.2.17.

In Table.2.2.2, the actual rebar diameter is calculated from the volume of specimen (weight multiplies the density) and the length of the specimen. This information was used to determine the strength of the specimen.

Table.2.2.2. Test results for reinforcement used for specimens

Test No.	F_y [kN]	F_{max} [kN]	$Ø_{norm}$ [mm]	$Ø_{cal}$ [mm]	f_y [MPa]	f_u [MPa]
Ribbed bars						
10	63.64	69.70	12	12.04	559.3	612.6
11	62.17	68.58	12	12.02	548.2	604.7
12	61.86	68.78	12	12.03	544.5	605.4
13	108.65	119.96	16	16.16	529.6	584.7
14	109.19	119.45	16	16.15	533.3	583.5
15	107.92	119.27	16	16.16	526.5	581.8
16	184.25	215.54	20	20.02	585.3	684.8
17	183.58	214.85	20	20.01	583.9	683.4
18	181.71	213.52	20	20.05	575.8	676.6
24	110.46	118.80	16	16.11	541.7	582.6
25	110.44	118.77	16	16.18	537.1	577.6
26	110.19	118.48	16	16.15	537.7	578.2
			mean f_y	550 MPa	COV	3.6%
Plain bars						
27	94.24	133.84	20	19.99	300.3	426.4
28	94.61	134.75	20	19.99	301.4	429.4
29	132.71	219.48	25	25.15	267.1	441.8
30	133.10	224.10	25	25.13	268.4	451.8
			k ean f_y	284 MPa	COV	5.8%

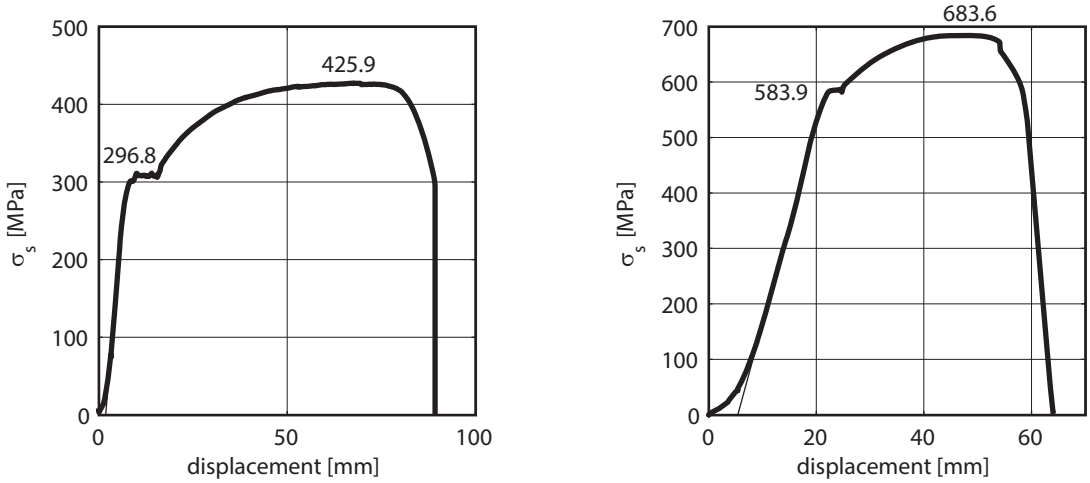


Fig. 2.2.17. Comparison of typical stress-displacement curve of plain bar(left) and ribbed bar(right).

In the rebar tests, not all the steel bars have distinghisible yielding plateu in the stress – displacement relationship. A possible explanation is that the bars were already yielded before they were taken as test specimen. In that case, a 0.2% offset of the linear branch of the stress – displacement curve was used to determing the value of fy. An example of such case is given in Fig. 2.2.18.

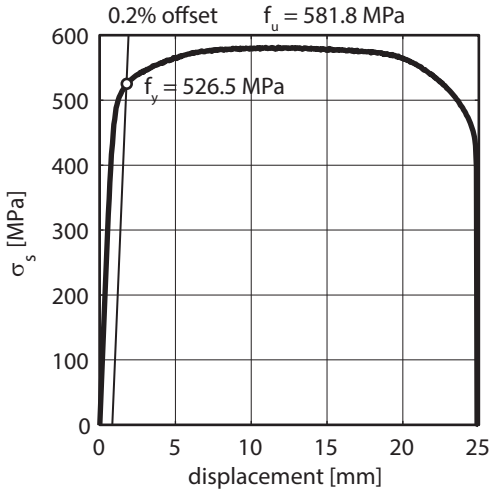


Fig. 2.2.18. Determination of f_y in tests which no clear yielding plateu could be distinguished.

In addition the the rebars that were employed in this research program, several additional bars obtained from an existing bridge (Ruytenschildt bridge) were tested. The results are given in Table 2.2.3. They are rather comparible to what was obtained from the newly ordered plain bars.

Table 2.2.3. Test result for reinforcement as used in practice (Ruytenschildt bridge)

Test No.	F_y [kN]	F_{max} [kN]	$Ø_{norm}$ [mm]	$Ø_{cal}$ [mm]	f_y [MPa]	f_u [MPa]
31	97.40	130.55	22	21.93	257.9	345.6
32	92.05	128.80	22	21.98	242.6	339.4
33	94.65	130.50	22	21.99	249.2	343.6

2.3. SPECIMEN DIMENSIONS AND REINFORCEMENT CONFIGURATIONS

Regarding the dimensions of the specimens, they can be distinguished into three groups depending to the height of the specimens. For members with h = 300 mm and 500 mm, their length is 8000 mm, while for members with h = 800 mm, the length of which is 10000 mm. All the members are of 300 mm wide.

The reinforcement configurations of the specimens varies among the test series. In general, the reinforcement ratios are indicated roughly by the specimen numbers. A detailed drawing of all the specimens are given in Fig. 2.3.1 and Fig. 2.3.2. It has to be remarked that for test series A, the initial design was to have an anchorage zone of 500 mm at the beam end. In the later phase of the test, in order to carry out more tests on the same specimen, it was decided to reduce it to 300 mm. In the tests A121xx, because the additional anchorage length were not aware of, the support was firstly located at 300 mm away from the edge of the specimen. As a result, the shear failure was prevented by the last stirrup in the critical shear span. A detailed decription of the failure modes of these tests were given in the corresponding test descriptions.

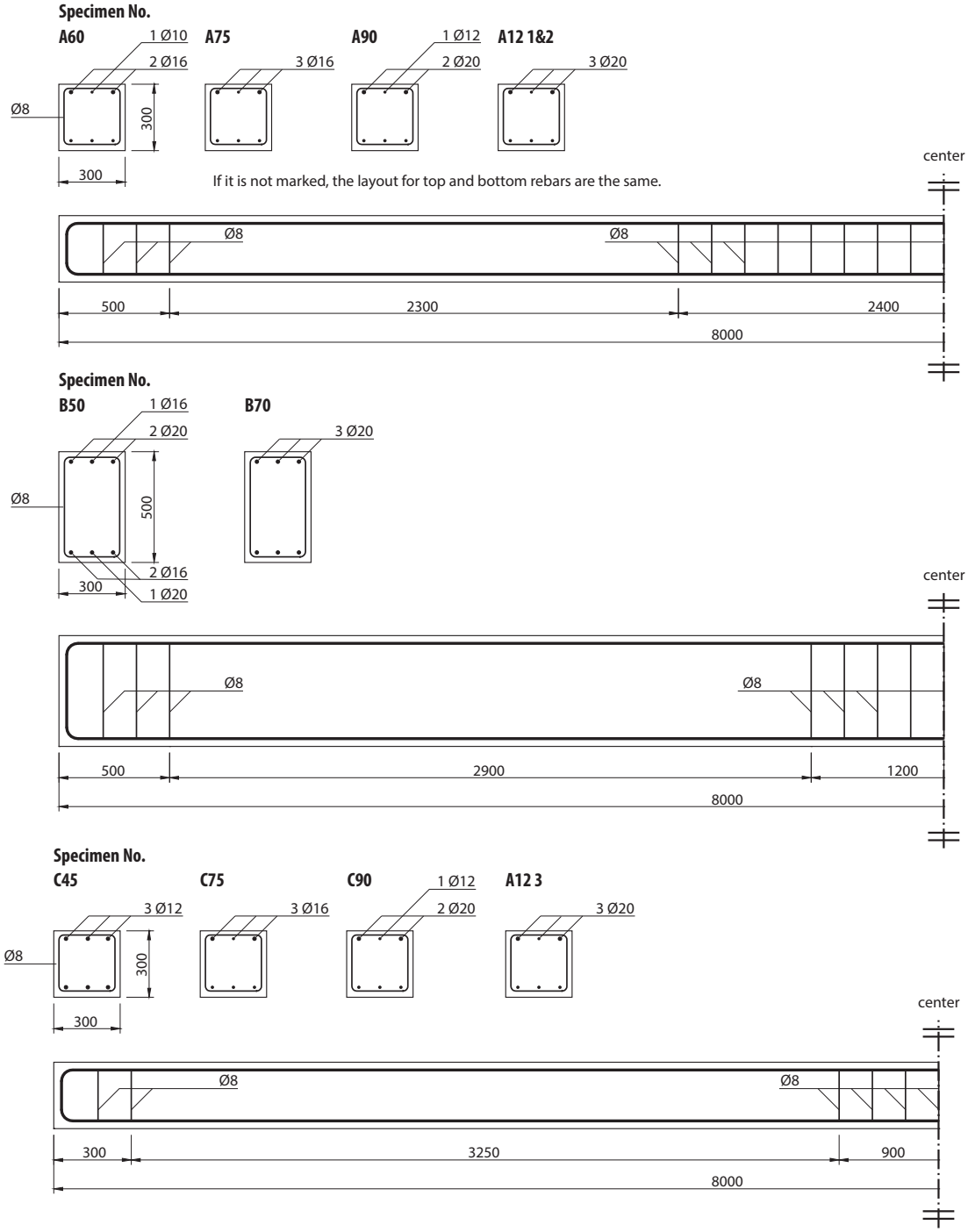


Fig. 2.3.1. Reinforcement layout for tested specimens in A, B and C series.

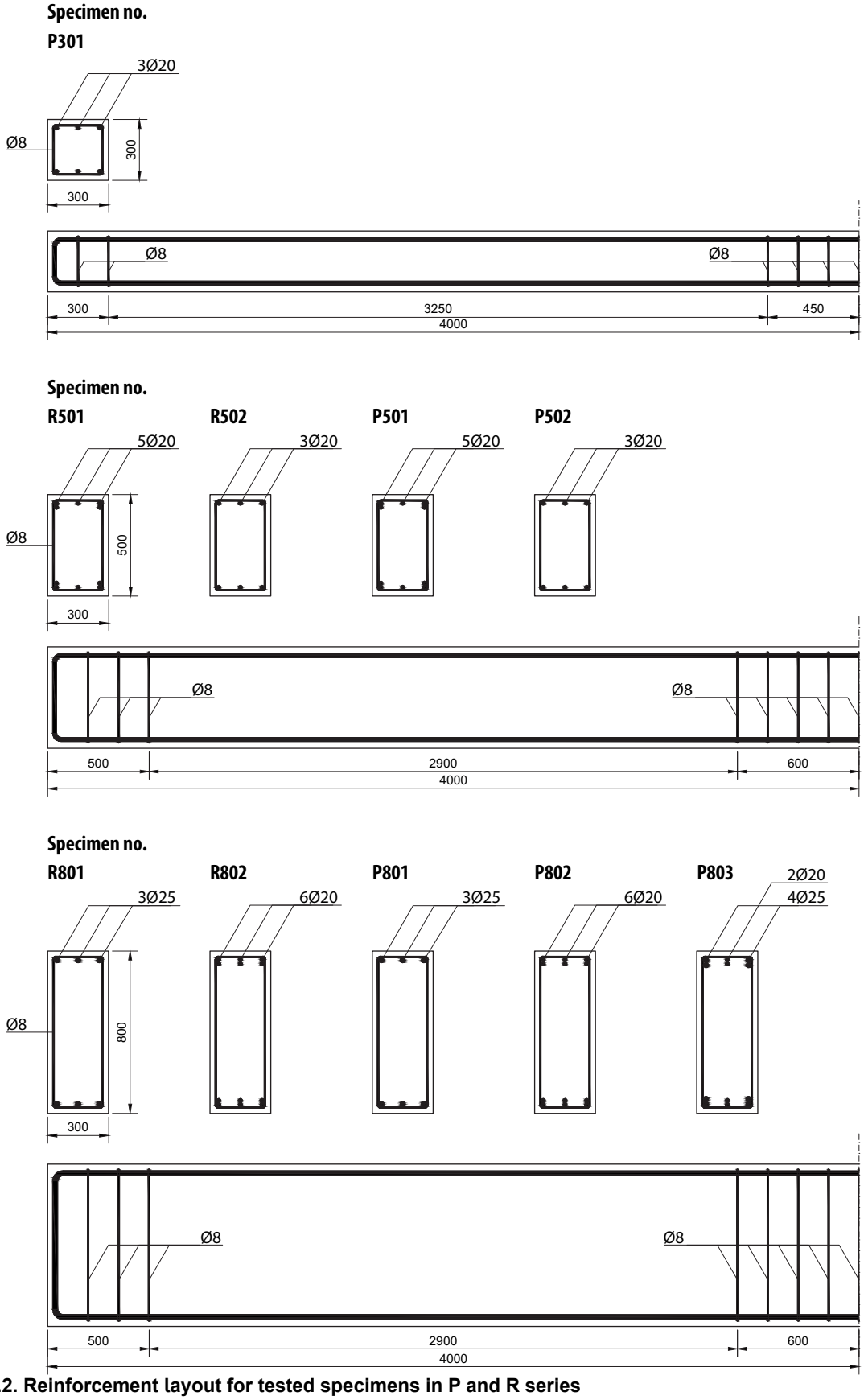


Fig. 2.3.2. Reinforcement layout for tested specimens in P and R series

3. TEST CONFIGURATION AND PROGRAM

3.1. TEST SETUP AND PROGRAM

In all the tests, the tested specimens were simply supported, and loaded by a point load. The positions of the loading point varies between tests in order to find the expected failure modes. The postions of the supports and the loading points are given in Fig. 3.1.1. For all the specimens, the two ends of which were tested separately. For that perpose, a long cantilever was left out of the longer end support. In the case of the specimens with 300 mm height, a cantilever of 1500 mm long was made before the first shear failure test. The intension was that because of the smaller effective depth, not a very large *a* is needed to reach the required shear slenderness ratio. The additional cantilever can be researved for addional tests.

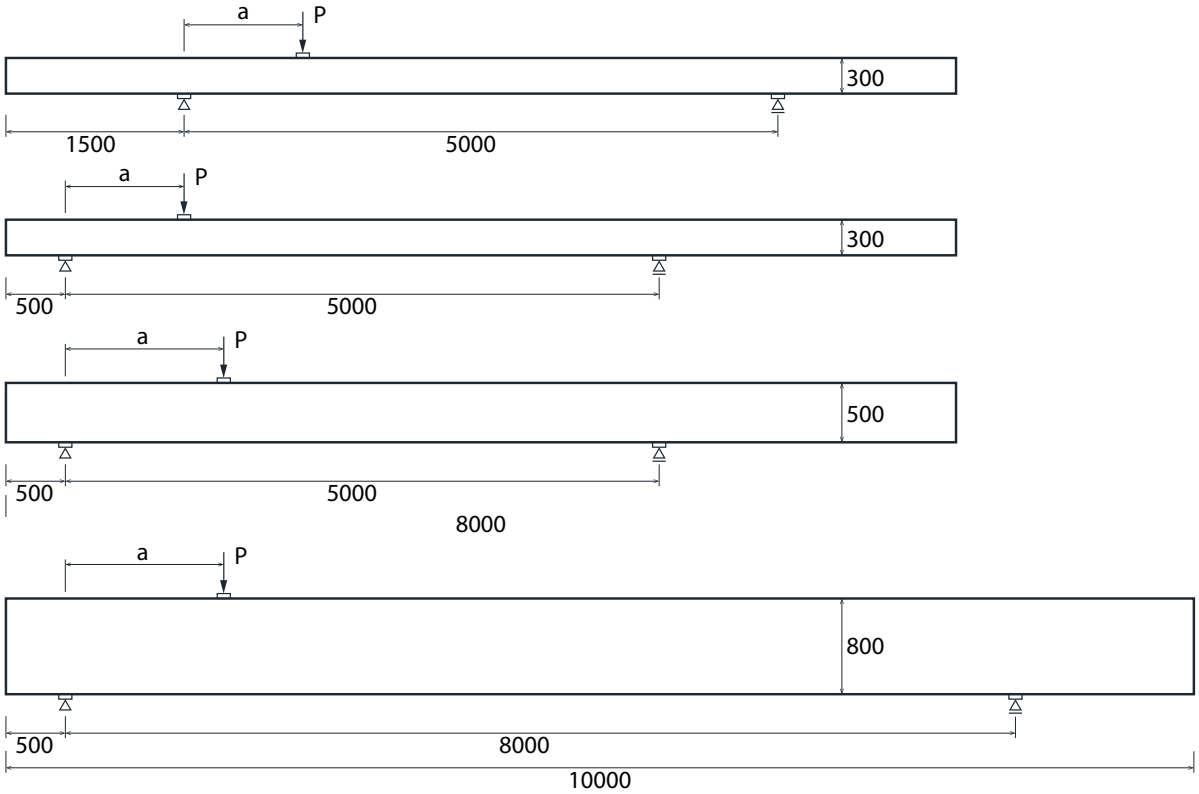


Fig. 3.1.1. Configurations of the boundary conditions of the tests.

In the vmin study, the target of the experimental research is to find out the minimum shear force which can still cause shear failure. To serve this purpose, on the specimens with the same reinforcement ratio, more than one test were executed. The test series started from placing the point load at a location relatively further away from the support so that flexural failure is obtained. This is judged by the yielding of the longitudinal reinforcement up to certain strain. The specimen was unloaded afterwards, and the point load was moved to the next loading position which is usually closer to the support. A second test is carried out at the newer position. In case of shear failure, the loading plate will be moved further. This procedure was repeated until shear failure was obtained, which affected the integrity of the shear span of the specimen. After the first shear failure, more tests were executed with the point load located between the last flexural failure and the first shear failure. So that a refined critical position is obtained eventually. A summary of the loading procedure is given in Fig. 3.1.2.

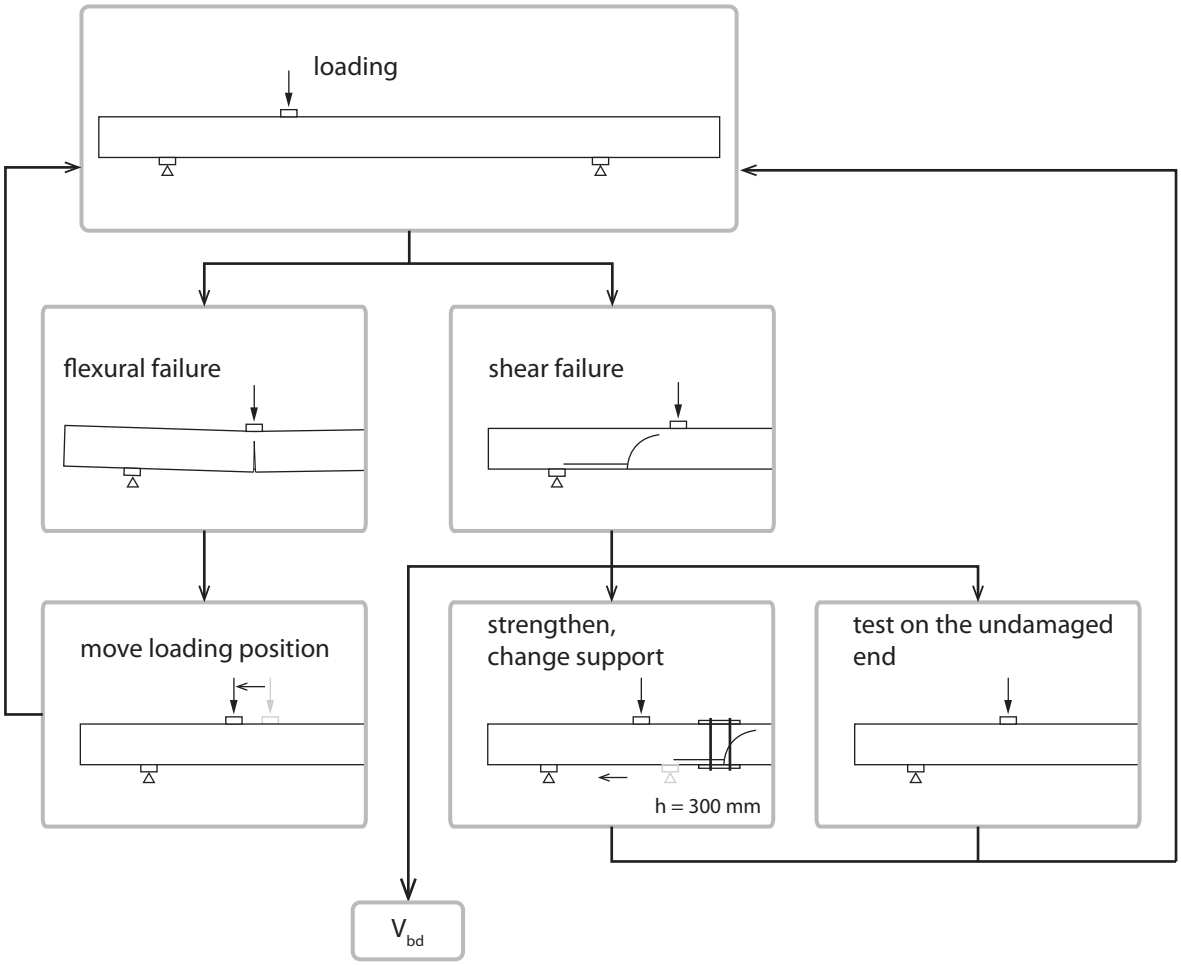


Fig. 3.1.2. Flow chat of the test program for a given beam configuration.

3.2. MEASUREMENTS

During all tests, a number of measurements were performed. In the list below all type of measurements are indicated, and discussed briefly in the remaining of this paragraph.

- The force in the actuator measured by a load cell (1 in Fig. 3.2.1)
- The maximum deflection under the loading point, measured by a pair of laser triangulation displacement sensors at both sides of the member (2 in Fig. 3.2.1).
- Vertical deflection at both supports measured with lasers or LVDT's (3 in Fig. 3.2.1)
- Crack opening in vertical direction measured with LVDT's (4 in Fig. 3.2.1).
- Crack opening in an LVDT array, which consists of longitudinal LVDTs' at the level of tensile reinforcement, and at the mid-height of the specimen. Vertical LVDTs' in between.(Fig. 3.2.4)
- The elongation of the bottom fibre of the specimen over 1m, measured with LVDT (Fig. 3.2.2)
- Acoustic emission during the testing process, with acoustic sensors (Fig. 3.2.4), the results of AE measurement in combination with DIC measurement will be given separately.
- Digital image correlation measurement (Fig. 3.2.3). With the pattern painted on the surface of the specimen, the crack distribution and the crack opening of the target surface can be measured. An illuatration of the measured result is given in Fig. 3.2.3.

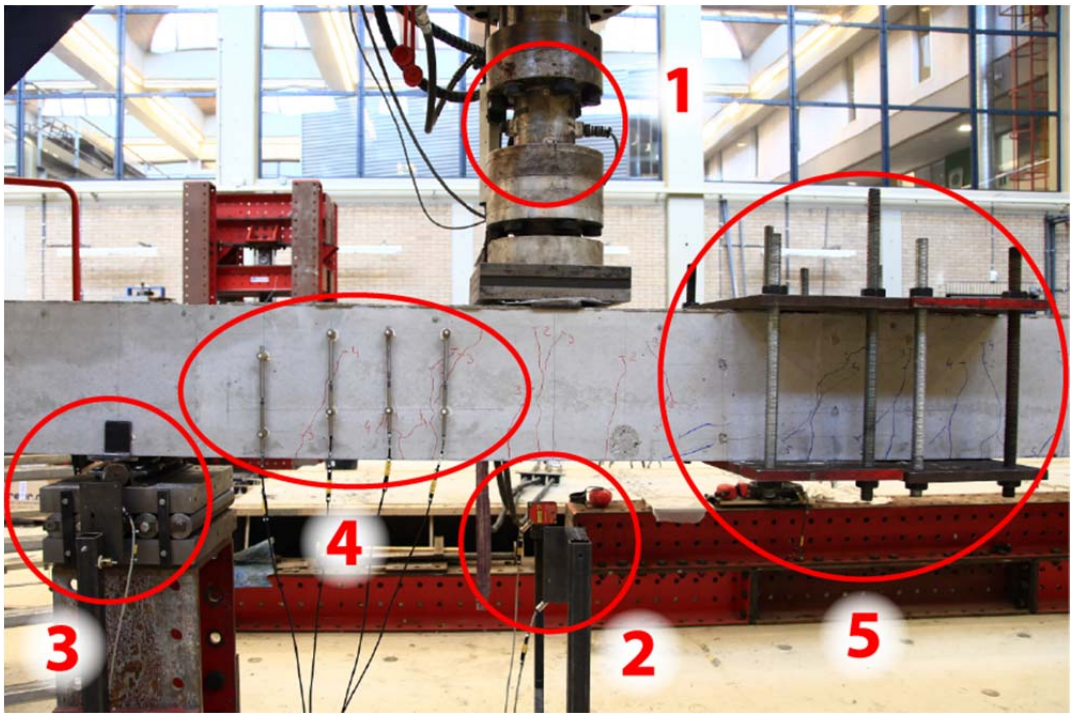


Fig. 3.2.1. Measurements (1-4) and strengthening of cracked specimen (5)

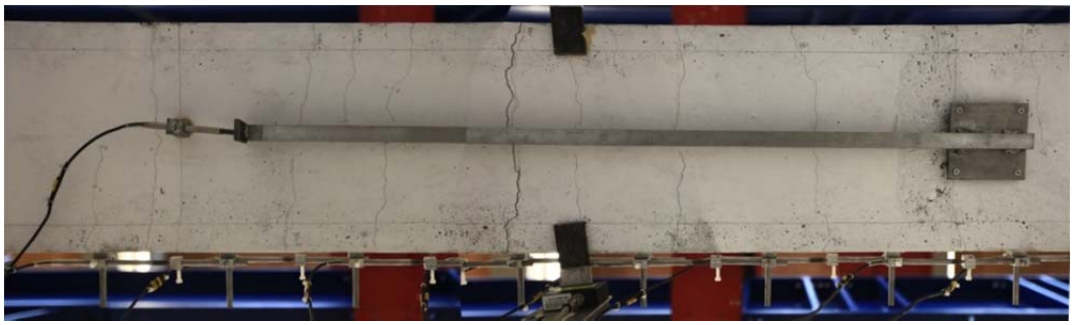
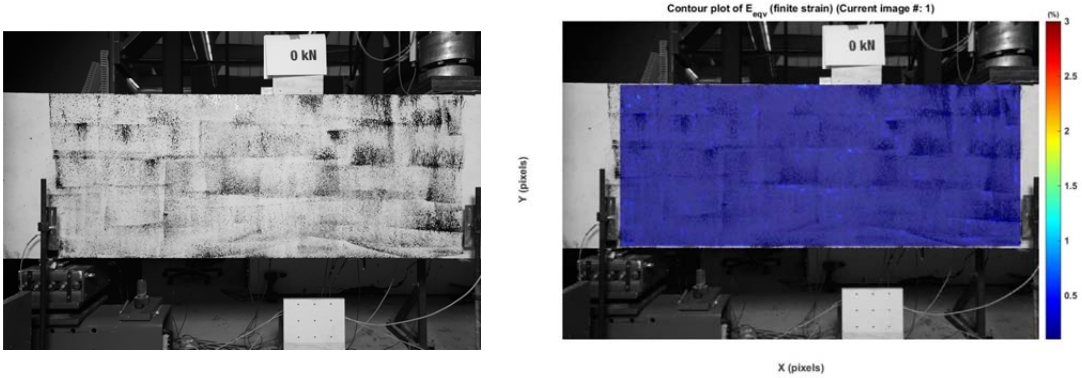


Fig. 3.2.2. Elongation measurement of bottom fibre of specimen using 1m steel rod and LVDT



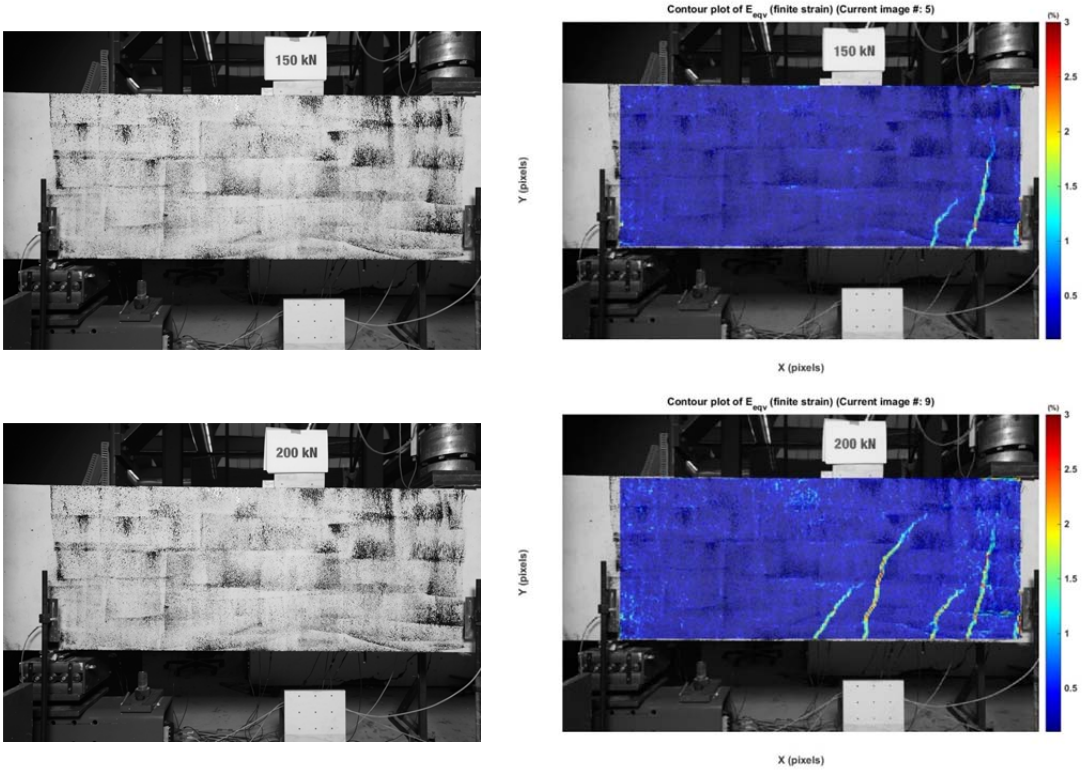


Fig. 3.2.3. DIC input pictures and results of 3 load steps

3.2.1. Load

One of the most important values measured is the applied load on the specimen. The jack which loads the specimen applies the load in a displacement controlled manner. By increasing the vertical displacement of the loading jack the load increases up to failure, where the load drops in case of shear failure, or the load remains constant in case of flexural failure. The variation of the applied load is measured using a load cell placed in between a loading plate and the loading jack.

3.2.2. Deflection

Directly under the loading point, at the bottom side of the specimen, the vertical deflection of the specimen is measured. The vertical deflection measured under the load is corrected for the vertical 24ongitutions measured ath the supports. The measurement range of the two lasers are not always the same. In some tests, two lasers with 100 mm and 50 mm measurement ranges were used at both sides of the specimen. The one with smaller range offers higher resolution while the other one was able to cover larger deflection.

3.2.3. Crack opening

The crack opening of the cracks formed in the specimen is measured using LVDT's. Depending on the specimen size and beam type, a regular grid of LVDT's or single LVDT's are applied.

In the test series A to C, the vertical LVDTs' were installed after the formation of a major flexural crack to measure the additional shear displacement in the target cracks. In the other tests, the LVDT array shown in Fig. 3.2.4 was used. Since in those test, DIC was adapted to track the whole deformation field of the surface. It was thus not necessary to track the shear displacement of specifica cracks separately.

Fig. 3.2.4. Acoustic emission sensors and the LVDT grid for the deformation field.

3.2.4. Position of the critical flexural shear crack

For the tests with shear failure, the position of the flexural shear crack was measured after the test. The measurement was done at the level of tensile reinforcement $x_{cr,b}$ and at mid – depth $x_{cr,m}$.

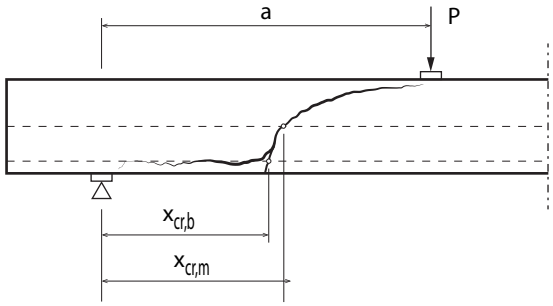


Fig. 3.2.5. Definition of shear crack location at bottom reinforcement of specimen ($x_{cr,b}$) and centre of the specimen ($x_{cr,m}$).

4. TEST RESULTS

4.1. TYPICAL FAILURE MODES

In the test series, four types of failure mode were typically observed. They are abbreviated as shear failure, flexural failure and mixed failure. Futher explanation on these failure modes are given as follows.

4.1.1. (Flexural) Shear failure

The shear failure referred in this report is flexural shear failure. The definition is that the specimen lost its capacity at the moment when unstable secondary cracks develop along the tensile reinforcement and the compressive zone.

4.1.2. Fexural failure (yielding of tensile reinforcement)

Though the definition of flexural failure at the ultimate limit state is different, the yielding of the tensile reinforcement in the loading process is defined as a sign of the flexural failure. During the test, the flexural failure is defined by the yielding of the tensile reinforcement with certain additional plastic deformation. The additional deflection is usually larger than 10 mm, to make sure that the already yielded cross section still has sufficient capacity for the following test.

For beams with ribbed bars, a drop of load level is typically observed in the load – deflection relationship at yielding. That local peak value is defined as the yielding strength of the speciemen. For members with plain bars, the transition towards yielding of tensile reinforcement is not that clear anymore. In that case, the 1 m LVDT at the bottom of the specimen was used to assist the definition of yielding loading. P_u was defined when large elongation of the LVDT was obtained.

4.1.3. Mixed failure (Flexural/shear failure)

In addition to the aforementioned two failure modes, a mixed failure mode failure mode was also obtained in some of the tests. They are marked as S/F in this report. Such failure mode is usually obtained at the shear slenderness ratio where the transition between the two failure modes is expected. With such failure mode, the yielding of the tensile reinforcement usually occurred first, meanwhile, the secondary crack initiated. Further increase of the deflection or load level of the specimen resulted in the unstable development of the secondary crack branches, which resulted in the loss of the global capacity. Therefore both the yielding load and the ultimate load were recorded in the report. They are marked as P_y and P_u respectively.

4.1.4. Shear compression failure

In very few cases, when the shear span is relatively small, the specimen did not lost its capacity after the formation of the flexural shear crack. Instead, a compressive strut was able to form from the loading point to the support. The final failure was due to the crush of the compressive strut at much higher load level. Such failure mode was defined as shear compression failure. In that case, P_u defines the ultimate load, and P_{cr} represents the load level when the flexural shear crack opens.

4.2. SUMMARY OF TEST RESULTS

As the main part of this report, a description of each test in this research is given. In addition to that, a selection of measurement results are included for each tests. That includes:

- General properties of the specimen and the boundary conditions of the test;
- Photos of the specimen after failure;
- Definition of the load steps;
- Loading process (Load – time relationship);

- Load – deflection relationship;
- Load – Crack opening relationship, (based on the LVDT measurement on the side surfaces)
- Load – average strain relationship (the average strain was measured by an LVDT installed on the bottom surface of the specimen over 1m length)

In addition to the detailed description of all the tests, the main results of all the tests are summerized in the following table. This can be used as an overview of the whole test program.

Test no.	Date of casting	Date of testing	Age [days]	$f_{c.cube}$ [MPa]	Rebar config.	a [mm]	d [mm]	a/d [-]	ρ [%]	P_u* [kN]	P_y** [kN]	$x_{c.b}$ [mm]	$x_{c.m}$ [mm]	Mode [F/S]	Misc.
A121A1	18-2-2015	08-04-2015	49	77.5	3Ø20	1500	269.5	5.57	1.17	115.3				F	
A121A2	18-2-2015	09-04-2015	50	77.7	3Ø20	1255	269.5	4.66	1.17	138.8				F	Shear failure was prevented by a stirrup in the shear span.
A121A3	18-2-2015	09-04-2015	50	77.7	3Ø20	1000	269.5	3.71	1.17	144.6		458.0	494.0	S	
A121B1	18-2-2015	10-04-2015	51	77.8	3Ø20	1000	269.5	3.71	1.17	160.6	157.6			F+S	Shear failure was prevented by a stirrup in the shear span.
A122A1	18-2-2015	13-04-2015	54	78.2	3Ø20	750	270.5	2.77	1.16	194.7	191.6			F+S	Shear failure was prevented by a stirrup in the shear span.
A122B1	18-2-2015	15-04-2015	56	78.5	3Ø20	1000	270.5	3.70	1.16	152.3		245.0	303.0	S	
A122B2	18-2-2015	16-04-2015	57	78.5	3Ø20	750	270.5	2.77	1.16	139.1		293.0	372.0	S	Fixated shear crack from previous test. Unloaded because loading plate touched reinforcement plate.
A123A1	15-7-2015	07-09-2015	54	79.2*	3Ø20	1000	270.0	3.70	1.16	136.5		245.0	372.5	S	
A123A2	15-7-2015	29-09-2015	76	80.1*	3Ø20	800	270.0	2.96	1.16	139.0		215.0	312.5	S	Returned to 0, lasers out of range.
A123B1	15-7-2015	08-09-2015	55	79.3*	3Ø20	1250	270.0	4.63	1.16	134.9				F	
A123B2	15-7-2015	08-09-2015	55	79.3*	3Ø20	1150	270.0	4.26	1.16	151.4	138.3	722.5	825.0	F+S	
A901A1	18-2-2015	17-04-2015	58	78.5	1Ø12+2Ø20	1250	274.0	4.56	0.90	105.6				F	No measurement data between 60-75 kN.
A901A2	18-2-2015	20-04-2015	61	78.5	1Ø12+2Ø20	1000	274.0	3.65	0.90	123.9				F	
A901A3	18-2-2015	20-04-2015	61	78.5	1Ø12+2Ø20	750	274.0	2.74	0.90	145.0		312.0	346.0	S	
A901B1	18-2-2015	21-04-2015	62	78.5	1Ø12+2Ø20	880	274.0	3.21	0.90	127.5		295.0	346.0	S	
A901B2	18-2-2015	22-04-2015	63	78.5	1Ø12+2Ø20	750	274.0	2.74	0.90	124.2		261.0	328.0	S	Fixated shear crack from previous test.
A902A1	18-2-2015	19-05-2015	90	78.5	1Ø12+2Ø20	995	276.0	3.61	0.90	120.7		375.0	452.0	S	
A902A2	18-2-2015	20-05-2015	91	78.5	1Ø12+2Ø20	900	276.0	3.26	0.90	136.0				F	Fixated shear crack from previous test. Used wrong configuration file. Started new test at 60 kN.
A902A3	18-2-2015	20-05-2015	91	78.5	1Ø12+2Ø20	800	276.0	2.90	0.90	149.4		403.0	470.0	S	

Test no.	Date of casting	Date of testing	Age [days]	$f_{c.cube}$ [MPa]	Rebar config.	a [mm]	d [mm]	a/d [-]	ρ [%]	P_u* [kN]	P_y** [kN]	$x_{c.b}$ [mm]	$x_{c.m}$ [mm]	Mode [F/S]	Misc.
A902B1	18-2-2015	21-05-2015	92	78.5	1Ø12+2Ø20	1100	276.0	3.99	0.90	121.5				F	
A902B2	18-2-2015	21-05-2015	92	78.5	1Ø12+2Ø20	1000	276.0	3.62	0.90	124.2		384.0	396.0	S	
A751A1	18-2-2015	23-04-2015	64	78.5	3Ø16	1000	274.5	3.64	0.73	97.1				F	
A751A2	18-2-2015	23-04-2015	64	78.5	3Ø16	750	274.5	2.73	0.73	118.4		357.0	447.0	S	
A751B1	18-2-2015	24-04-2015	65	78.5	3Ø16	800	274.5	2.91	0.73	106.7				S	
A751B2	18-2-2015	24-04-2015	65	78.5	3Ø16	850	274.5	3.10	0.73	111.3	110.1	355.0	410.0	F+S	Fixated shear crack from previous test.
A752A1	18-2-2015	28-05-2015	99	78.5	3Ø16	900	273.0	3.30	0.74	108.7				F	
A752A2	18-2-2015	29-05-2015	100	78.5	3Ø16	850	273.0	3.11	0.74	119.0		359.0	402.5	S	
A752A3	18-2-2015	29-05-2015	100	78.5	3Ø16	850	273.0	3.11	0.74	121.6	113.6	261.5	377.5	F+S	Fixated shear crack from previous test.
A752B1	18-2-2015	04-06-2015	106	78.5	3Ø16	750	273.0	2.75	0.74	122.1				F	Applied load cycles and used AE sensors.
A752B2	18-2-2015	05-06-2015	107	78.5	3Ø16	700	273.0	2.56	0.74	141.9	137.7	216.0	306.5	F+S	Applied load cycles and used AE sensors. Reset LVDT 3 because of errors in data.
A601A1	18-2-2015	28-04-2015	69	78.5	1Ø10+2Ø16	1000	275.5	3.63	0.58	80.3				F	
A601A2	18-2-2015	29-04-2015	70	78.5	1Ø10+2Ø16	750	275.5	2.72	0.58	102.1		310.0	408.0	F+S	
A601B1	18-2-2015	29-04-2015	70	78.5	1Ø10+2Ø16	700	275.5	2.54	0.58	118.7	106.4	315.0	392.0	S	
A601B2	18-2-2015	30-04-2015	71	78.5	1Ø10+2Ø16	600	275.5	2.18	0.58	114.2	123.2	317.0	434.0	F	Fixated shear crack from previous test.
A602A1	18-2-2015	22-05-2015	93	78.5	1Ø10+2Ø16	750	272.5	2.75	0.59	98.9				F	
A602A2	18-2-2015	26-05-2015	97	78.5	1Ø10+2Ø16	700	272.5	2.57	0.59	112.8				F	
A602A3	18-2-2015	27-05-2015	98	78.5	1Ø10+2Ø16	695	272.5	2.55	0.59	114.2	107.9	257.0	295.0	F+S	

Test no.	Date of casting	Date of testing	Age [days]	$f_{c.cube}$ [MPa]	Rebar config.	a [mm]	d [mm]	a/d [-]	ρ [%]	P_u* [kN]	P_y** [kN]	$x_{c.b}$ [mm]	$x_{c.m}$ [mm]	Mode [F/S]	Misc.
A602B1	18-2-2015	03-07-2015	135	78.5	1Ø10+2Ø16	1500	272.5	5.50	0.59	58.0				F	Replaced all LVDT's and rear-ranged support measurements. Applied load cycles and used AE sensors.
A602B2	18-2-2015	06-07-2015	138	78.5	1Ø10+2Ø16	650	272.5	2.39	0.59	117.5	107.4			F+S	Applied load cycles and used AE sensors.
B701A1	2-4-2015	08-07-2015	97	81.0	3Ø20	2250	471.5	4.77	0.67	175.5				F	
B701A2	2-4-2015	10-07-2015	99	81.0	3Ø20	2000	471.5	4.24	0.67	179.5				F	
B701A3	2-4-2015	10-07-2015	99	81.0	3Ø20	1750	471.5	3.71	0.67	185.7			1050.0	F	
B701B1	2-4-2015	14-07-2015	103	81.1	3Ø20	1700	471.5	3.61	0.67	193.6				F	LVDT 3 out of range before 120 kN, unloaded to 0 kN to fix range.
B701B2	2-4-2015	14-07-2015	103	81.1	3Ø20	1500	471.5	3.18	0.67	202.4		880.0	960.0	S	
B702A1	2-4-2015	12-08-2015	132	81.7	3Ø20	1250	471.5	2.65	0.67	183.2		755.0	800.0	S	
B702B1	2-4-2015	12-08-2015	132	81.7	3Ø20	1450	471.5	3.08	0.67	164.9		690.0	910.0	S	
B501A1	2-4-2015	13-08-2015	133	81.8	1Ø16+2Ø20	2000	471.5	4.24	0.59	168.5				F	
B501A2	2-4-2015	14-08-2015	134	81.8	1Ø16+2Ø20	1750	471.5	3.71	0.59	166.4		957.5	1117.5	S	
B501B1	2-4-2015	17-08-2015	137	81.8	1Ø16+2Ø20	1800	471.5	3.82	0.59	165.7		935.0	960.0	S	
B502A1	2-4-2015	18-08-2015	138	81.9	1Ø16+2Ø20	1900	472.5	4.02	0.59	166.9				F	
B502A2	2-4-2015	18-08-2015	138	81.9	1Ø16+2Ø20	1800	472.5	3.81	0.59	175.1				F	
B502A3	2-4-2015	19-08-2015	139	81.9	1Ø16+2Ø20	1700	472.5	3.60	0.59	173.6			1040.0	S	
B502B1	2-4-2015	20-08-2015	140	81.9	1Ø16+2Ø20	1700	472.5	3.60	0.59	173.2		570.0	652.5	S	Returned to 0 kN to measure beginning of cracks.
C901A1	15-7-2015	22-09-2015	69	23.7	1Ø12+2Ø20	1250	271.5	4.60	0.91	98.5				F	Applied load cycles and used AE sensors. Re-zeroed LVDT's before last load step.

Test no.	Date of casting	Date of testing	Age [days]	$f_{c.cube}$ [MPa]	Rebar config.	a [mm]	d [mm]	a/d [-]	ρ [%]	P_u* [kN]	P_y** [kN]	$x_{c.b}$ [mm]	$x_{c.m}$ [mm]	Mode [F/S]	Misc.
C901A2	15-7-2015	23-09-2015	70	23.7	1Ø12+2Ø20	1000	271.5	3.68	0.91	103.4		630.0	725.0	S/F	Applied load cycles and used AE sensors.
C901A3	15-7-2015	24-09-2015	71	23.7	1Ø12+2Ø20	1000	271.5	3.68	0.91	84.1		355.0	450.0	S	Fixated shear crack from previous test.
C901B1	15-7-2015	25-09-2015	72	23.7	1Ø12+2Ø20	1250	271.5	4.60	0.91	101.7		265.0	330.0	S	Applied load cycles and used AE sensors.
C751A1	15-7-2015	17-09-2015	64	23.7	3Ø16	1250	270.0	4.63	0.74	76.5				F	
C751A2	15-7-2015	17-09-2015	64	23.7	3Ø16	1000	270.0	3.70	0.74	84.5		395.0	480.0	S	
C751A3	15-7-2015	18-09-2015	65	23.7	3Ø16	1000	270.0	3.70	0.74	86.7		280.0	355.0	S	
C751B1	15-7-2015	18-09-2015	65	23.7	3Ø16	1000	270.0	3.70	0.74	82.8	75.6	630.0	765.0	F+S	
C451A1	15-7-2015	09-09-2015	56	23.7	3Ø12	1250	272.5	4.59	0.42	41.4				F	
C451A2	15-7-2015	10-09-2015	57	23.7	3Ø12	1000	272.5	3.67	0.42	52.9				F	LVDT 3 came in a hole of steel plate.
C451A3	15-7-2015	11-09-2015	58	23.7	3Ø12	750	272.5	2.75	0.42	73.5	68.4	310.0	360.0	F+S	
C451A4	15-7-2015	11-09-2015	58	23.7	3Ø12	750	272.5	2.75	0.42	70.9		330.0	420.0	F+S	Fixated shear crack from previous test. LVDT 3 could not be placed because of reinforcement plate.
C451B0	15-7-2015	14-09-2015	61	23.7	3Ø12	850	272.5	3.12	0.42	-				-	Shear crack at unloaded side opened. Test halted and shear crack is closed by steel plates.
C451B1	15-7-2015	14-09-2015	61	23.7	3Ø12	850	272.5	3.12	0.42	58.5				F	
C451B2	15-7-2015	15-09-2015	62	23.7	3Ø12	800	272.5	2.94	0.42	70.6	70.6	350.0	400.0	F+S	LVDT 3 at same position as for previous test.
C451B3	15-7-2015	15-09-2015	62	23.7	3Ø12	800	272.5	2.94	0.42	61.8				F	Fixated shear crack from previous test. LVDT 3 could not be placed because of reinforcement plate.
C451B4	15-7-2015	16-09-2015	63	23.7	3Ø12	700	272.5	2.57	0.42	77.2		170.0	270.0	F+S	

Test no.	Date of casting	Date of testing	Age [days]	$f_{c.cube}$ [MPa]	Rebar config.	a [mm]	d [mm]	a/d [-]	ρ [%]	P_u* [kN]	P_y** [kN]	$x_{c.b}$ [mm]	$x_{c.m}$ [mm]	Mode [F/S]	Misc.
P301A1	13-11-2015	21-01-2016	69	80.5	3Ø20	800	265.0	3.02	1.19	100.2				F	Test with photogrammetry.
P301A2	13-11-2015	22-01-2016	70	80.5	3Ø20	600	265.0	2.26	1.19	122.6	124.1	220.0	305.0	F+S	Test with photogrammetry.
P301A3	13-11-2015	25-01-2016	73	80.5	3Ø20	600	265.0	2.26	1.19	123.8		220.0	305.0	F	Fixated shear crack from previous test. Test with photogrammetry.
P301A4	13-11-2015	25-01-2016	73	80.5	3Ø20	550	265.0	2.08	1.19	135.9		220.0	305.0	F	Test with photogrammetry.
P301B1	13-11-2015	26-01-2016	74	80.5	3Ø20	550	265.0	2.08	1.19	135.2	144.9	220.0	305.0	F(+S)	Test with photogrammetry.
P501A1	13-11-2015	25-02-2016	104	80.5	5Ø20 (2 layers)	2000	455.0	4.40	1.15	147.2				F	Test with photogrammetry. Crack at lifting hook, break in 33ongitudenal reinforcement at welding point. Force dropped to 125 kN.
P501A2	13-11-2015	26-02-2016	105	80.5	5Ø20 (2 layers)	1250	455.0	2.75	1.15	175.5		540.0	745.0	S	Cracked spot from previous test reinforced with metal strip. Test with photogrammetry.
P501B1	13-11-2015	29-01-2016	77	80.5	5Ø20 (2 layers)	1250	455.0	2.75	1.15	207.8				F	Test with photogrammetry.
P501B2	13-11-2015	01-03-2016	109	80.5	5Ø20 (2 layers)	1000	455.0	2.20	1.15	202.0	244.3	465.0	595.0	F(+S)	Test with photogrammetry.
P502A1	8-10-2015	04-03-2016	148	87.2	3Ø20	1250	465.0	2.69	0.68	130.6				F	Test with photogrammetry. Unloaded 0 kN after load step 4.
P502A2	8-10-2015	07-03-2016	151	87.2	3Ø20	1000	465.0	2.15	0.68	148.8				F	Test with photogrammetry. Unloaded to 0 kN after load step 3, 7 and 9.
P502B1	8-10-2015	11-03-2016 to 14-03-2016	155	87.2	3Ø20	1500	465.0	3.23	0.68	131.0				-	Test used for student Master thesis.
P801A1	8-10-2015	06-01-2016	90	86.9	3Ø25	2000	762.5	2.62	0.64	196.6				F	Test with photogrammetry. Used new calibration for LVDT's.
P801A2	8-10-2015	07-01-2016	91	87.0	3Ø25	1750	762.5	2.30	0.64	205.9				F	Returned to 0 kN after load step 4, changed loading speed to 0.012 mm/s. Test with photogrammetry.

Test no.	Date of casting	Date of testing	Age [days]	$f_{c.cube}$ [MPa]	Rebar config.	a [mm]	d [mm]	a/d [-]	ρ [%]	P_u* [kN]	P_y** [kN]	$x_{c.b}$ [mm]	$x_{c.m}$ [mm]	Mode [F/S]	Misc.
P801A3	8-10-2015	07-01-2016	91	87.0	3Ø25	1500	762.5	1.97	0.64	227.6		520.0	1025.0	S/F	Test with photogrammetry.
P801B1	8-10-2015	08-01-2016	92	87.2	3Ø25	1500	762.5	1.97	0.64	231.0				F	Stopped loading because of hear crack at A-side. Fixated crack with steel plates. Test with photogrammetry.
P802A1	30-9-2015	02-12-2015	63	75.8	6Ø20 (2 layers)	2000	755.0	2.65	0.83	249.0		1250.0	1380.0	S	Test with photogrammetry.
P802B1	30-9-2015	04-12-2015	65	75.8	6Ø20 (2 layers)	2000	755.0	2.65	0.83	208.1		1050.0	1375.0	S	Test with photogrammetry.
P803A1	30-9-2015	12-01-2016	104	75.8	2Ø20+4Ø25 (2 layers)	2000	755.0	2.65	1.14	290.4		670.0	1007.5	S	Test with photogrammetry.
P803B1	30-9-2015	15-01-2016	107	75.8	2Ø20+4Ø25 (2 layers)	3000	755.0	3.97	1.14	269.0				F	Test with photogrammetry.
P803B2	30-9-2015	18-01-2016	110	75.8	2Ø20+4Ø25 (2 layers)	2750	755.0	3.64	1.14	274.6	277.9			F+S	Test with photogrammetry.
P804A1	10-03-2016	08-06-2016	90	85.1	6Ø20 (2 layers)	3000	755.0	3.97	0.84	207.4				F	Test for stop criteria (Eva), cyclic loading + AE measurement.
P804A2	10-03-2016	09-06-2016	90	85.1	6Ø20 (2 layers)	2500	755.0	3.31	0.84	231.7				S	Test for stop criteria (Eva), cyclic loading + AE measurement.
P804B1	10-03-2016	13-06-2016	94	85.1	6Ø20 (2 layers)	2500	755.0	3.31	0.84	195.6				S	Test for RWS visit, AE measurement.
R501A1	13-11-2015	23-02-2016	102	80.5	5Ø20 (2 layers)	2500	455.0	5.49	1.15	276.8		1400.0	1850.0	S	Test with photogrammetry.
R501B1	13-11-2015	23-03-2016	131	75.8	5Ø20 (2 layers)	1500	455.0	3.30	1.15	210.2		664.5	857.0	S	Applied load cycles and used AE sensors. Test with photogrammetry.
R502A1	17-3-2016	06-04-2016	20	75.3	3Ø20	2000	465.0	4.30	0.68	173.1				F	Applied load cycles and used AE sensors. Test with photogrammetry.
R502A2	17-3-2016	12-04-2016	26	75.6	3Ø20	1600	465.0	3.44	0.68	163.9				S	Applied load cycles and used AE sensors. Test with photogrammetry.

Test no.	Date of casting	Date of testing	Age [days]	$f_{c.cube}$ [MPa]	Rebar config.	a [mm]	d [mm]	a/d [-]	ρ [%]	P_u* [kN]	P_y** [kN]	$x_{c.b}$ [mm]	$x_{c.m}$ [mm]	Mode [F/S]	Misc.
R502B1	17-3-2016	19-04-2016	33	77.1	3Ø20	1750	465.0	3.76	0.68	154.9				S	Test with photogrammetry.
R801A1	8-10-2015	16-12-2015	69	84.0	3Ø25	2000	762.5	2.62	0.64	213.1	373.2	1145.0	1355.0	S	Test with photogrammetry. Reduced load to 0 kN after load step 8 to zero LVDT 16. Shear compression failure, the value in table Py represents Pu
R801B1	8-10-2015	25-5-2016	230	91.1	3Ø25	2000	762.5	2.62	0.64	204.8				S	Support at 7.2m. Old crack damaged the beam to heavily for the support.
R802A1	30-9-2015	30-11-2015	61	75.8	6Ø20 (2 layers)	2000	755.0	2.65	0.83	219.4		1015.0	1167.5	S	Test with photogrammetry. Reduced load to 0 kN after load step 5 to zero LVDT 16..
R802B1	30-9-2015	11-12-2015	72	75.8	6Ø20 (2 layers)	2000	755.0	2.65	0.83	270.2	375.0	1050.0	1375.0	S	Test with photogrammetry. Reduced load to 0 kN after load step 4 to place LVDT 15. Shear compression failure, the value in table Py represents Pu
R803A1	17-03-2016	06-03-2016	78	83.3	6Ø20 (2 layers)	3500	762.5	4.59	0.82	279.3				S	Test with photogrammetry. AE measurement included, load cycles included. Failure occurred at the waiting period.
R803B1	17-03-2016	23-08-2016	159	83.0	6Ø20 (2 layers)	3500	762.5	4.59	0.82	307.9				S	Test with photogrammetry. AE measurement included, load cycles included. Due to damaged beam in test 1, span of specimen was reduced to 7400 mm.
R804A1	10-03-2016	16-06-2016	98	85.1	3Ø25	3500	755	4.64	0.65	269.4				S	Test with photogrammetry. AE measurement included, load cycles included

Test no.	Date of casting	Date of testing	Age [days]	$f_{c.cube}$ [MPa]	Rebar config.	a [mm]	d [mm]	a/d [-]	ρ [%]	P_u* [kN]	P_y** [kN]	$x_{c.b}$ [mm]	$x_{c.m}$ [mm]	Mode [F/S]	Misc.
R804B1	10-03-2016	08-08-2016	151	85.1	3Ø25	3500	755	4.64	0.65	249.9				S	Test with photogrammetry. AE measurement included, load cycles included. Beam was strengthened on other side with 3 pairs of threaded steel.

* P_u is the maximum load for yielding or shear failure, when only one failure mechanism is observed.

** P_y is the load at which yielding of the reinforcement is observed, when afterwards also shear failure is developed.

5. TEST DESCRIPTIONS

5.1. A121A1

5.1.1. Test properties

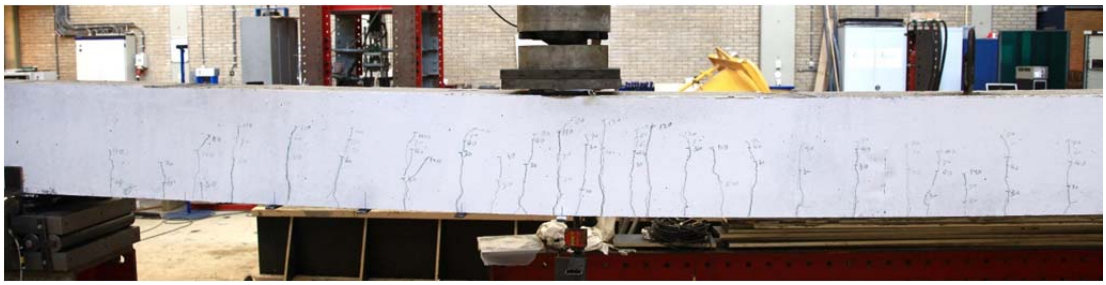


Fig. 5.1.1. Crack pattern after failure north side

Fig. 5.1.2. Crack pattern after failure south side

Table 5.1.1. Beam properties

Date of test	08-04-2015
Reinforcement	3Ø20
Reinforcement ratio	1.17%
a	1510 mm
a / *d*	5.60
Concrete cube strength at testing	77.5 MPa
Peak load	115.3 kN
Failure mode	Flexural

Table 5.1.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Connected to the AE computer
1	20	Flexural cracks are observed
2	40	Many flexural cracks. Deflection limit at 30 mm, restarted
3	50	
4	60	
5	70	
6	80	
7	90	
8	100	
9	110	
10	117.9	
11	120	Stopped at jack deflection of 70 mm

5.1.2. Measurement results

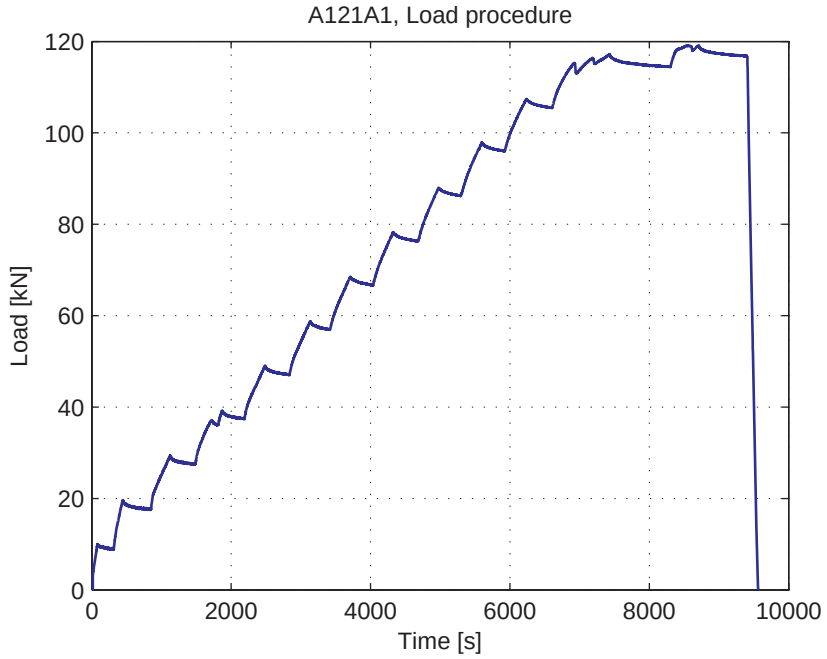


Fig. 5.1.3. Load-Time curve

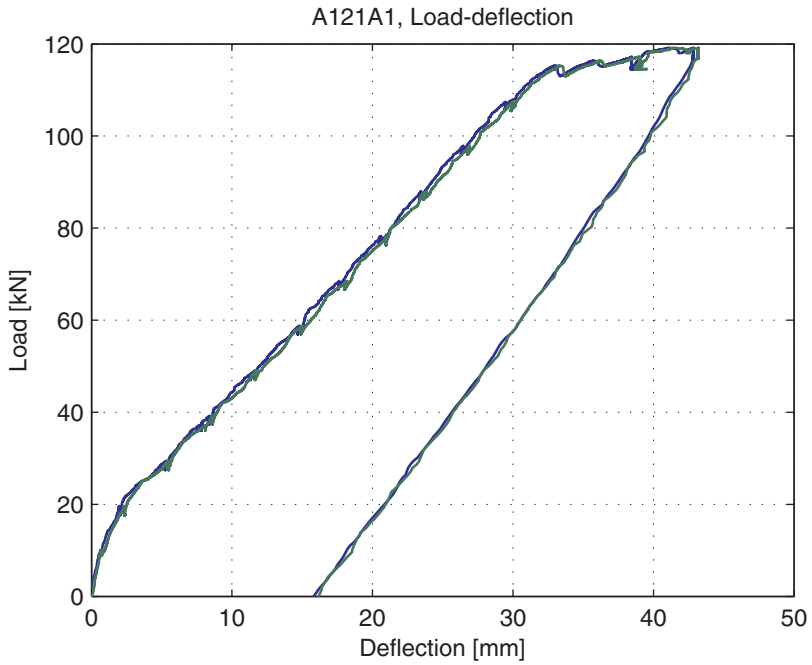


Fig. 5.1.4. Load-deflection curve

5.2. A121A2

5.2.1. Test properties

Fig. 5.2.1. Crack pattern after failure north side

Fig. 5.2.2. Crack pattern after failure south side

Table 5.2.1. Beam properties

Date of test	09-04-2015
Reinforcement	3Ø20
Reinforcement ratio	1.17%
a	1255 mm
a / *d*	4.66
Concrete cube strength at testing	77.7 MPa
Peak load	138.8 kN
Failure mode	Flexural

Table 5.2.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Placed LVDT1, 2 and 3
1	20	LVDT2 not working, replaced
2	40	
3	60	
4	80	
5	100	
6	120	
7	140	Stopped after jack displacement of 40 mm

Table 5.2.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	South	Vertical	300	50
2	South	Horizontal	360	Mid - depth
3	North	Vertical	810	50

5.2.2. Measurement results

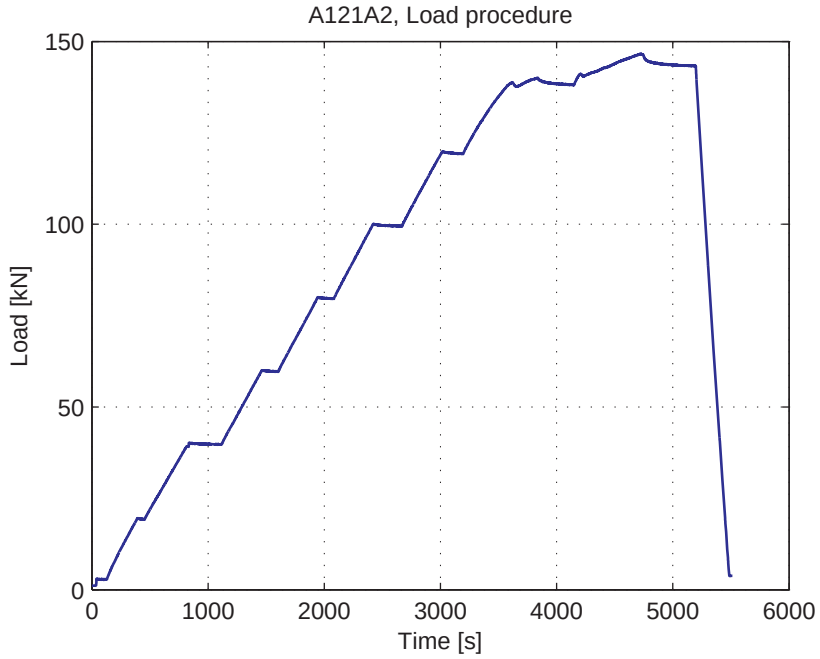


Fig. 5.2.3. Load-Time curve

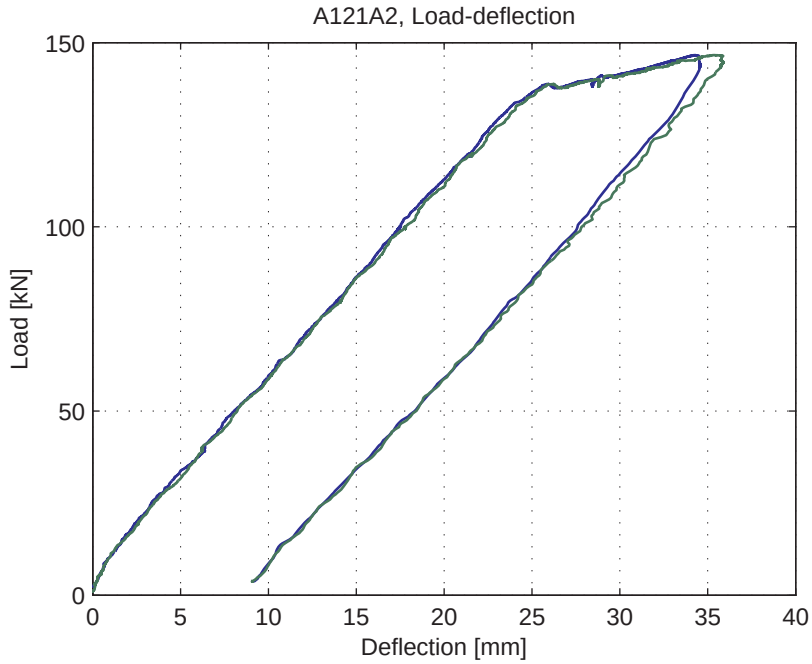


Fig. 5.2.4. Load-deflection curve

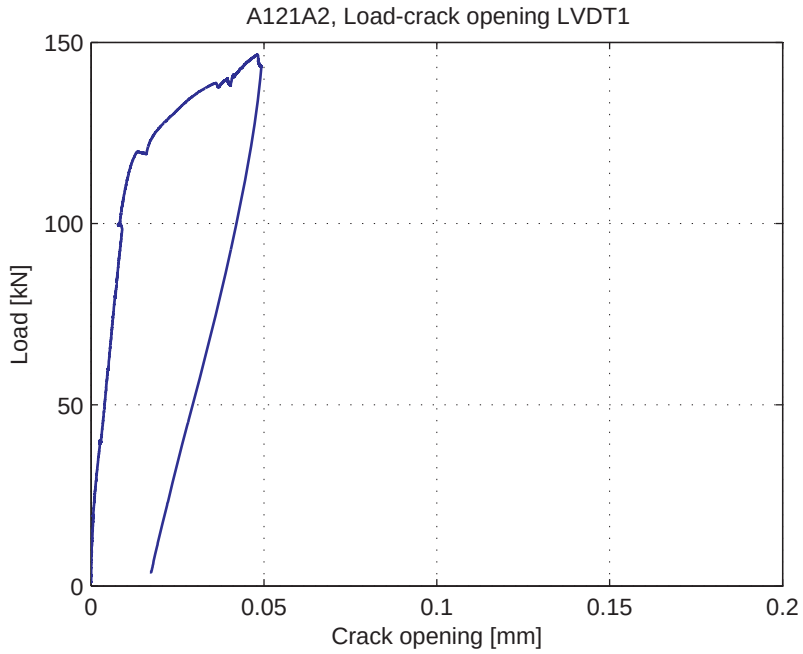


Fig. 5.2.5. Load-Crack opening for LVDT1

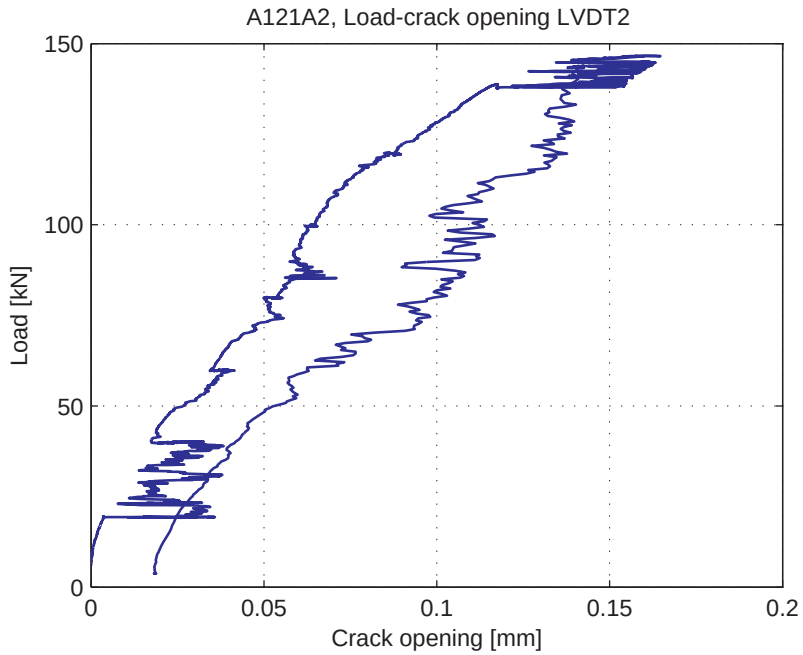


Fig. 5.2.6. Load-Crack opening for LVDT2

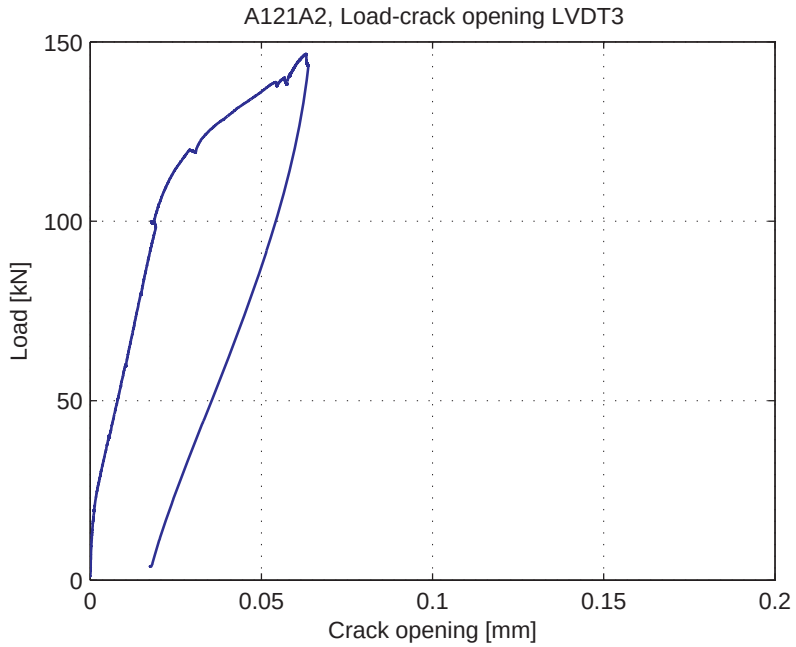


Fig. 5.2.7. Load-Crack opening for LVDT3

5.3. A121A3

5.3.1. Test properties

Fig. 5.3.1. Crack pattern after failure north side

Fig. 5.3.2. Crack pattern after failure south side

Table 5.3.1. Beam properties

Date of test	09-04-2015
Reinforcement	3Ø20
Reinforcement ratio	1.17%
a	1000 mm
a / *d*	3.71
Concrete cube strength at testing	77.7 MPa
Peak load	144.6 kN
Failure mode	Shear

Table 5.3.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Added LVDT4, 5 and 6
1	20	
2	40	
3	60	
4	80	
5	100	
6	120	

Table 5.3.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	South	Vertical	300	-
2	South	Horizontal	360	-
3	North	Vertical	810	-
4	North	Vertical	323	-
5	North	Vertical	464	-
6	North	Vertical	574	-

5.3.2. Measurement results

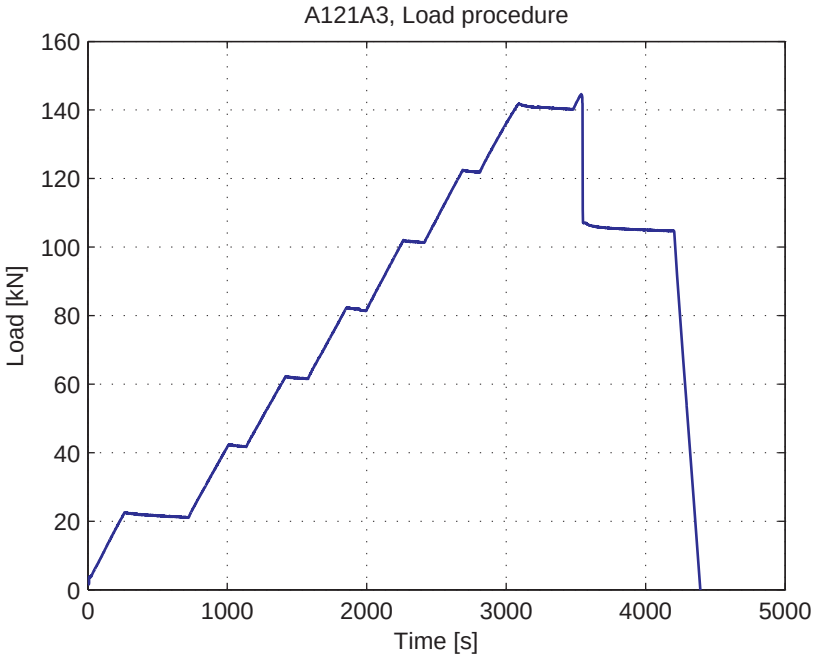


Fig. 5.3.3. Load-Time curve

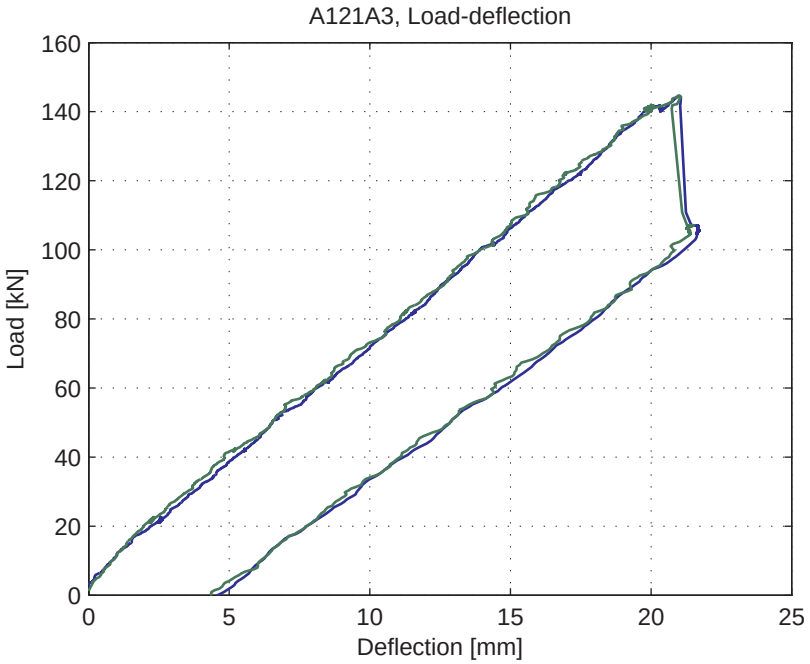


Fig. 5.3.4. Load-deflection curve

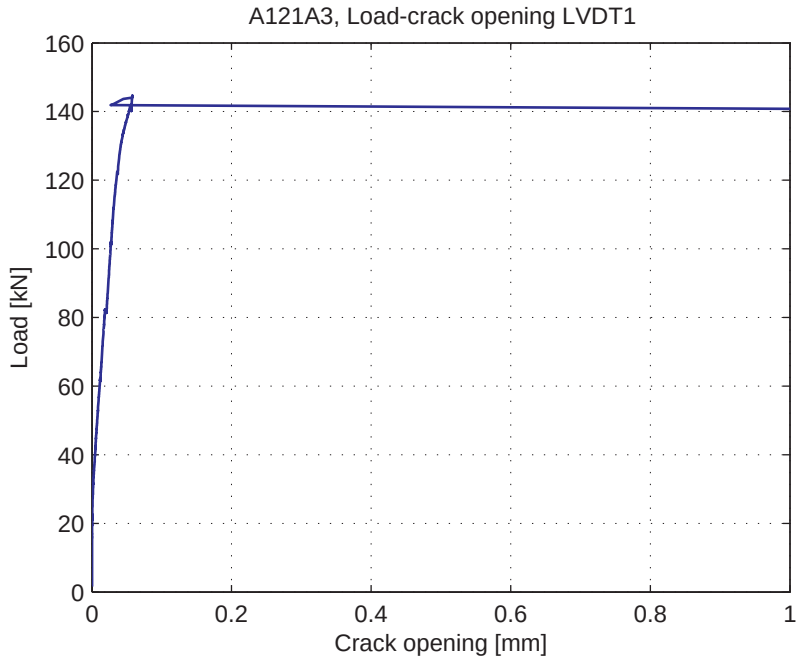


Fig. 5.3.5. Load-Crack opening for LVDT1

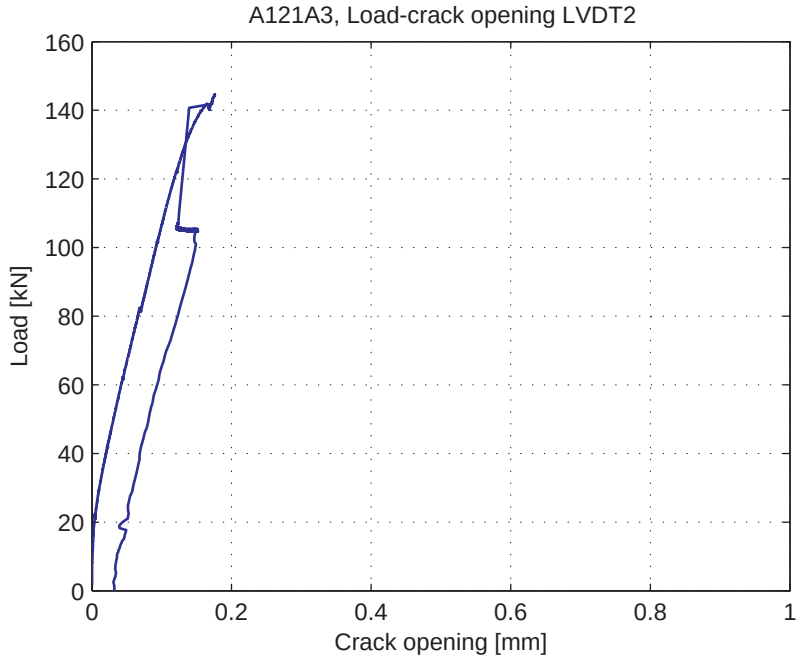


Fig. 5.3.6. Load-Crack opening for LVDT2

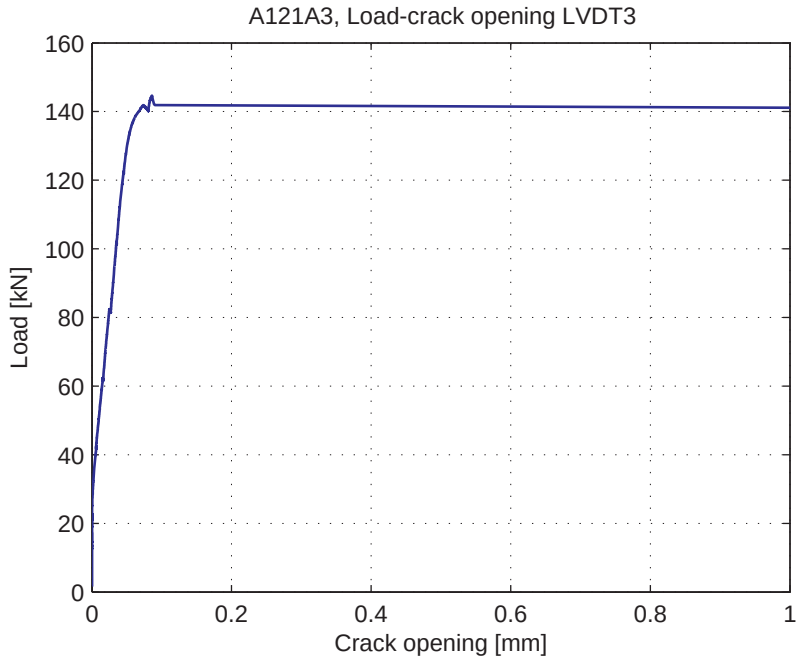


Fig. 5.3.7. Load-Crack opening for LVDT3

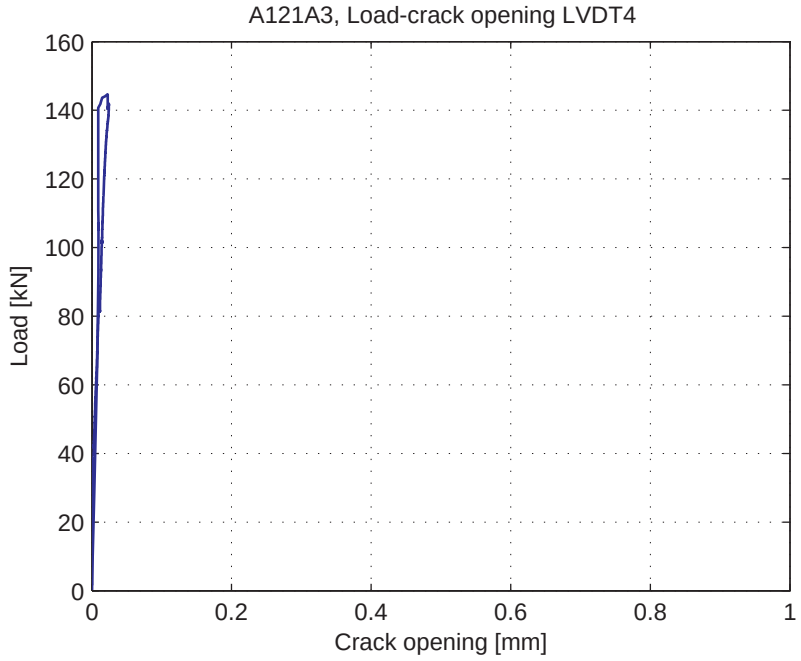


Fig. 5.3.8. Load-Crack opening for LVDT4

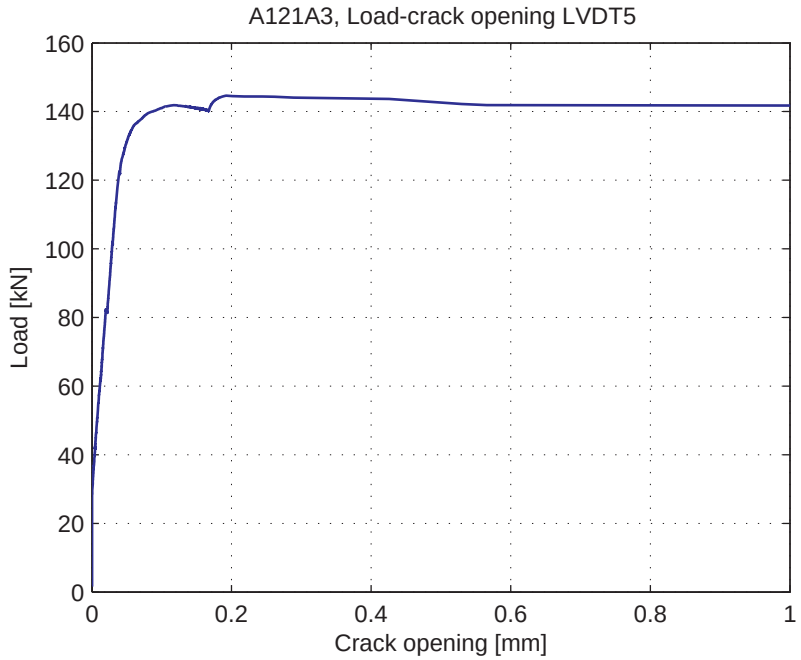


Fig. 5.3.9. Load-Crack opening for LVDT5

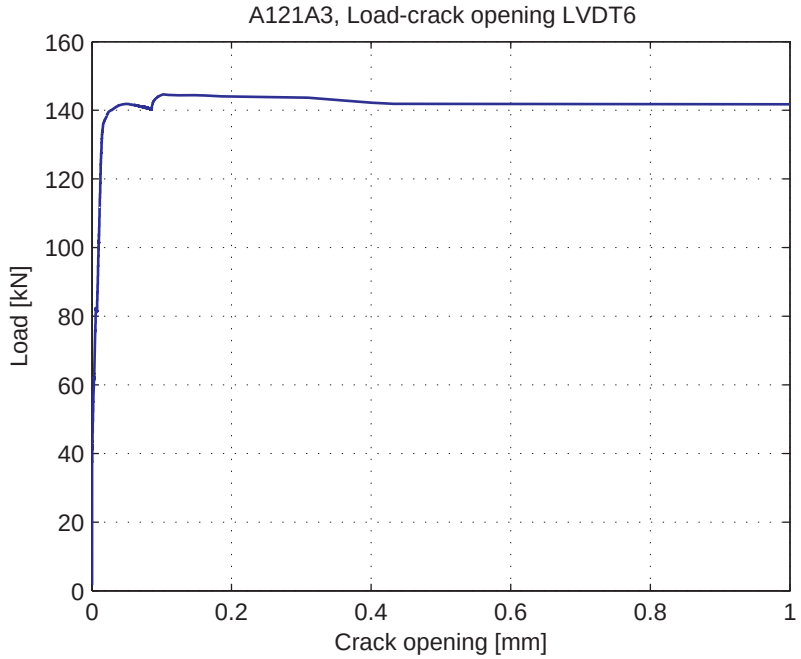


Fig. 5.3.10. Load-Crack opening for LVDT6

5.4. A121B1

5.4.1. Test properties

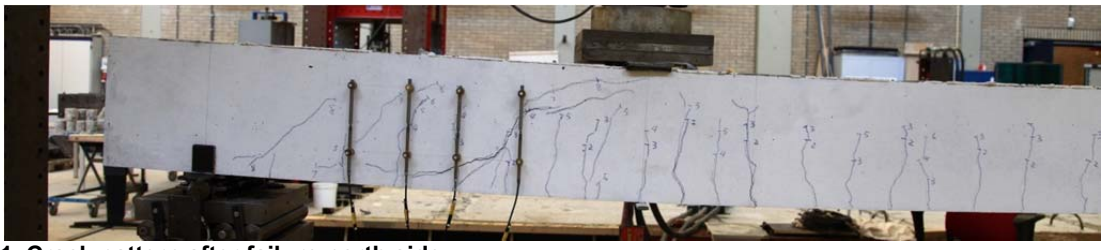


Fig. 5.4.1. Crack pattern after failure north side

Fig. 5.4.2. Crack pattern after failure south side

Table 5.4.1. Beam properties

Date of test	10-04-2015
Reinforcement	3Ø20
Reinforcement ratio	1.17%
a	1000 mm
a / *d*	3.71
Concrete cube strength at testing	77.8 MPa
Peak load flexural / shear	157.6 kN
Failure mode	Flexural with Shear crack formed

Table 5.4.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	Offset between measured load and load on PC. Back to zero and zeroing the load
2	0	
3	22	
4	40	
5	60	
6	80	Four LVDT's (1-4) are installed
7	100	
8	120	Moved laser03
9	140	
10	160	Developed shear crack, also flexural . Small top at 157 kN. Difference of 2 kN between measured load and real load.

Table 5.4.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	335	-
2	North	Vertical	465	-
3	North	Vertical	580	-
4	North	Vertical	720	-

5.4.2. Measurement results

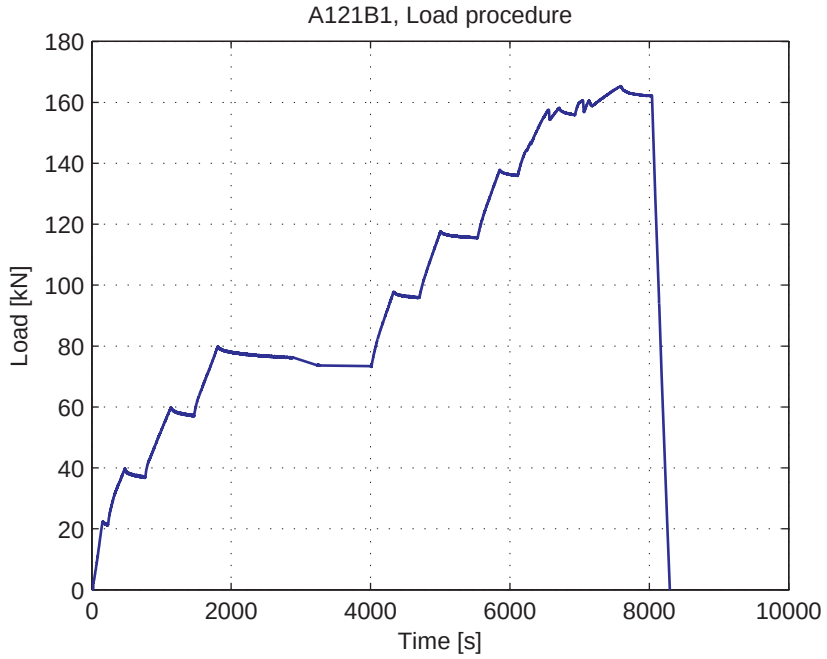


Fig. 5.4.3. Load-Time curve

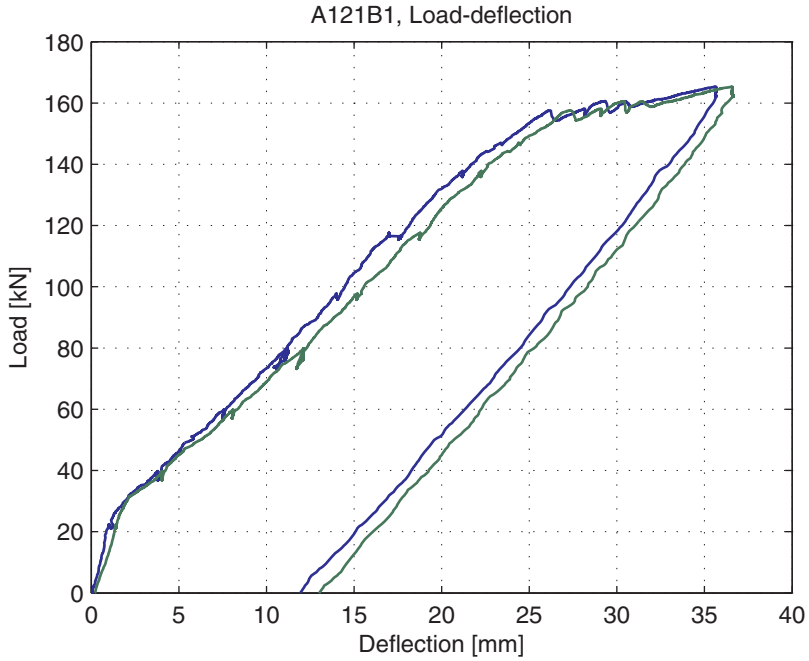


Fig. 5.4.4. Load-deflection curve

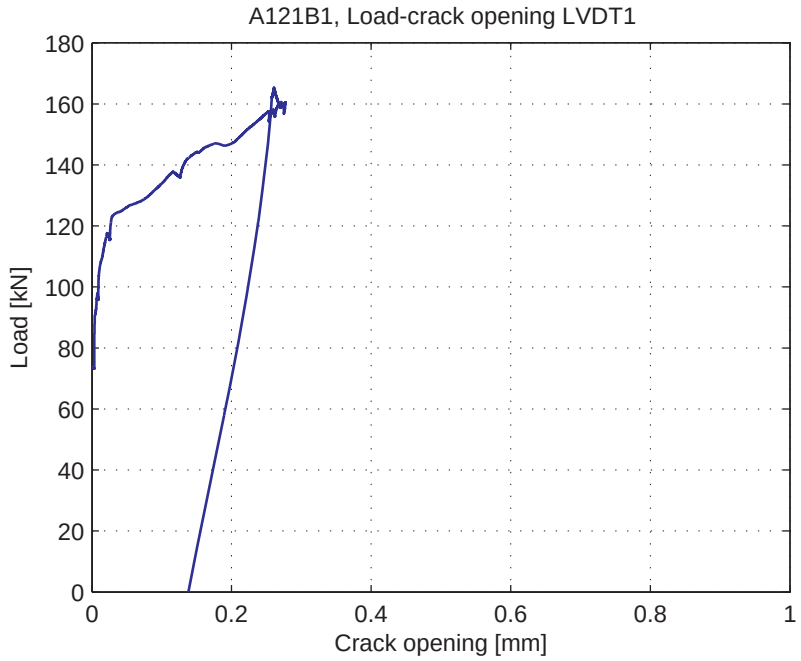


Fig. 5.4.5. Load-Crack opening for LVDT1

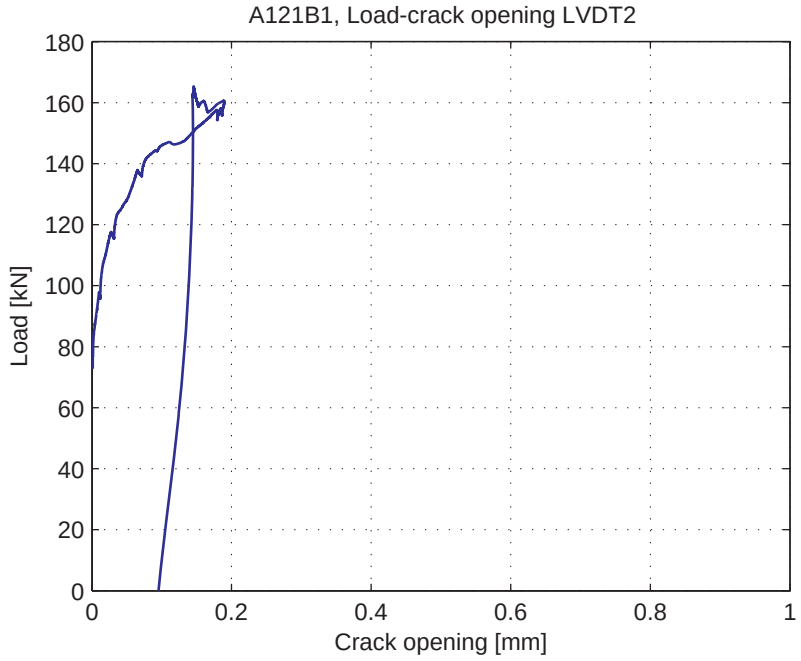


Fig. 5.4.6. Load-Crack opening for LVDT2

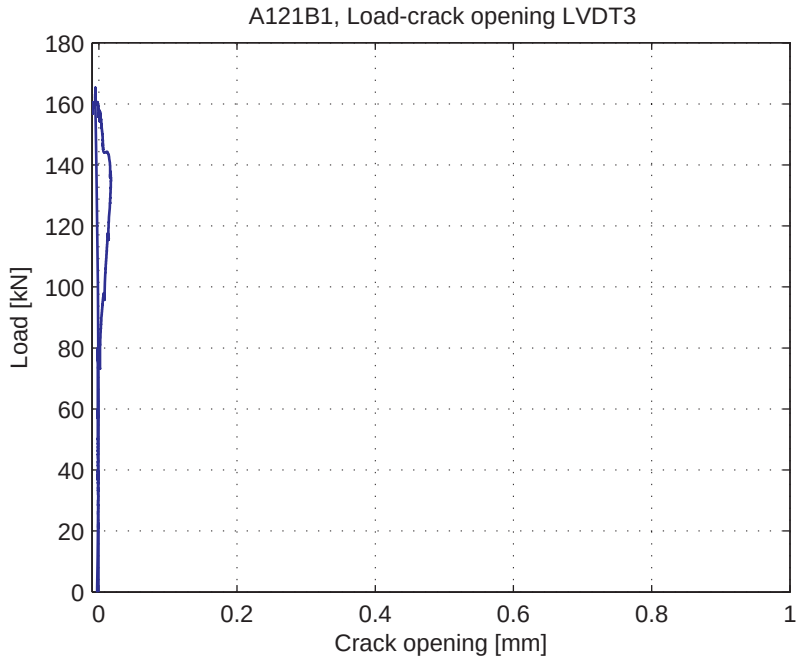


Fig. 5.4.7. Load-Crack opening for LVDT3

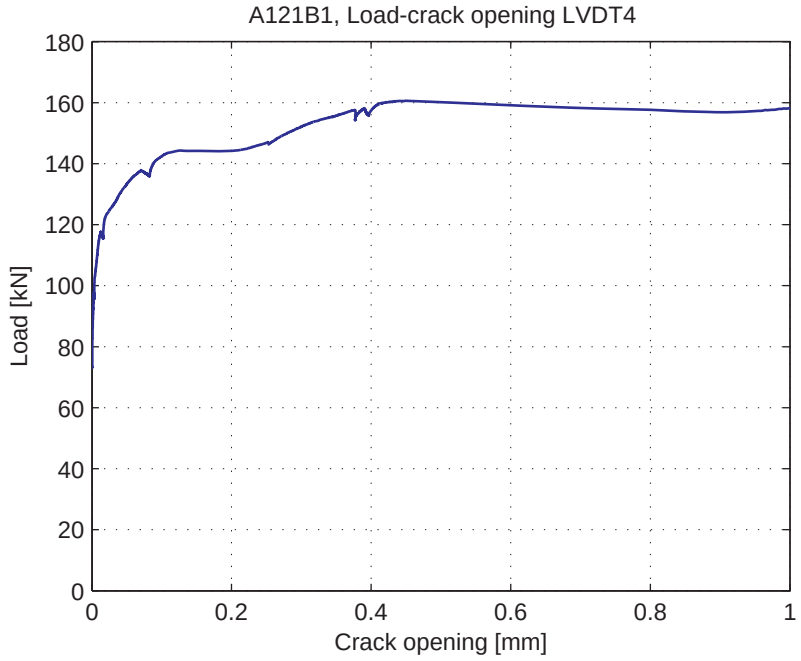


Fig. 5.4.8. Load-Crack opening for LVDT4

5.5. A122A1

5.5.1. Test properties

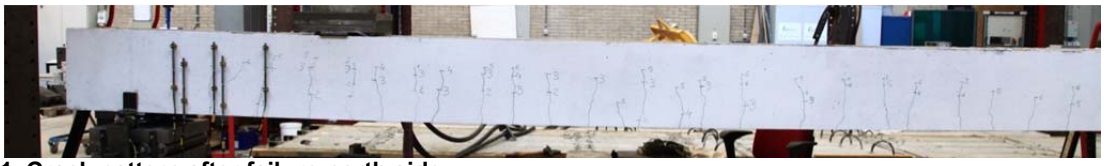


Fig. 5.5.1. Crack pattern after failure north side

Fig. 5.5.2. Crack pattern after failure south side

Table 5.5.1. Beam properties

Date of test	13-04-2015
Reinforcement	3Ø20
Reinforcement ratio	1.16%
a	750 mm
a / *d*	2.77
Concrete cube strength at testing	78.2 MPa
Peak load flexural / shear	191.6 kN / 194.7 kN
Failure mode	Flexural and shear

Table 5.5.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	Glued LVDT 1-3, 5 and 6 on north side. LVDT 4 not good?
5	100	
6	120	
7	140	
8	160	
9	180	Stopped after jack displacement of 32.5 mm. Load offset 9.3 kN

Table 5.5.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	-	-
2	North	Vertical	-	-
3	North	Vertical	-	-
4	North	Vertical	-	-

5.5.2. Measurement results

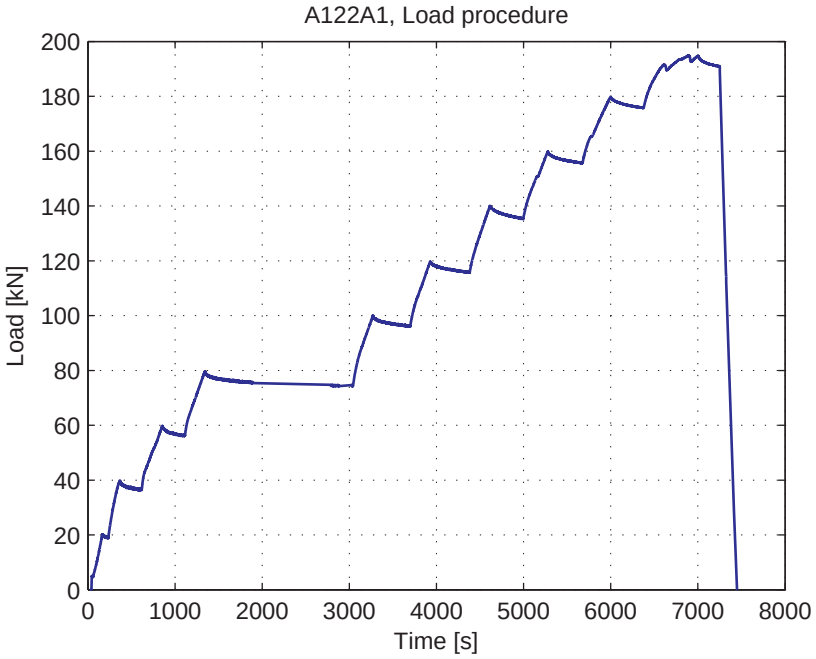


Fig. 5.5.3. Load-Time curve

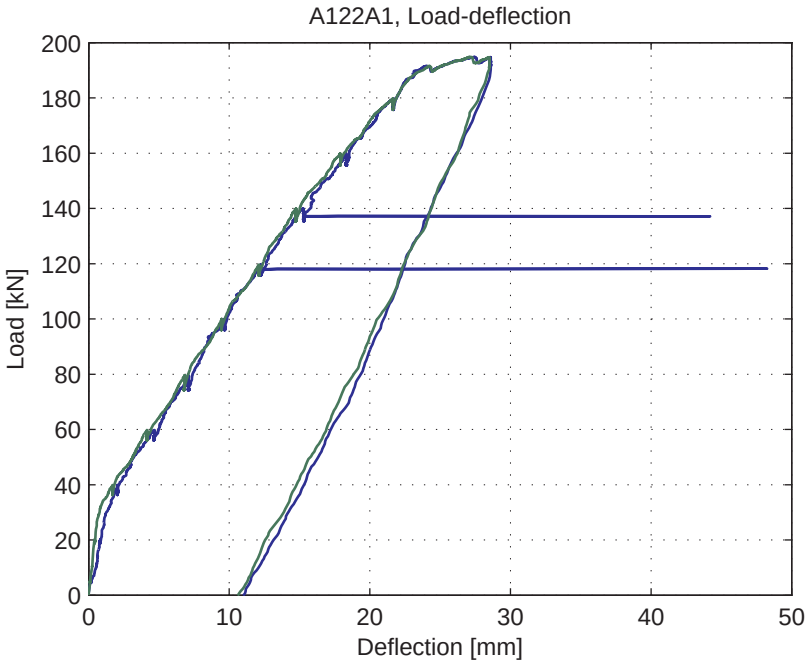


Fig. 5.5.4. Load-deflection curve

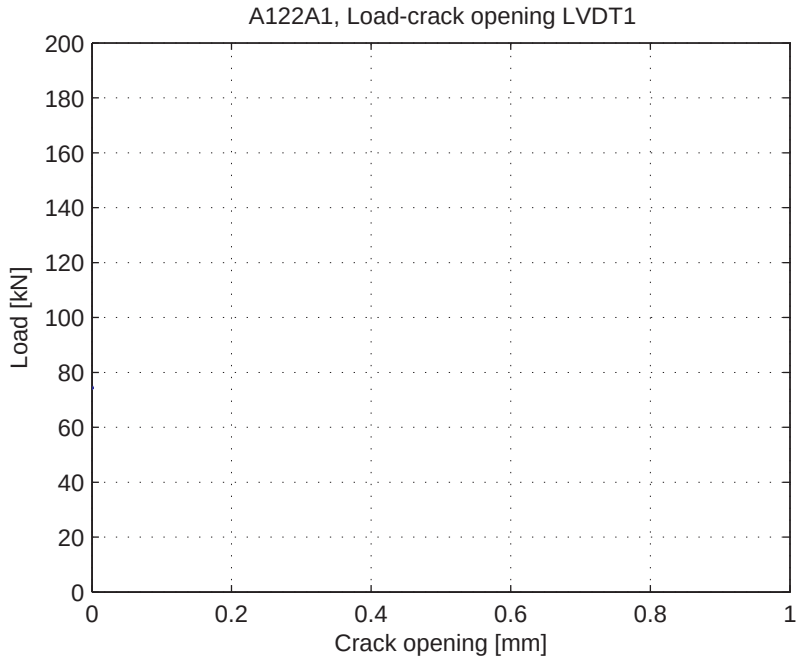


Fig. 5.5.5. Load-Crack opening for LVDT1

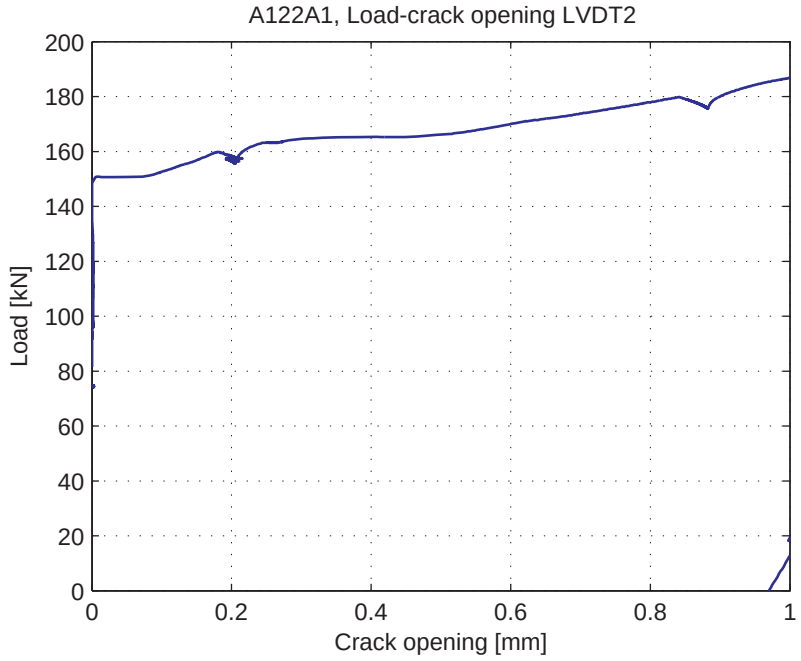


Fig. 5.5.6. Load-Crack opening for LVDT2

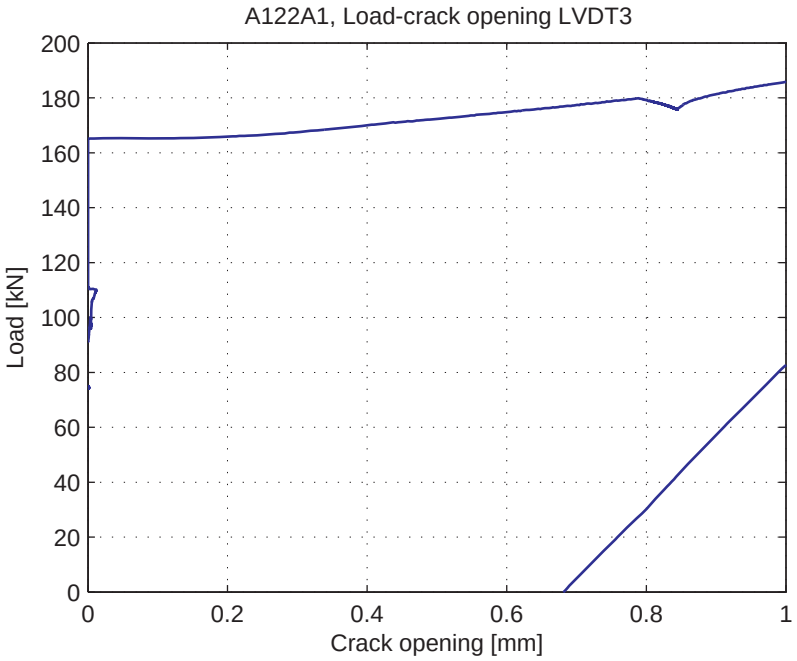


Fig. 5.5.7. Load-Crack opening for LVDT3

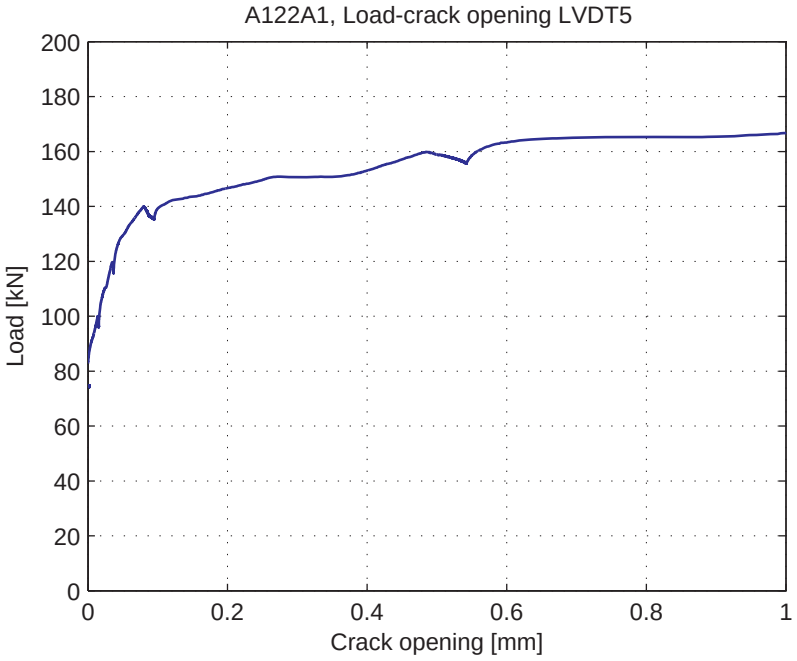


Fig. 5.5.8. Load-Crack opening for LVDT5

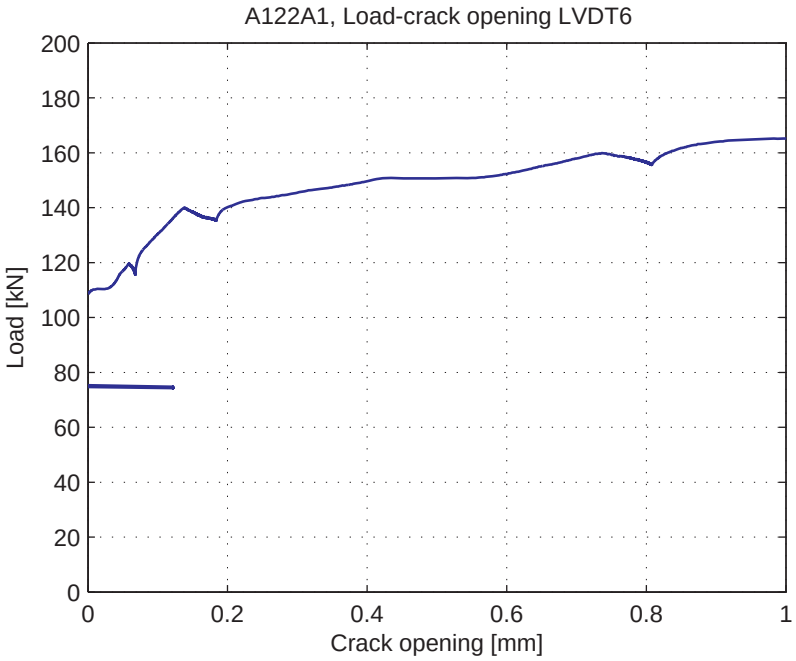


Fig. 5.5.9. Load-Crack opening for LVDT6

5.6. A122B1

5.6.1. Test properties

Fig. 5.6.1. Crack pattern after failure north side

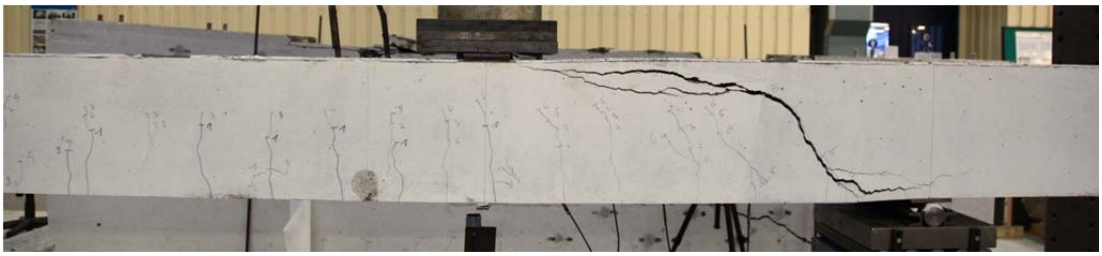


Fig. 5.6.2. Crack pattern after failure south side

Table 5.6.1. Beam properties

Date of test	15-04-2015
Reinforcement	3Ø20
Reinforcement ratio	1.16%
a	1000 mm
a / *d*	3.70
Concrete cube strength at testing	78.5 MPa
Peak load	152.3 kN
Failure mode	Shear

Table 5.6.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	
5	100	LVDT's 1-4 added
6	152	Shear failure

Table 5.6.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	328	50
2	North	Vertical	553	50
3	North	Vertical	698	100
4	North	Vertical	783	100

5.6.2. Measurement results

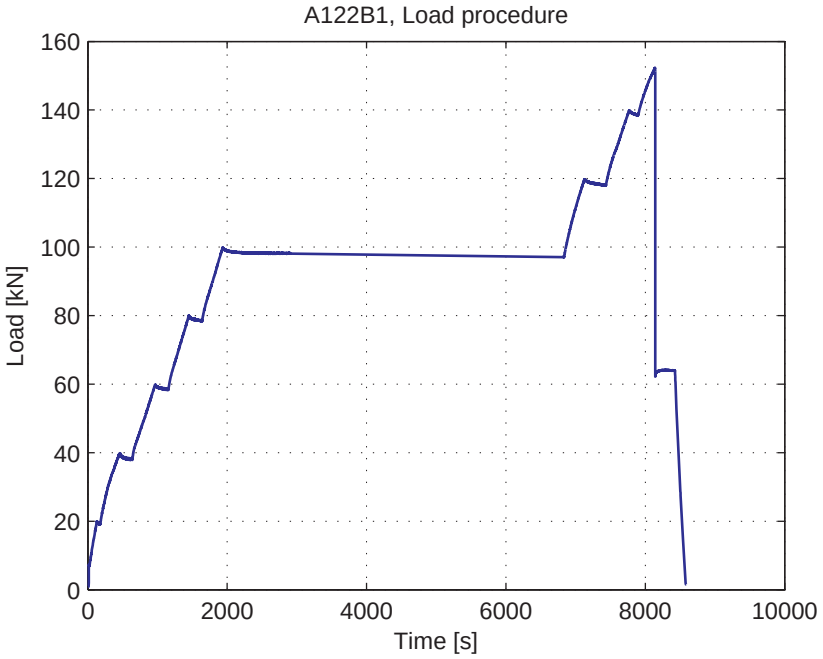


Fig. 5.6.3. Load-Time curve

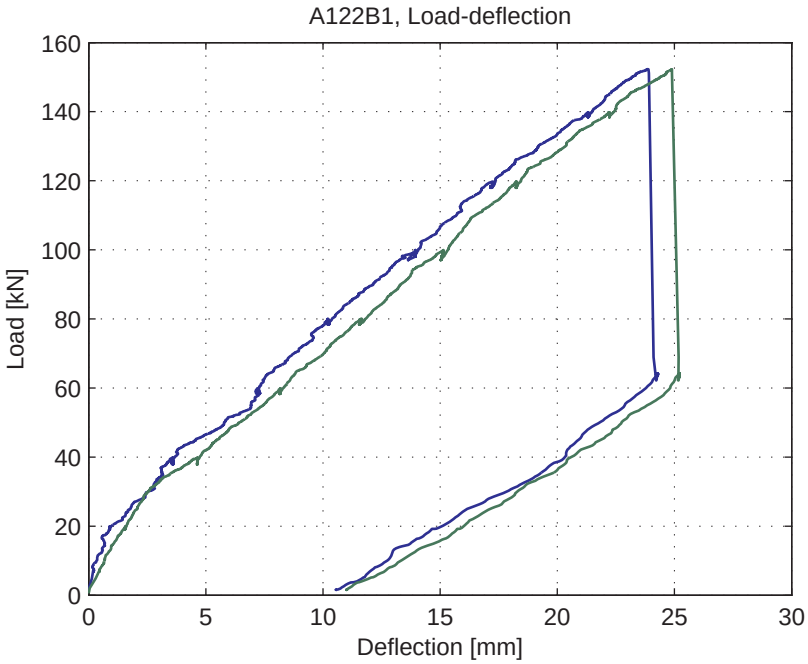


Fig. 5.6.4. Load-deflection curve

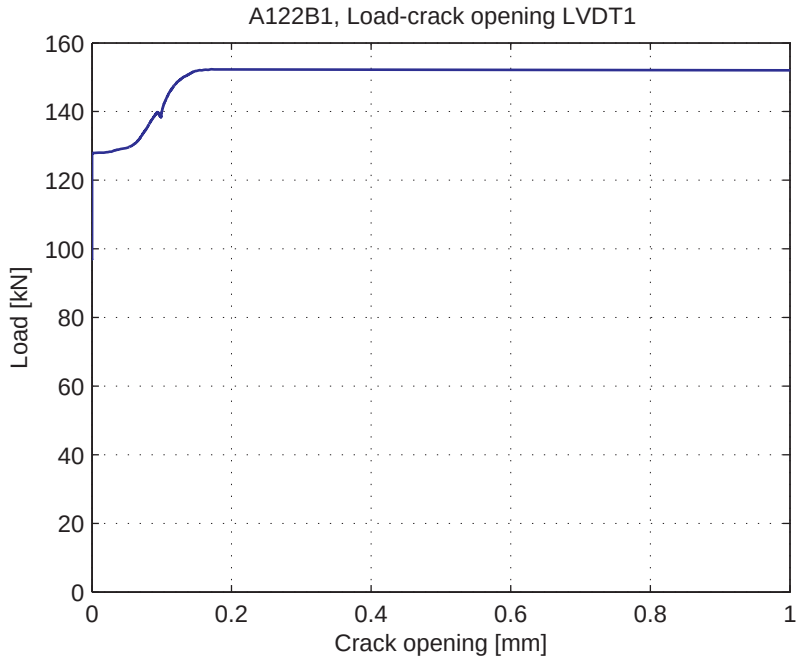


Fig. 5.6.5. Load-Crack opening for LVDT1

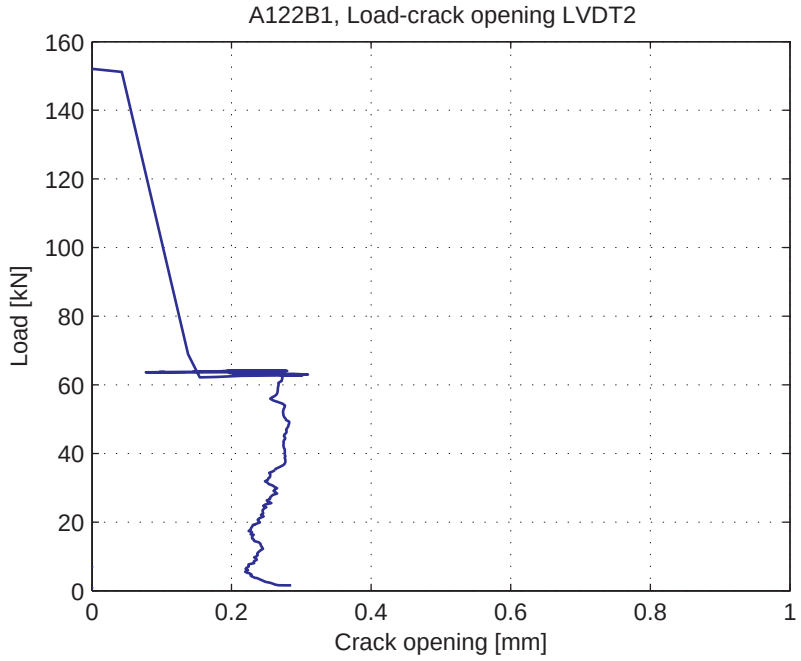


Fig. 5.6.6. Load-Crack opening for LVDT2

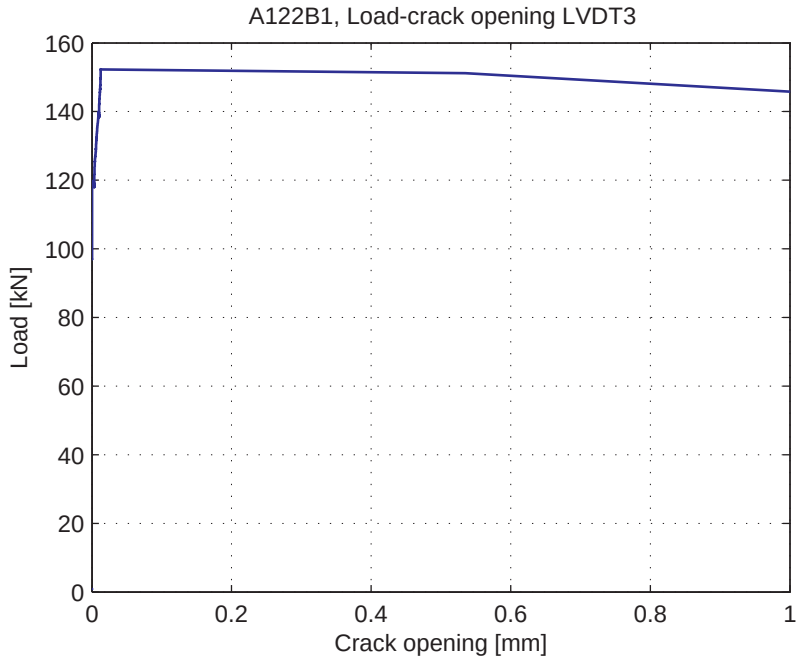


Fig. 5.6.7. Load-Crack opening for LVDT2

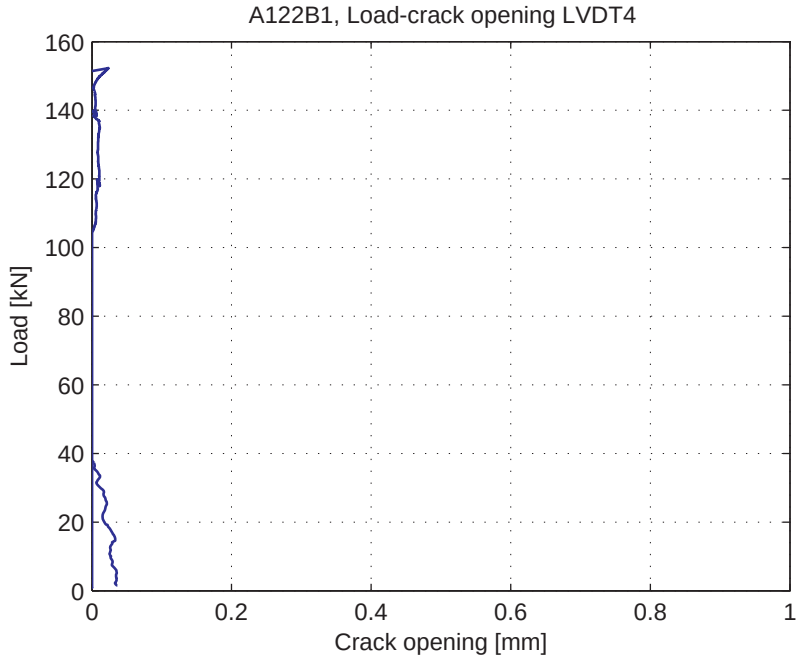


Fig. 5.6.8. Load-Crack opening for LVDT2

5.7. A122B2

5.7.1. Test properties

Fig. 5.7.1. Crack pattern after failure north side

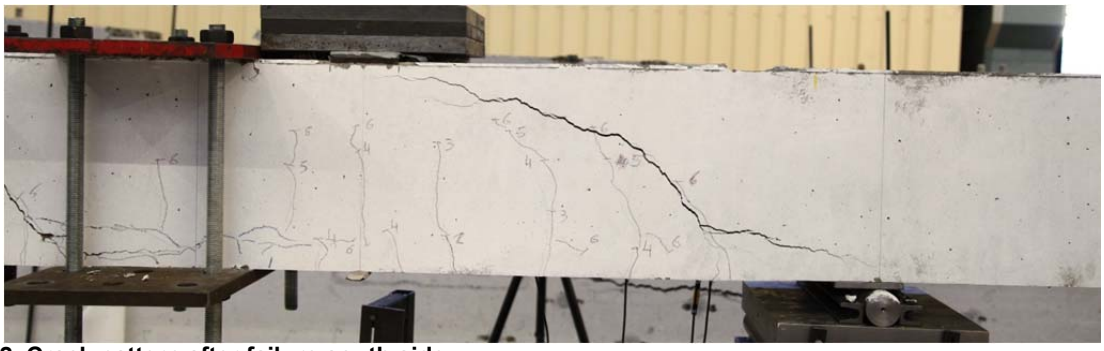


Fig. 5.7.2. Crack pattern after failure south side

Table 5.7.1. Beam properties

Date of test	16-04-2015
Reinforcement	3Ø20
Reinforcement ratio	1.16%
a	750 mm
a / *d*	2.77
Concrete cube strength at testing	78.5 MPa
Peak load	139.1 kN
Failure mode	Shear

Table 5.7.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Crack from test A122B1 is fixated by two steel plates and 8 M24 threads, prestressed by air hammer
1	20	
2	40	
3	60	Unloading, steel plate touches the reinforcement plate, started new file
4	80	
5	100	LVDT1-3 and 5 installed
6	120	
7	139.1	Shear failure

Table 5.7.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1			197	100
2			520	100
3			350	100
5			222	100

5.7.2. Measurement results

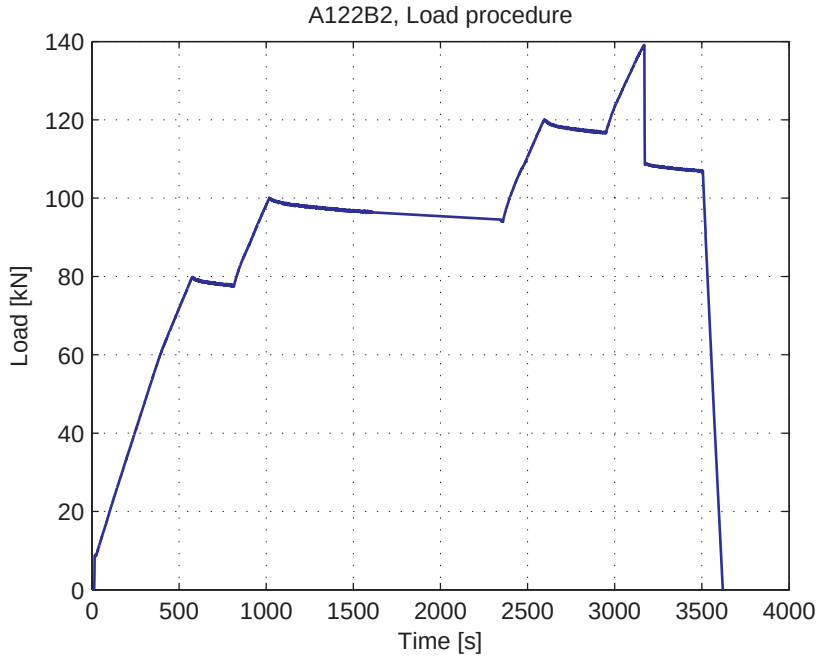


Fig. 5.7.3. Load-Time curve

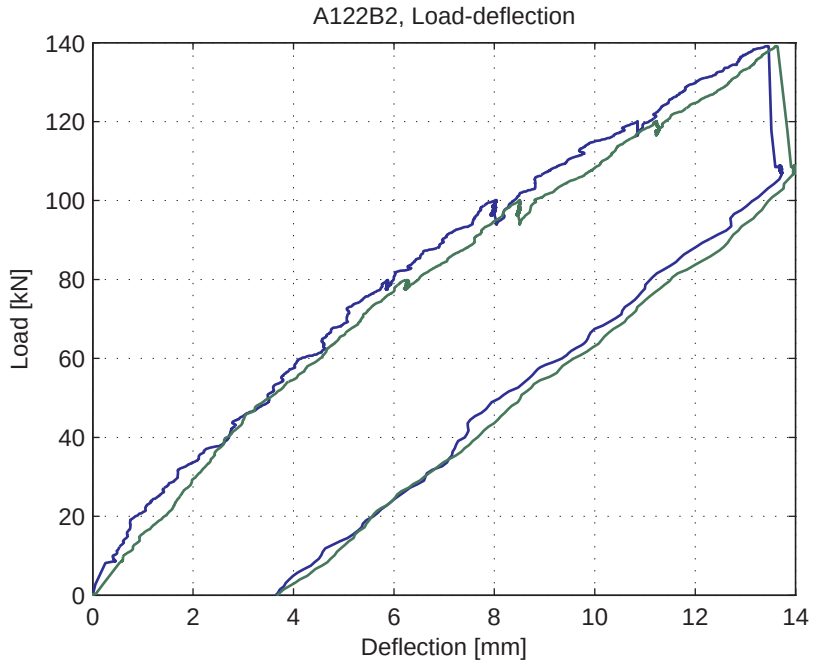


Fig. 5.7.4. Load-deflection curve

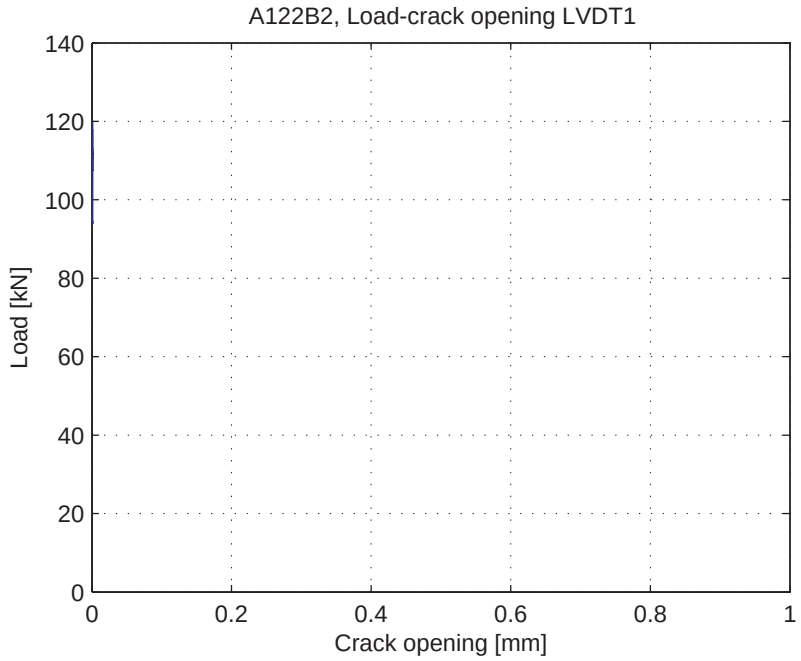


Fig. 5.7.5. Load-Crack opening for LVDT1

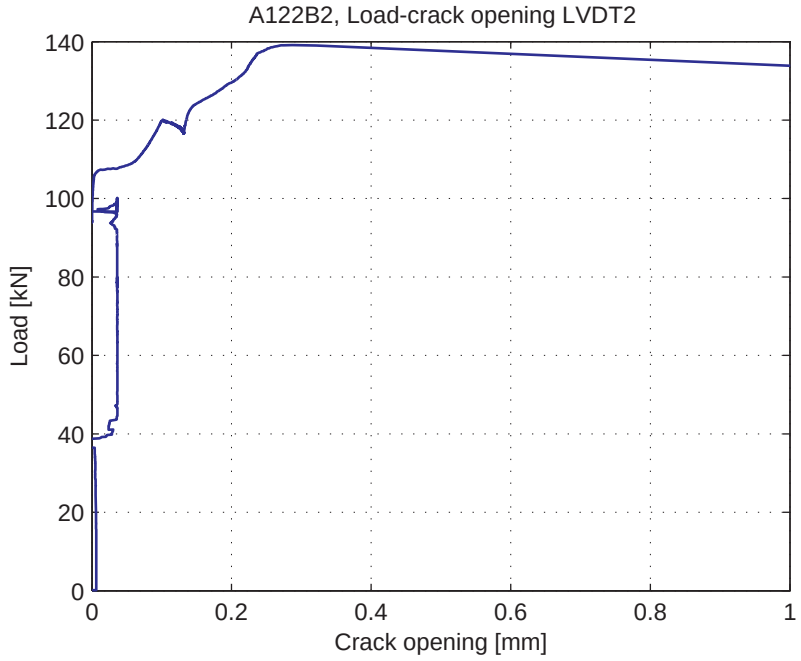


Fig. 5.7.6. Load-Crack opening for LVDT2

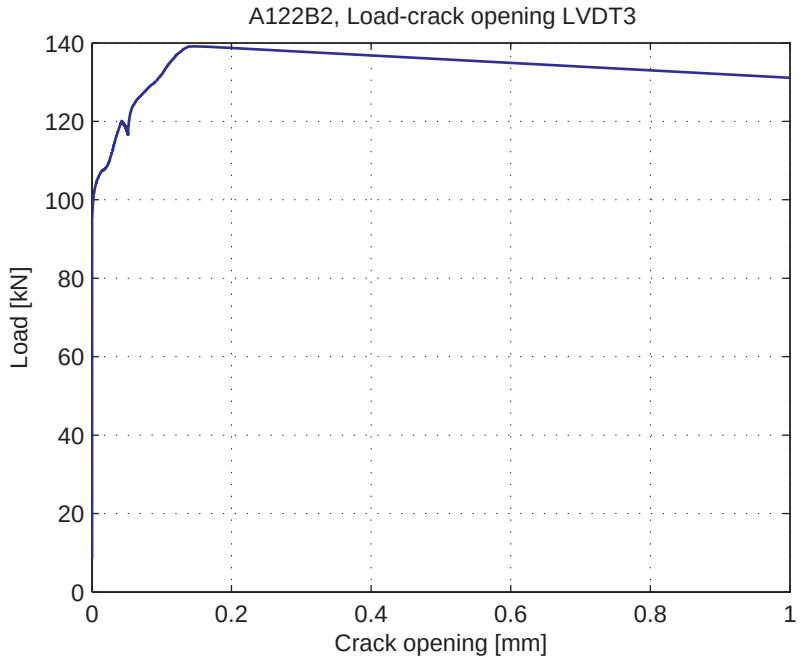


Fig. 5.7.7. Load-Crack opening for LVDT3

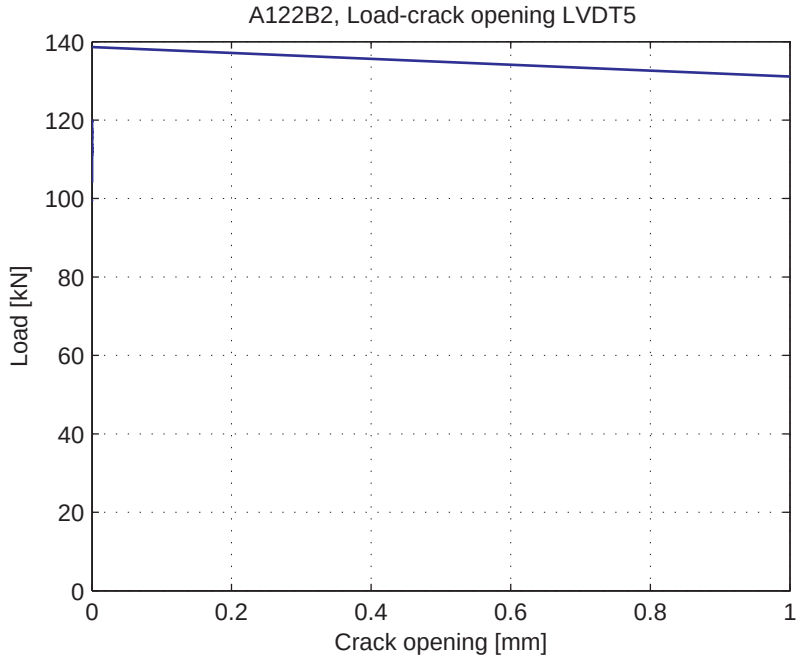


Fig. 5.7.8. Load-Crack opening for LVDT5

5.8. A123A1

5.8.1. Test properties

Fig. 5.8.1. Crack pattern after failure north side

Fig. 5.8.2. Crack pattern after failure south side

Table 5.8.1. Beam properties

Date of test	07-09-2015
Reinforcement	3Ø20
Reinforcement ratio	1.16%
a	1000 mm
a / *d*	3.70
Concrete cube strength at testing	79.2 MPa[1]
Peak load	136.5 kN
Failure mode	Shear

[1] For concrete batch used for casting this beam no cubes were tested. Therefore the average strength of all other casts (casts 1,2, 5, 6 and 7) at the same age is used for the cube compressive strength of this beam.

Table 5.8.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	
5	90	Added LVDT's 4-6
6	100	
7	120	
8	136.5	Shear failure

Table 5.8.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	410	50
5	North	Vertical	735	50
6	North	Vertical	845	50

5.8.2. Measurement results

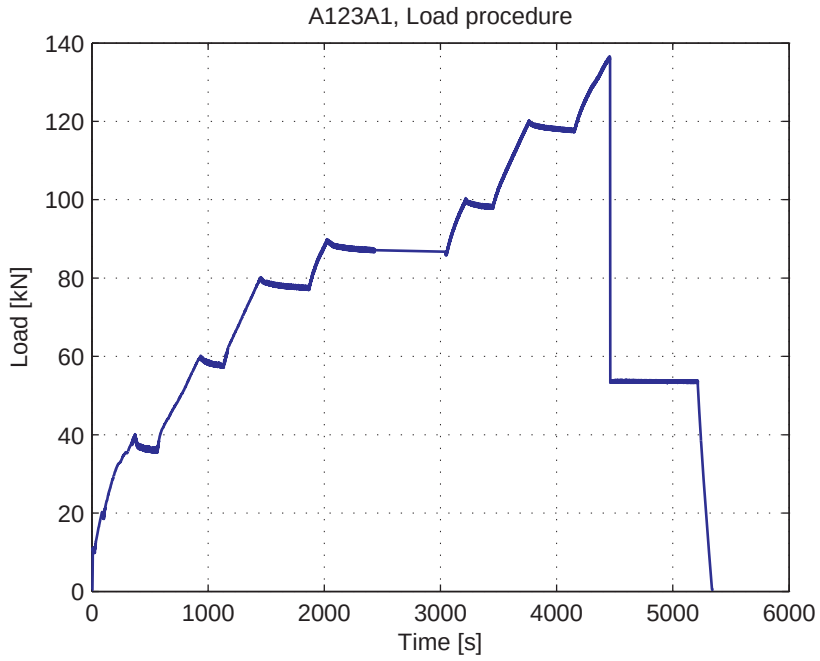


Fig. 5.8.3. Load-Time curve

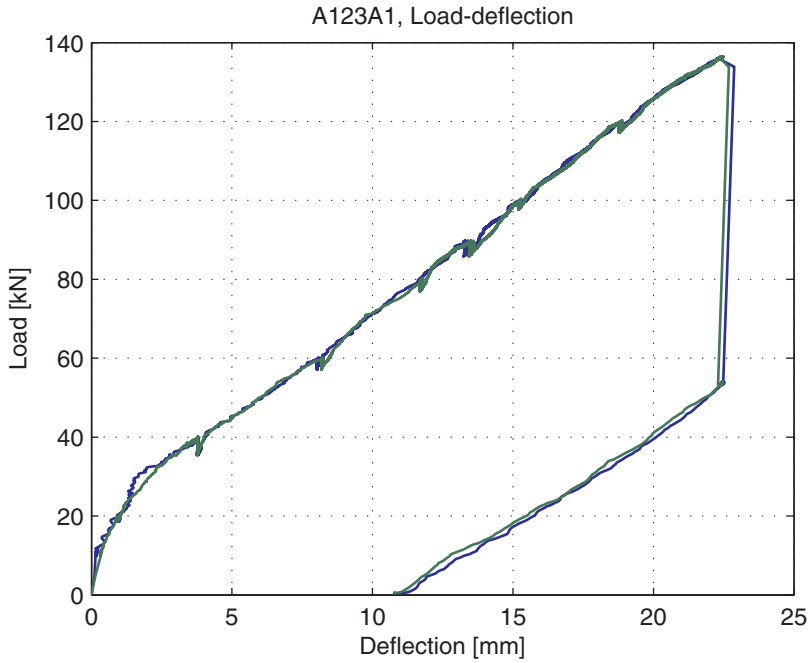


Fig. 5.8.4. Load-deflection curve

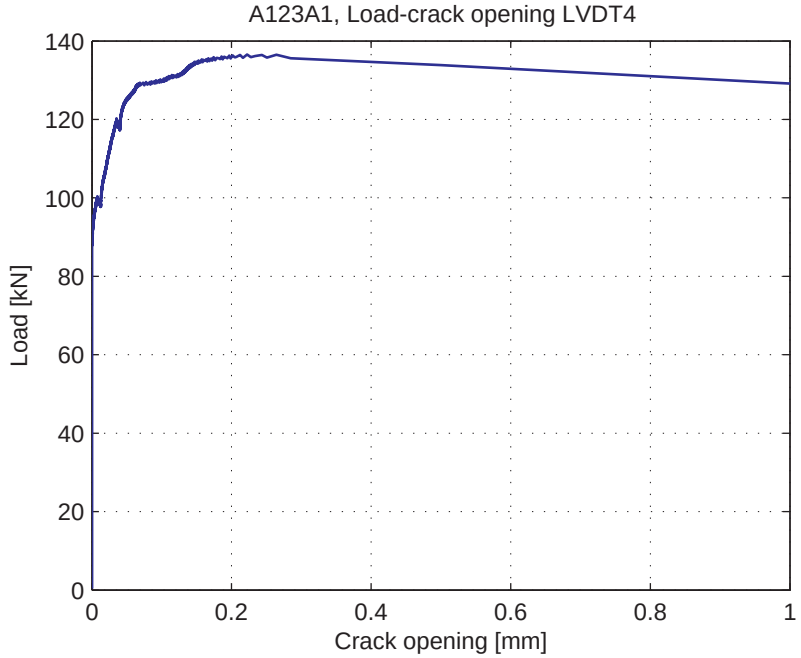


Fig. 5.8.5. Load-Crack opening for LVDT4

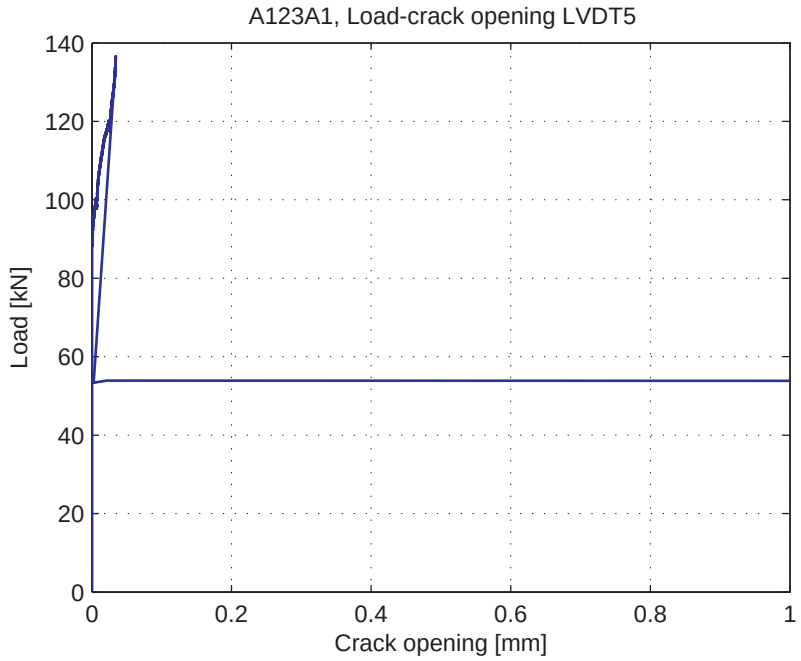


Fig. 5.8.6. Load-Crack opening for LVDT5

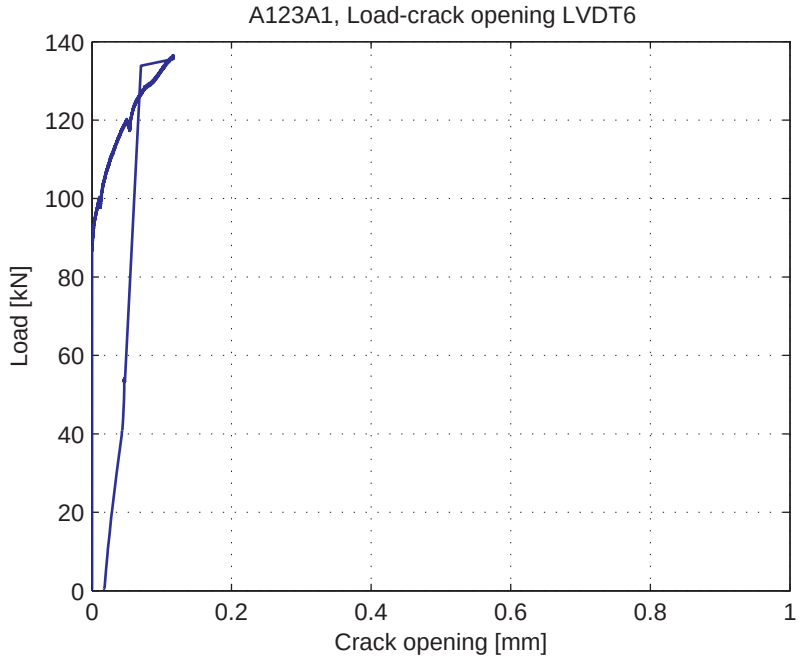


Fig. 5.8.7. Load-Crack opening for LVDT6

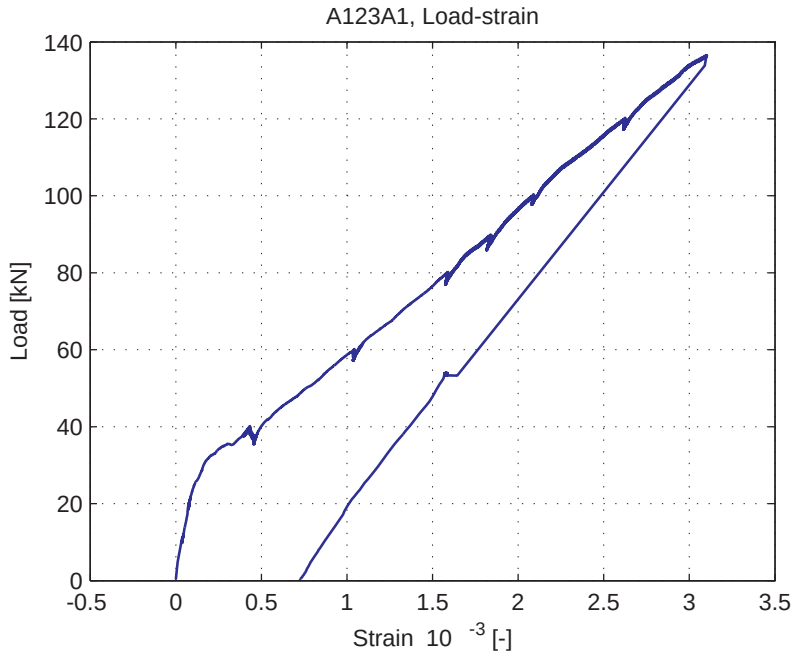


Fig. 5.8.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.9. A123A2

5.9.1. Test properties

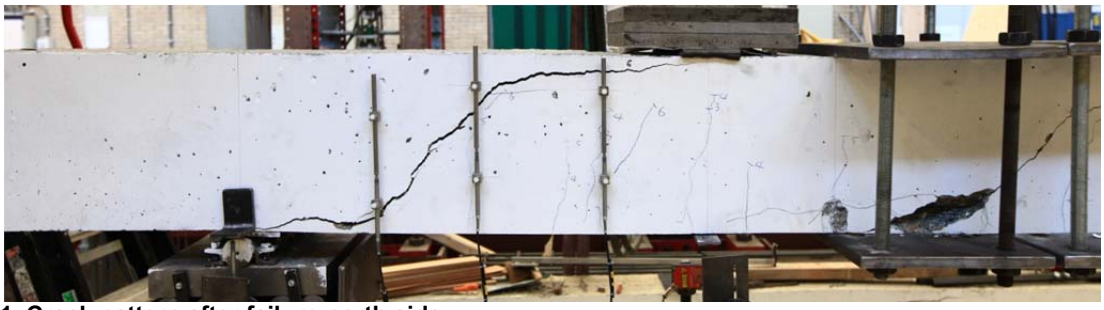


Fig. 5.9.1. Crack pattern after failure north side

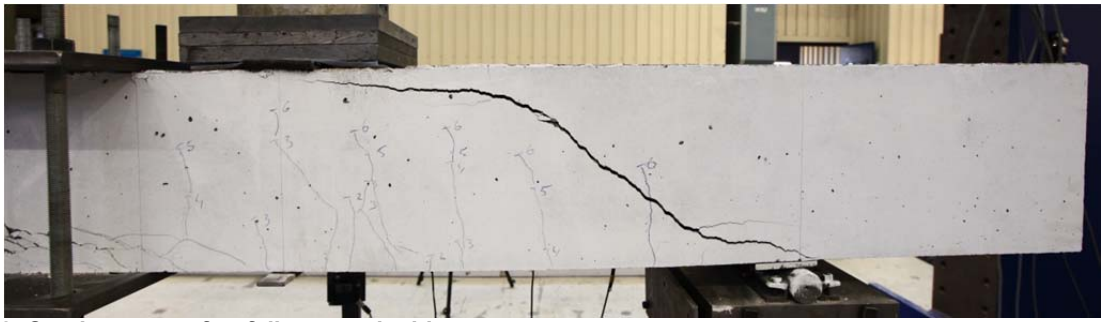


Fig. 5.9.2. Crack pattern after failure south side

Table 5.9.1. Beam properties

Date of test	29-09-2015
Reinforcement	3Ø20
Reinforcement ratio	1.16%
a	800 mm
a / *d*	2.96
Concrete cube strength at testing	80.1 MPa[2]
Peak load	139.0 kN
Failure mode	Shear

Table 5.9.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Old shear crack clamped, no LVDT03
1	20	
2	0	Returned to 0. Laser01 out of range
3	40	
4	60	
5	80	
6	100	Installed LVDT4-6
7	120	
8	139.0	Shear failure

[2] For concrete batch used for casting this beam no cubes were tested. Therefore the average strength of all other casts (casts 1,2, 5, 6 and 7) at the same age is used for the cube compressive strength of this beam.

Table 5.9.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	235	50
5	North	Vertical	405	100
6	North	Vertical	620	100

5.9.2. Measurement results

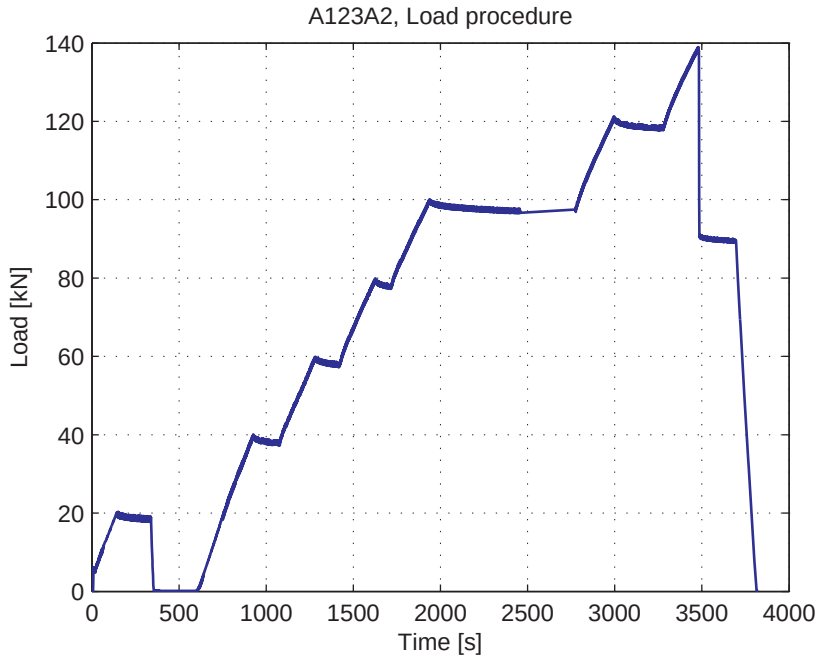


Fig. 5.9.3. Load-Time curve

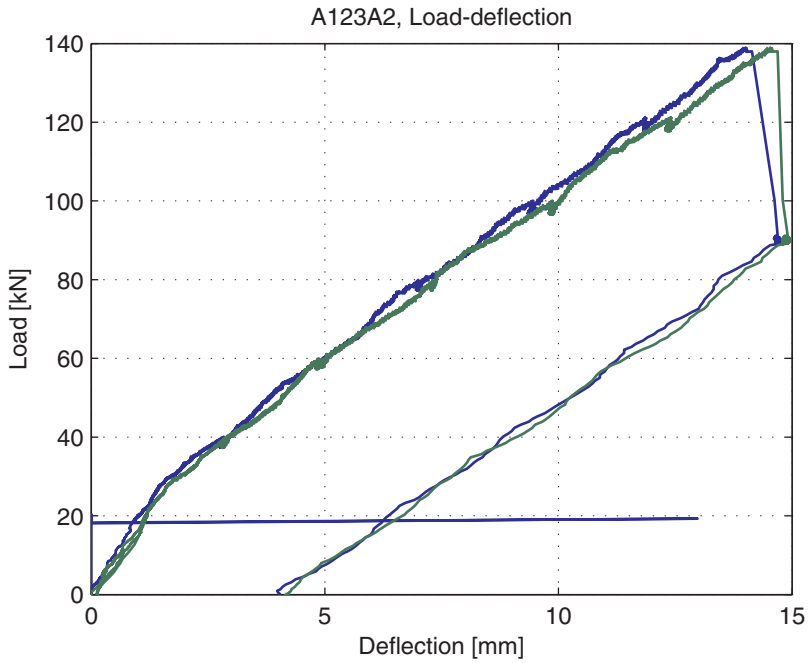


Fig. 5.9.4. Load-deflection curve

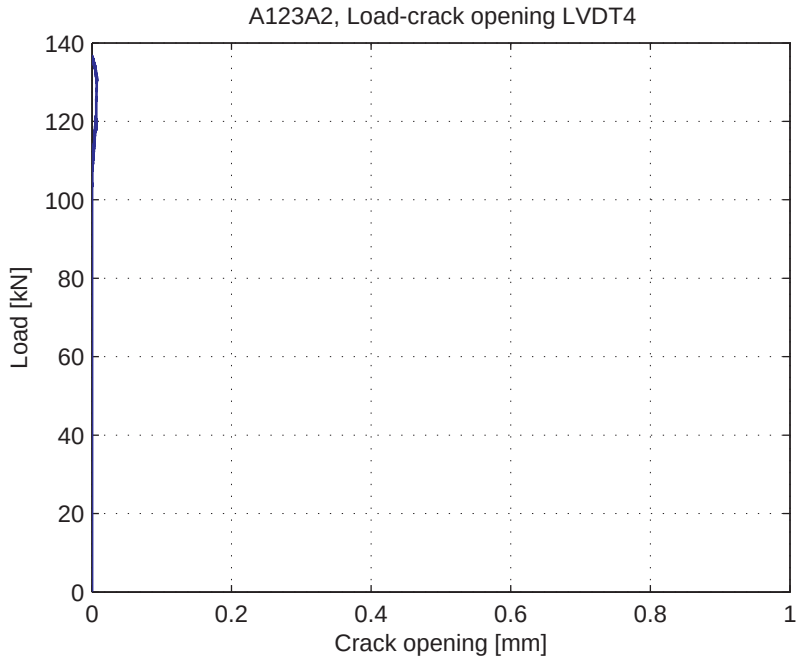


Fig. 5.9.5. Load-Crack opening for LVDT4

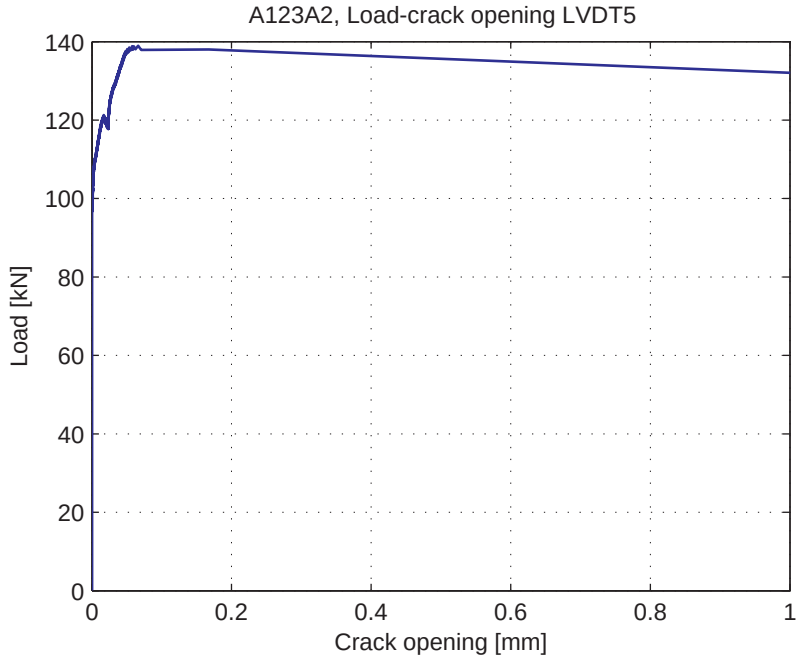


Fig. 5.9.6. Load-Crack opening for LVDT5

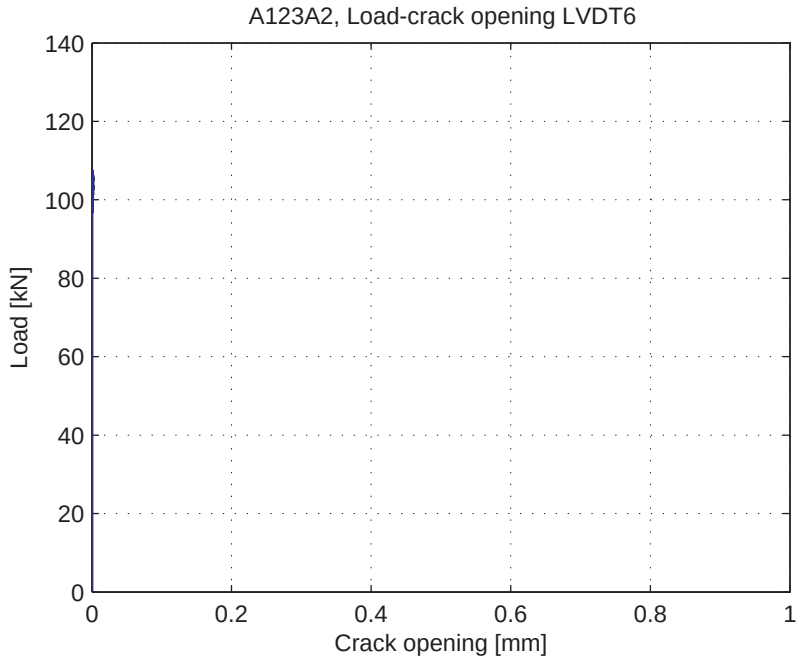


Fig. 5.9.7. Load-Crack opening for LVDT6

5.10. A123B1

5.10.1. Test properties

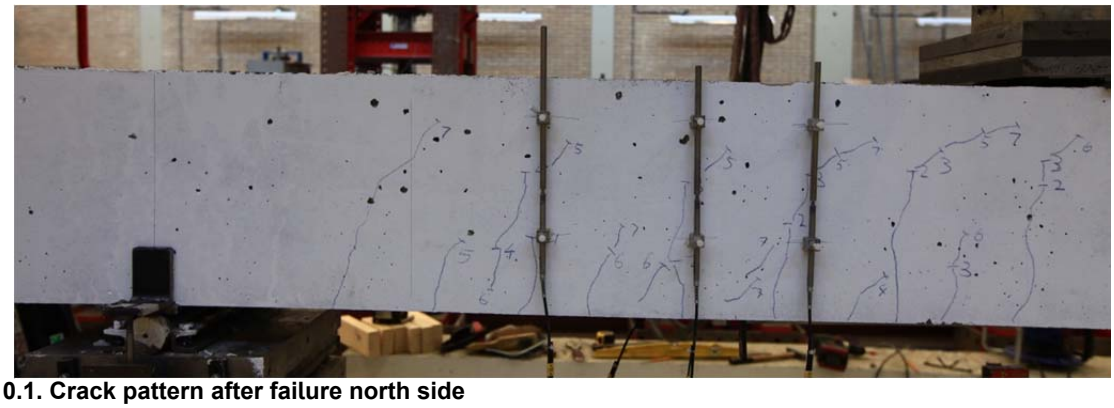


Fig. 5.10.1. Crack pattern after failure north side

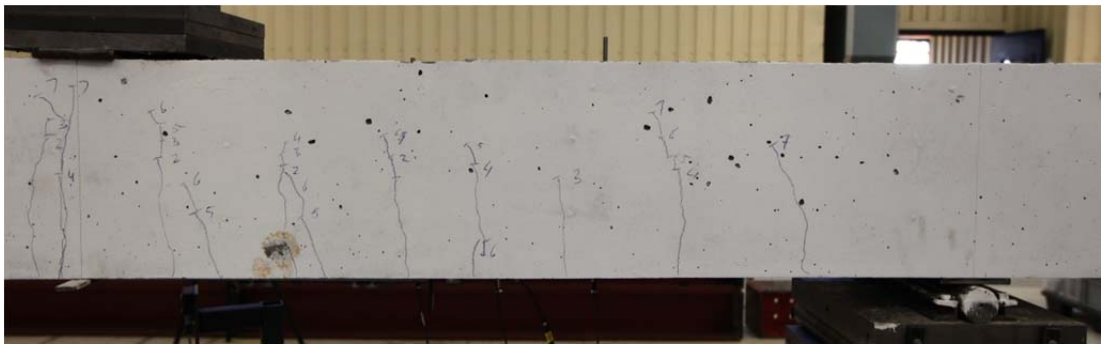


Fig. 5.10.2. Crack pattern after failure south side

Table 5.10.1. Beam properties

Date of test	08-09-2015
Reinforcement	3Ø20
Reinforcement ratio	1.16%
a	1250 mm
a / *d*	4.63
Concrete cube strength at testing	79.3 MPa[3]
Peak load	134.9 kN
Failure mode	Flexural

[3] For concrete batch used for casting this beam no cubes were tested. Therefore the average strength of all other casts (casts 1,2, 5, 6 and 7) at the same age is used for the cube compressive strength of this beam.

Table 5.10.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	Added LVDT4-6
5	100	
6	120	
7	138.0	Yielding, stopped after jack displacement of 35.6 mm

Table 5.10.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	500	100
5	North	Vertical	690	100
6	North	Vertical	835	100

5.10.2. Measurement results

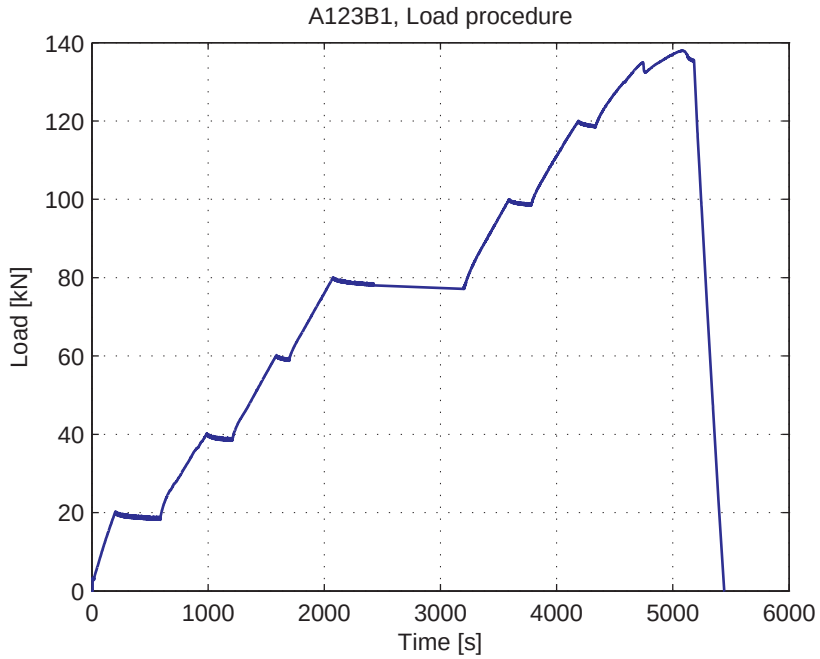


Fig. 5.10.3. Load-Time curve

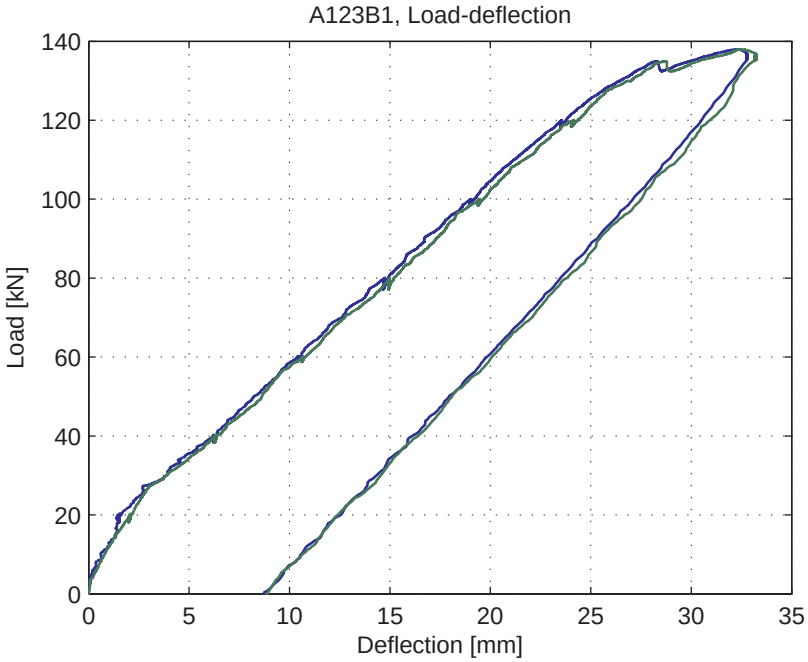


Fig. 5.10.4. Load-deflection curve

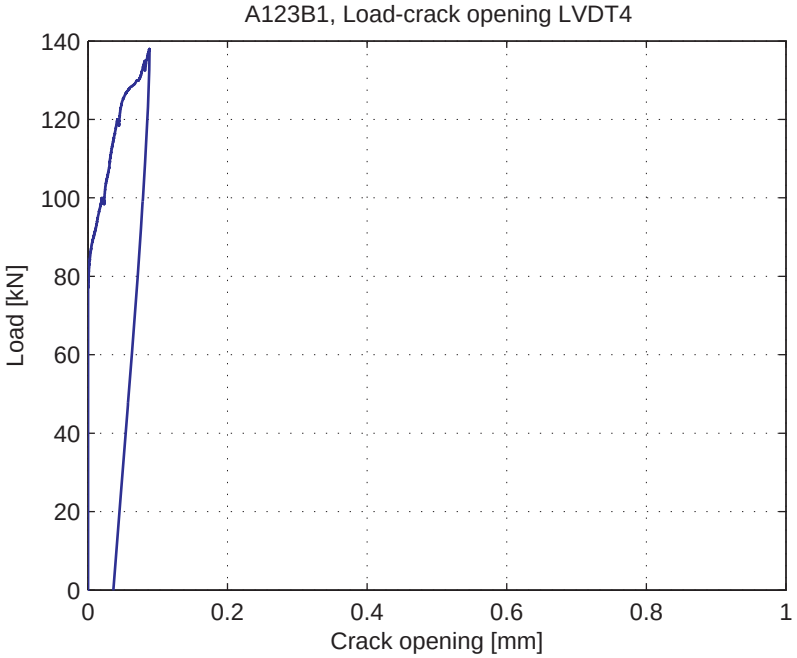


Fig. 5.10.5. Load-Crack opening for LVDT4

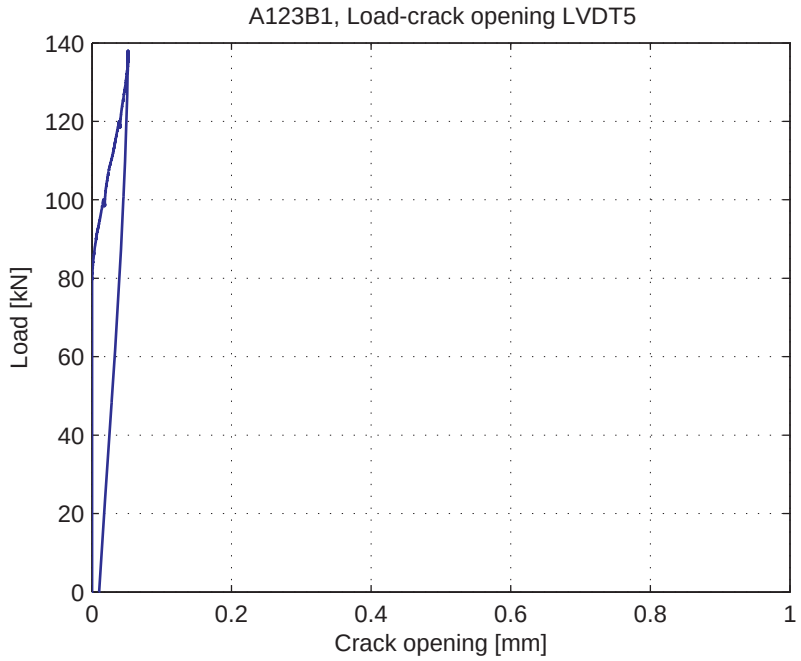


Fig. 5.10.6. Load-Crack opening for LVDT5

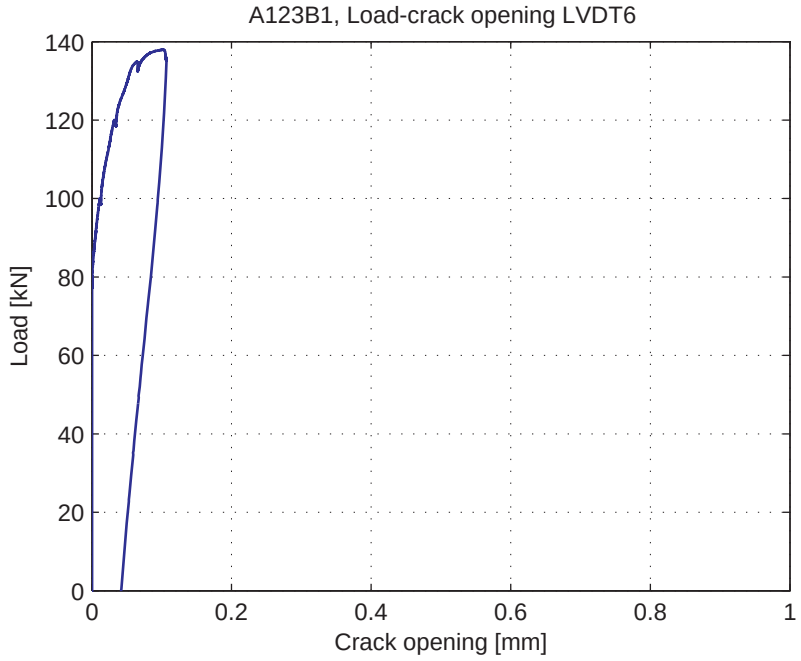


Fig. 5.10.7. Load-Crack opening for LVDT6

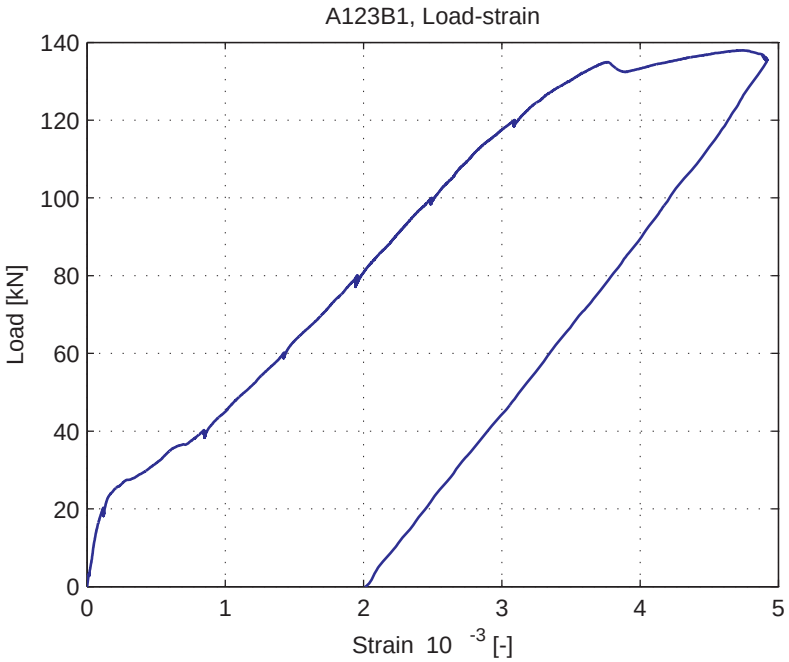


Fig. 5.10.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.11. A123B2

5.11.1. Test properties

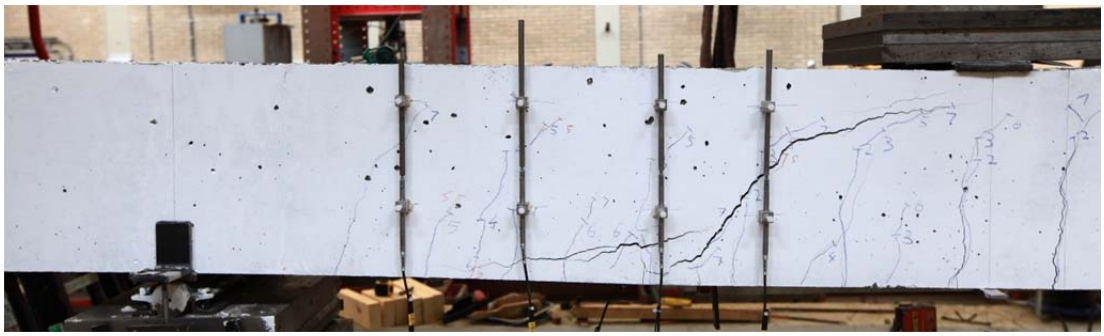


Fig. 5.11.1. Crack pattern after failure north side

Fig. 5.11.2. Crack pattern after failure south side

Table 5.11.1. Beam properties

Date of test	08-09-2015
Reinforcement	3Ø22
Reinforcement ratio	1.16%
a	1150 mm
a / *d*	4.26
Concrete cube strength at testing	79.3 MPa[4]
Peak load flexural / shear	148.9 kN / 138.3 kN
Failure mode	Flexural with flexural shear crack (first)

Table 5.11.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	100	
2	120	Added LVDT 7
3	151.4	First yielding at Fmax = 136.7 kN. Stopped after jack deflection of 37.5 mm.

[4] For concrete batch used for casting this beam no cubes were tested. Therefore the average strength of all other casts (casts 1,2, 5, 6 and 7) at the same age is used for the cube compressive strength of this beam.

Table 5.11.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	500	100
5	North	Vertical	690	100
6	North	Vertical	835	100
7	North	Vertical	330	100

5.11.2. Measurement results

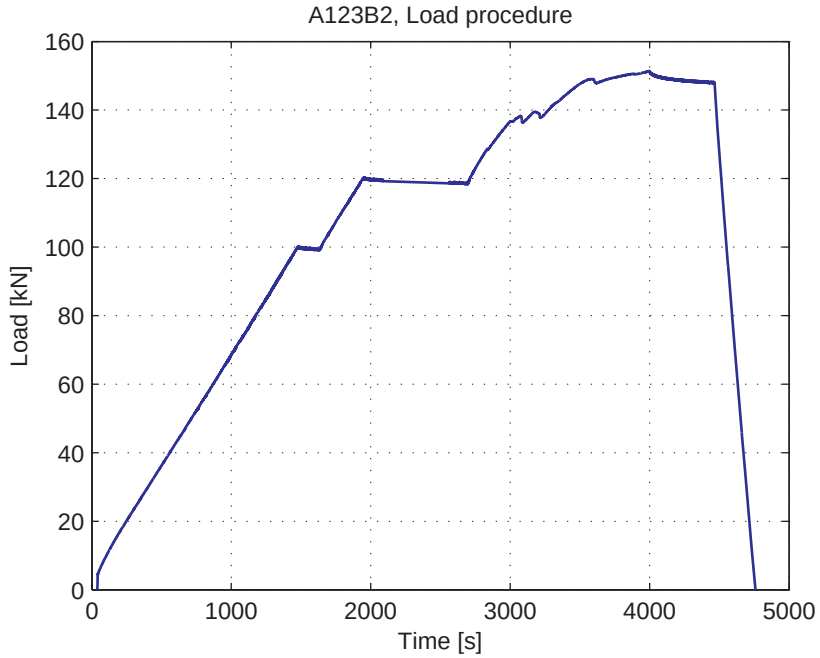


Fig. 5.11.3. Load-Time curve

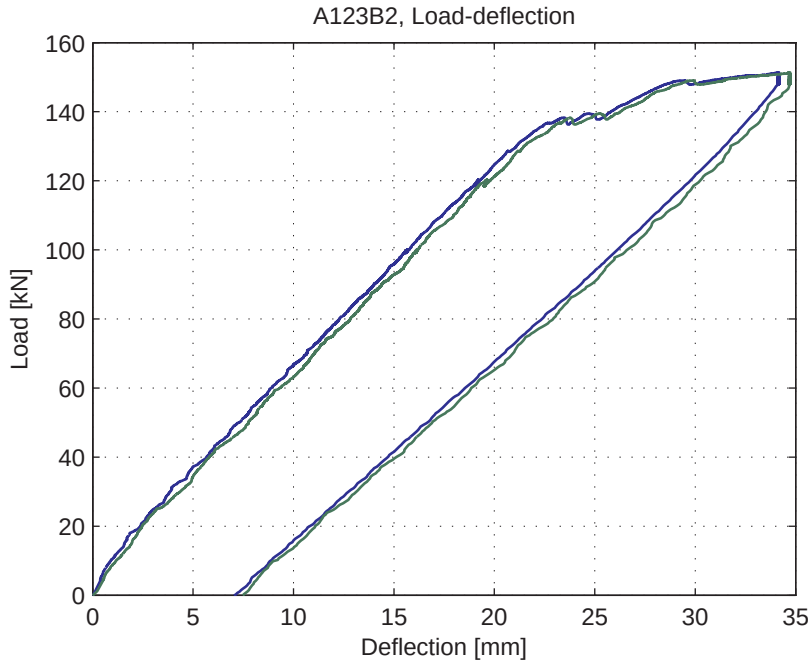


Fig. 5.11.4. Load-deflection curve

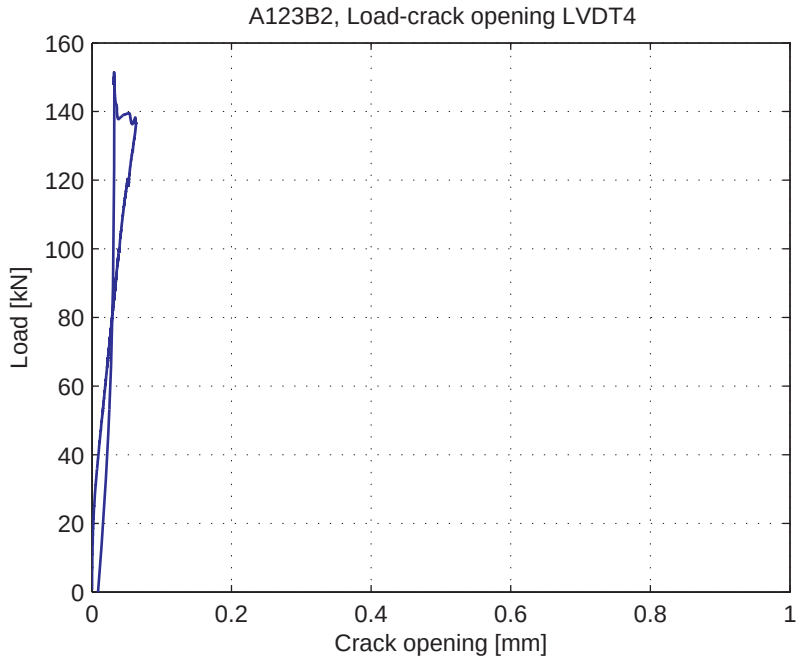


Fig. 5.11.5. Load-Crack opening for LVDT4

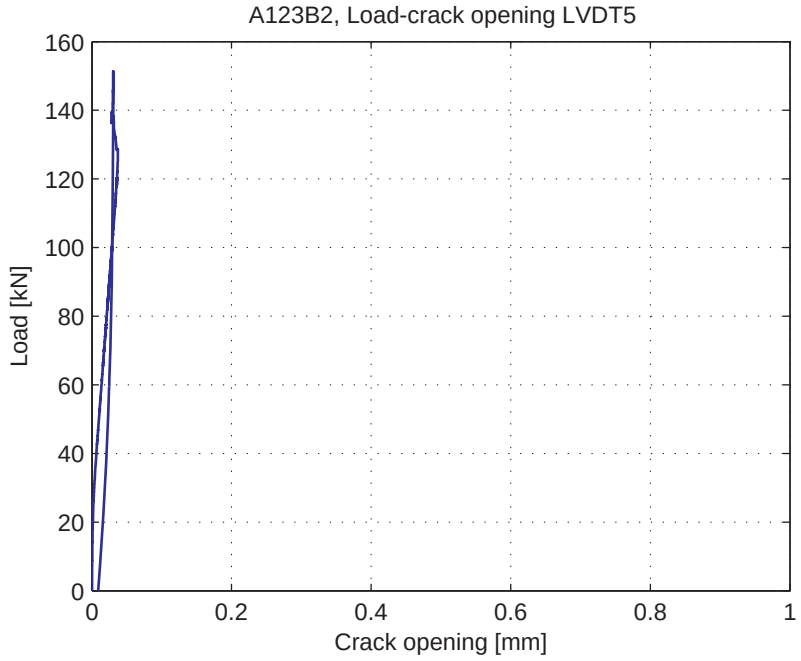


Fig. 5.11.6. Load-Crack opening for LVDT5

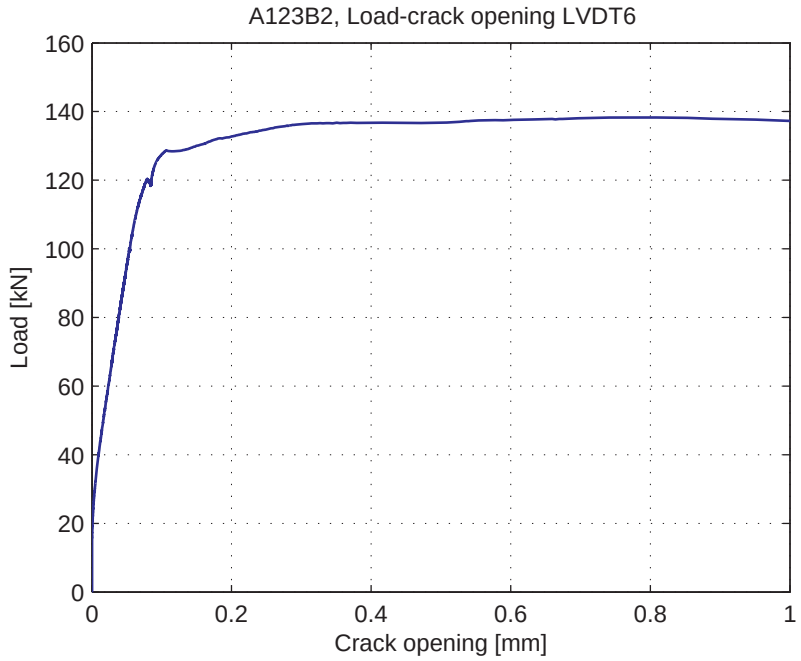


Fig. 5.11.7. Load-Crack opening for LVDT6

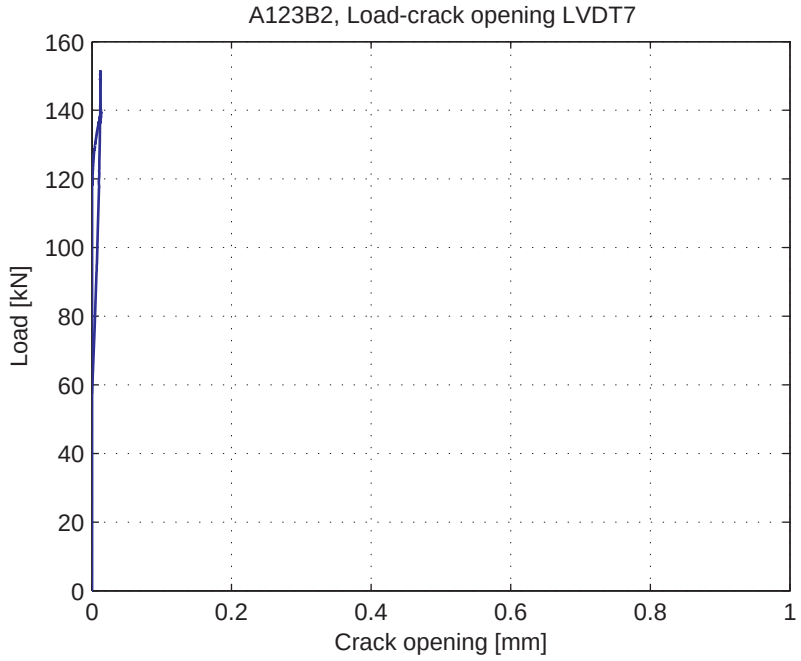


Fig. 5.11.8. Load-Crack opening for LVDT7

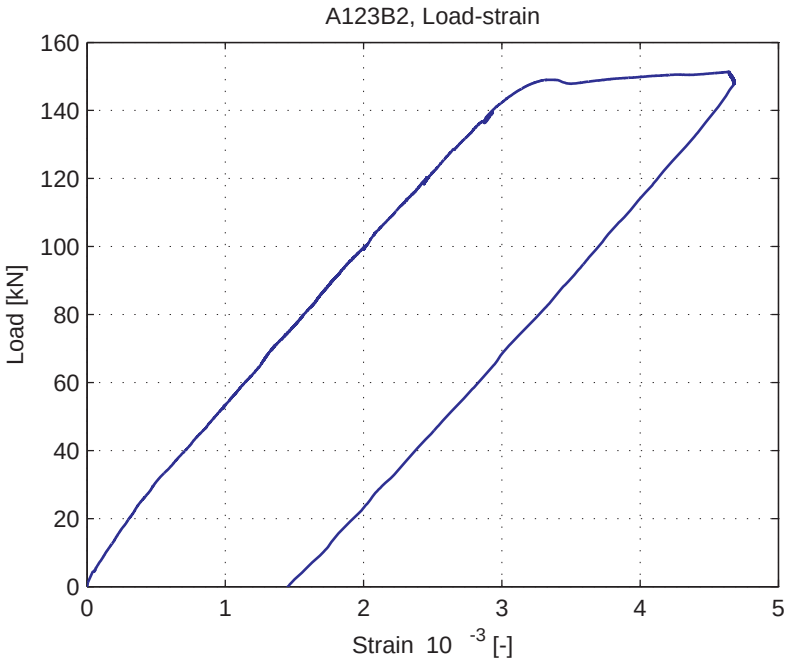


Fig. 5.11.9. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.12. A901A1

5.12.1. Test properties

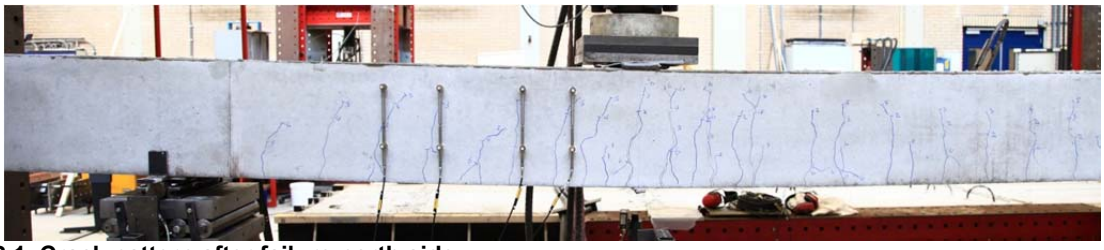


Fig. 5.12.1. Crack pattern after failure north side

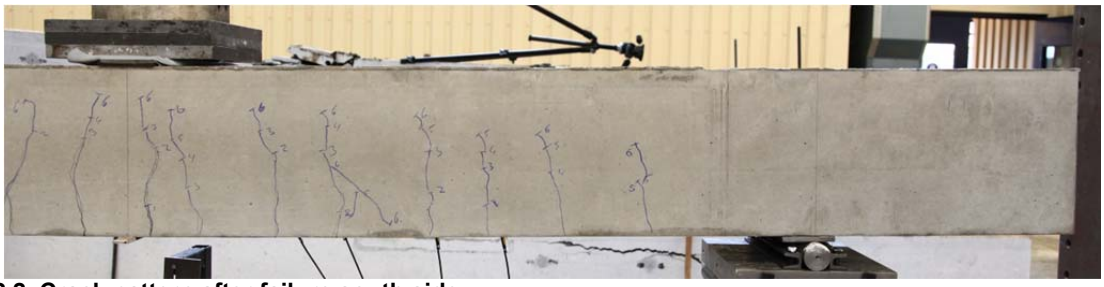


Fig. 5.12.2. Crack pattern after failure south side

Table 5.12.1. Beam properties

Date of test	17-04-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.90%
a	1250 mm
a / *d*	4.56
Concrete cube strength at testing	78.5 MPa
Peak load	105.6 kN
Failure mode	Flexural

Table 5.12.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	Added LVDT's 1-3 and 5
4	80	Measurements not started, started at 75 kN
5	100	
6	111.0	

Table 5.12.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	590	100
2	North	Vertical	735	100
3	North	Vertical	945	100
5	North	Vertical	1070	100

5.12.2. Measurement results

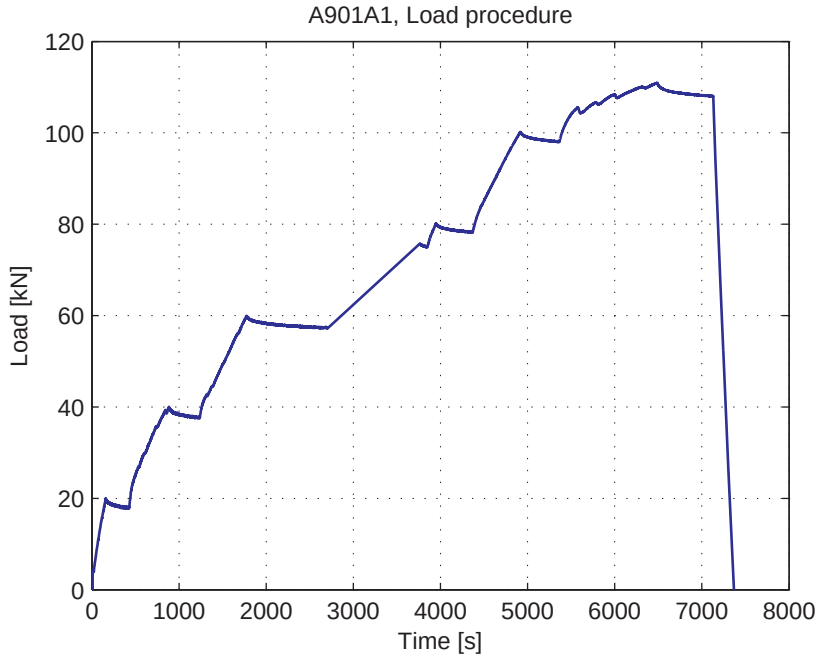


Fig. 5.12.3. Load-Time curve

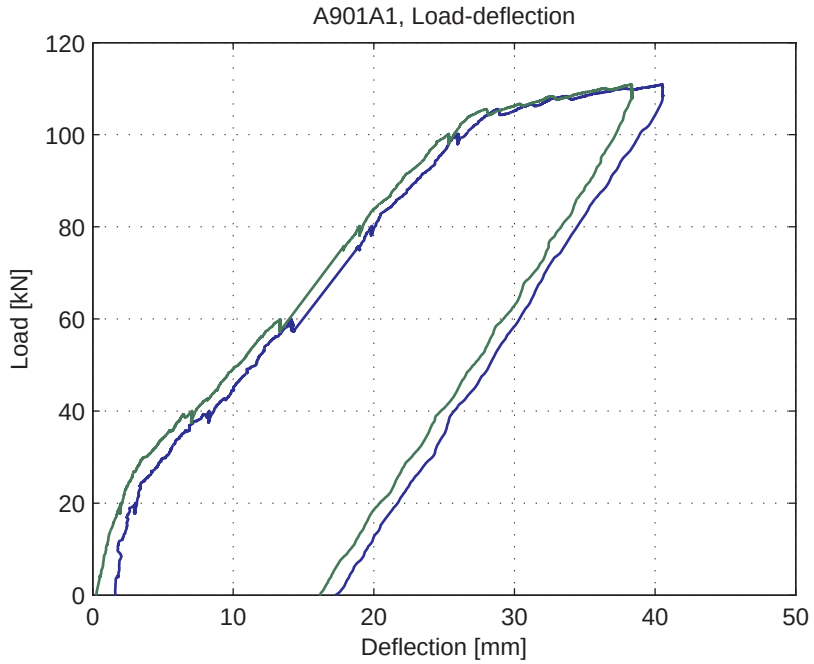


Fig. 5.12.4. Load-deflection curve

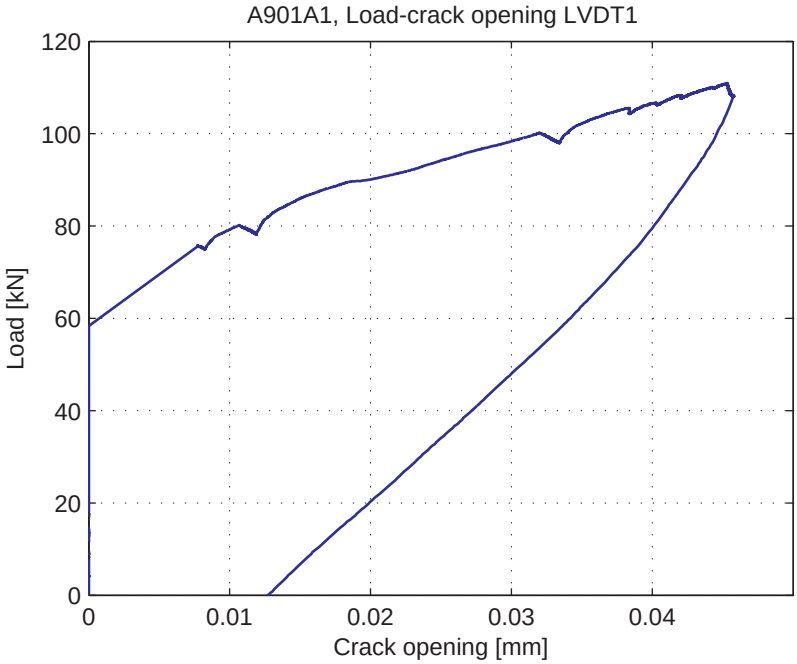


Fig. 5.12.5. Load-Crack opening for LVDT1

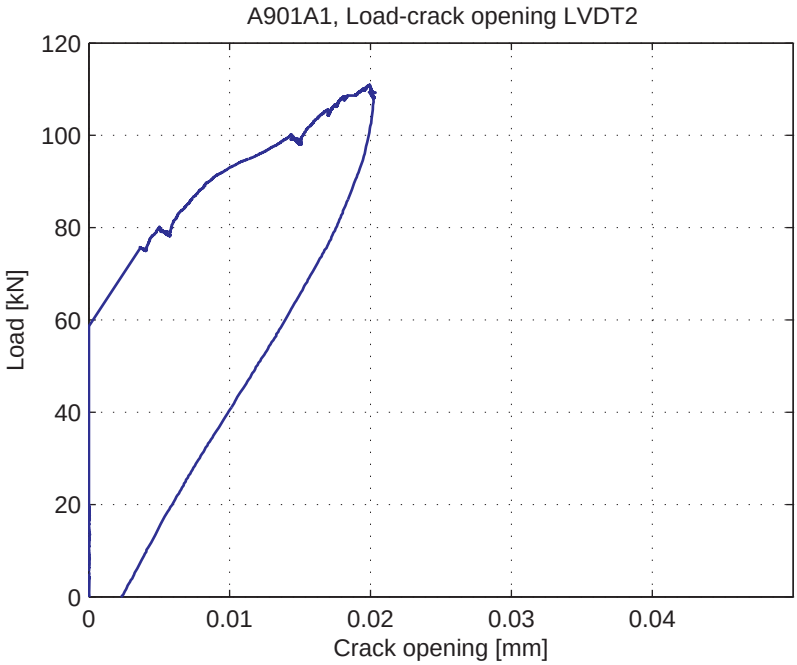


Fig. 5.12.6. Load-Crack opening for LVDT2

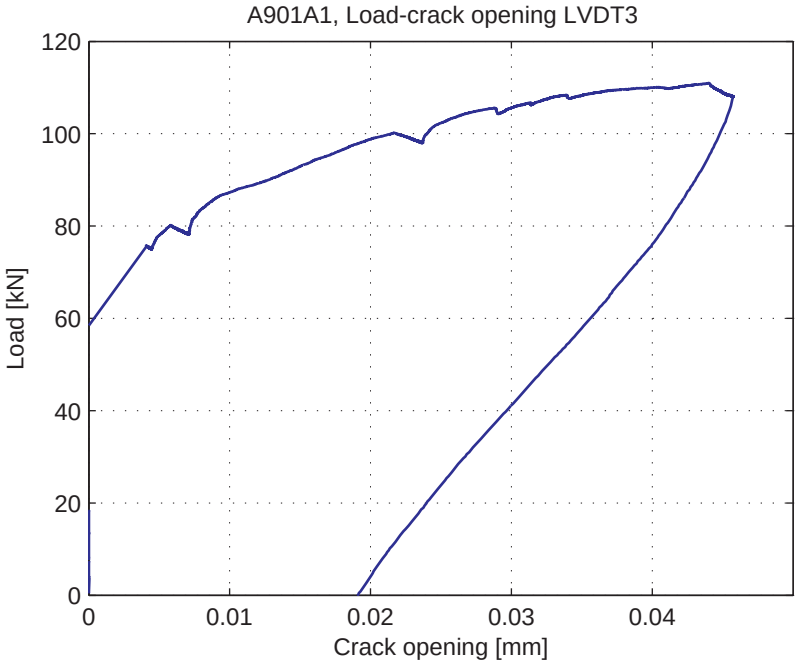


Fig. 5.12.7. Load-Crack opening for LVDT3

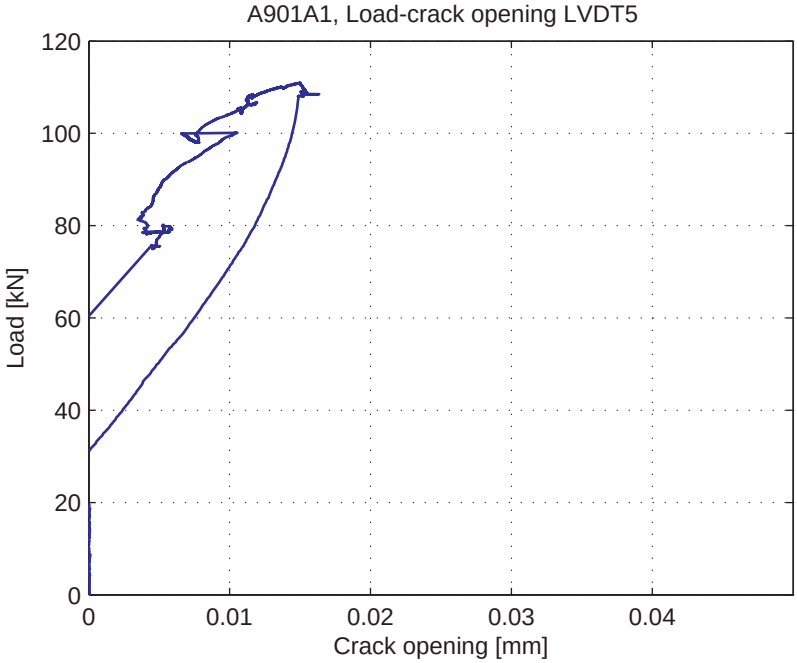


Fig. 5.12.8. Load-Crack opening for LVDT5

5.13. A901A2

5.13.1. Test properties

Fig. 5.13.1. Crack pattern after failure north side

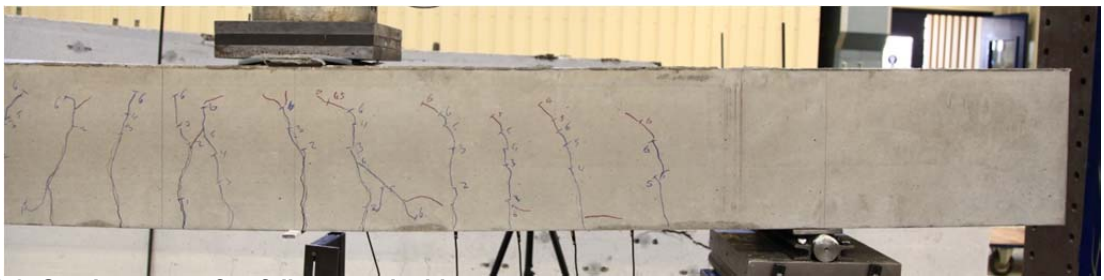


Fig. 5.13.2. Crack pattern after failure south side

Table 5.13.1. Beam properties

Date of test	20-04-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.90%
a	1000 mm
a / *d*	3.65
Concrete cube strength at testing	78.5 MPa
Peak load	123.9 kN
Failure mode	Flexural

Table 5.13.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Replaced LVDT 5 and added LVDT6
1	20	
2	40	
3	60	
4	80	
5	100	
6	120	
7	132.5	Stopped after jack displacement of 30 mm

Table 5.13.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	590	100
2	North	Vertical	735	100
3	North	Vertical	945	100
5	North	Vertical	320	90
6	North	Vertical	475	90

5.13.2. Measurement results

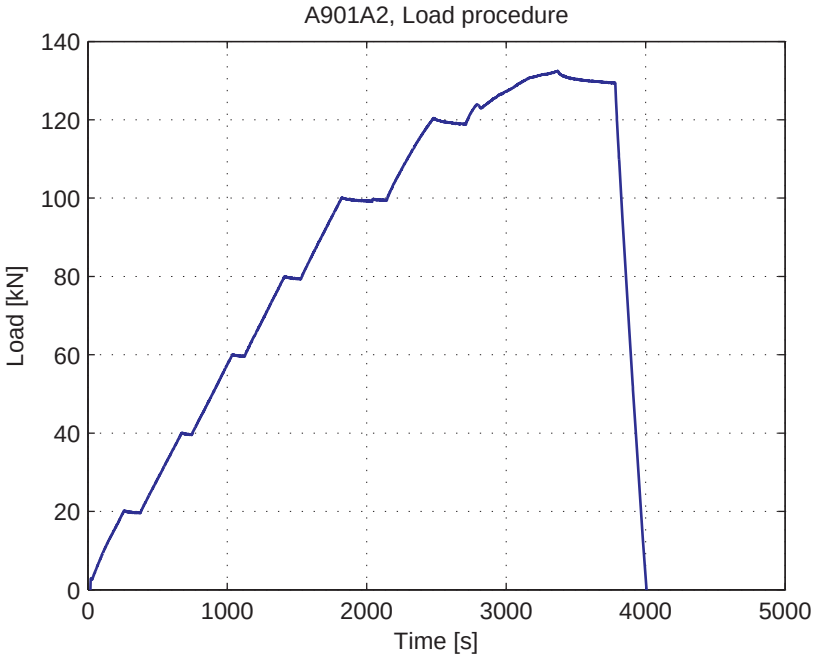


Fig. 5.13.3. Load-Time curve

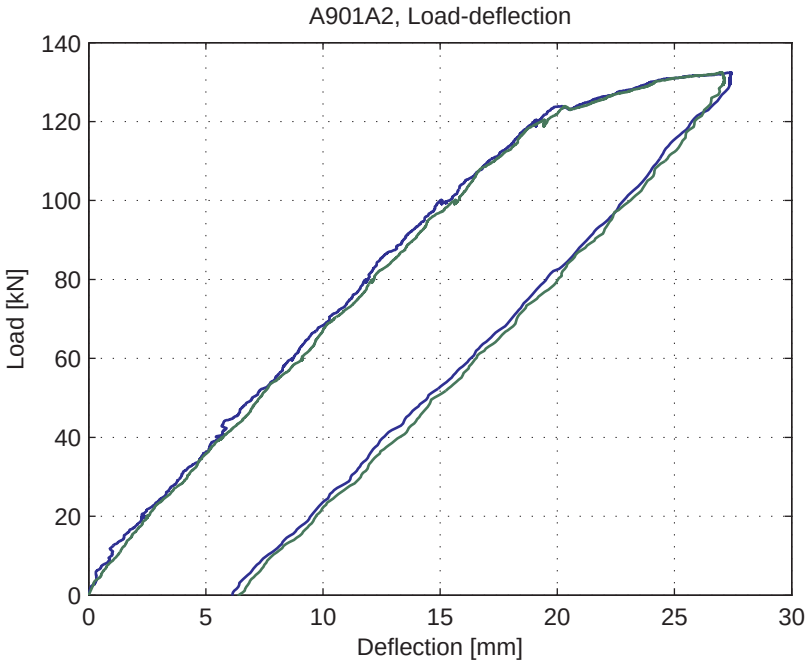


Fig. 5.13.4. Load-deflection curve

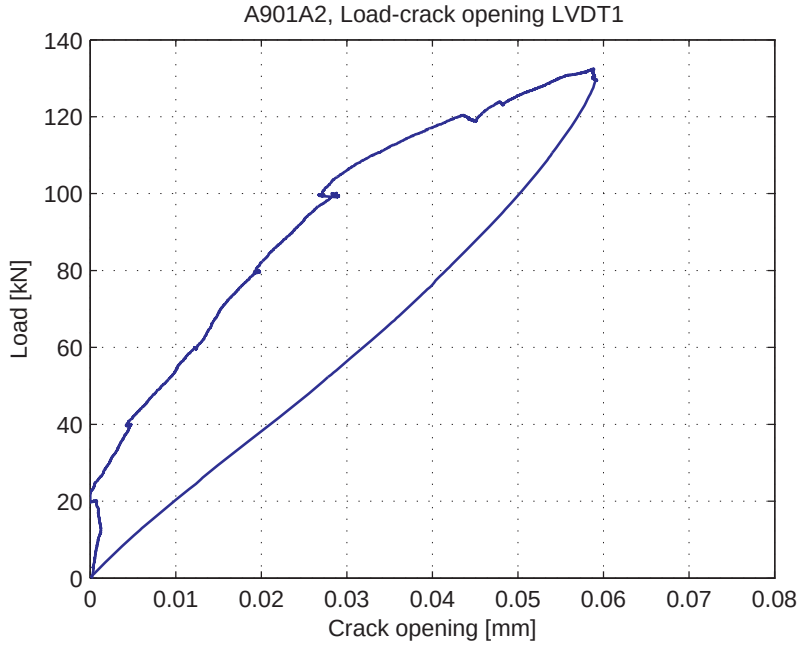


Fig. 5.13.5. Load-Crack opening for LVDT1

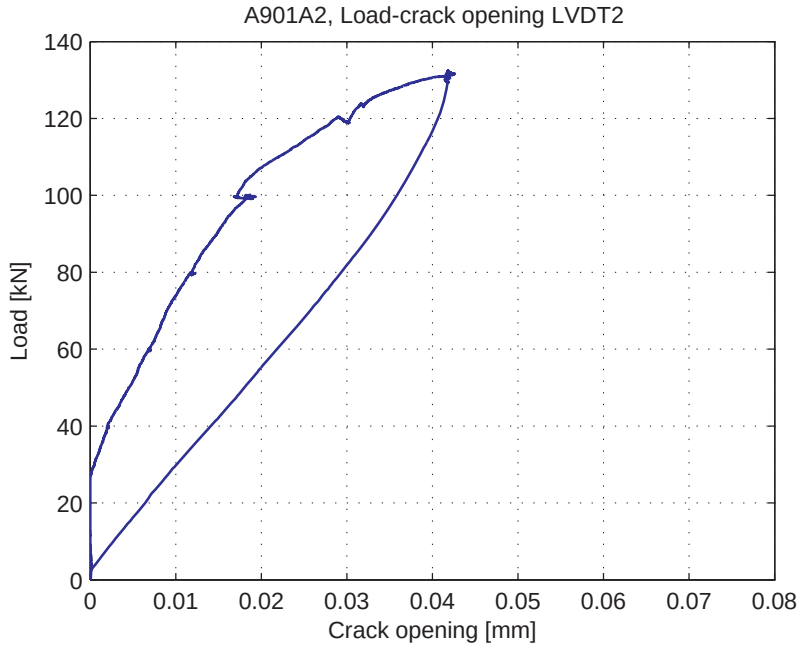


Fig. 5.13.6. Load-Crack opening for LVDT2

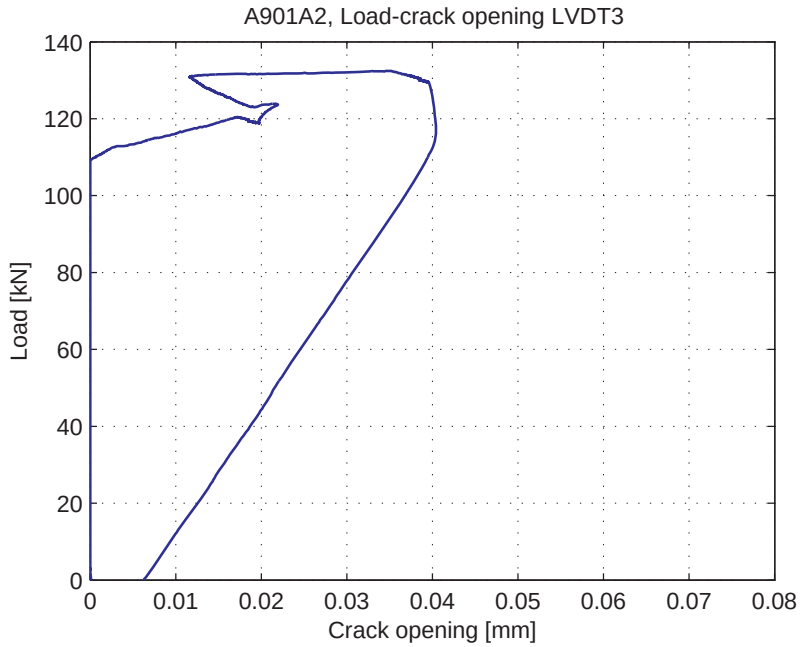


Fig. 5.13.7. Load-Crack opening for LVDT3

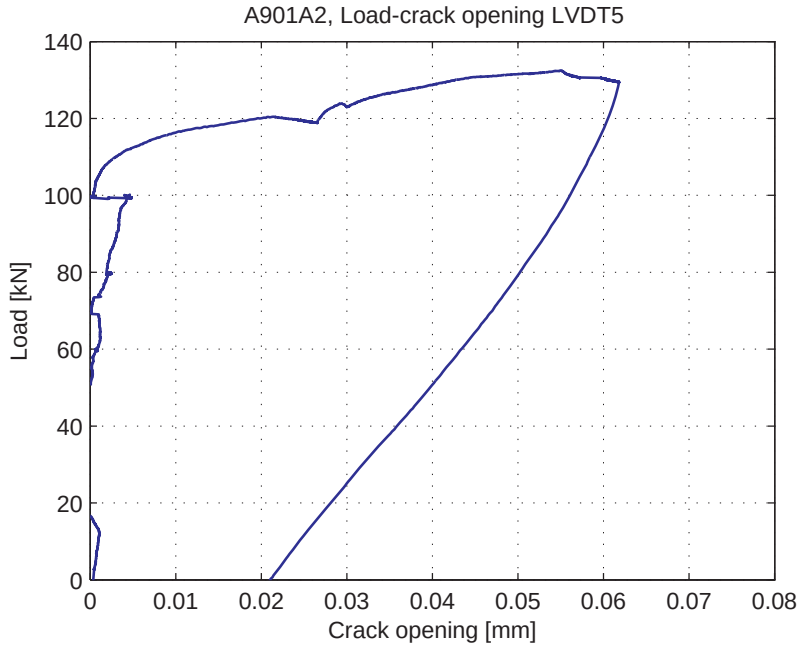


Fig. 5.13.8. Load-Crack opening for LVDT5

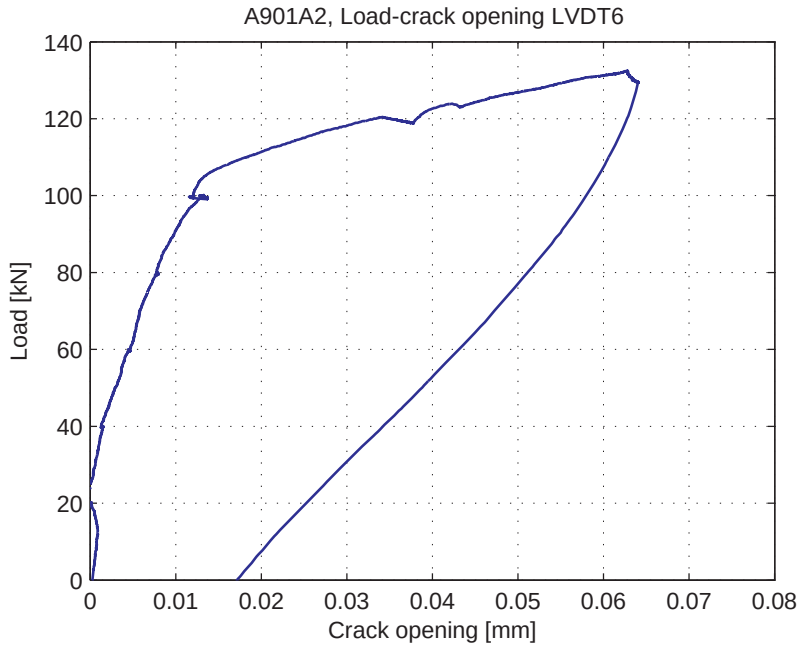


Fig. 5.13.9. Load-Crack opening for LVDT6

5.14. A901A3

5.14.1. Test properties

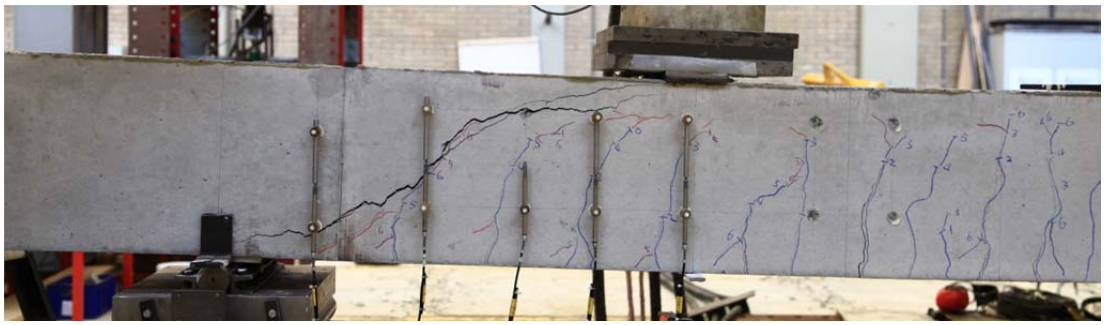


Fig. 5.14.1. Crack pattern after failure north side

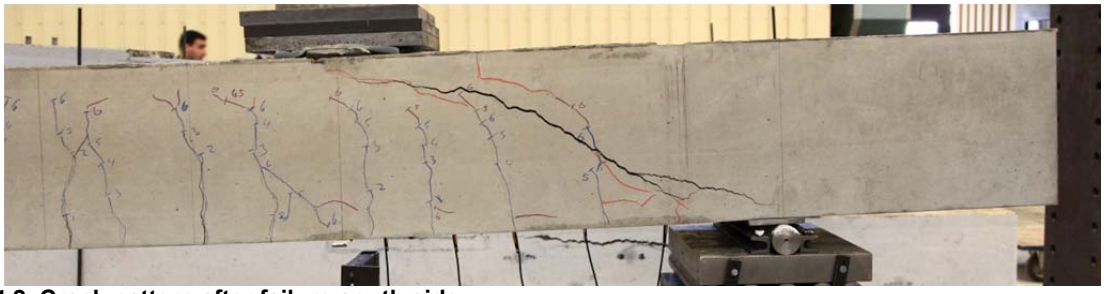


Fig. 5.14.2. Crack pattern after failure south side

Table 5.14.1. Beam properties

Date of test	20-04-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.90%
a	750
a / *d*	2.74
Concrete cube strength at testing	78.5 MPa
Peak load	145.0 kN
Failure mode	Shear

Table 5.14.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	LVDT 3 replaced
1	20	
2	40	
3	60	
4	80	
5	100	
6	120	
7	145.0	Shear failure

Table 5.14.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	590	100
2	North	Vertical	735	100
3	North	Vertical	250	50
5	North	Vertical	320	100
6	North	Vertical	475	90

5.14.2. Measurement results

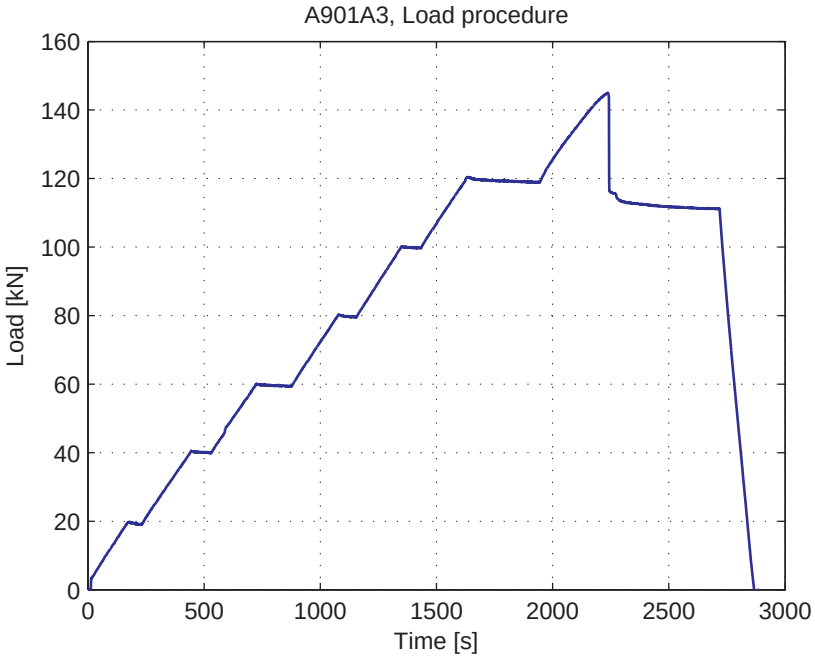


Fig. 5.14.3. Load-Time curve

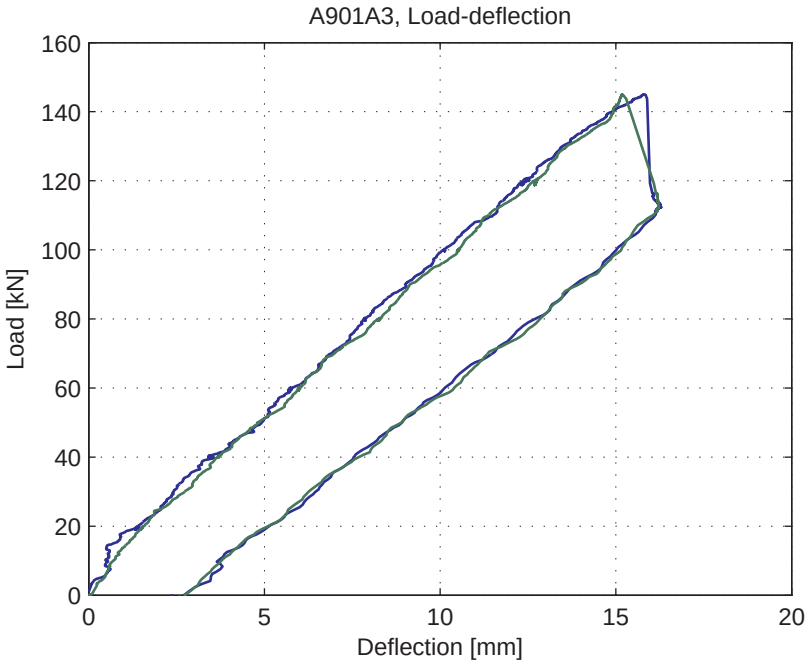


Fig. 5.14.4. Load-deflection curve

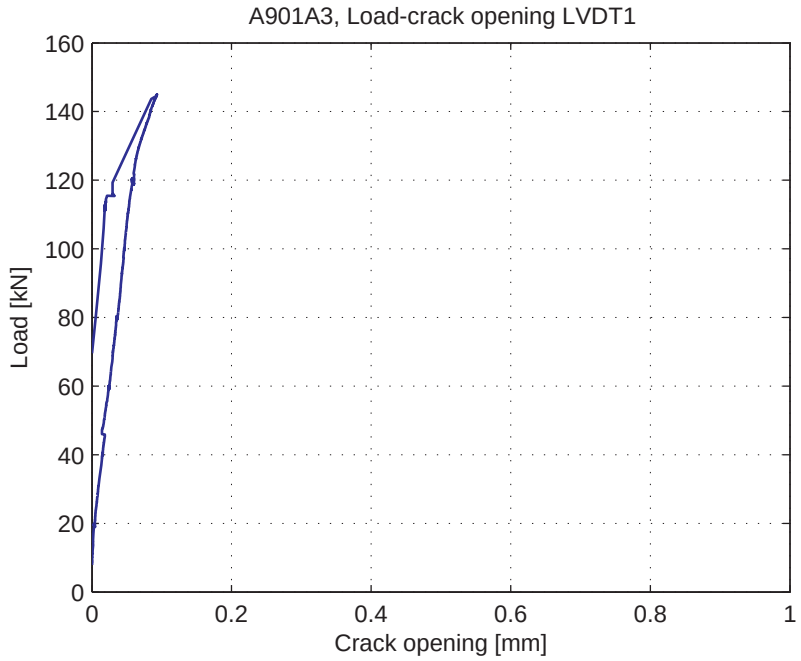


Fig. 5.14.5. Load-Crack opening for LVDT1

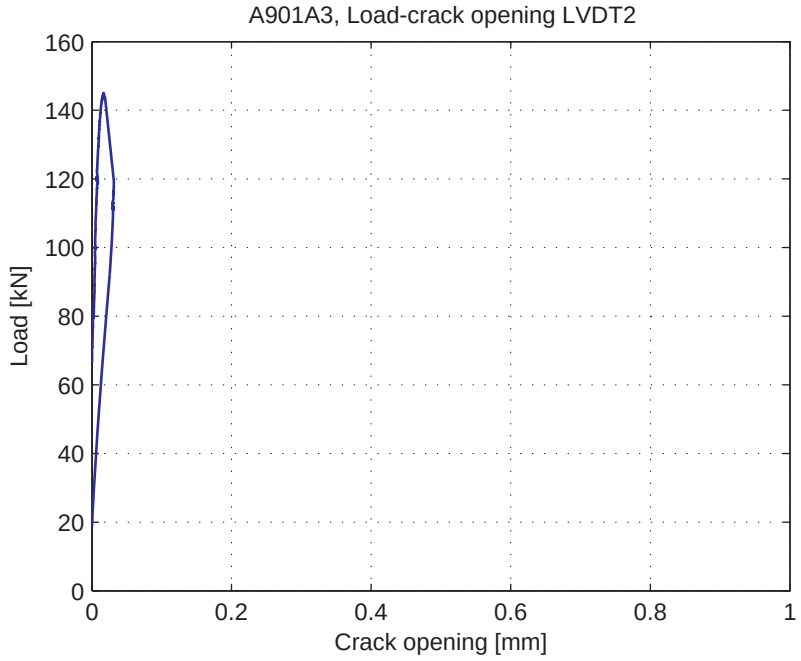


Fig. 5.14.6. Load-Crack opening for LVDT2

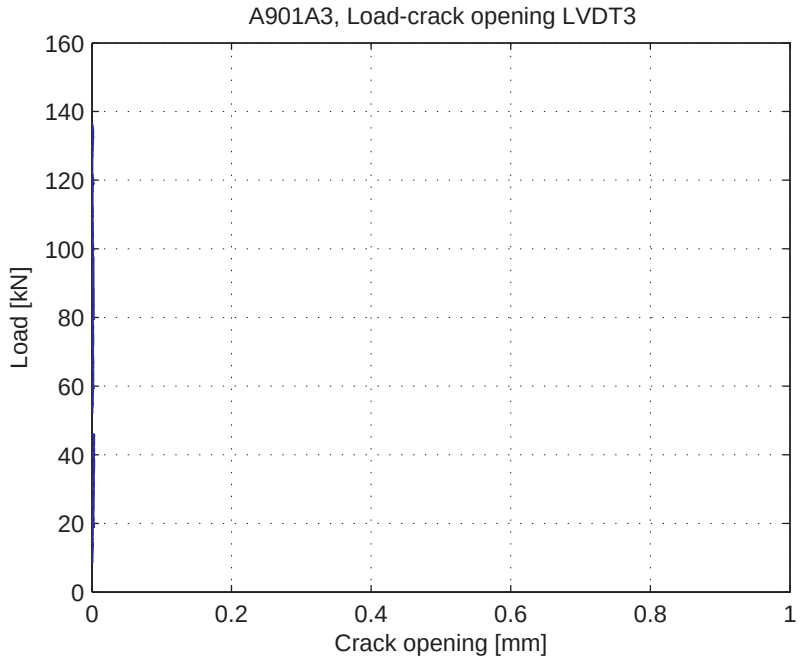


Fig. 5.14.7. Load-Crack opening for LVDT3

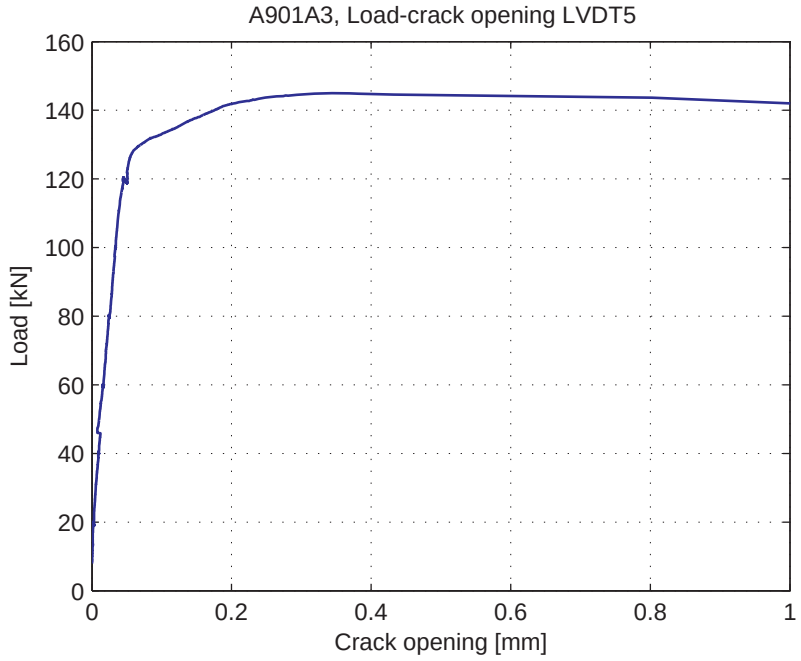


Fig. 5.14.8. Load-Crack opening for LVDT5

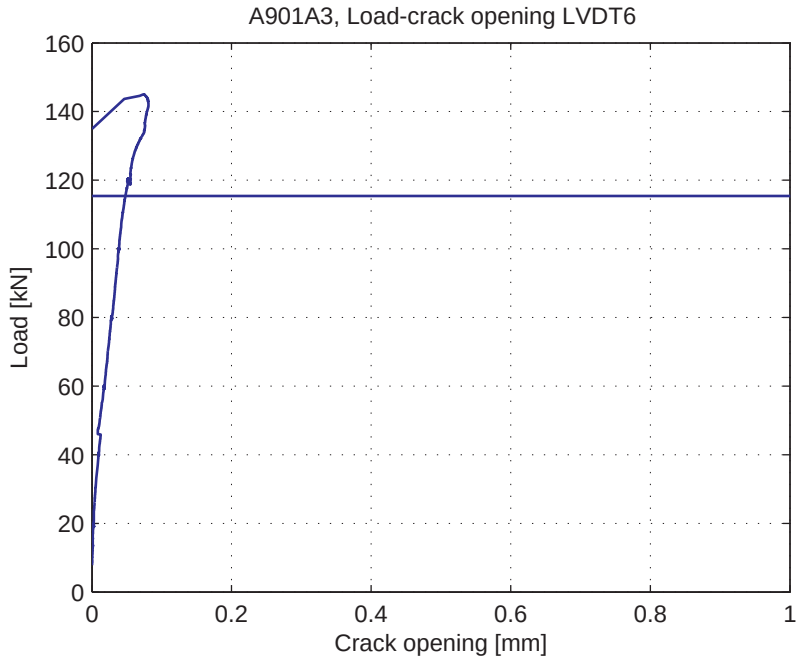


Fig. 5.14.9. Load-Crack opening for LVDT6

5.15. A901B1

5.15.1. Test properties

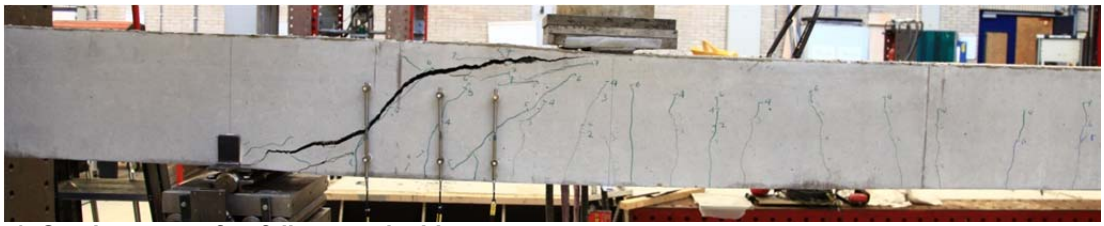


Fig. 5.15.1. Crack pattern after failure north side

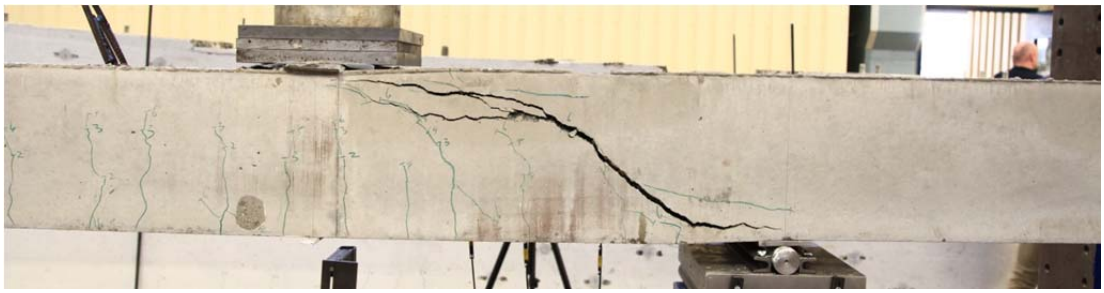


Fig. 5.15.2. Crack pattern after failure south side

Table 5.15.1. Beam properties

Date of test	21-04-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.90%
a	880
a / *d*	3.21
Concrete cube strength at testing	78.5 MPa
Peak load	127.5 kN
Failure mode	Shear

Table 5.15.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	
5	100	Added LVDT's 1-3
6	120	
7	127.5	Shear failure

Table 5.15.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	317	50
2	North	Vertical	485	50
3	North	Vertical	610	50

5.15.2. Measurement results

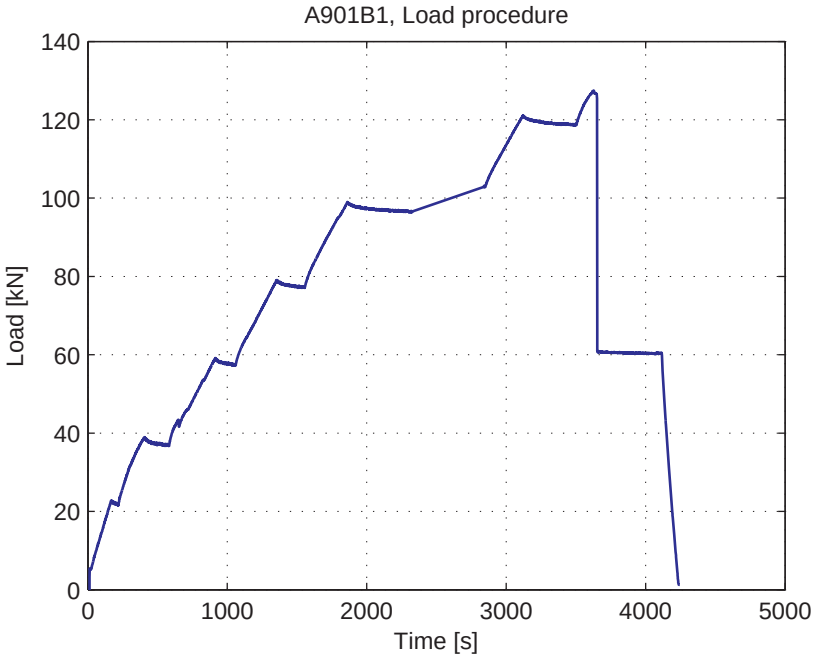


Fig. 5.15.3. Load-Time curve

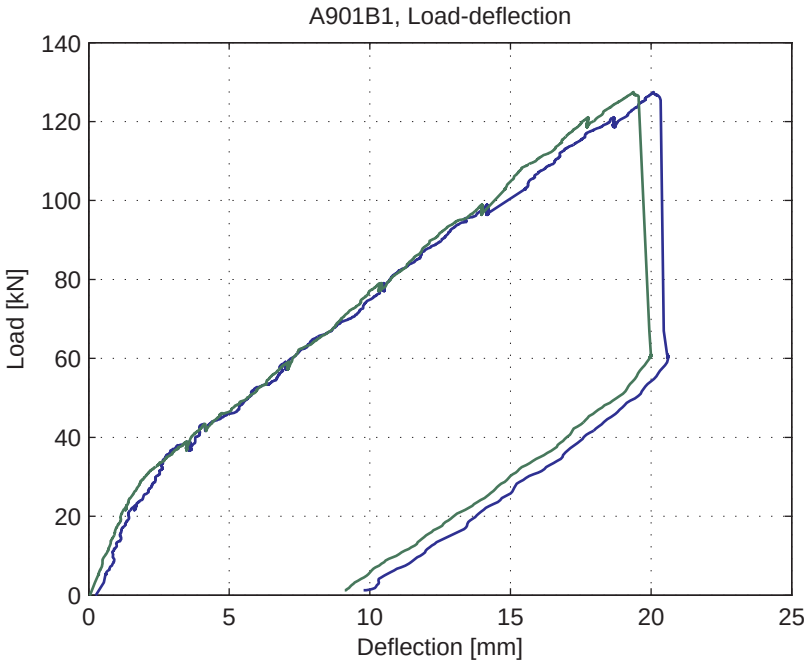


Fig. 5.15.4. Load-deflection curve

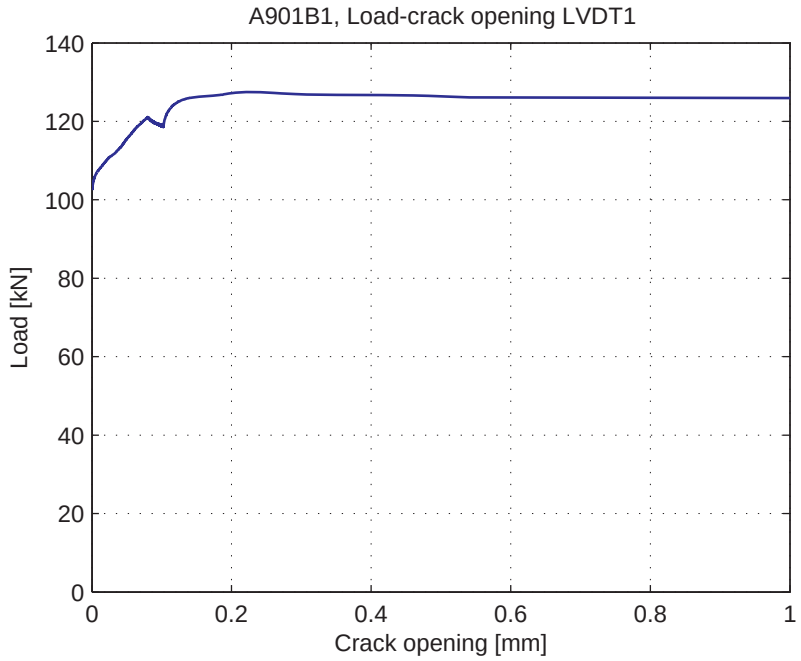


Fig. 5.15.5. Load-Crack opening for LVDT1

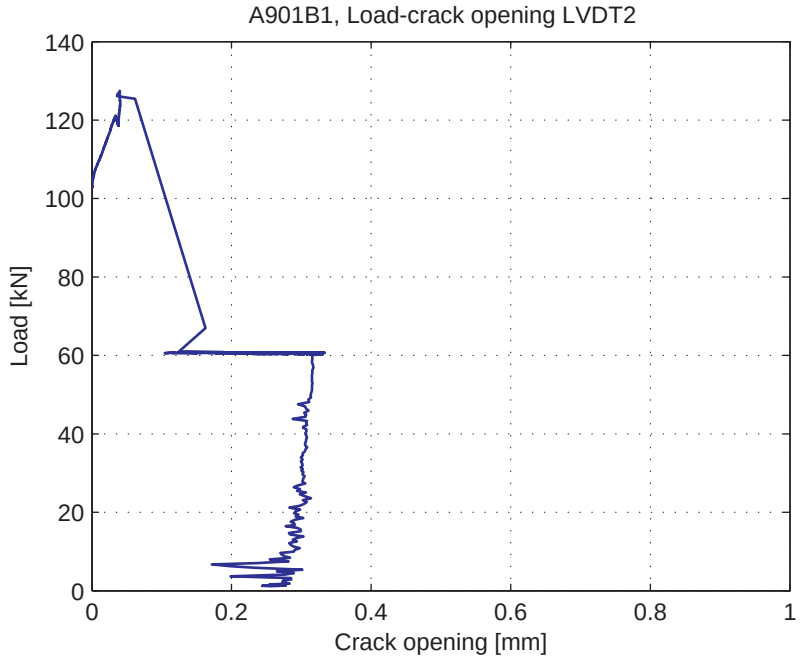


Fig. 5.15.6. Load-Crack opening for LVDT2

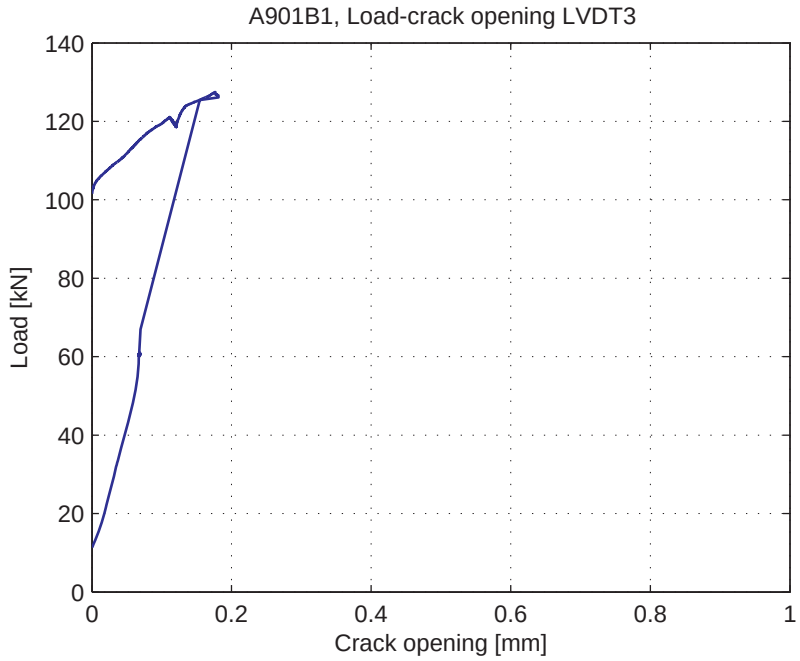


Fig. 5.15.7. Load-Crack opening for LVDT3

5.16. A901B2

5.16.1. Test properties

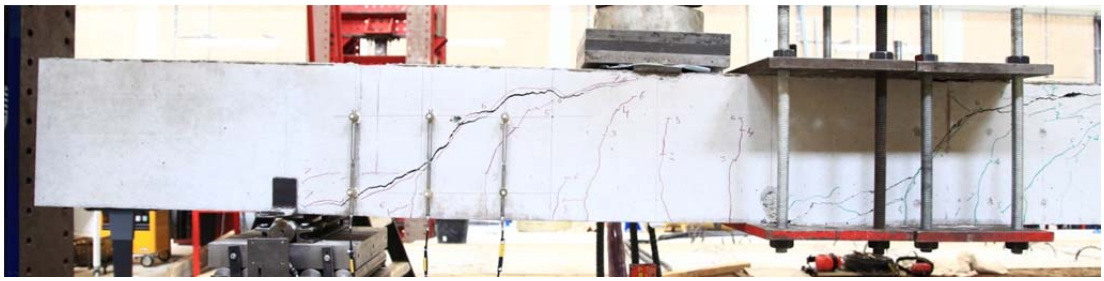


Fig. 5.16.1. Crack pattern after failure north side

Fig. 5.16.2. Crack pattern after failure south side

Table 5.16.1. Beam properties

Date of test	22-04-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.90%
a	750
a / *d*	2.74
Concrete cube strength at testing	78.5 MPa
Peak load	124.2
Failure mode	Shear

Table 5.16.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Old crack from previous test is fixed by two plates, prestressed with air hammer
1	20	
2	40	
3	60	
4	80	Placed LVDT's 1-3
5	120	
6	124.2	Shear failure

Table 5.16.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	140	50
2	North	Vertical	290	50
3	North	Vertical	440	50

5.16.2. Measurement results

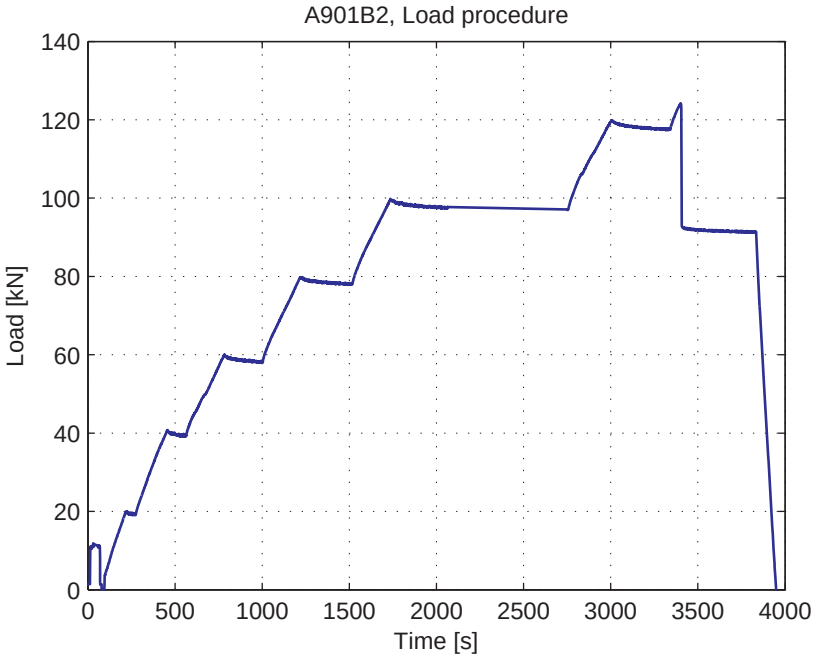


Fig. 5.16.3. Load-Time curve

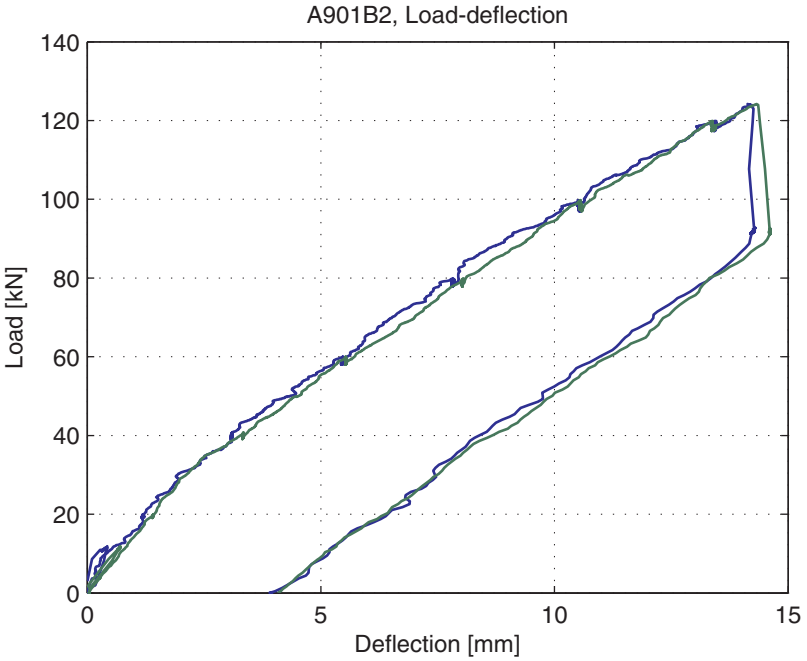


Fig. 5.16.4. Load-deflection curve

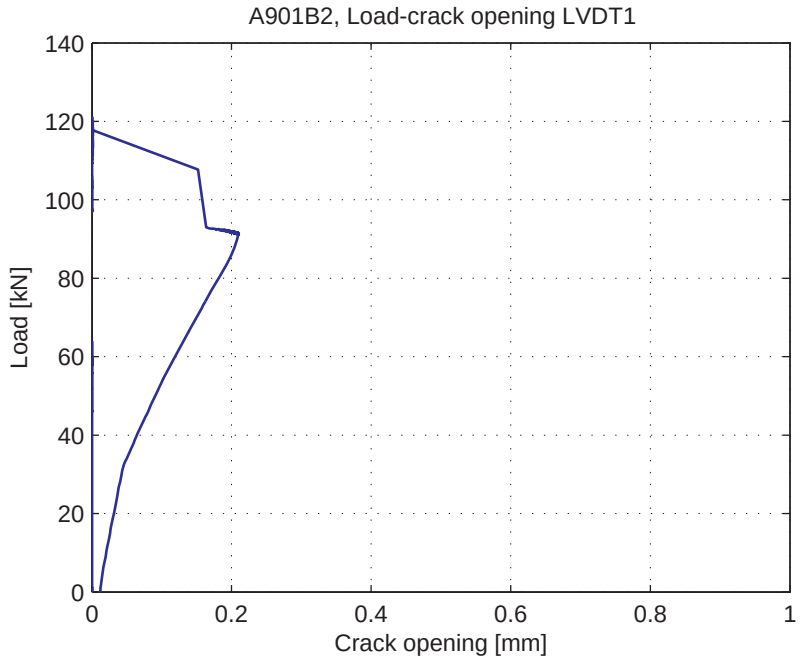


Fig. 5.16.5. Load-Crack opening for LVDT1

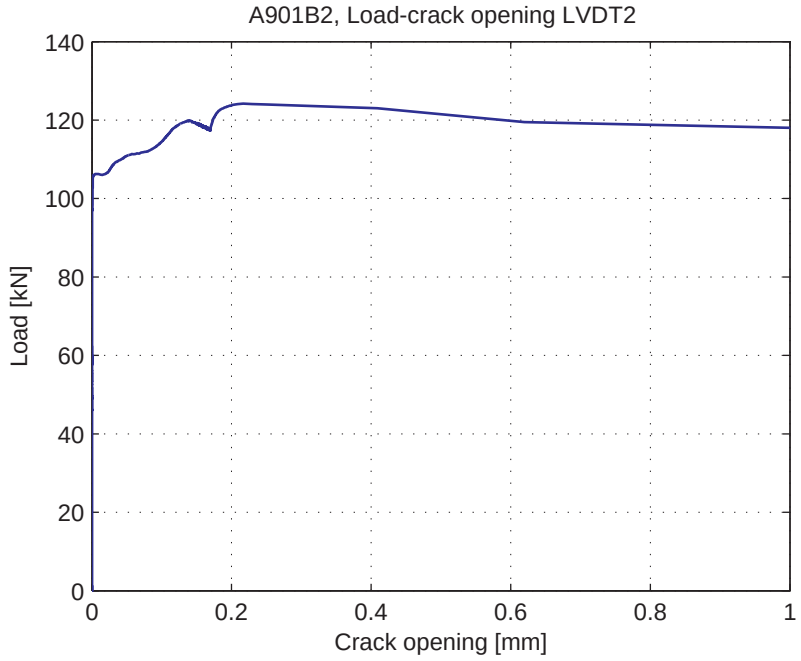


Fig. 5.16.6. Load-Crack opening for LVDT2

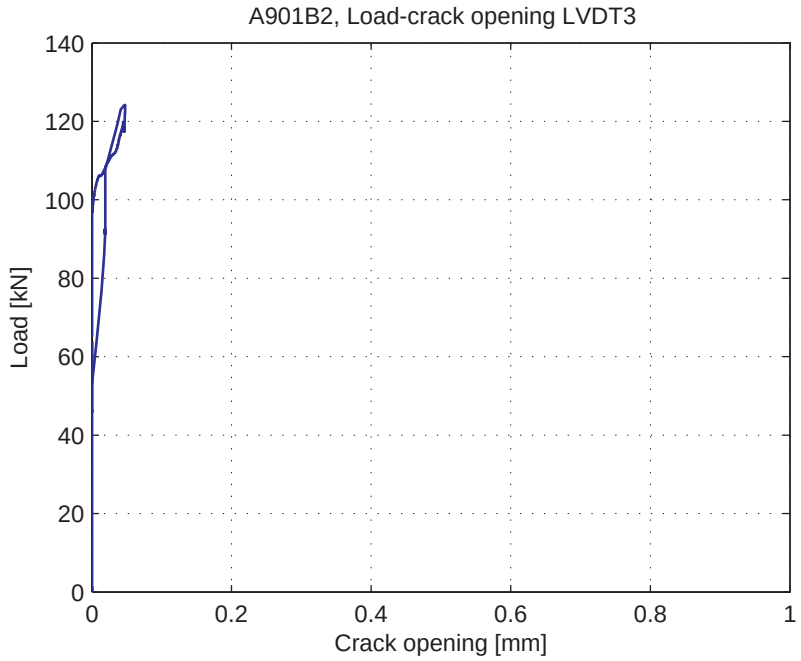


Fig. 5.16.7. Load-Crack opening for LVDT3

5.17. A902A1

5.17.1. Test properties

Fig. 5.17.1. Crack pattern after failure north side

Fig. 5.17.2. Crack pattern after failure south side

Table 5.17.1. Beam properties

Date of test	19-05-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.90%
a	995 mm
a / *d*	3.61
Concrete cube strength at testing	78.5 MPa
Peak load	120.7 kN
Failure mode	Shear

Table 5.17.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	Offset of 1.3 kN
4	80	Added LVDT's 1-3 and 5. LVDT 1 has an offset of 1.2 mm
5	100	
6	120.6	Shear failure

Table 5.17.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	310	50
2	North	Vertical	415	50
3	North	Vertical	585	100
5	North	Vertical	755	100

5.17.2. Measurement results

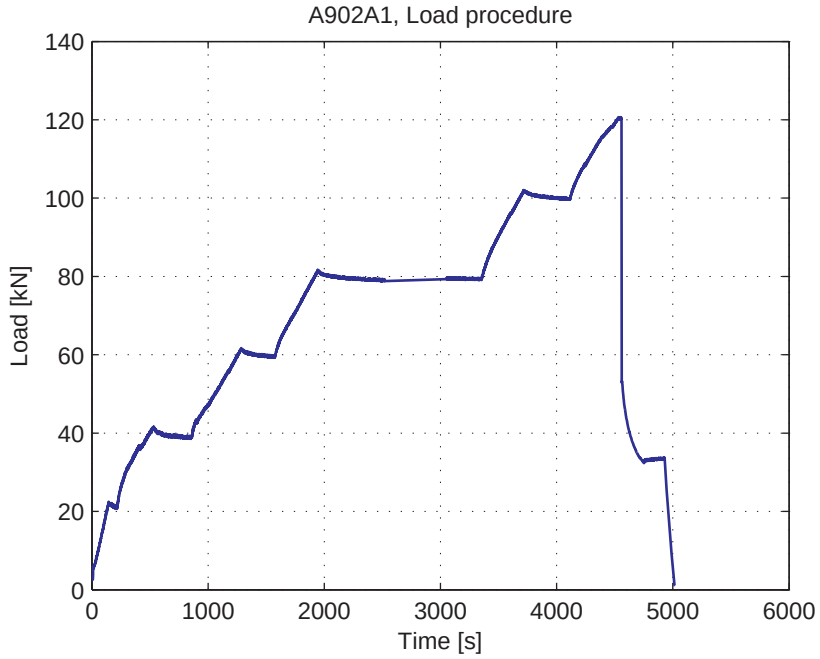


Fig. 5.17.3. Load-Time curve

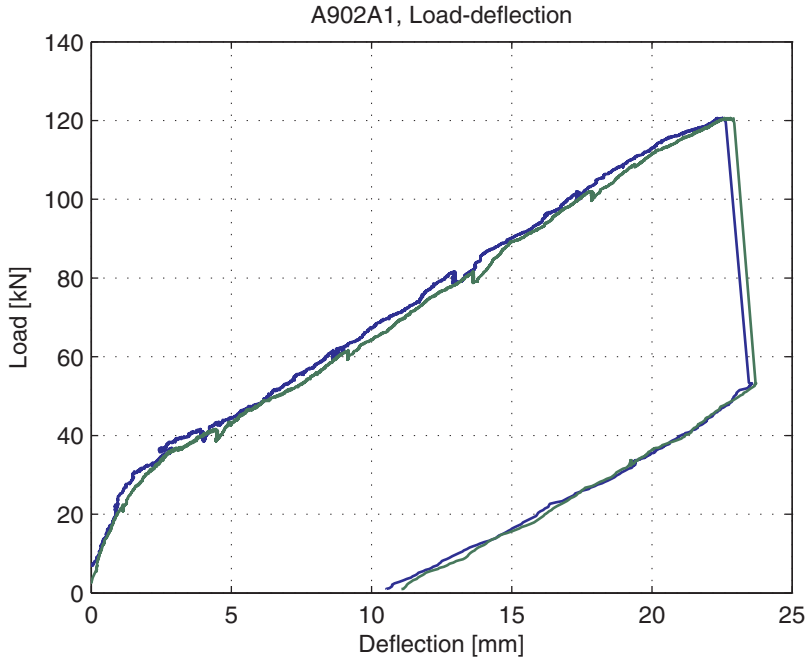


Fig. 5.17.4. Load-deflection curve

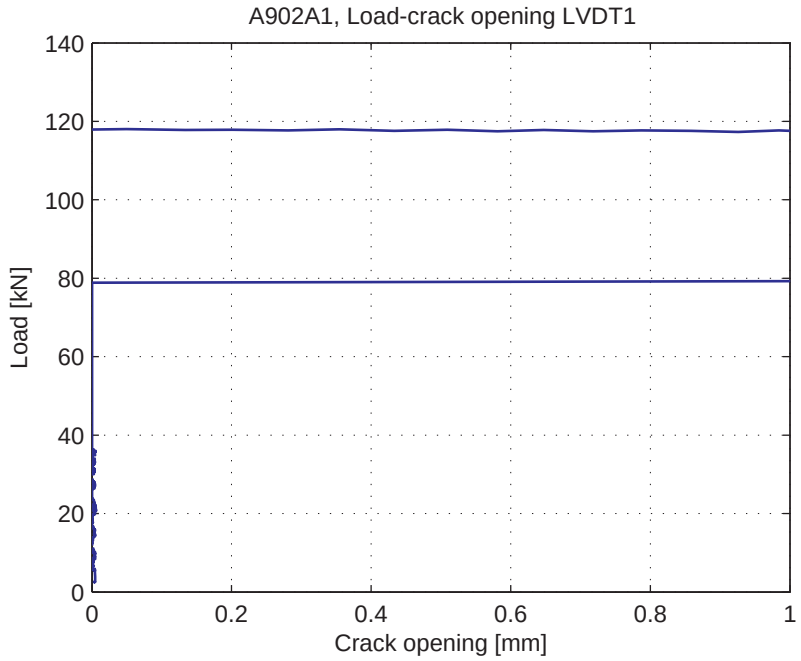


Fig. 5.17.5. Load-Crack opening for LVDT1

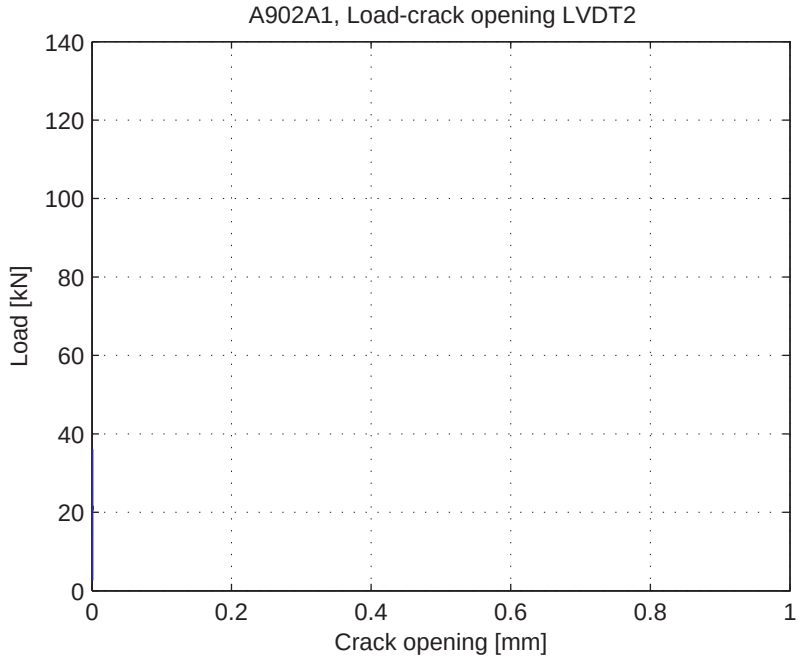


Fig. 5.17.6. Load-Crack opening for LVDT2

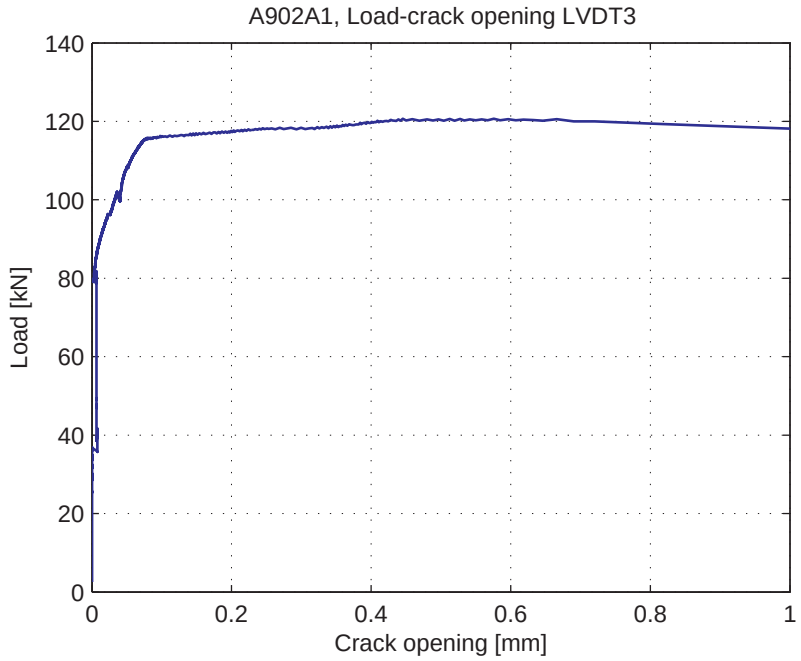


Fig. 5.17.7. Load-Crack opening for LVDT3

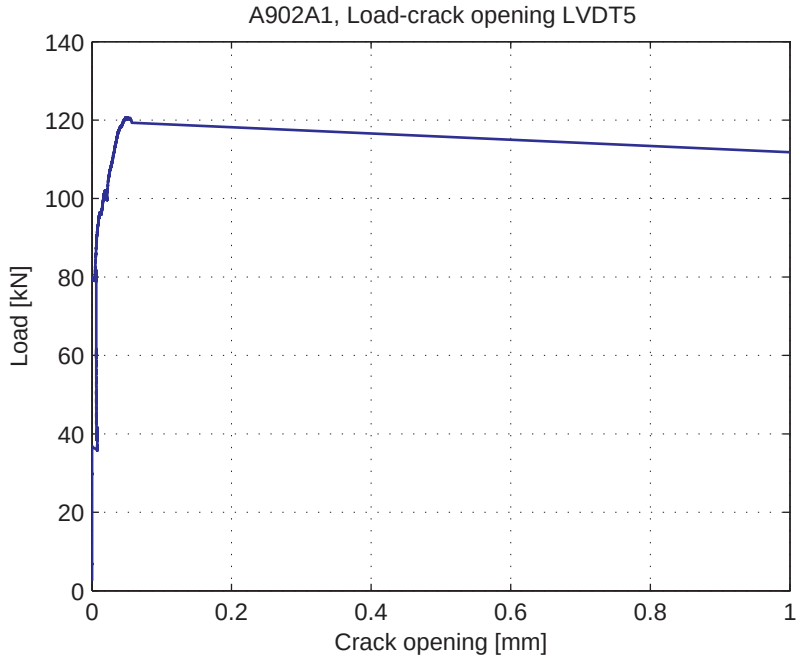


Fig. 5.17.8. Load-Crack opening for LVDT5

5.18. A902A2

5.18.1. Test properties

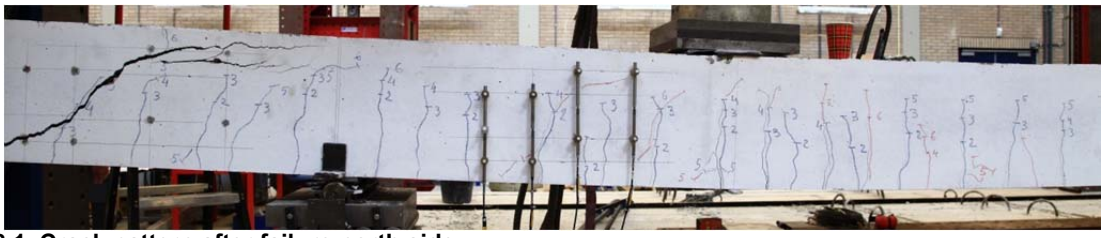


Fig. 5.18.1. Crack pattern after failure north side

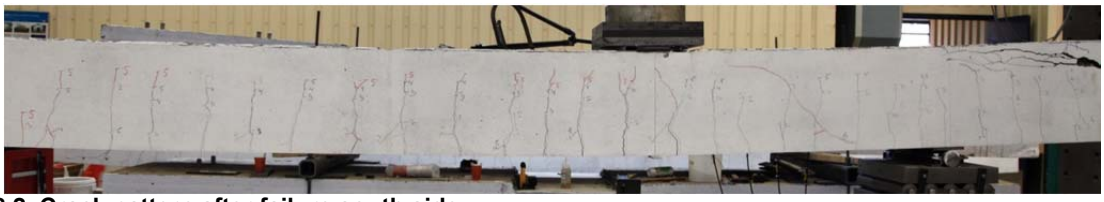


Fig. 5.18.2. Crack pattern after failure south side

Table 5.18.1. Beam properties

Date of test	20-05-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.90%
a	900 mm
a / *d*	3.26
Concrete cube strength at testing	78.5 MPa
Yielding load	136.0 kN
Failure mode	Flexural

Table 5.18.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Shear crack from previous test is at other side support
1	20	
2	40	Wrong configuration file. Started new test
3	60	
4	80	
5	130	Added LVDT"s 1-3 and 5
6	145.0	First yielding at 135 kN. Stopped after jack displacement of 35 mm

Table 5.18.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	325	50
2	North	Vertical	430	50
3	North	Vertical	530	100
5	North	Vertical	655	100

5.18.2. Measurement results

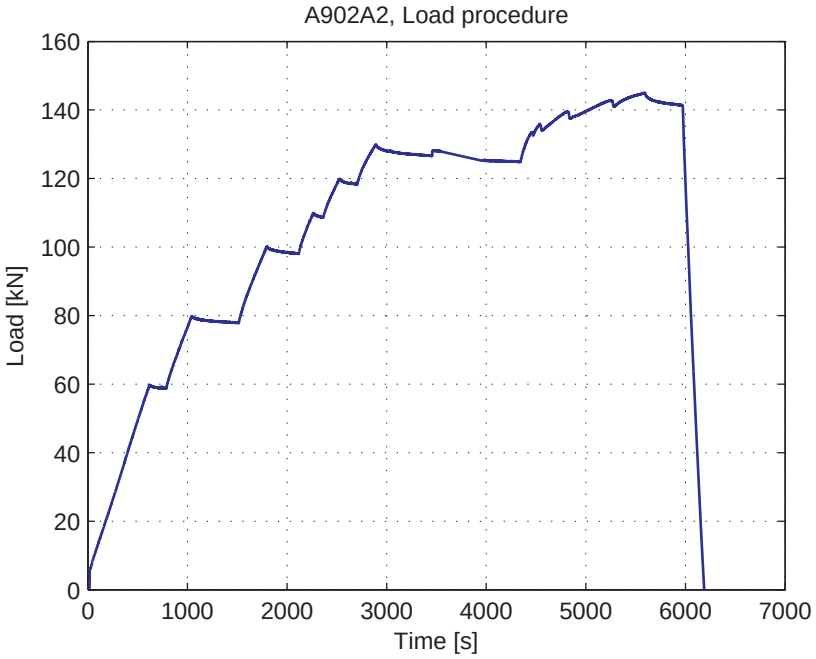


Fig. 5.18.3. Load-Time curve

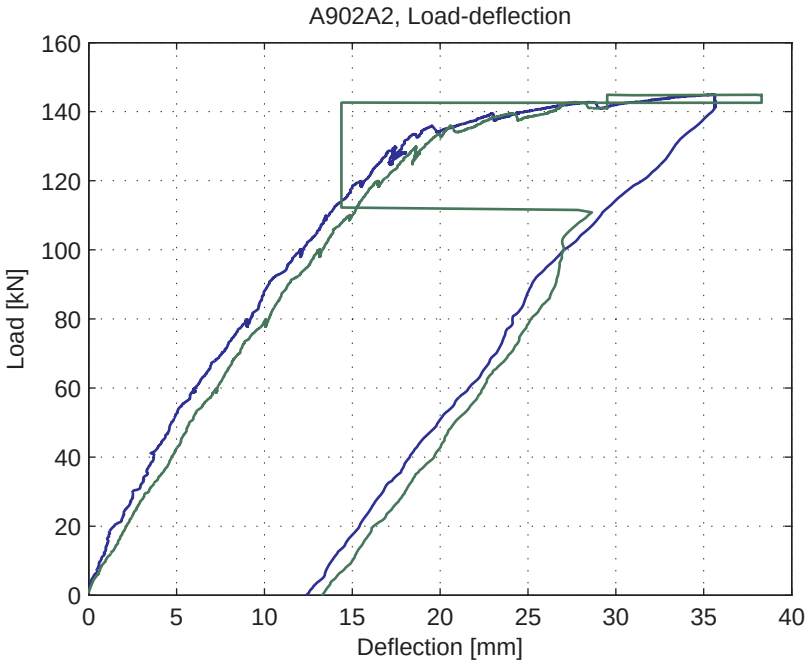


Fig. 5.18.4. Load-deflection curve

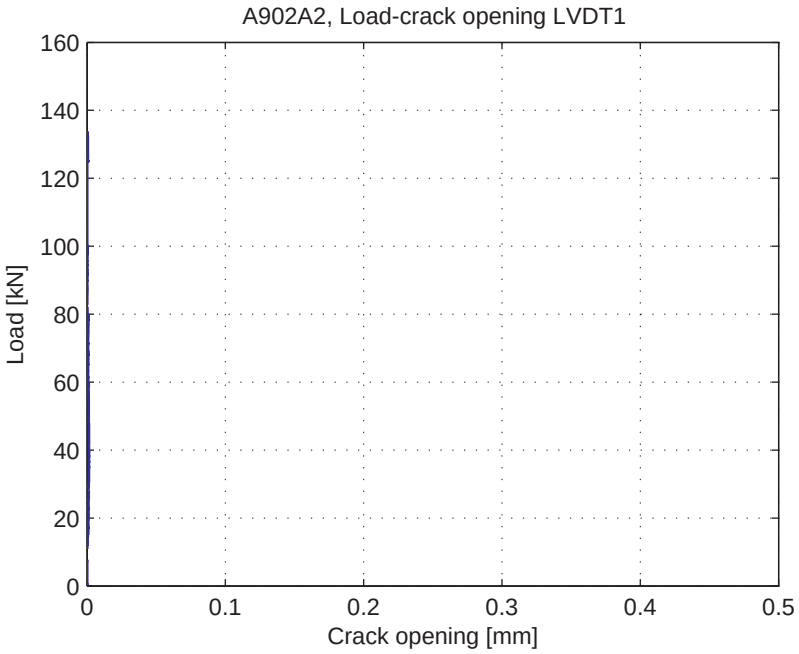


Fig. 5.18.5. Load-Crack opening for LVDT1

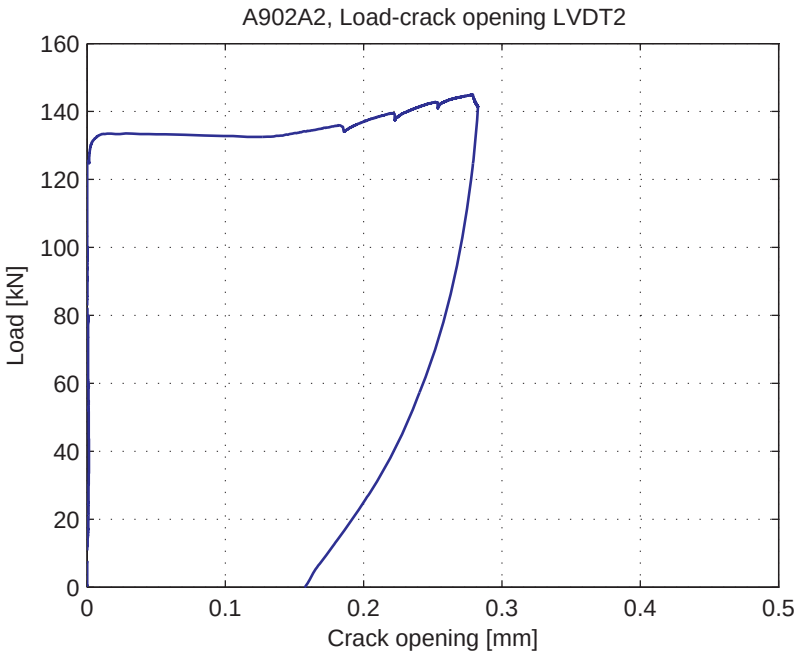


Fig. 5.18.6. Load-Crack opening for LVDT2

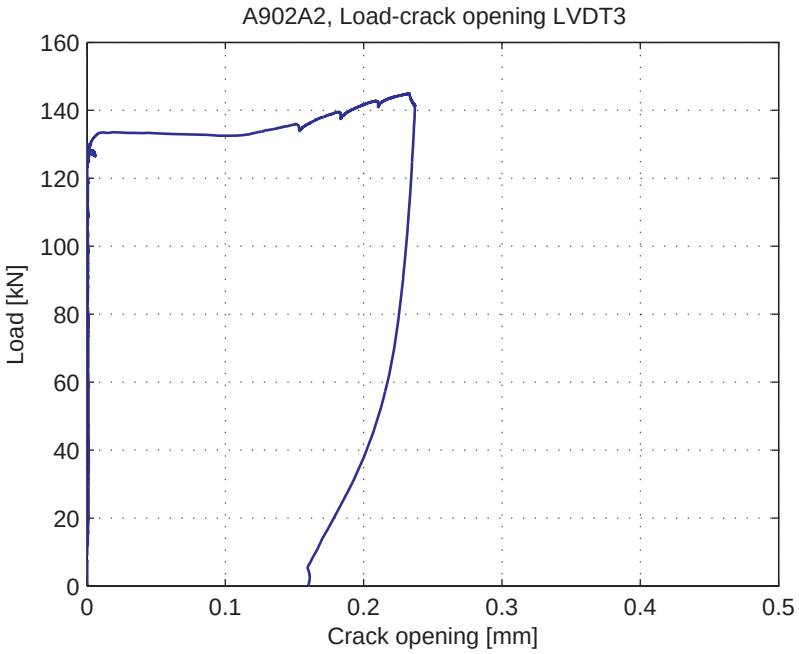


Fig. 5.18.7. Load-Crack opening for LVDT3

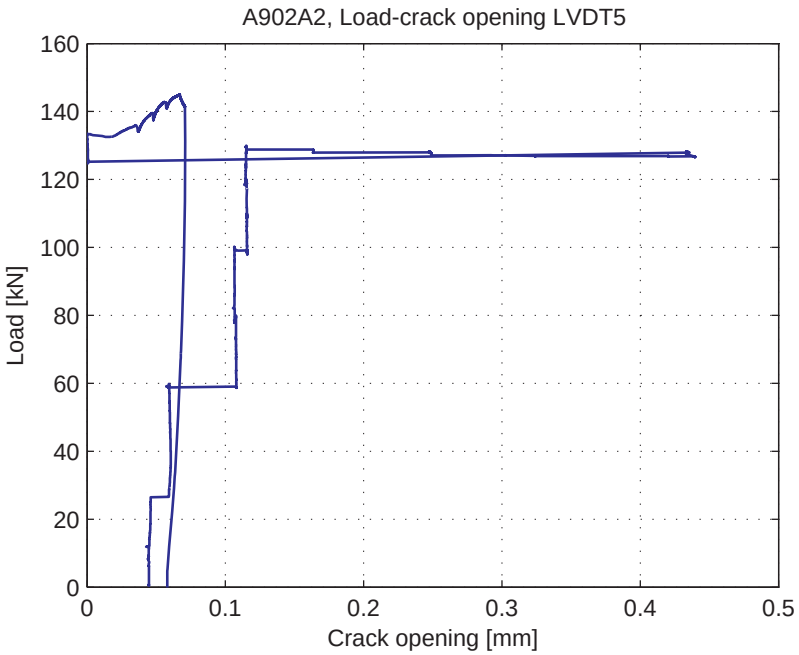


Fig. 5.18.8. Load-Crack opening for LVDT5

5.19. A902A3

5.19.1. Test properties

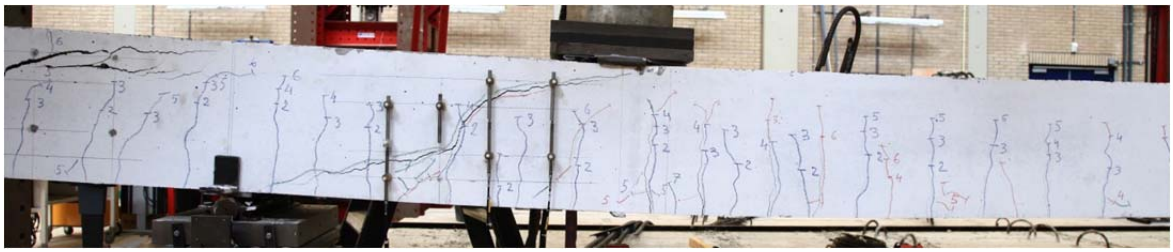


Fig. 5.19.1. Crack pattern after failure north side

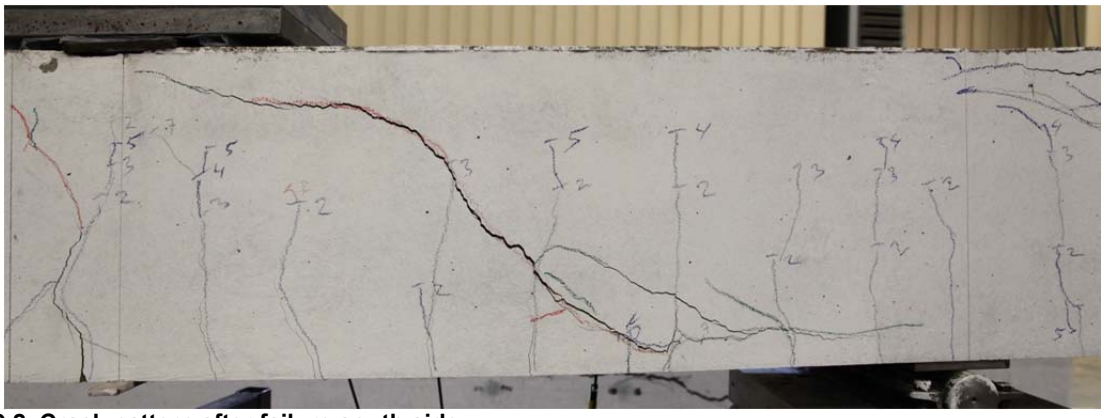


Fig. 5.19.2. Crack pattern after failure south side

Table 5.19.1. Beam properties

Date of test	20-05-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.90%
a	800 mm
a / *d*	2.90
Concrete cube strength at testing	78.5 MPa
Peak load	149.4 kN
Failure mode	Shear

Table 5.19.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	
5	100	
6	120	
7	140	
8	149.9	Shear failure

Table 5.19.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	325	50
2	North	Vertical	430	50
3	North	Vertical	530	100
5	North	Vertical	655	100

5.19.2. Measurement results

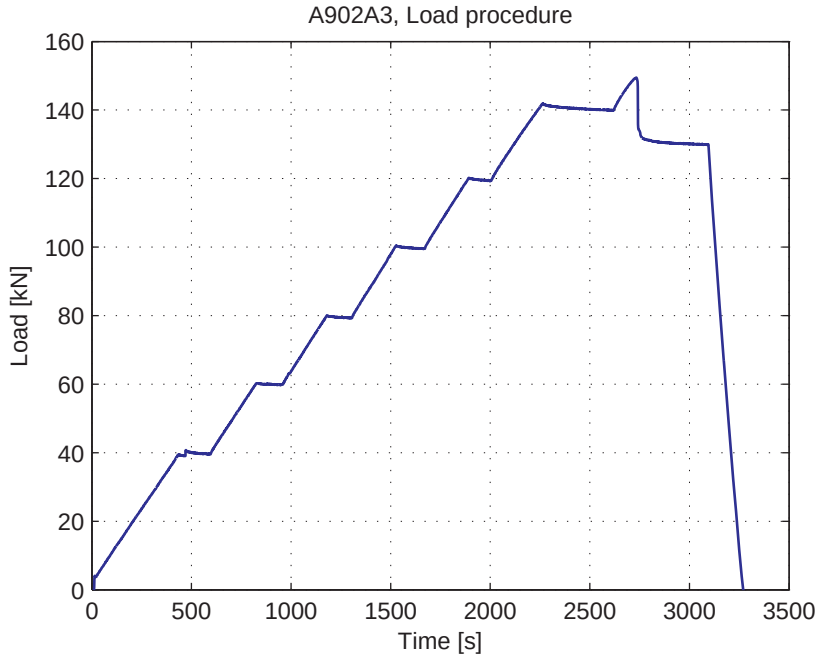


Fig. 5.19.3. Load-Time curve

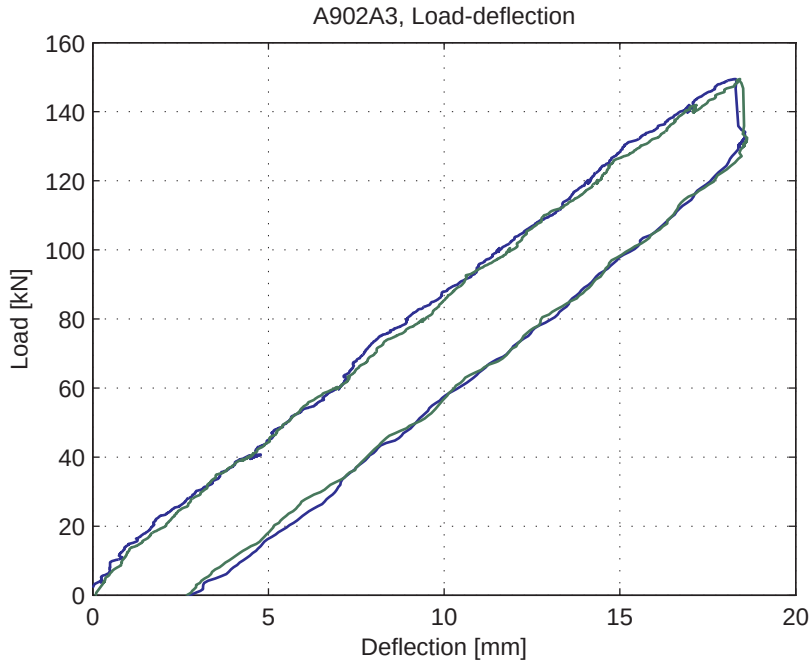


Fig. 5.19.4. Load-deflection curve

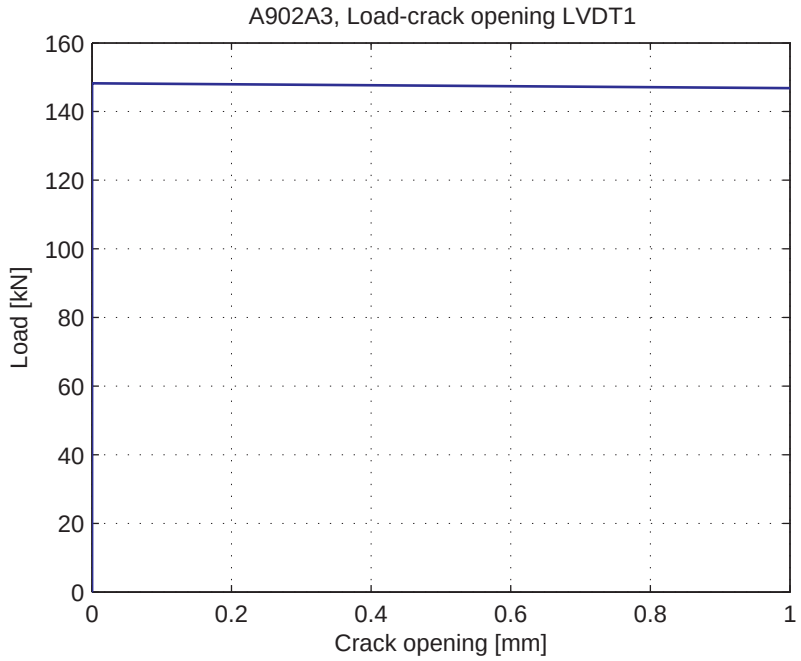


Fig. 5.19.5. Load-Crack opening for LVDT1

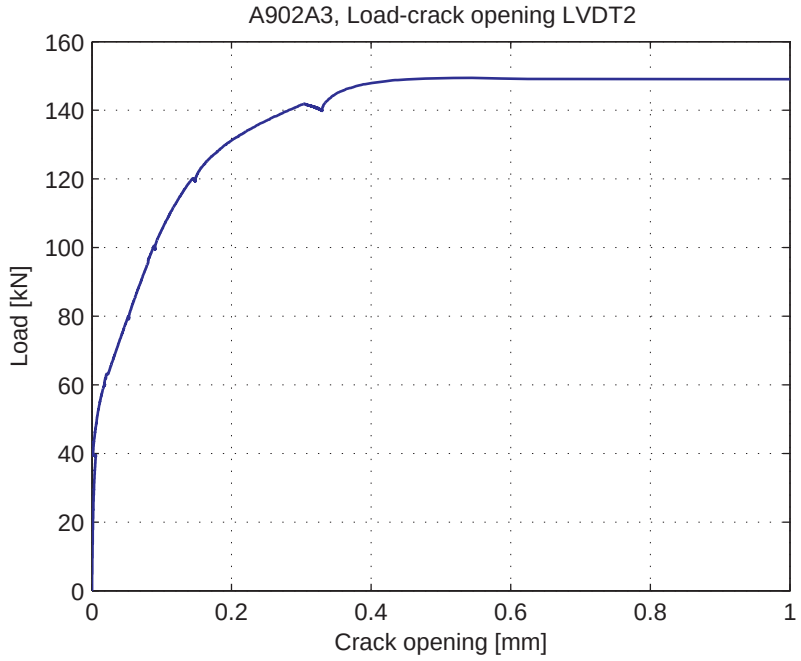


Fig. 5.19.6. Load-Crack opening for LVDT2

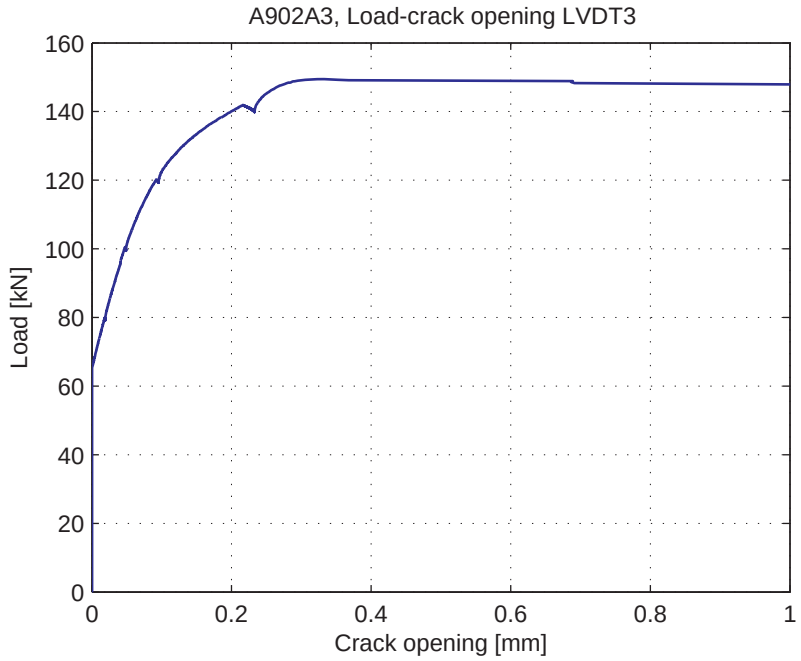


Fig. 5.19.7. Load-Crack opening for LVDT3

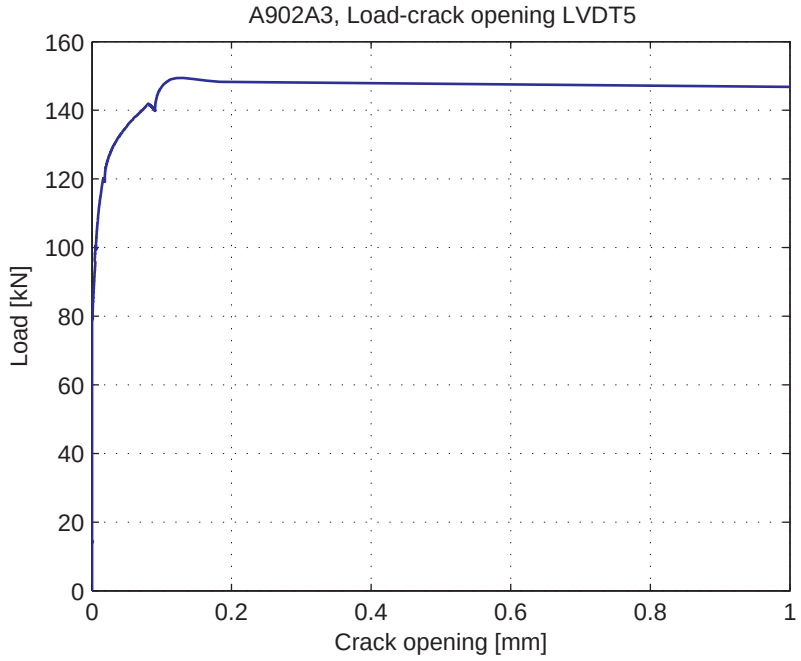


Fig. 5.19.8. Load-Crack opening for LVDT5

5.20. A902B1

5.20.1. Test properties

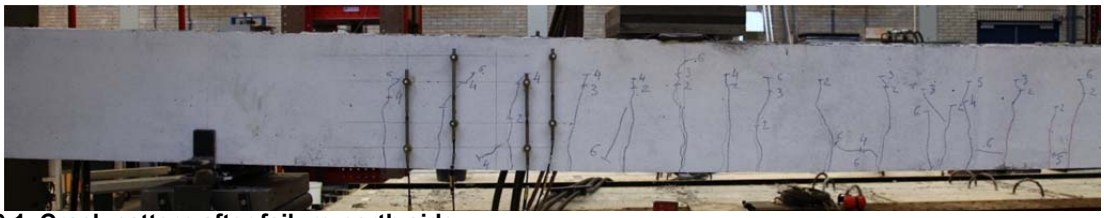


Fig. 5.20.1. Crack pattern after failure north side

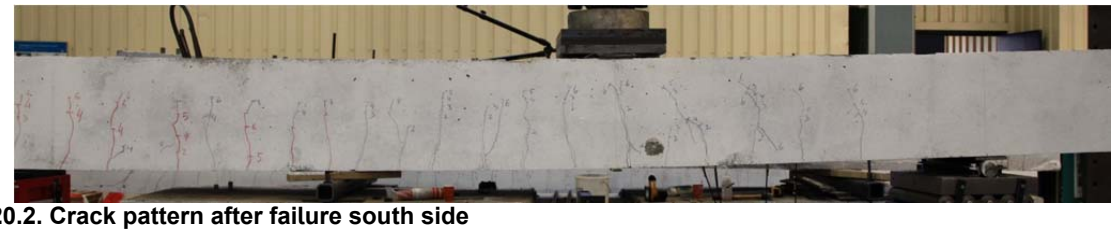


Fig. 5.20.2. Crack pattern after failure south side

Table 5.20.1. Beam properties

Date of test	21-05-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.90%
a	1100 mm
a / *d*	3.99
Concrete cube strength at testing	78.5 MPa
Peak load	121.5 kN
Failure mode	Flexural

Table 5.20.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	Added LVDT's 1-3 and 5
5	100	
6	120	Yielding at 119.3 kN

Table 5.20.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	465	50
2	North	Vertical	570	100
3	North	Vertical	740	50
5	North	Vertical	795	100

5.20.2. Measurement results

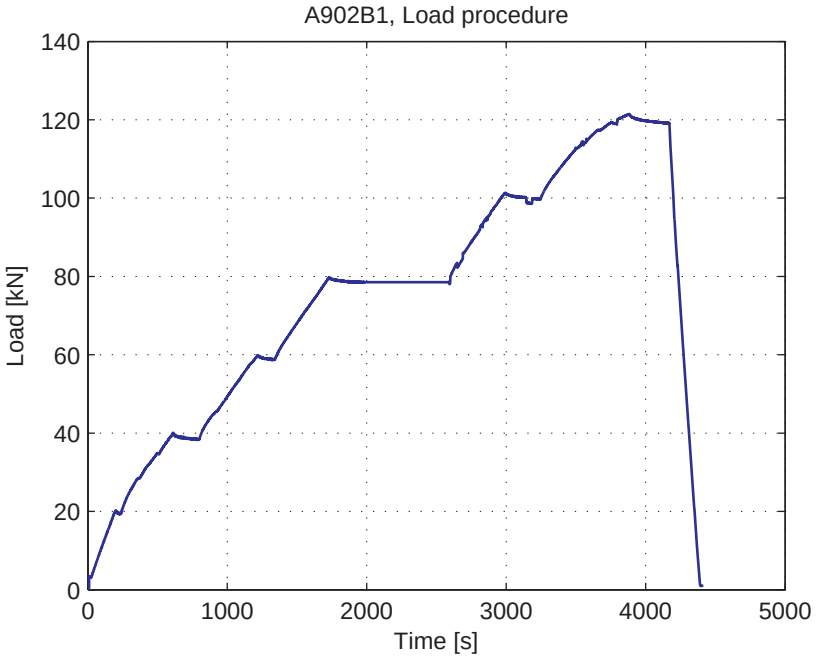


Fig. 5.20.3. Load-Time curve

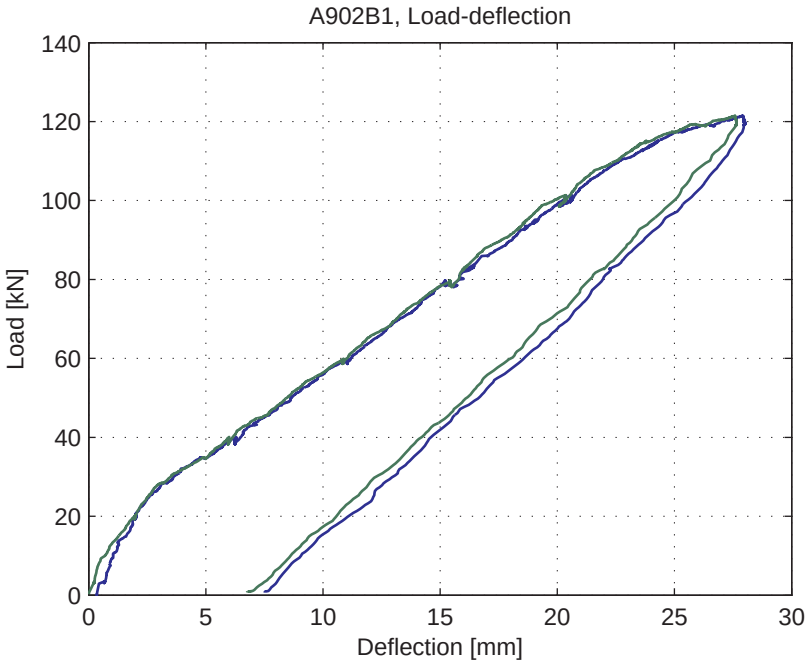


Fig. 5.20.4. Load-deflection curve

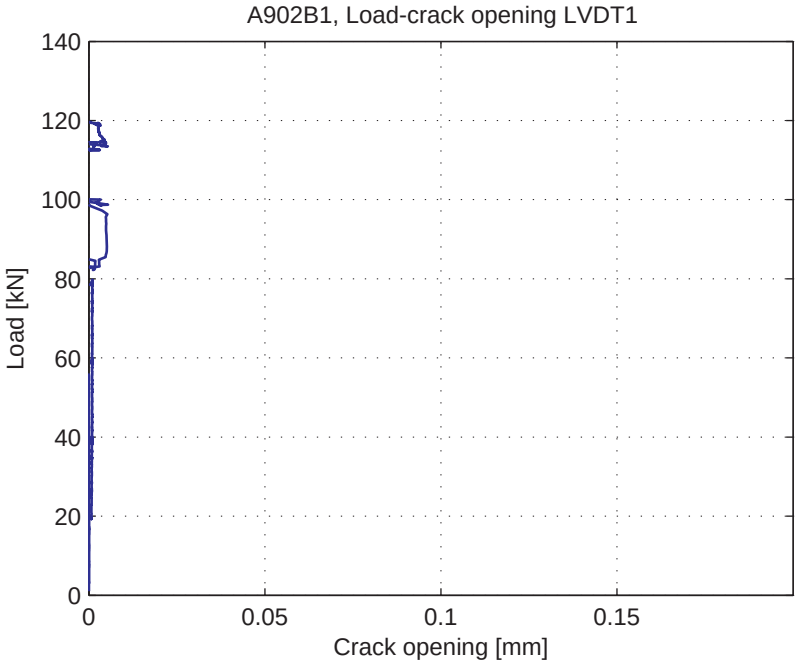


Fig. 5.20.5. Load-Crack opening for LVDT1

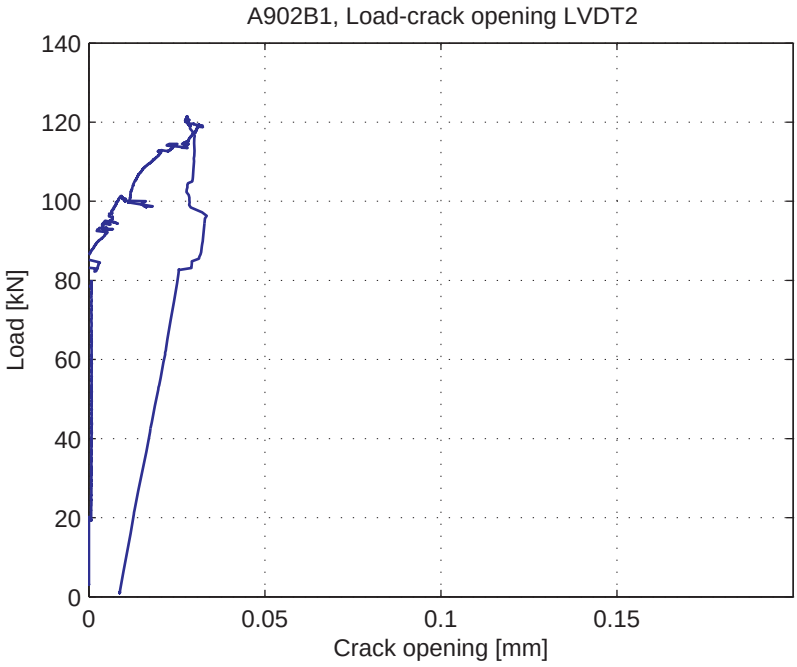


Fig. 5.20.6. Load-Crack opening for LVDT2

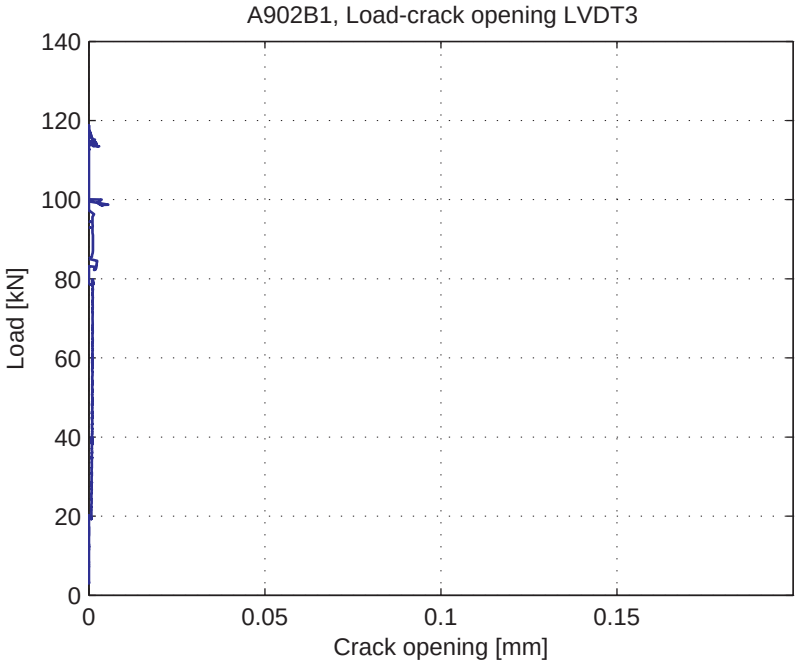


Fig. 5.20.7. Load-Crack opening for LVDT3

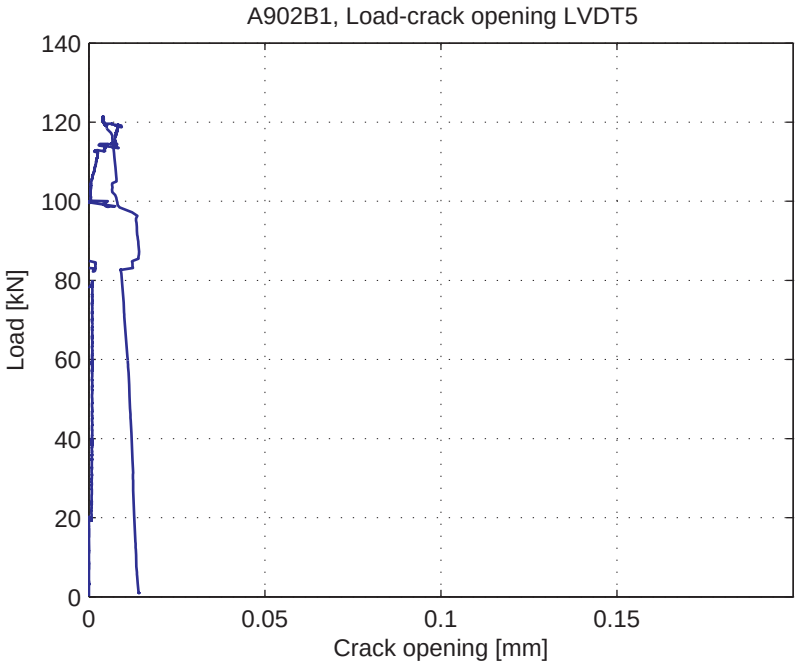


Fig. 5.20.8. Load-Crack opening for LVDT5

5.21. A902B2

5.21.1. Test properties

Fig. 5.21.1. Crack pattern after failure north side

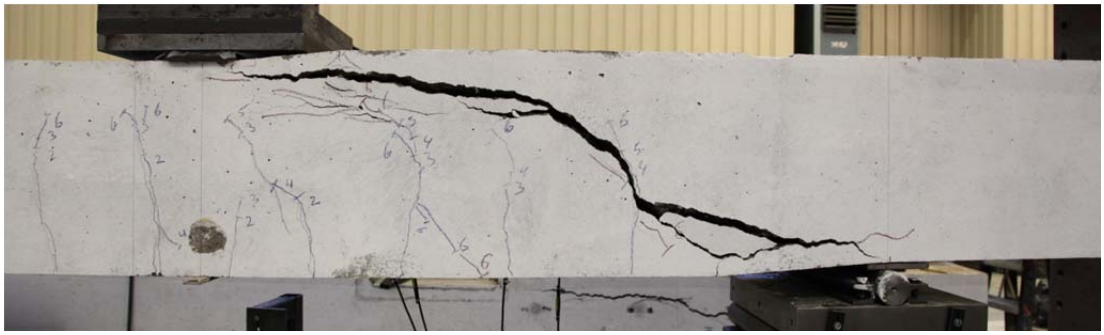


Fig. 5.21.2. Crack pattern after failure south side

Table 5.21.1. Beam properties

Date of test	21-05-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.90%
a	1000 mm
a / *d*	3.62
Concrete cube strength at testing	78.5 MPa
Peak load	124.2 kN
Failure mode	Shear

Table 5.21.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	
5	100	
6	120	Shear at 124.2 kN, just after first yielding

Table 5.21.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	465	50
2	North	Vertical	570	100
3	North	Vertical	740	50
5	North	Vertical	795	100

5.21.2. Measurement results

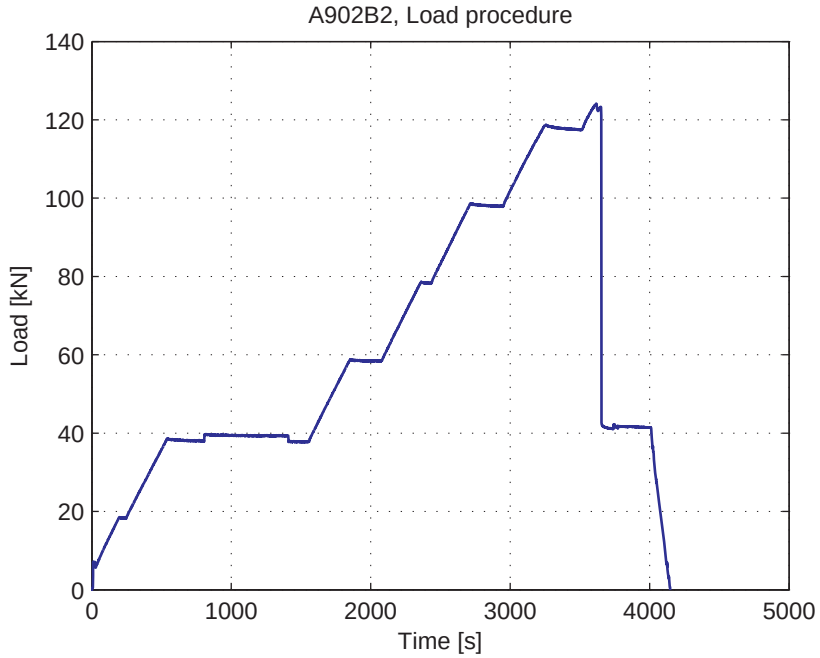


Fig. 5.21.3. Load-Time curve

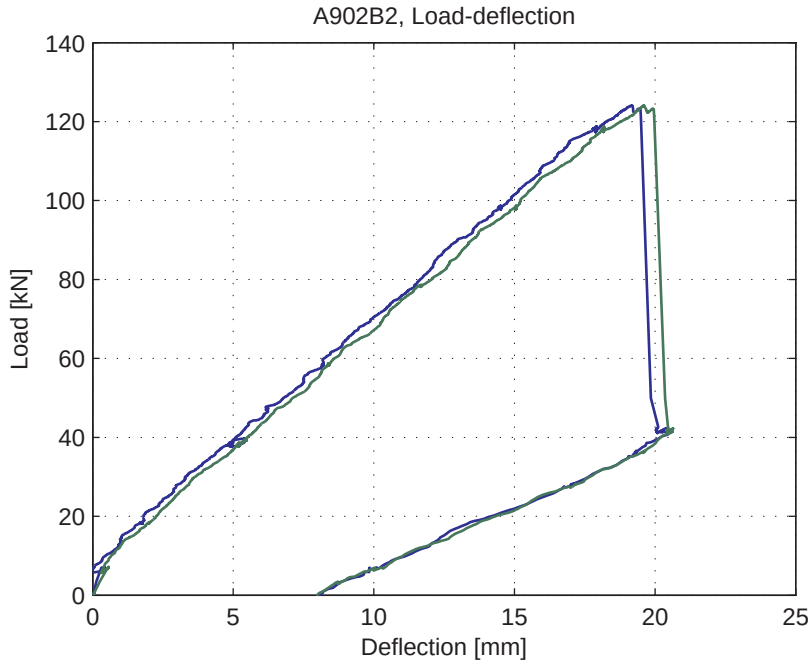


Fig. 5.21.4. Load-deflection curve

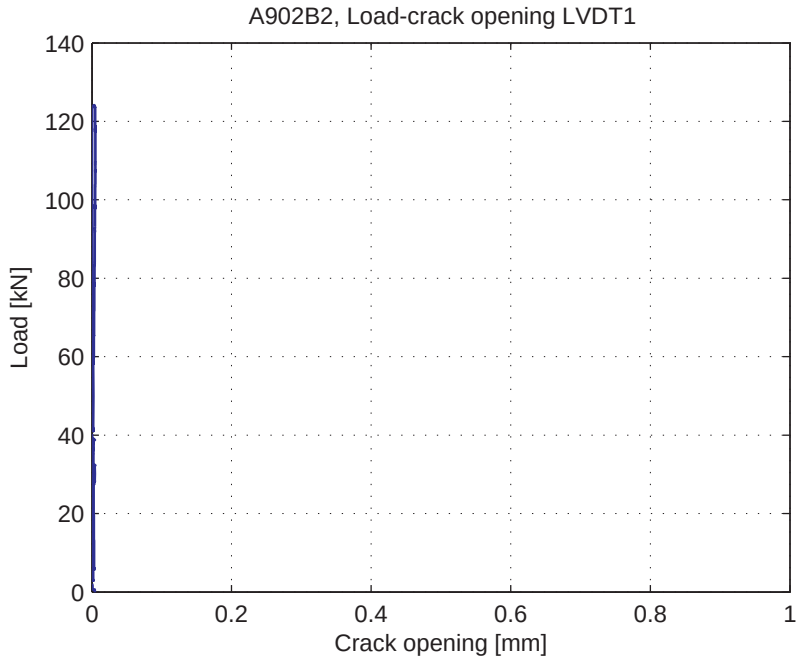


Fig. 5.21.5. Load-Crack opening for LVDT1

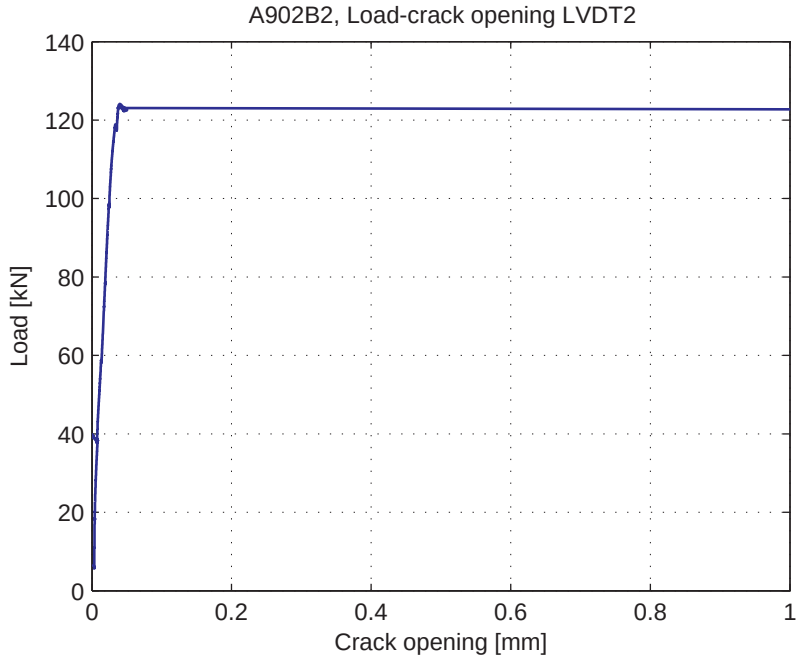


Fig. 5.21.6. Load-Crack opening for LVDT2

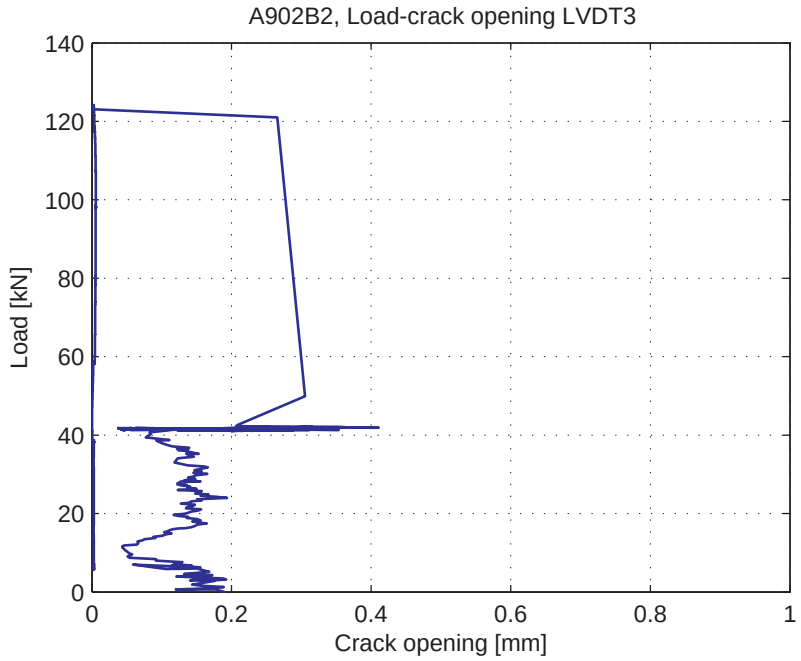


Fig. 5.21.7. Load-Crack opening for LVDT3

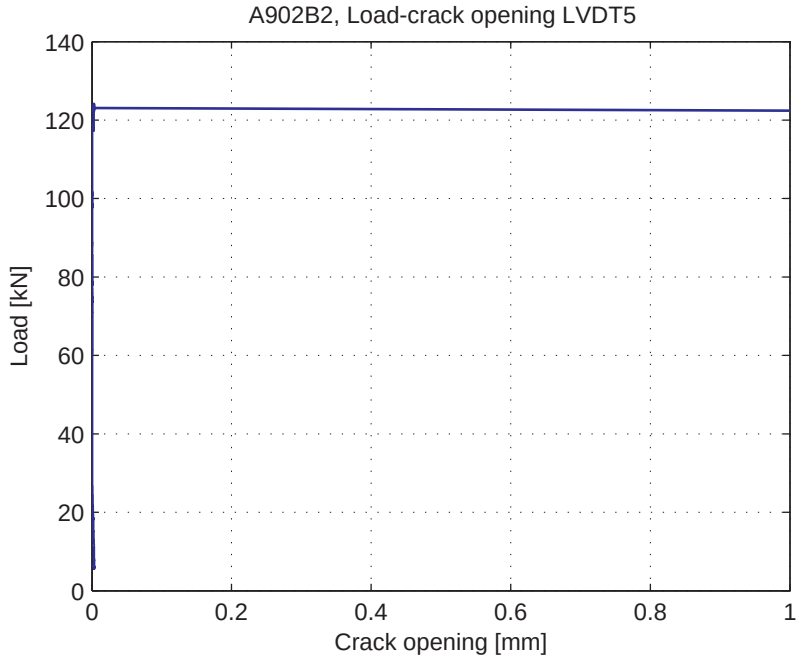


Fig. 5.21.8. Load-Crack opening for LVDT5

5.22. A751A1

5.22.1. Test properties

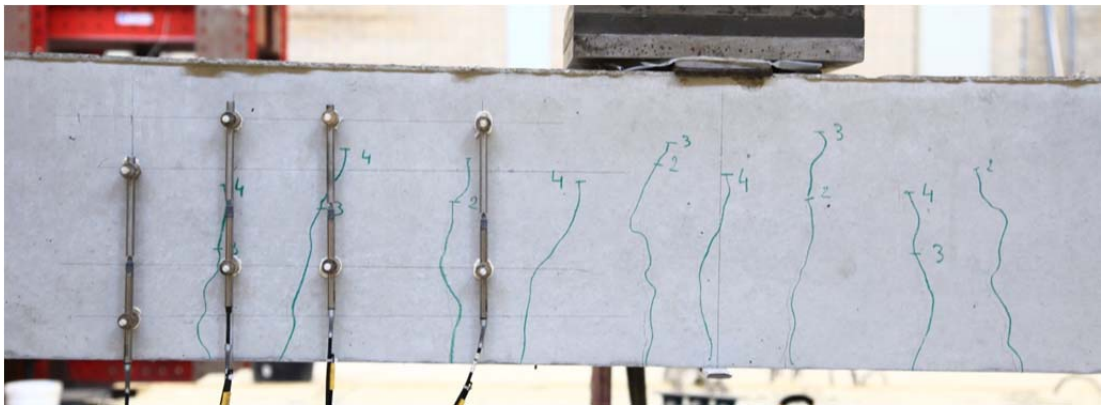


Fig. 5.22.1. Crack pattern after failure north side

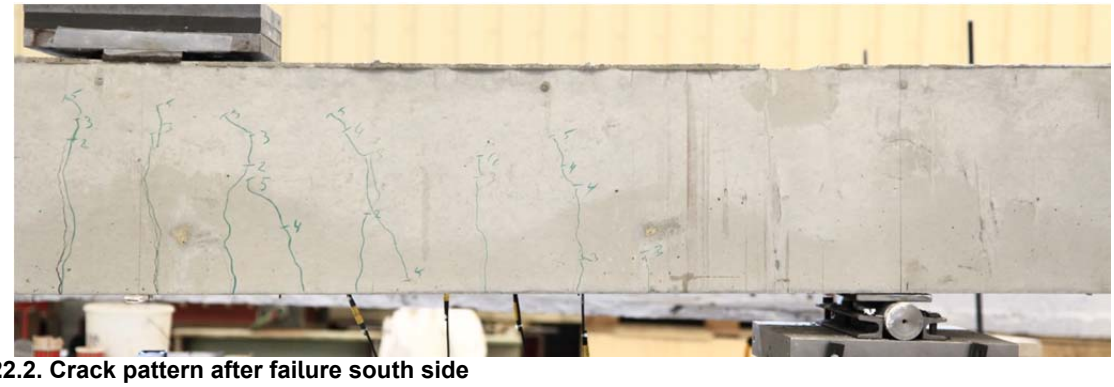


Fig. 5.22.2. Crack pattern after failure south side

Table 5.22.1. Beam properties

Date of test	23-04-2015
Reinforcement	3Ø16
Reinforcement ratio	0.73%
a	1000 mm
a / *d*	3.64
Concrete cube strength at testing	78.5 MPa
Peak load	97.1 kN
Failure mode	Flexural

Table 5.22.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	50	Checking for inclined crack, not found
4	60	
5	80	Placed LVDT's 1-3 and 5
6	100.7	Stopped after jack displacement of 30 mm

Table 5.22.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	400	50
2	North	Vertical	495	100
3	North	Vertical	595	100
4	North	Vertical	750	100

5.22.2. Measurement results

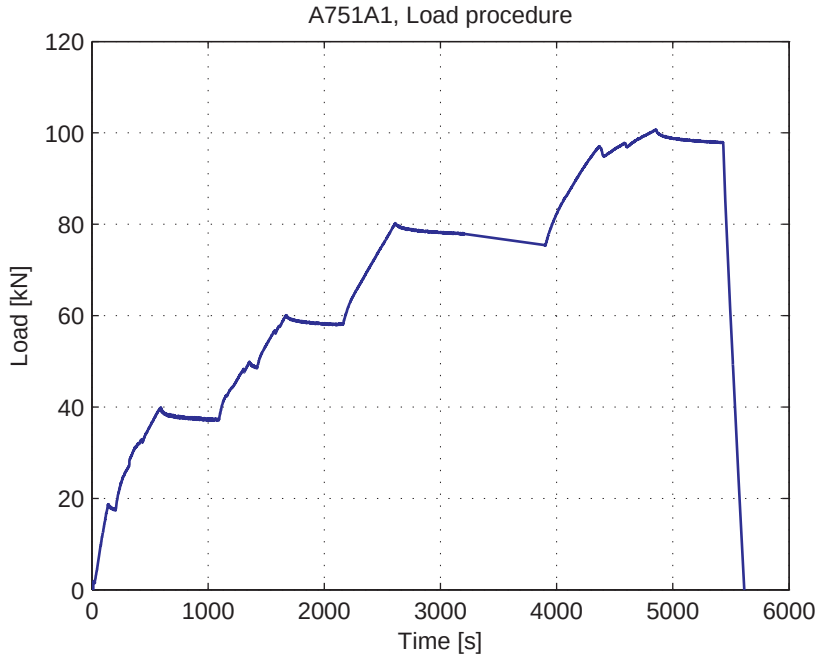


Fig. 5.22.3. Load-Time curve

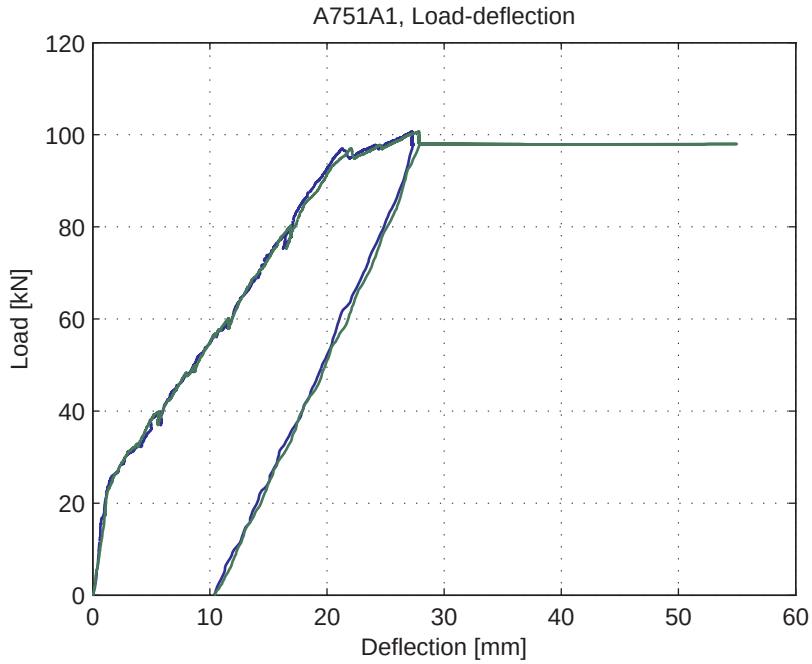


Fig. 5.22.4. Load-deflection curve

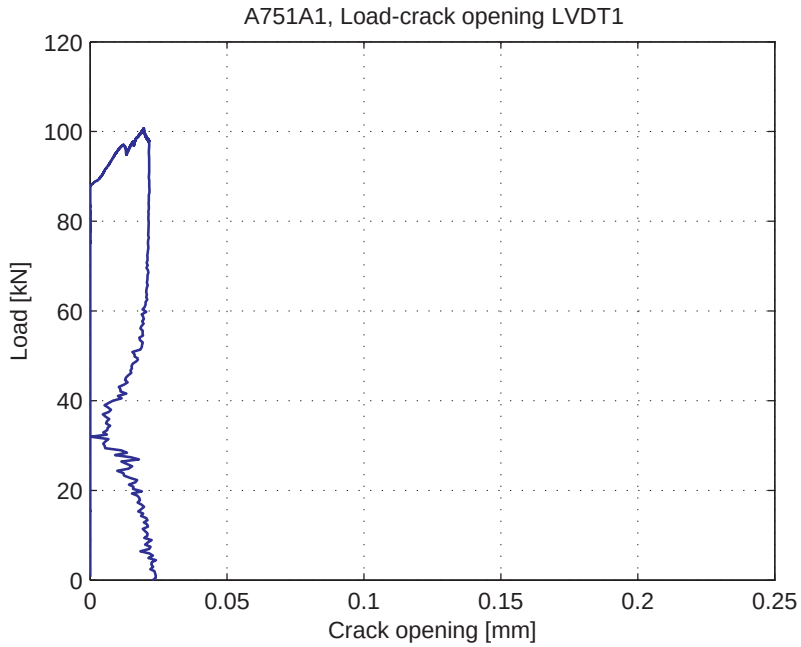


Fig. 5.22.5. Load-Crack opening for LVDT1

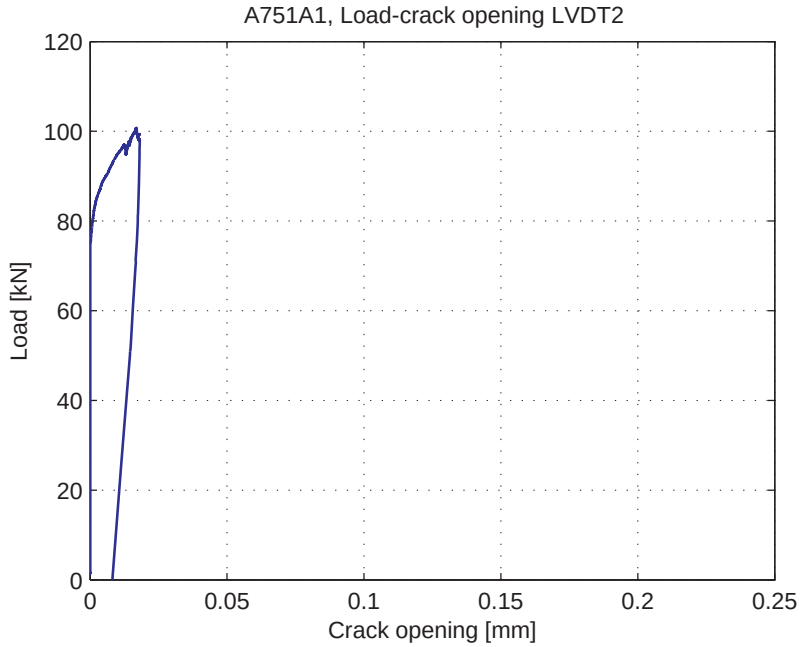


Fig. 5.22.6. Load-Crack opening for LVDT2

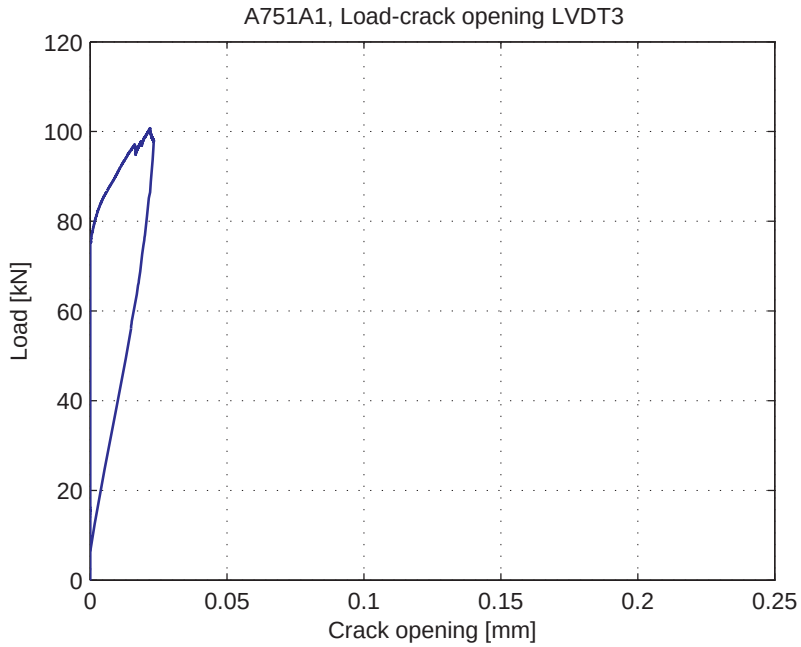


Fig. 5.22.7. Load-Crack opening for LVDT3

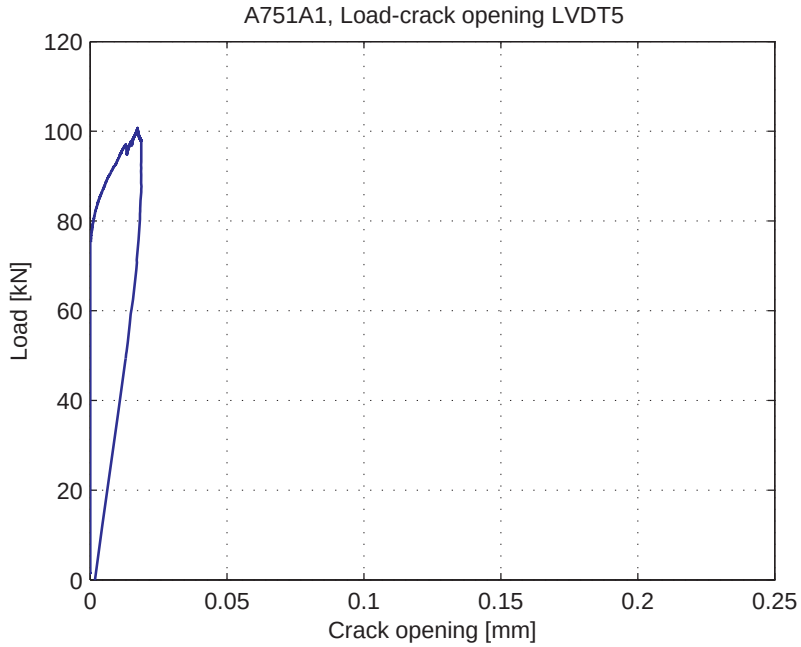


Fig. 5.22.8. Load-Crack opening for LVDT5

5.23. A751A2

5.23.1. Test properties

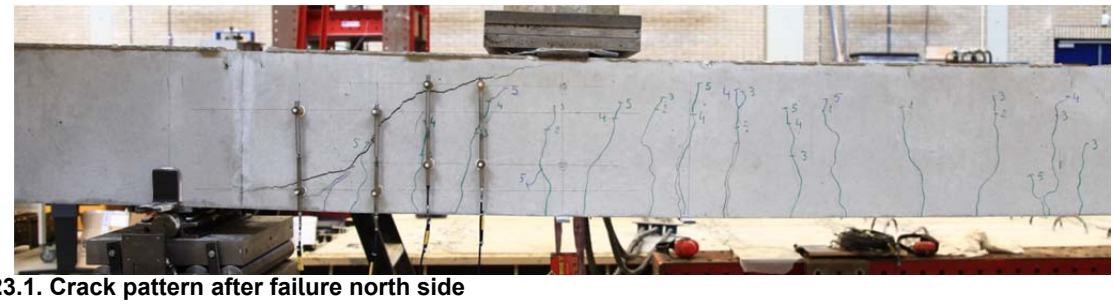


Fig. 5.23.1. Crack pattern after failure north side

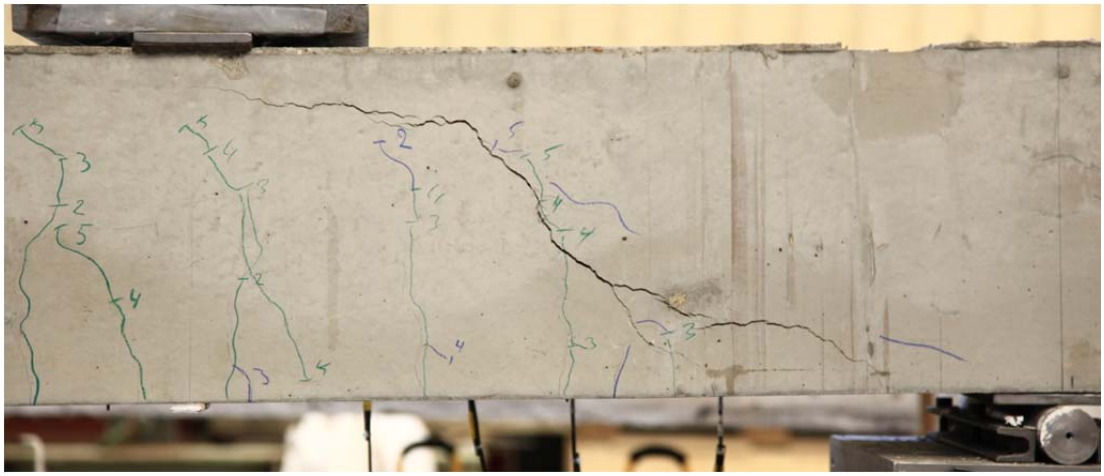


Fig. 5.23.2. Crack pattern after failure south side

Table 5.23.1. Beam properties

Date of test	23-04-2015
Reinforcement	3Ø16
Reinforcement ratio	0.73%
a	750 mm
a / *d*	2.73
Concrete cube strength at testing	78.5 MPa
Peak load	118.4 kN
Failure mode	Shear

Table 5.23.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	
5	100	Replaced LVDT 5. No measurement, started at about 1800 sec
6	118.4	Shear failure

Table 5.23.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	400	50
2	North	Vertical	495	100
3	North	Vertical	595	100
5	North	Vertical	250	50

5.23.2. Measurement results

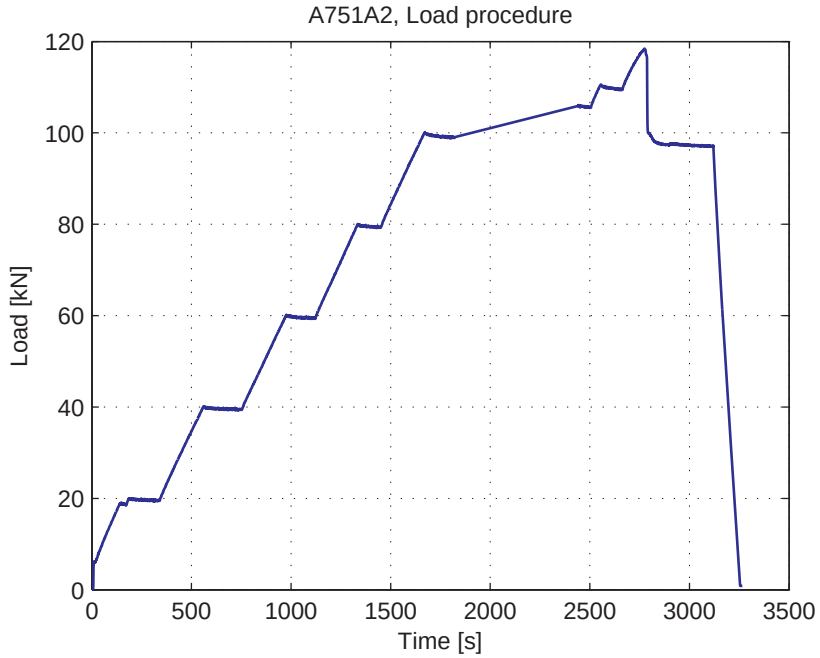


Fig. 5.23.3. Load-Time curve

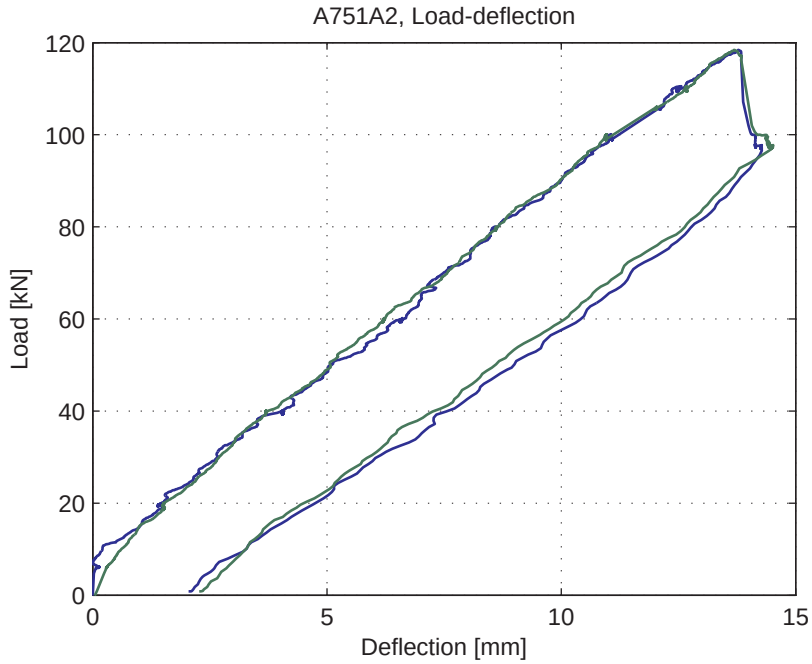


Fig. 5.23.4. Load-deflection curve

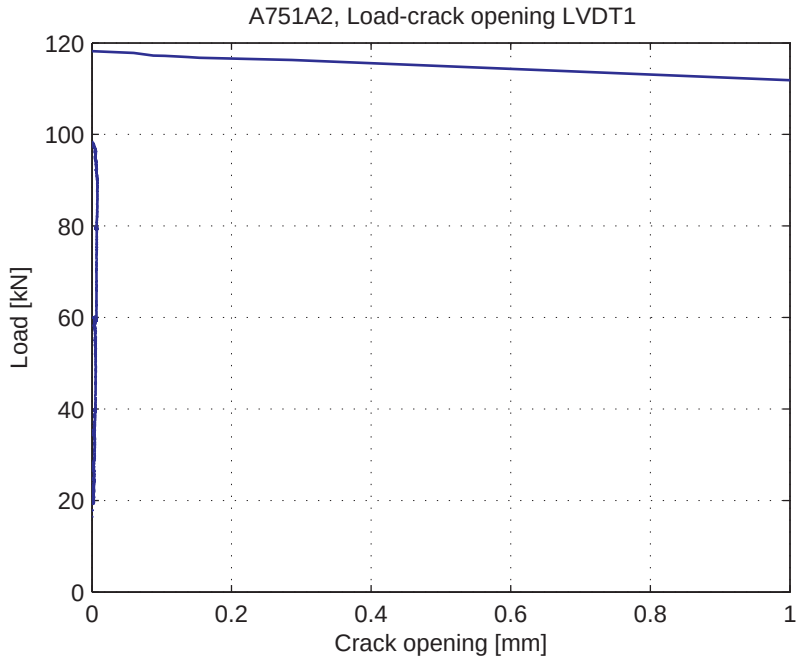


Fig. 5.23.5. Load-Crack opening for LVDT1

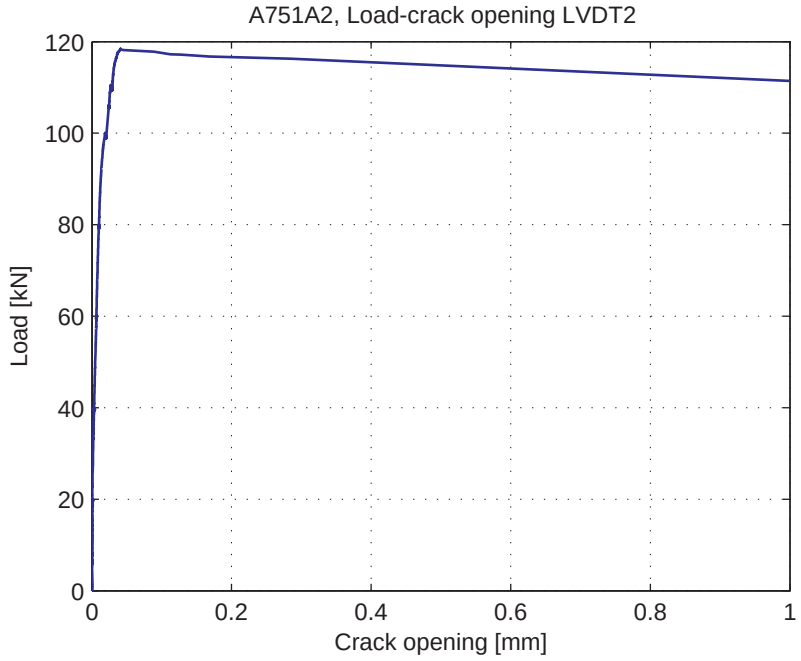


Fig. 5.23.6. Load-Crack opening for LVDT2

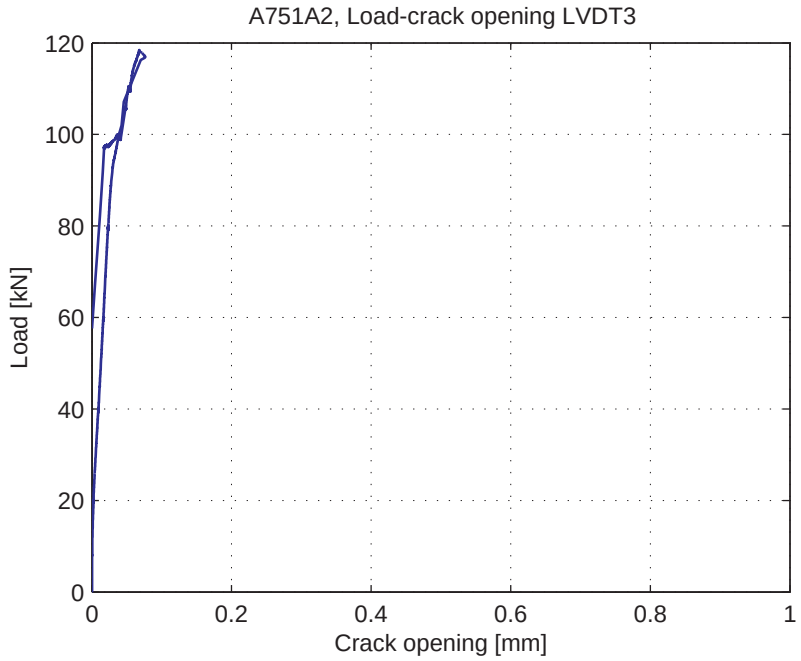


Fig. 5.23.7. Load-Crack opening for LVDT3

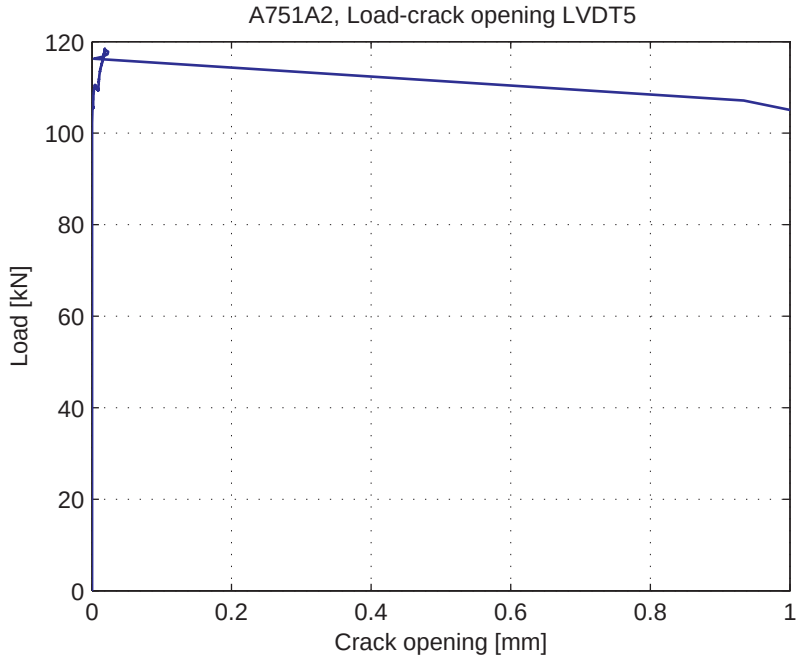


Fig. 5.23.8. Load-Crack opening for LVDT5

5.24. A751B1

5.24.1. Test properties

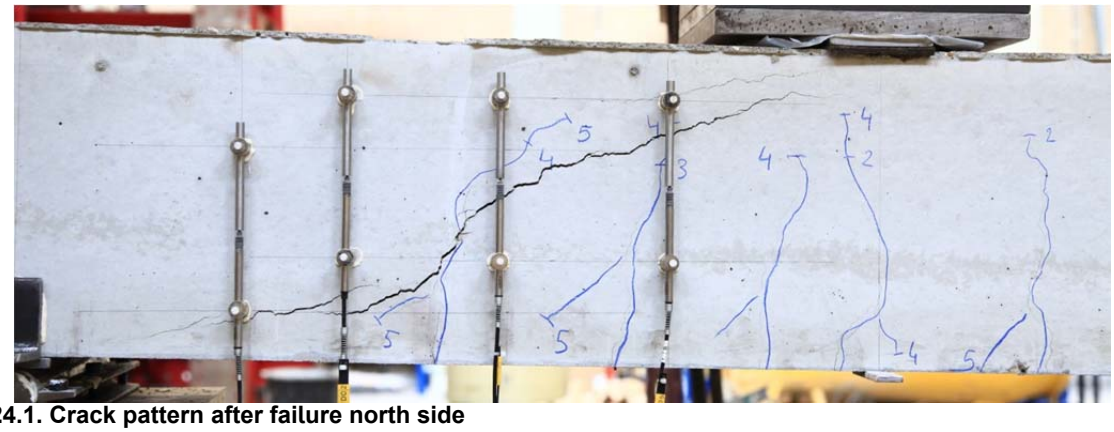


Fig. 5.24.1. Crack pattern after failure north side

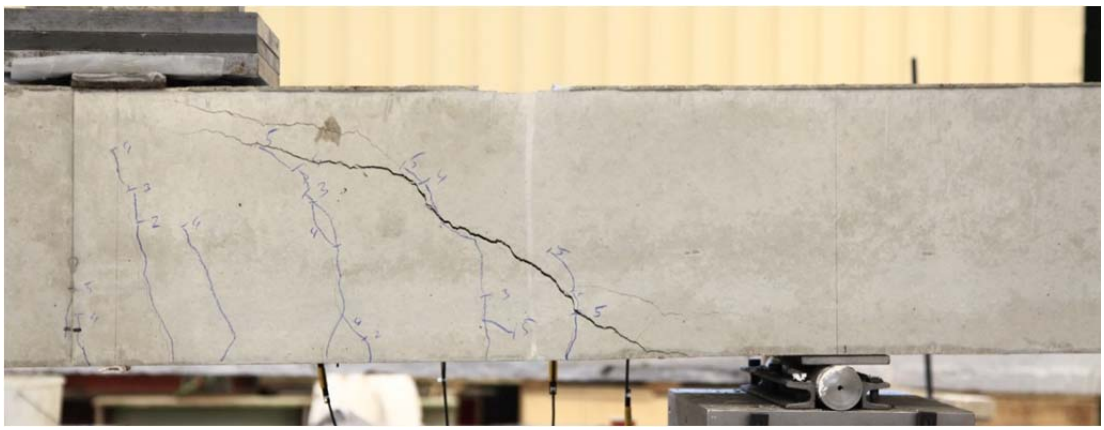


Fig. 5.24.2. Crack pattern after failure south side

Table 5.24.1. Beam properties

Date of test	24-04-2015
Reinforcement	3Ø16
Reinforcement ratio	0.73%
a	800 mm
a / *d*	2.91
Concrete cube strength at testing	78.5 MPa
Peak load	106.7 kN
Failure mode	Shear

Table 5.24.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	Placed LVDT's 1-3 and 5
5	100	
6	106.7	Shear failure

Table 5.24.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	200	50
2	North	Vertical	300	100
3	North	Vertical	435	100
5	North	Vertical	600	100

5.24.2. Measurement results

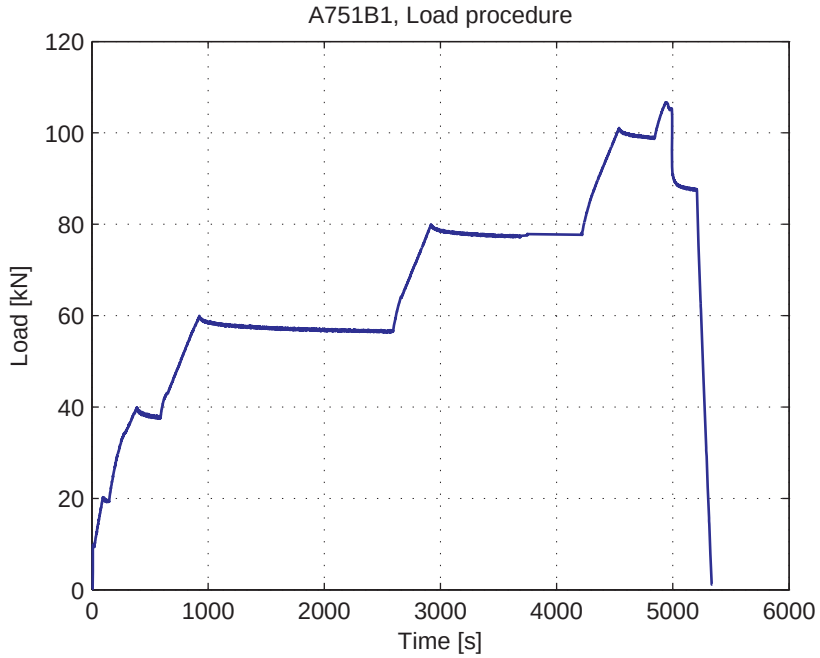


Fig. 5.24.3. Load-Time curve

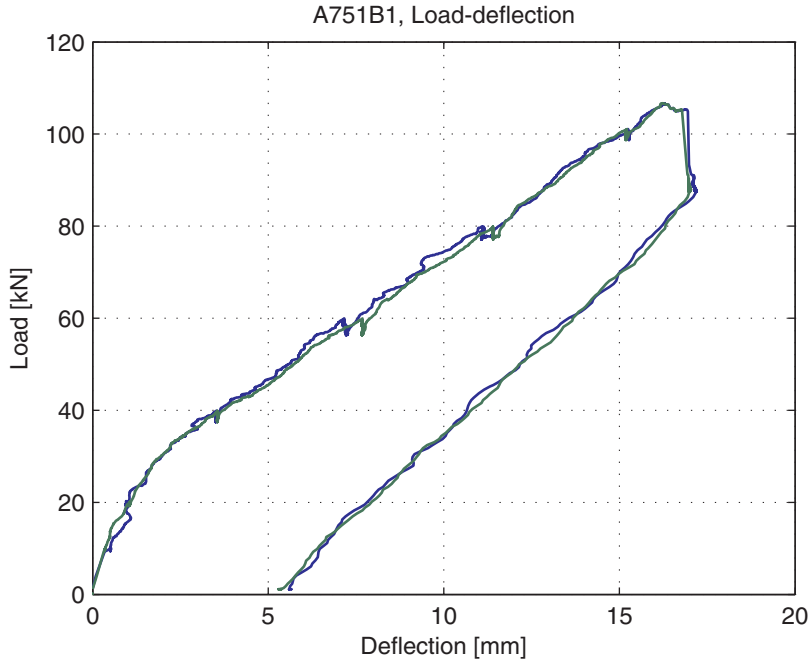


Fig. 5.24.4. Load-deflection curve

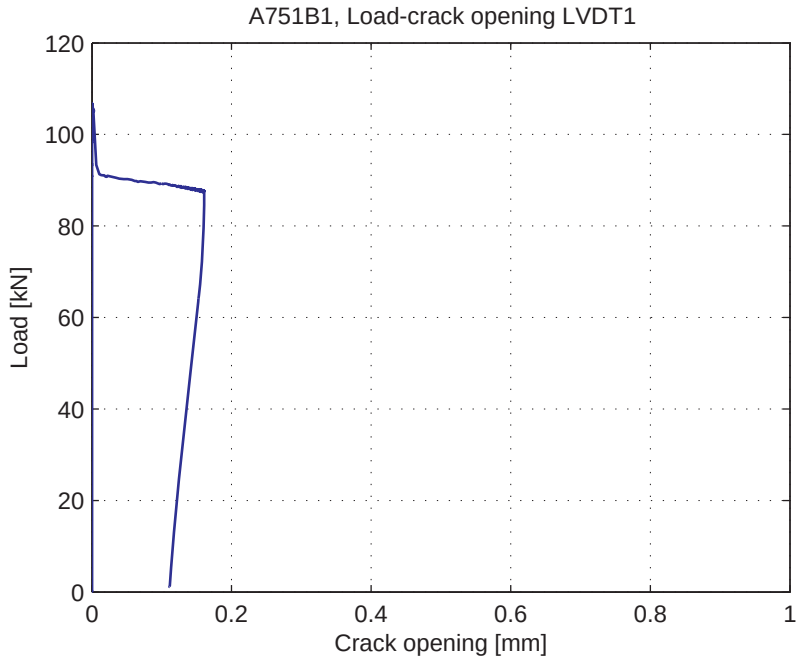


Fig. 5.24.5. Load-Crack opening for LVDT1

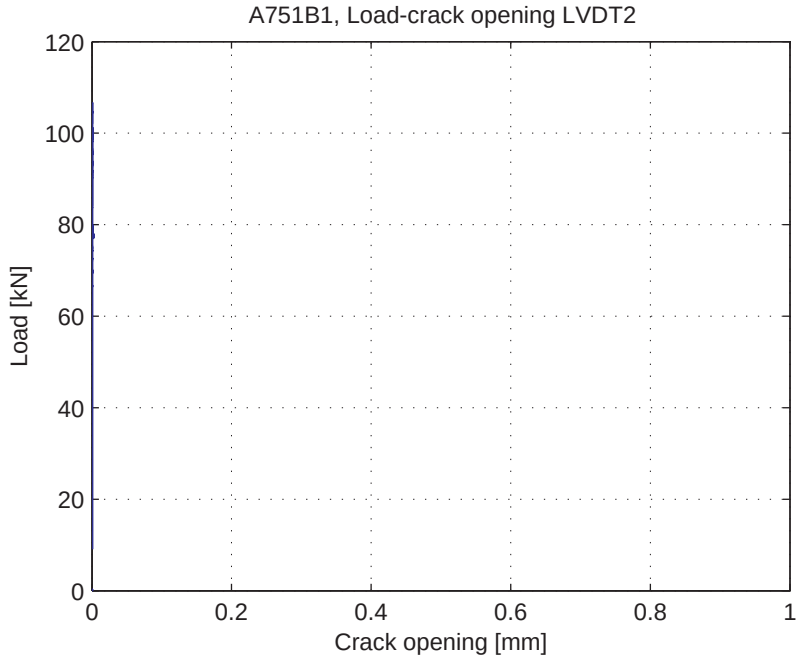


Fig. 5.24.6. Load-Crack opening for LVDT2

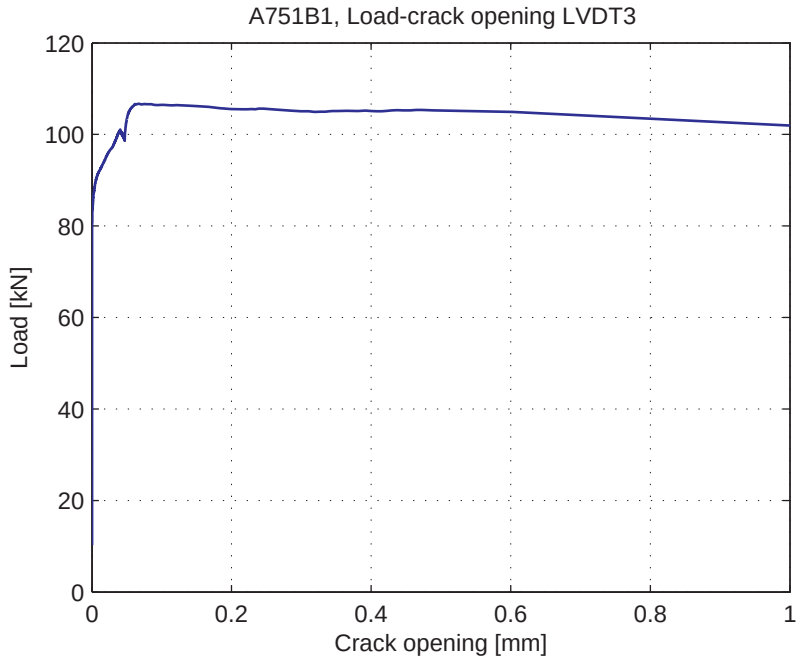


Fig. 5.24.7. Load-Crack opening for LVDT2

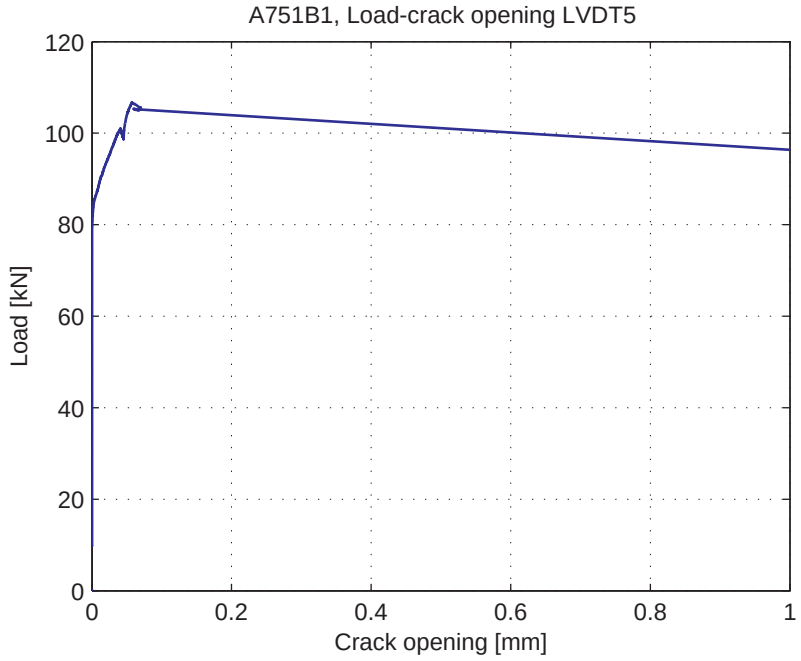


Fig. 5.24.8. Load-Crack opening for LVDT2

5.25. A751B2

5.25.1. Test properties

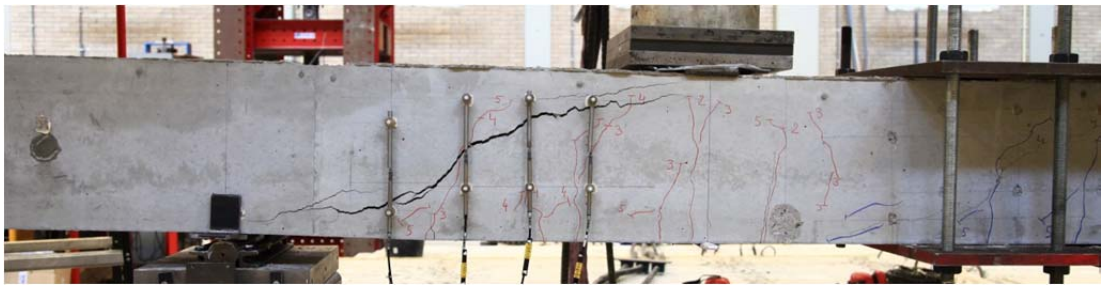


Fig. 5.25.1. Crack pattern after failure north side

Fig. 5.25.2. Crack pattern after failure south side

Table 5.25.1. Beam properties

Date of test	24-04-2015
Reinforcement	3Ø16
Reinforcement ratio	0.73%
a	850 mm
a / *d*	3.10
Concrete cube strength at testing	78.5 MPa
Peak load Flexural / shear	110.1 kN / 111.3 kN
Failure mode	Flexural and shear

Table 5.25.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Clamped crack from first test with plate and prestressed using air hammer
1	20	
2	40	
3	60	
4	80	Placed LVDT's 1-3 and 5
5	100	
6	111.3	Yielding at 110 kN, shear at 111 kN

Table 5.25.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	285	50
2	North	Vertical	415	100
3	North	Vertical	530	100
4	North	Vertical	635	100

5.25.2. Measurement results

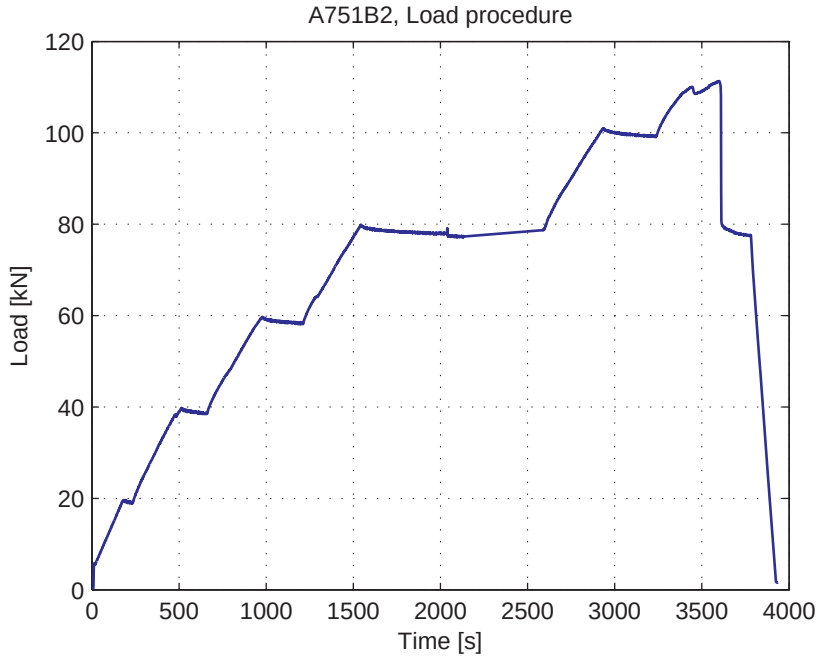


Fig. 5.25.3. Load-Time curve

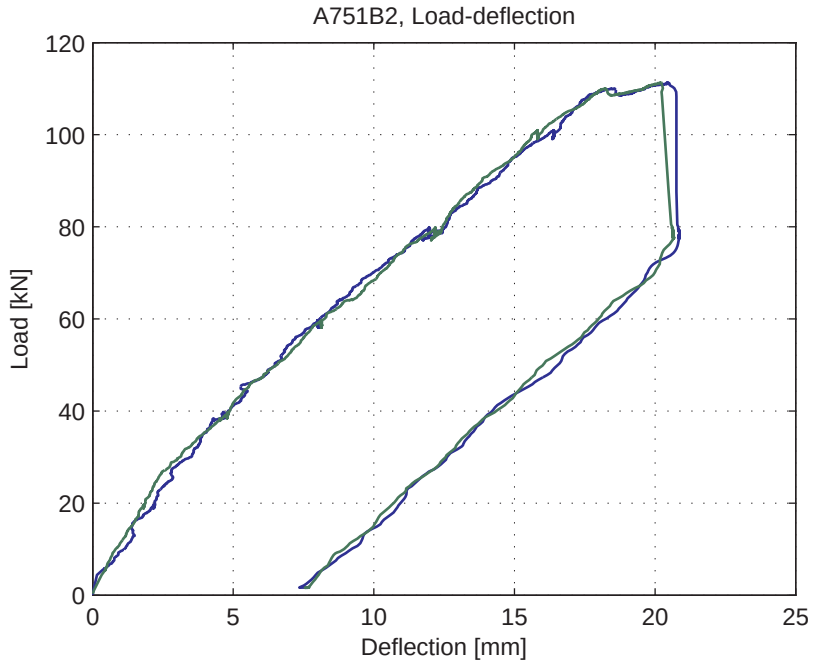


Fig. 5.25.4. Load-deflection curve

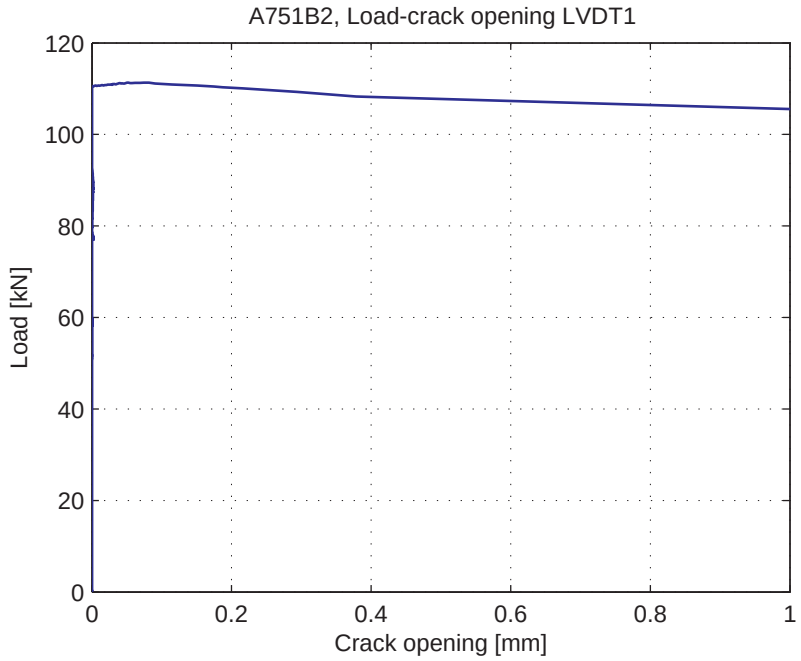


Fig. 5.25.5. Load-Crack opening for LVDT1

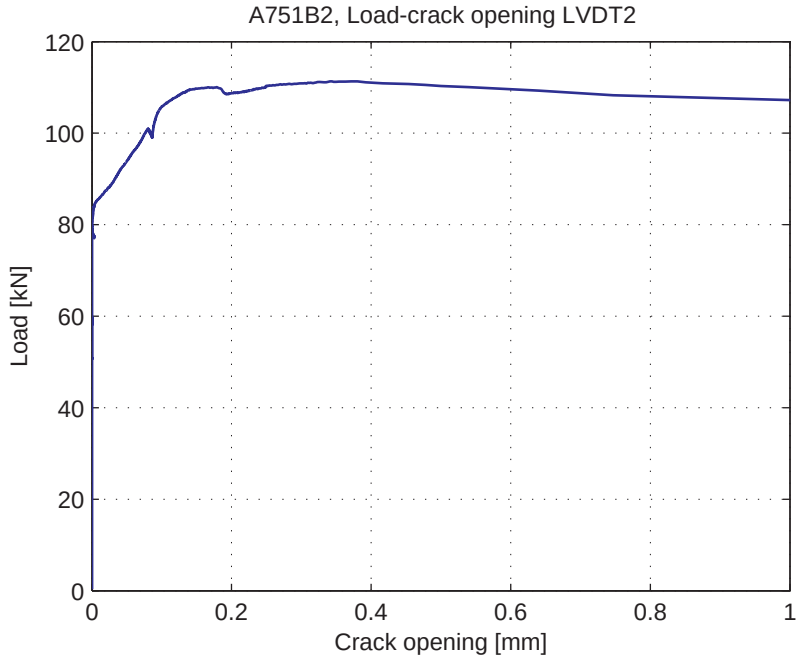


Fig. 5.25.6. Load-Crack opening for LVDT2

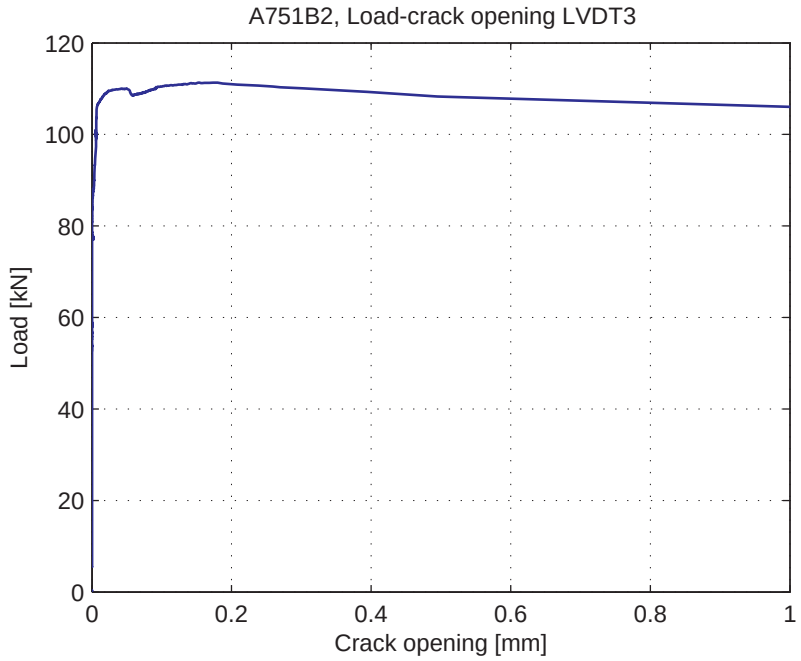


Fig. 5.25.7. Load-Crack opening for LVDT3

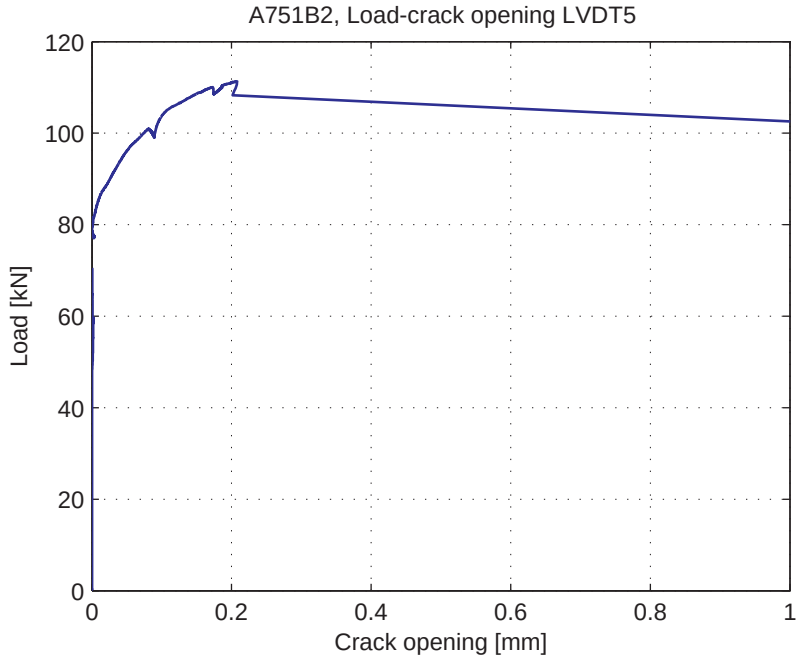


Fig. 5.25.8. Load-Crack opening for LVDT5

5.26. A752A1

5.26.1. Test properties

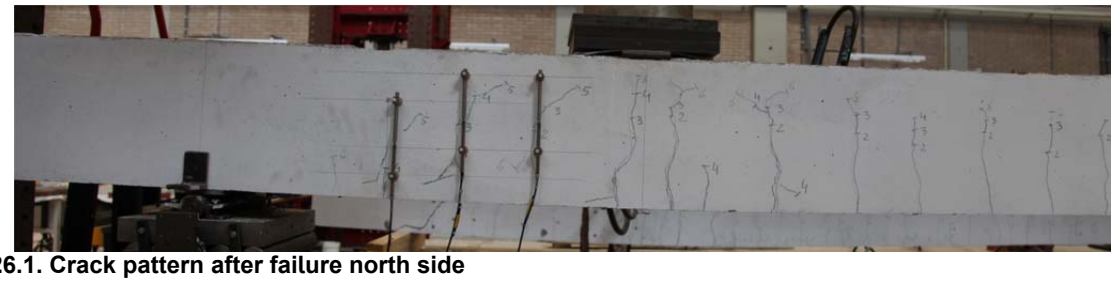


Fig. 5.26.1. Crack pattern after failure north side

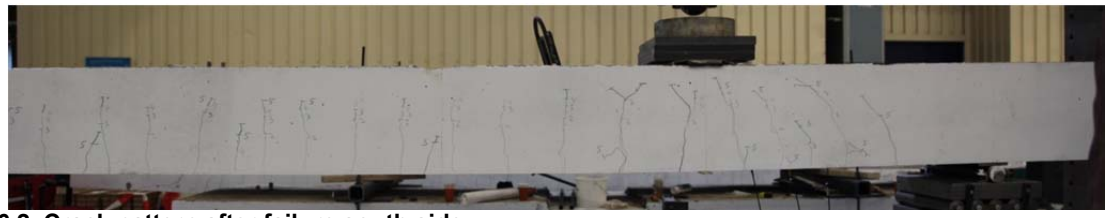


Fig. 5.26.2. Crack pattern after failure south side

Table 5.26.1. Beam properties

Date of test	28-05-2015
Reinforcement	3Ø16
Reinforcement ratio	0.74%
a	900 mm
a / *d*	3.30
Concrete cube strength at testing	78.5 MPa
Peak load	108.7 kN
Failure mode	Flexural

Table 5.26.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	60	
3	80	Added LVDT's 1-3
4	100	
5	114.1	Yielding at 108 kN. Stopped after jack deflection of 33.6 mm

Table 5.26.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	440	50
2	North	Vertical	535	100
3	North	Vertical	685	100

5.26.2. Measurement results

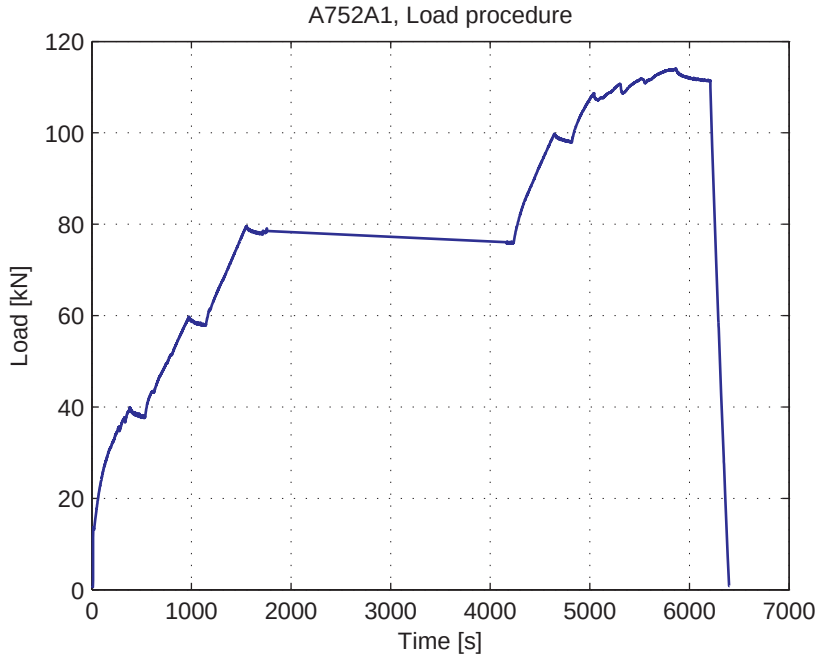


Fig. 5.26.3. Load-Time curve

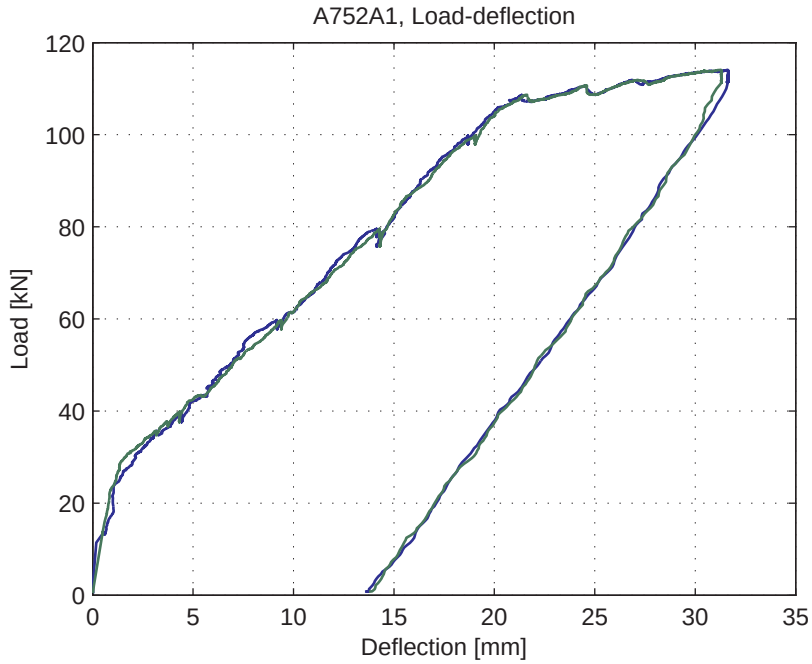


Fig. 5.26.4. Load-deflection curve

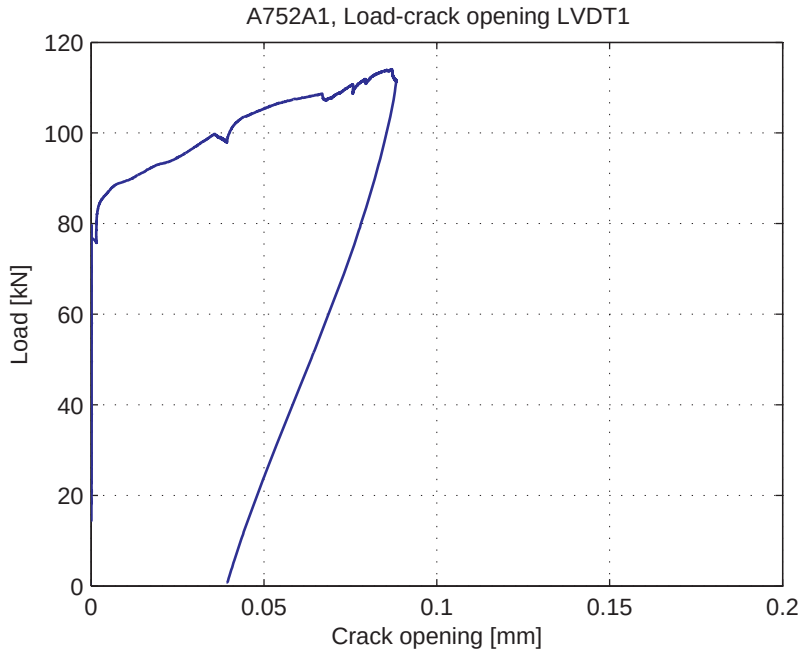


Fig. 5.26.5. Load-Crack opening for LVDT1

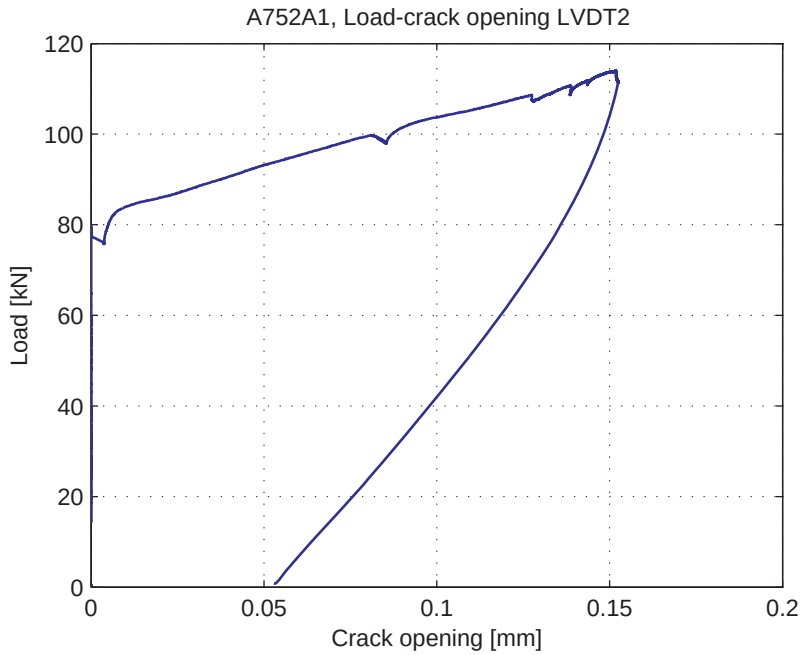


Fig. 5.26.6. Load-Crack opening for LVDT2

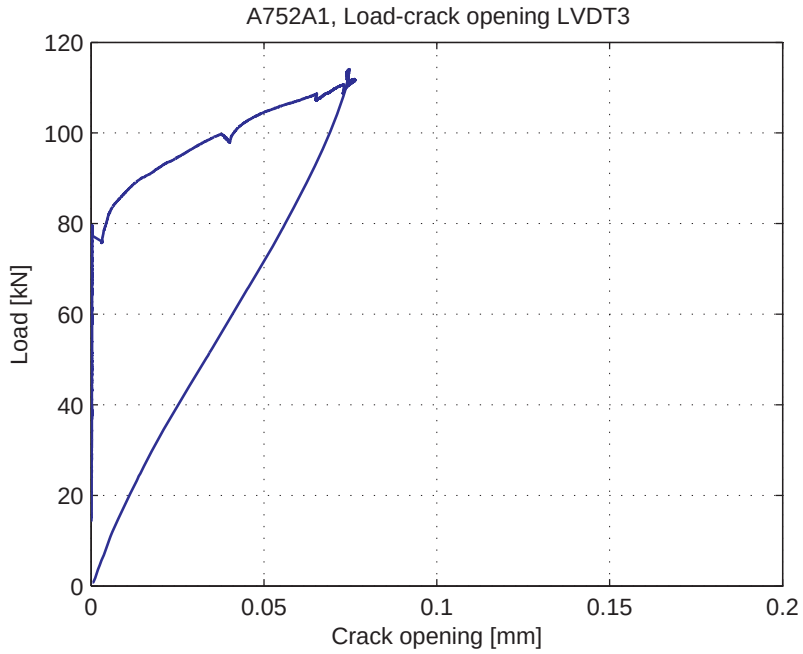


Fig. 5.26.7. Load-Crack opening for LVDT3

5.27. A752A2

5.27.1. Test properties

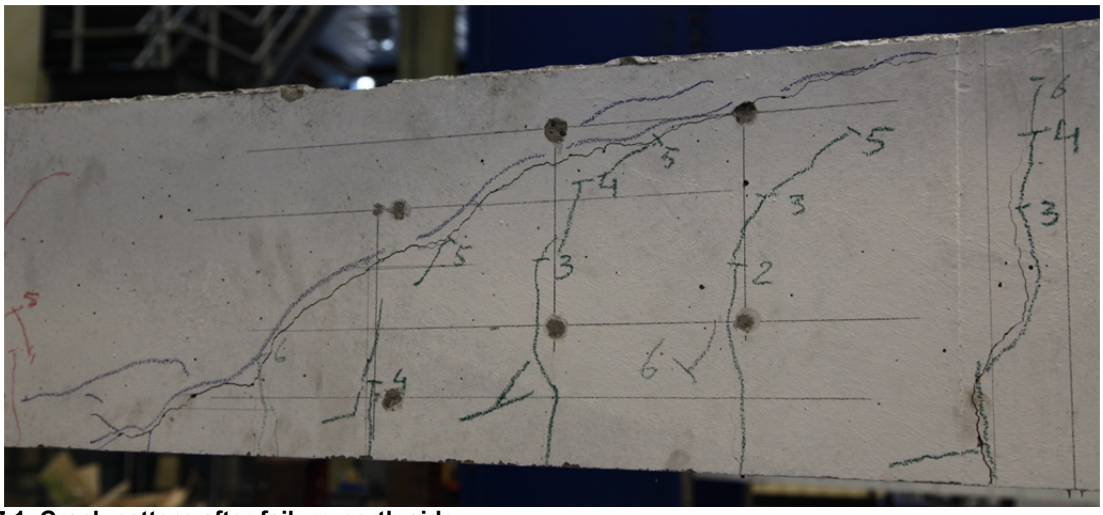


Fig. 5.27.1. Crack pattern after failure north side

Fig. 5.27.2. Crack pattern after failure south side

Table 5.27.1. Beam properties

Date of test	29-05-2015
Reinforcement	3Ø16
Reinforcement ratio	0.74%
a	850 mm
a / *d*	3.11
Concrete cube strength at testing	78.5 MPa
Peak load	119.0 kN
Failure mode	Shear

Table 5.27.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	60	
3	80	
4	100	
5	119.0	Shear failure

Table 5.27.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	440	50
2	North	Vertical	535	100
3	North	Vertical	685	100

5.27.2. Measurement results

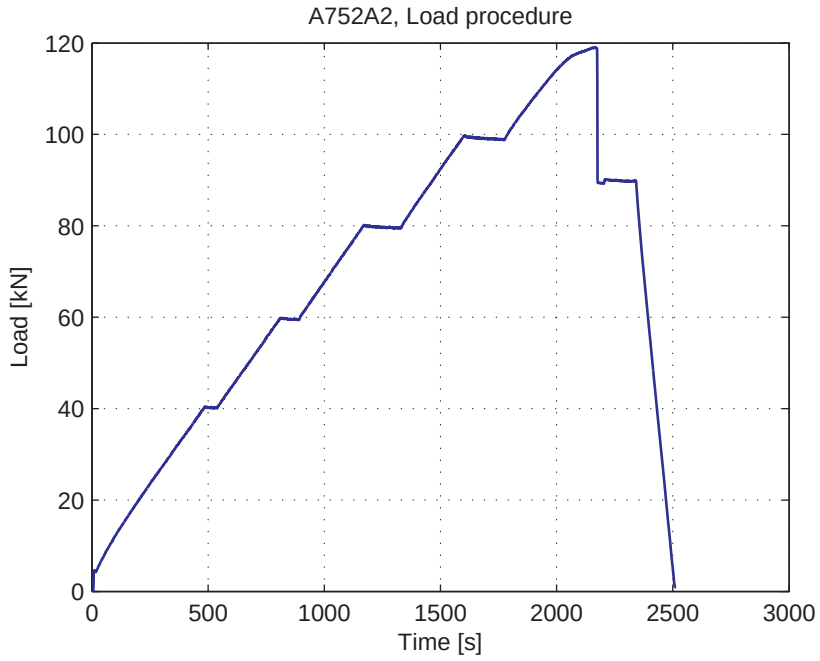


Fig. 5.27.3. Load-Time curve

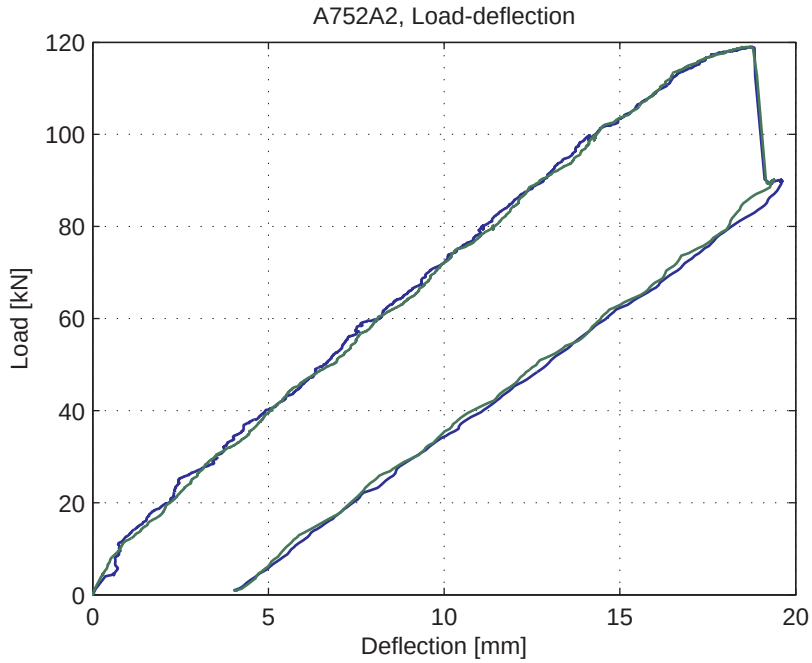


Fig. 5.27.4. Load-deflection curve

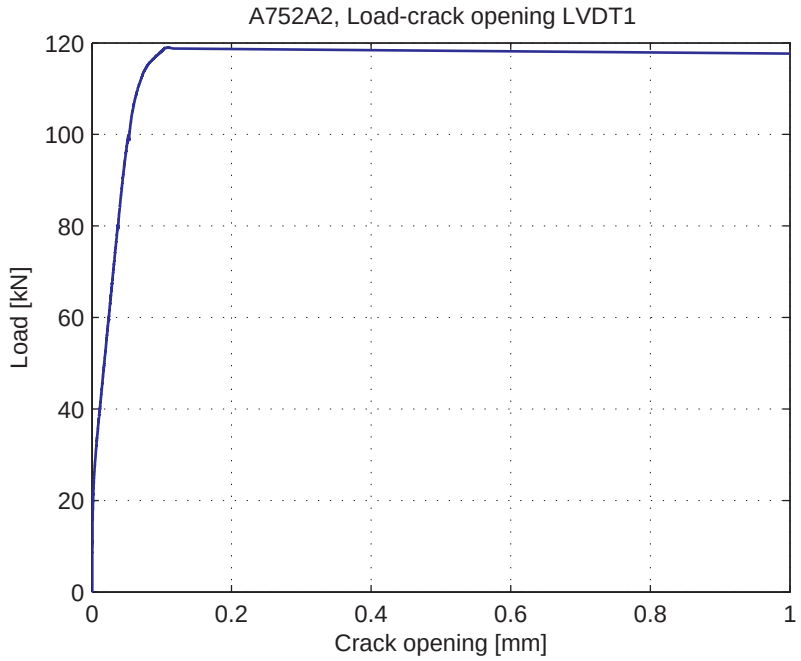


Fig. 5.27.5. Load-Crack opening for LVDT1

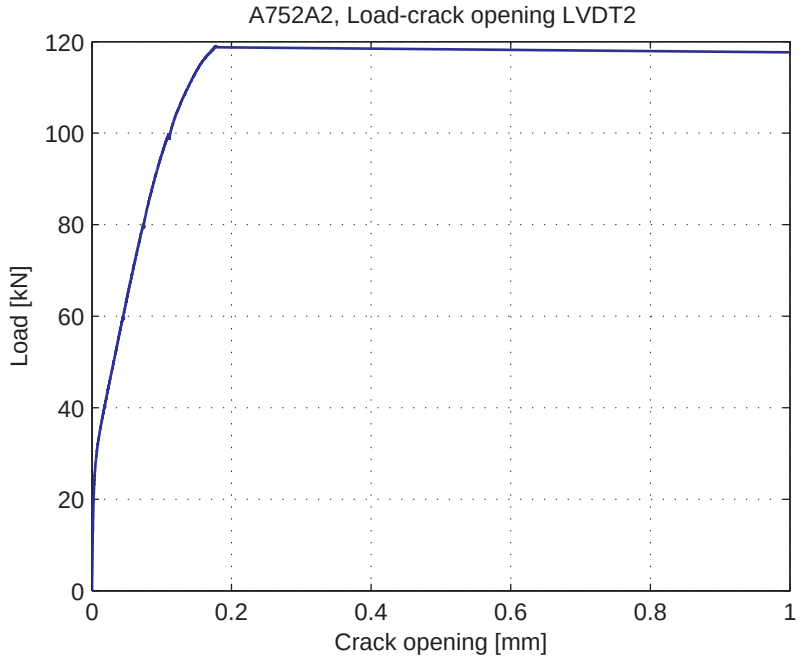


Fig. 5.27.6. Load-Crack opening for LVDT2

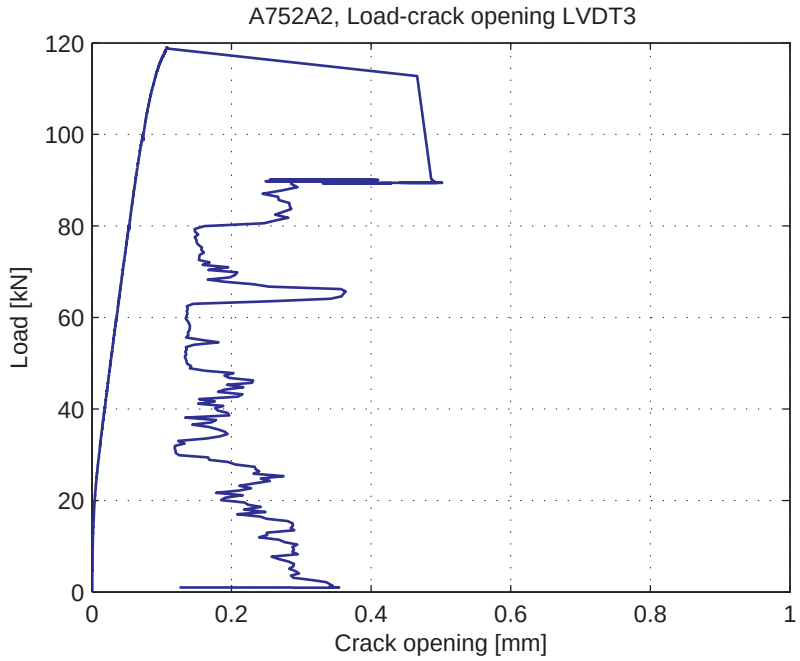


Fig. 5.27.7. Load-Crack opening for LVDT3

5.28. A752A3

5.28.1. Test properties

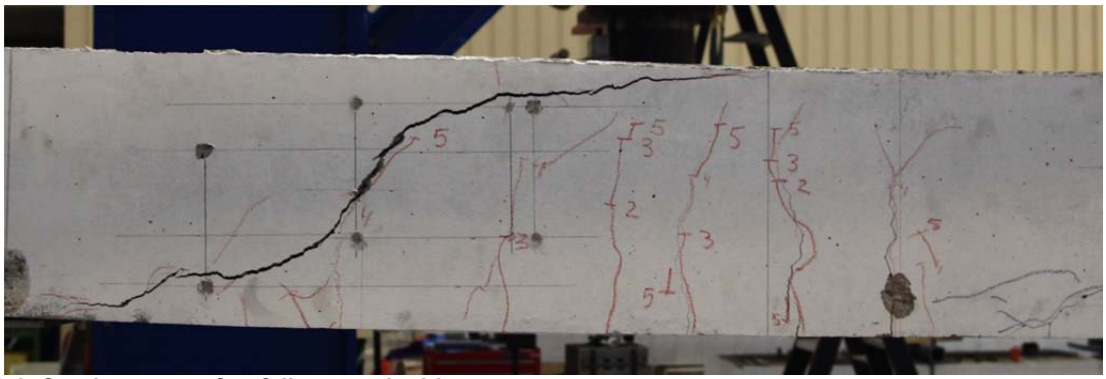


Fig. 5.28.1. Crack pattern after failure north side

Fig. 5.28.2. Crack pattern after failure south side

Table 5.28.1. Beam properties

Date of test	29-05-2015
Reinforcement	3Ø16
Reinforcement ratio	0.74%
a	850 mm
a / *d*	3.11
Concrete cube strength at testing	78.5 MPa
Peak load flexural / shear	113.6 kN / 121.6 kN
Failure mode	Flexural and shear

Table 5.28.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Old crack fixed by two steel plates and air hammer
1	40	
2	60	
3	80	
4	90	Visual inspection for shear crack. Placed LVDT's 1-3
5	100	
6	121.6	Yielding at 113.6 kN. Shear at 120.7 kN. Displacement of jack 32.2 mm

Table 5.28.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	220	50

2	North	Vertical	385	100
3	North	Vertical	585	100

5.28.2. Measurement results

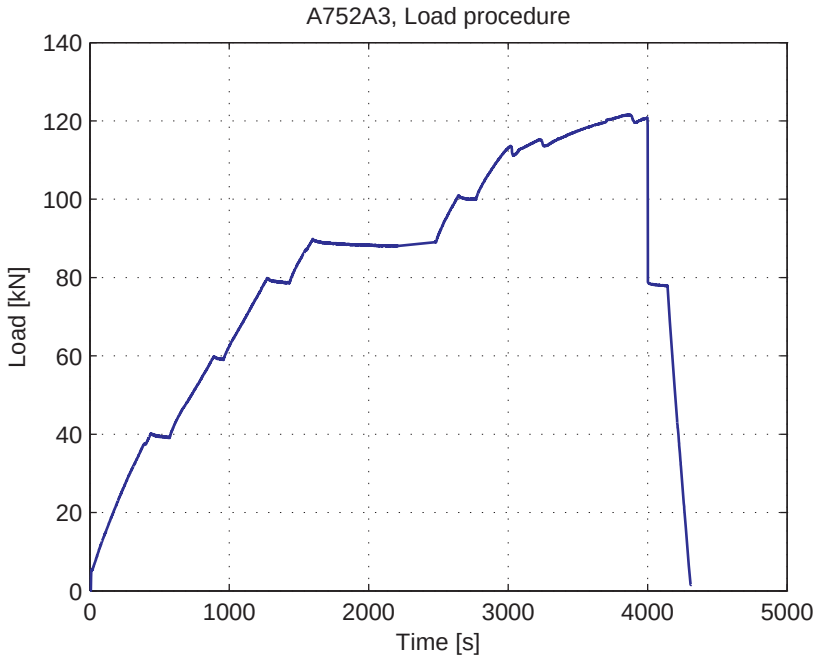


Fig. 5.28.3. Load-Time curve

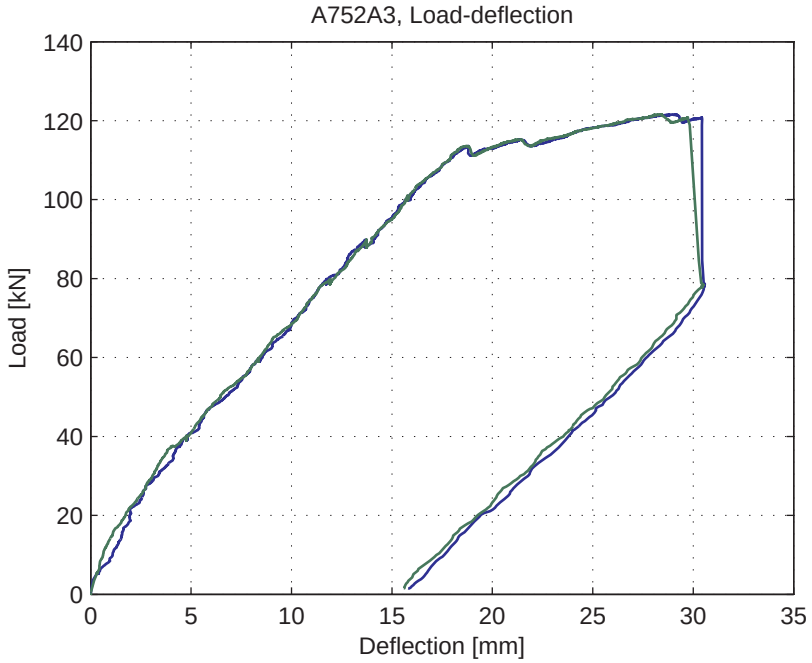


Fig. 5.28.4. Load-deflection curve

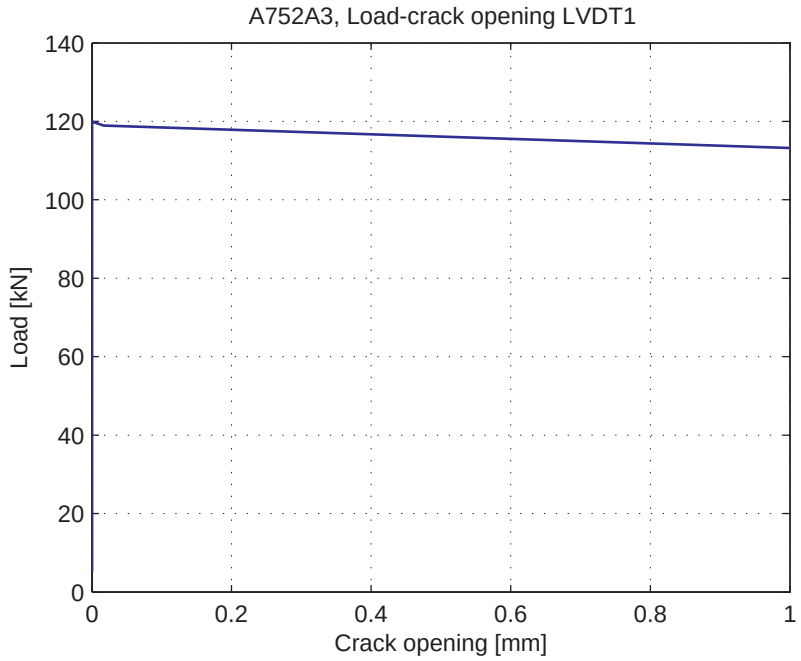


Fig. 5.28.5. Load-Crack opening for LVDT1

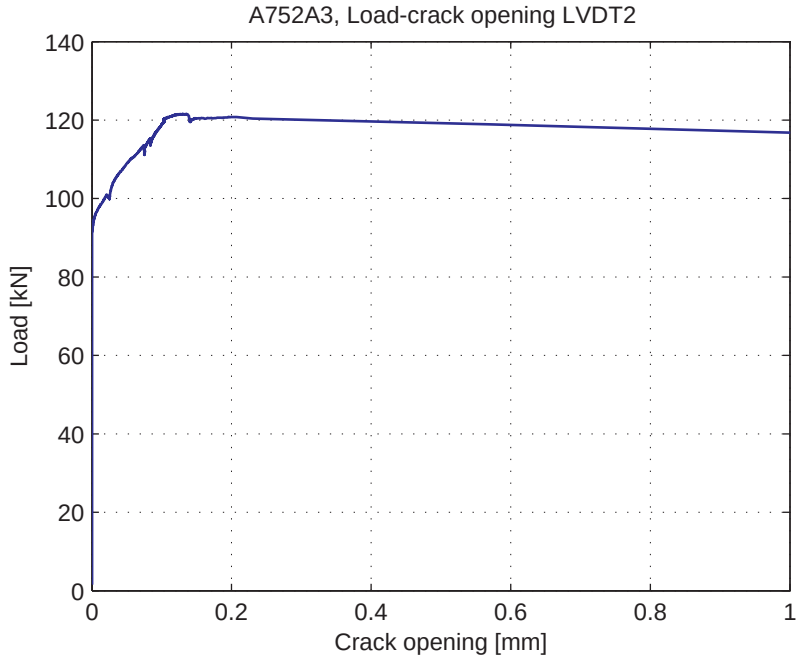


Fig. 5.28.6. Load-Crack opening for LVDT2

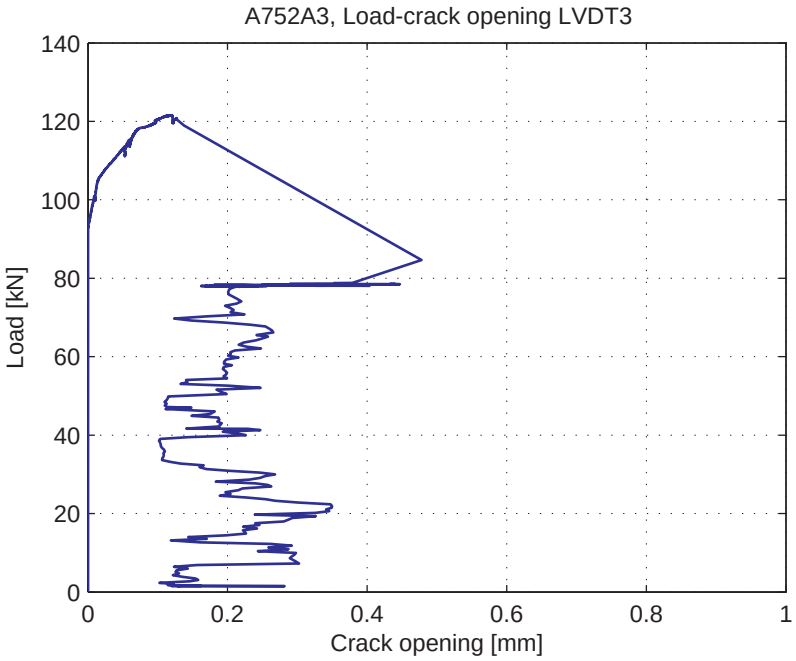


Fig. 5.28.7. Load-Crack opening for LVDT3

5.29. A752B1

5.29.1. Test properties

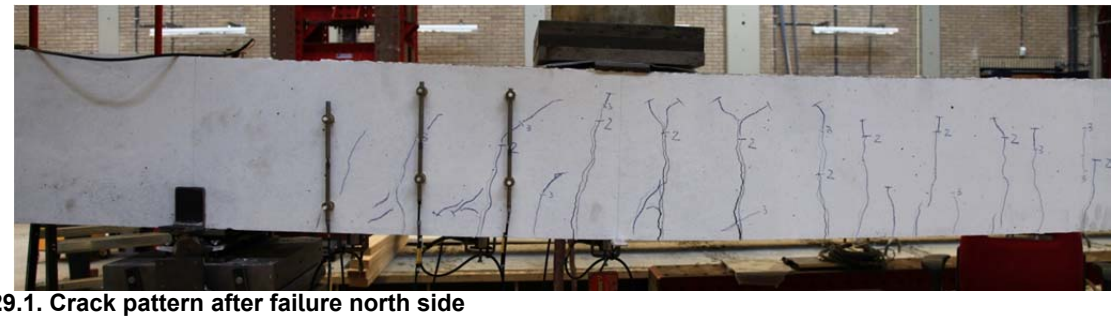


Fig. 5.29.1. Crack pattern after failure north side

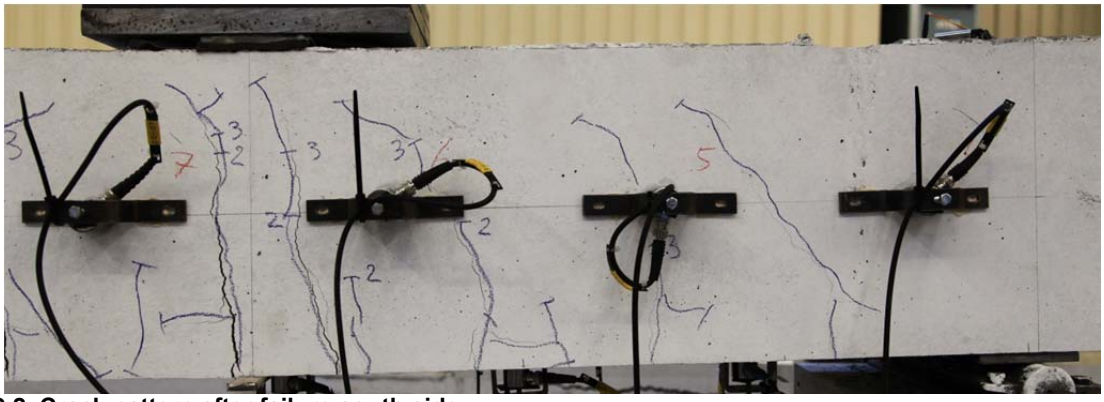


Fig. 5.29.2. Crack pattern after failure south side

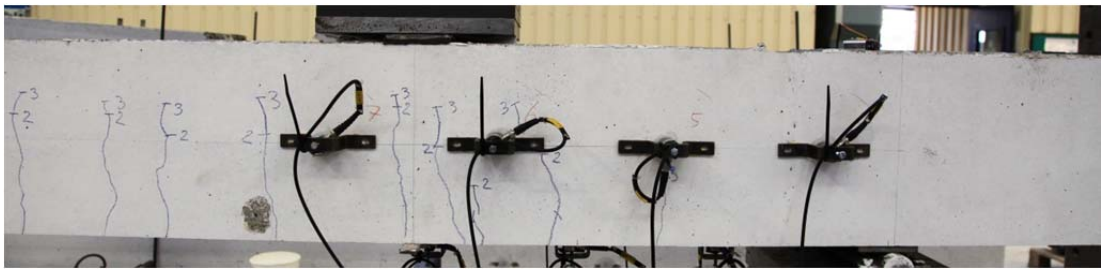


Fig. 5.29.3. Sensors used for Acoustic Emission measurements

Table 5.29.1. Beam properties

Date of test	04-06-2015
Reinforcement	3Ø16
Reinforcement ratio	0.74%
a	750 mm
a / *d*	2.75
Concrete cube strength at testing	78.5 MPa
Peak load	122.1 kN
Failure mode	Flexural

Table 5.29.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements
1	30	
2	2	
3	30	
4	2	
5	30	
6	2	
7	60	
8	2	
9	60	
10	2	
11	60	
12	2	
13	90	
14	2	Placed LVDT's 1-3
15	90	
16	2	
17	90	
18	2	
19	110	
20	131.7	Yielding at 122 kN. Stopped at jack displacement of 34 mm

Table 5.29.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	230	50
2	North	Vertical	400	100
3	North	Vertical	550	100

5.29.2. Measurement results

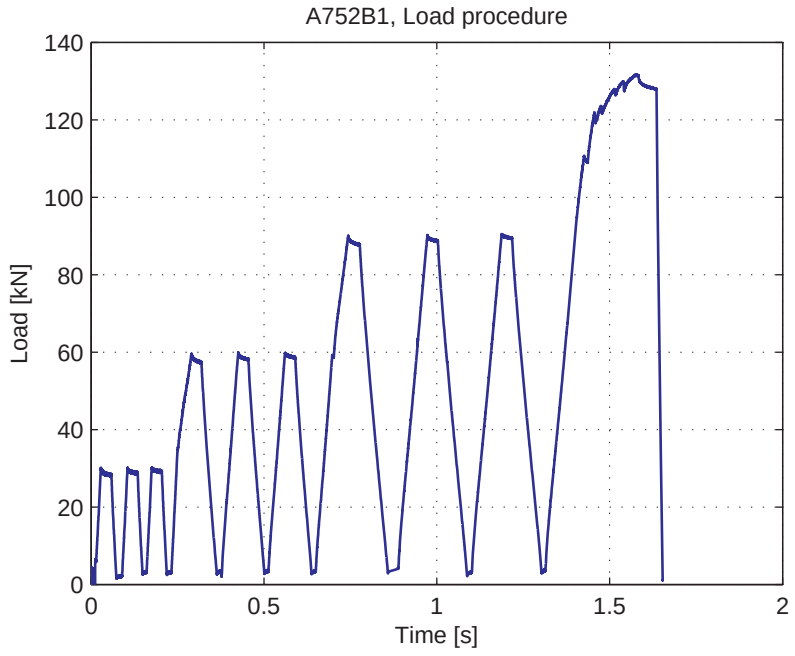


Fig. 5.29.4. Load-Time curve

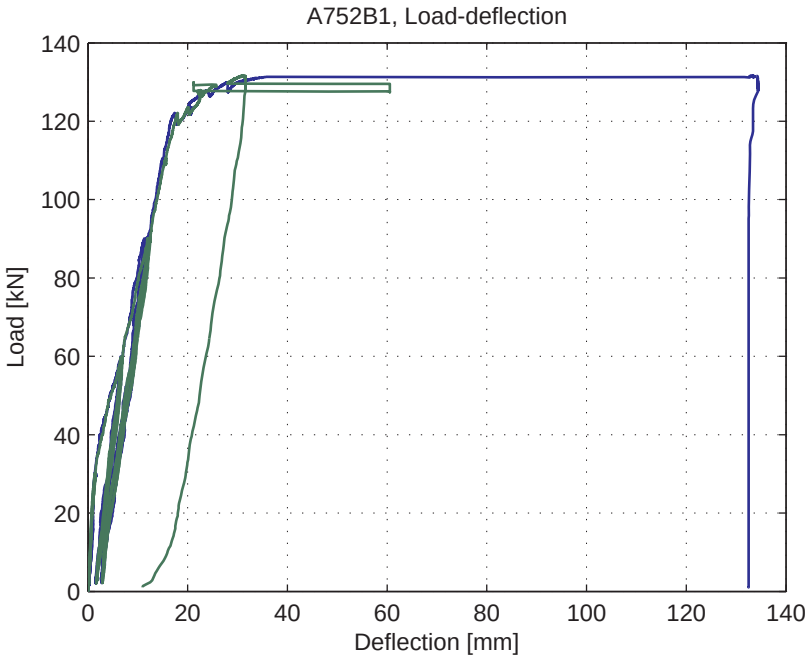


Fig. 5.29.5. Load-deflection curve

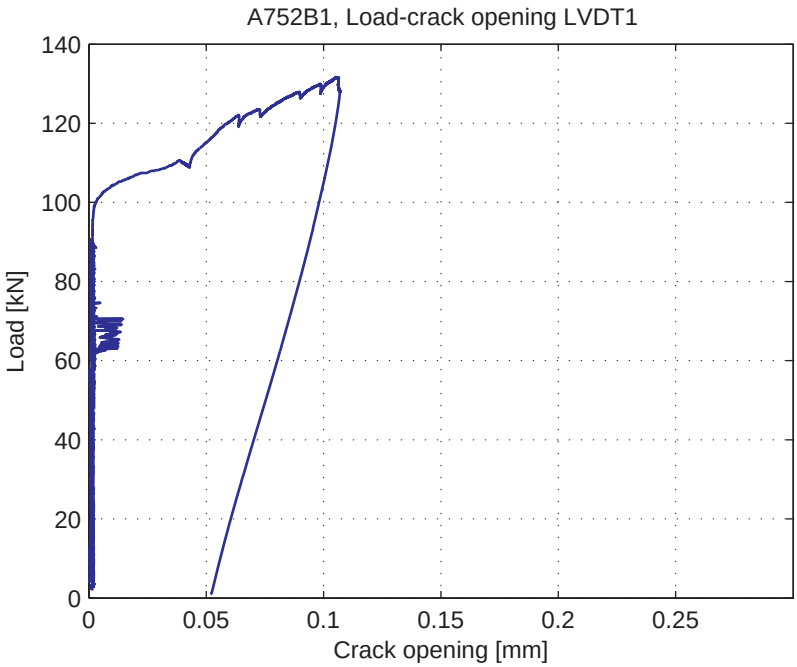


Fig. 5.29.6. Load-Crack opening for LVDT1

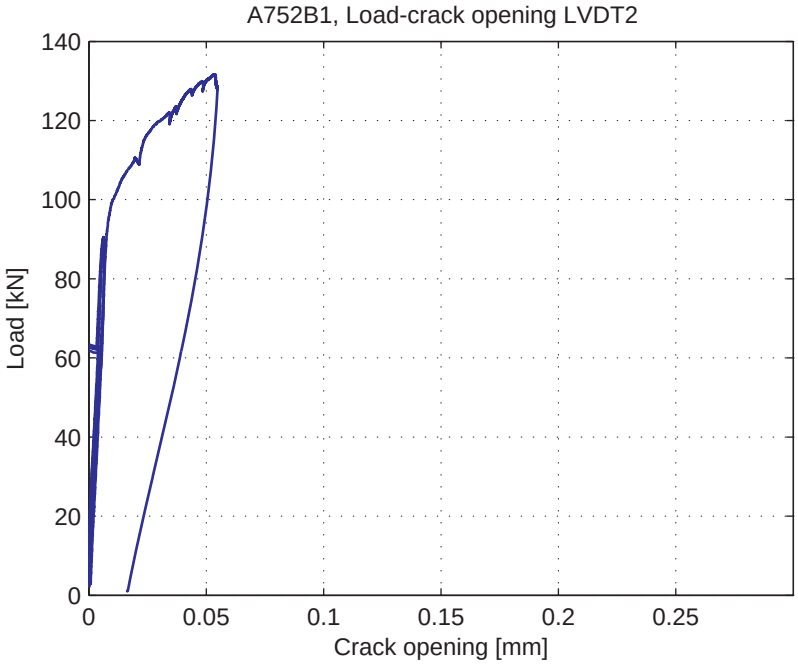


Fig. 5.29.7. Load-Crack opening for LVDT2

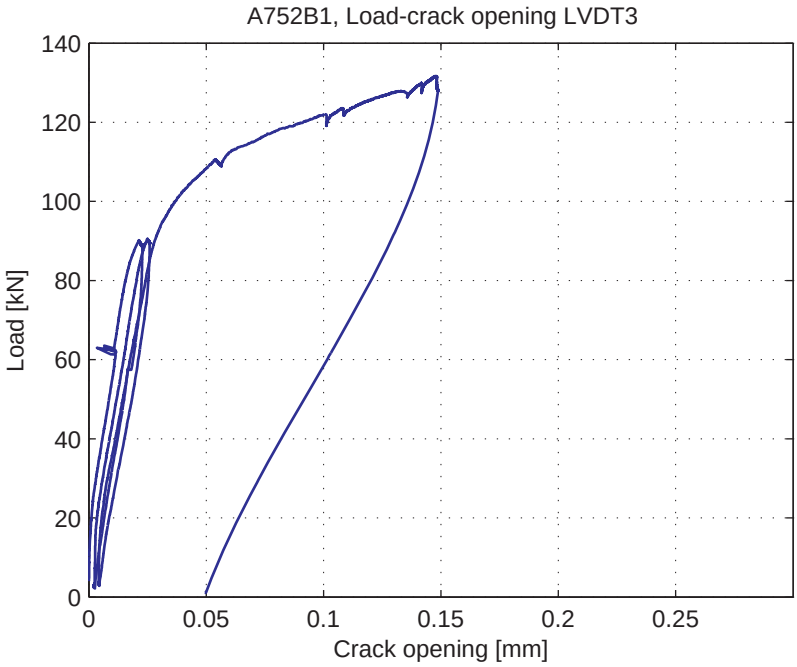


Fig. 5.29.8. Load-Crack opening for LVDT2

5.30. A752B2

5.30.1. Test properties

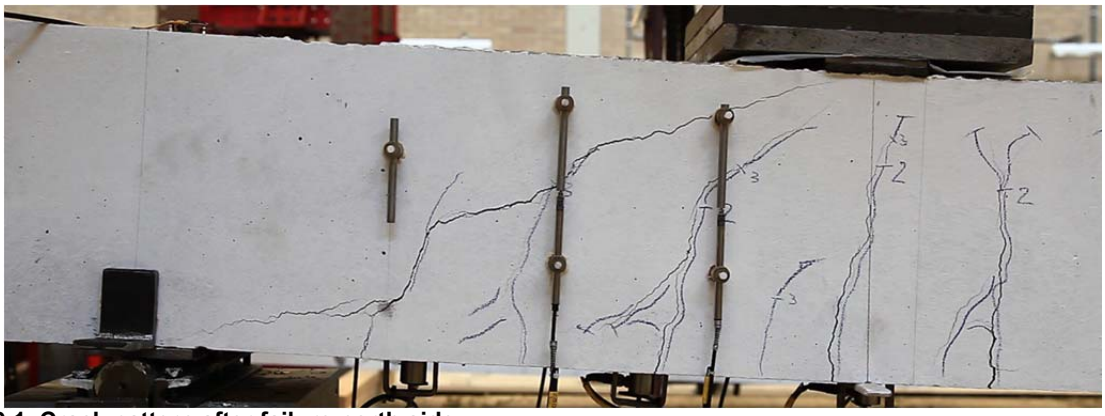


Fig. 5.30.1. Crack pattern after failure north side

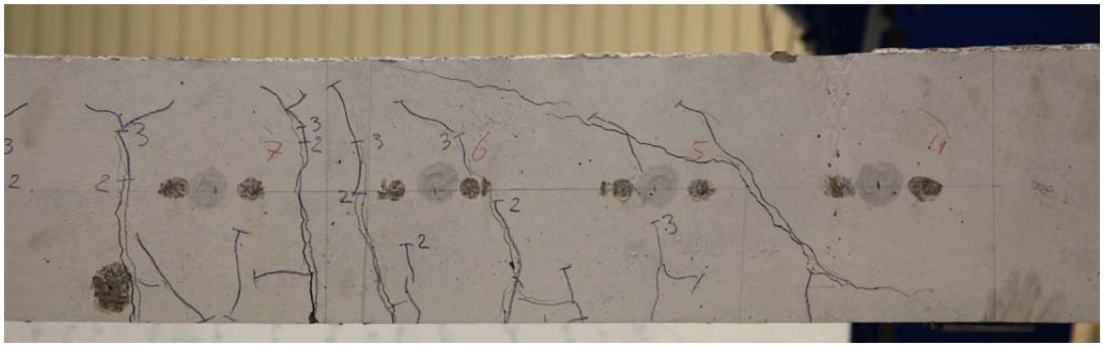


Fig. 5.30.2. Crack pattern after failure south side

Table 5.30.1. Beam properties

Date of test	05-06-2015
Reinforcement	3Ø16
Reinforcement ratio	0.74%
a	700 mm
a / *d*	2.56
Concrete cube strength at testing	78.5 MPa
Peak load flexural / shear	137.7 kN / 141.9 kN
Failure mode	Flexural and shear

Table 5.30.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements
1	90	
2	2	
3	90	LVDT amplifier turned off and on, LVDT 3 was giving rubbish
4	2	
5	90	
6	2	
7	100	
8	120	Stopped to turn on camera
9	141.9	Yielding at 139 kN, Shear failure at 141.9 kN

Table 5.30.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	230	50
2	North	Vertical	400	100
3	North	Vertical	550	100

5.30.2. Measurement results

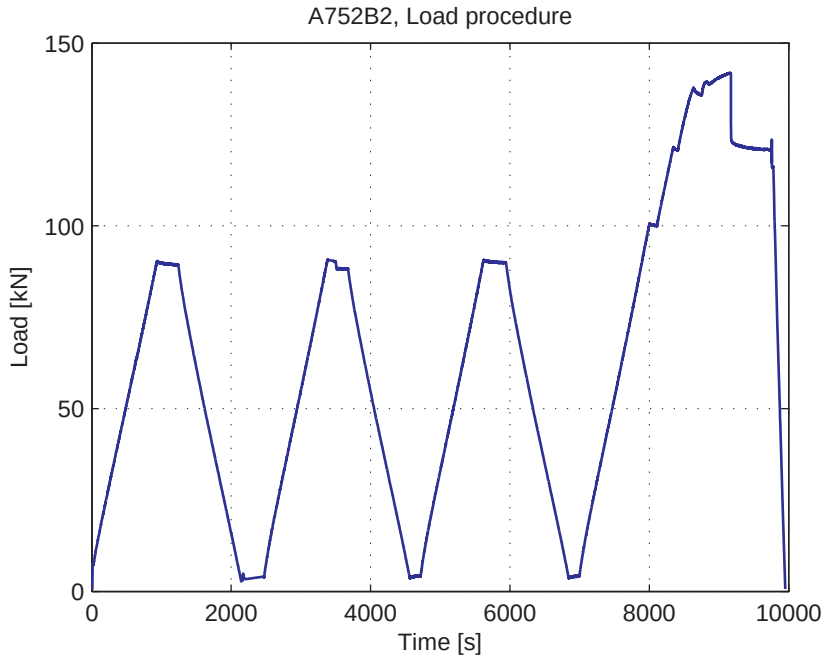


Fig. 5.30.3. Load-Time curve

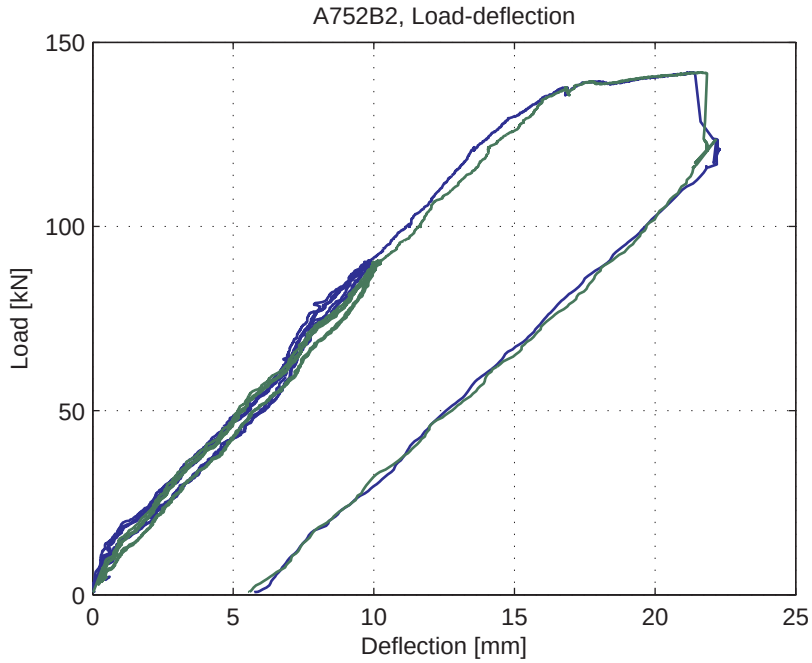


Fig. 5.30.4. Load-deflection curve

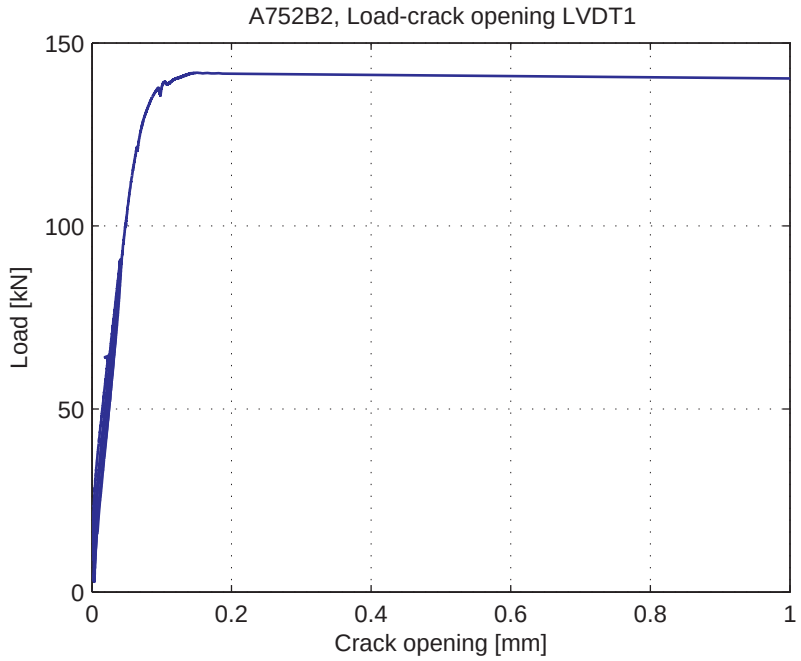


Fig. 5.30.5. Load-Crack opening for LVDT1

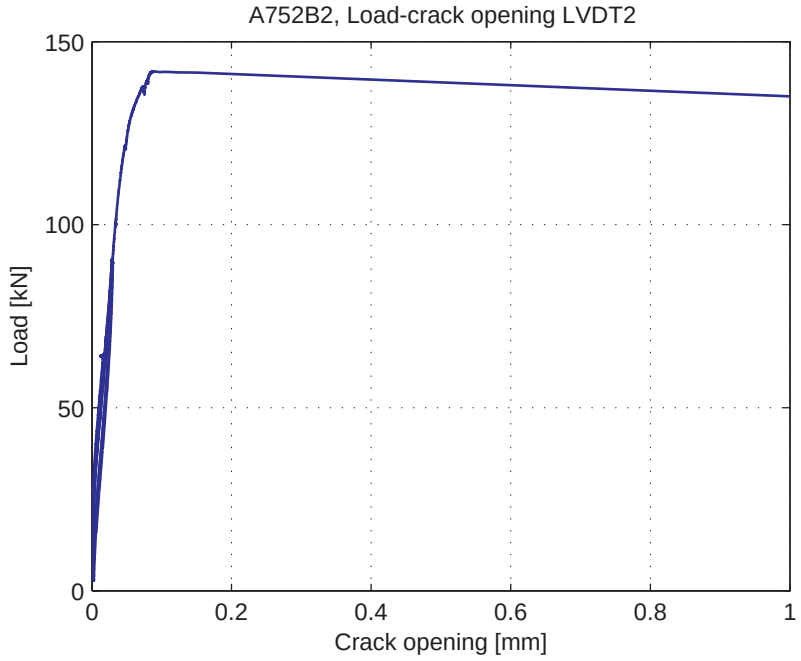


Fig. 5.30.6. Load-Crack opening for LVDT2

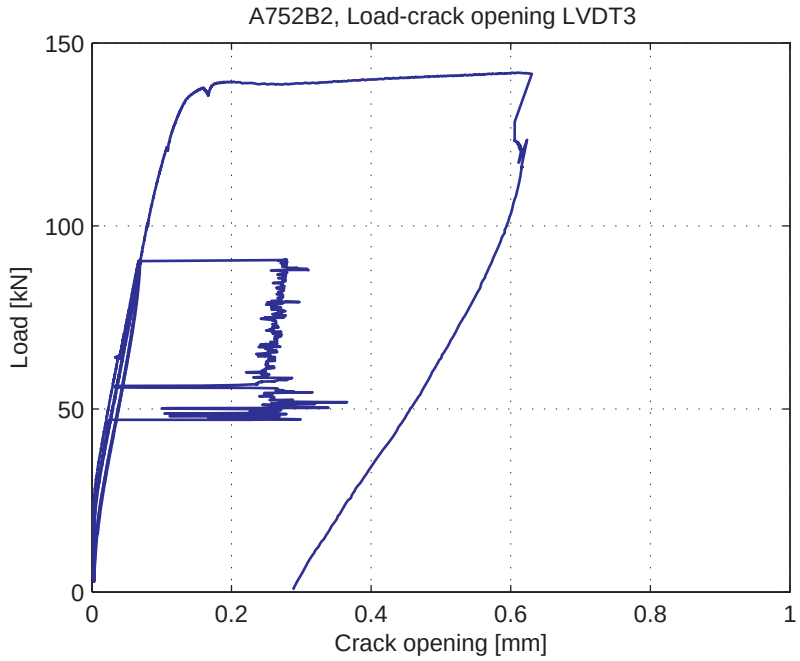


Fig. 5.30.7. Load-Crack opening for LVDT2

5.31. A601A1

5.31.1. Test properties

Table 5.31.1. Beam properties

Date of test	28-04-2015
Reinforcement	2Ø16 + 1Ø10
Reinforcement ratio	0.58%
a	1000 mm
a / *d*	3.63
Concrete cube strength at testing	78.5 MPa
Peak load	80.3 kN
Failure mode	Flexural

Table 5.31.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	83.1	Yielding of reinforcement. Stopped after jack displacement of 30 mm.

5.31.2. Measurement results

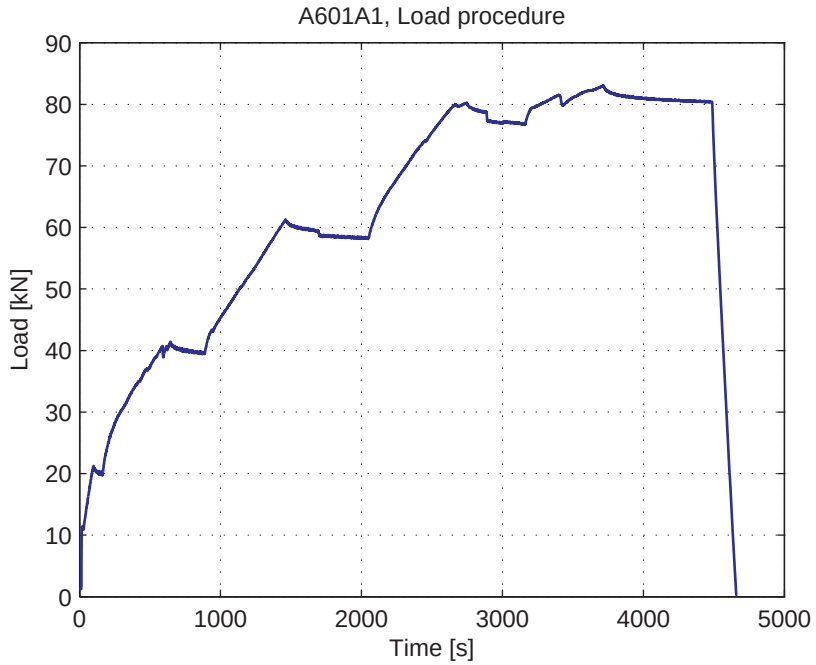


Fig. 5.31.1. Load-Time curve

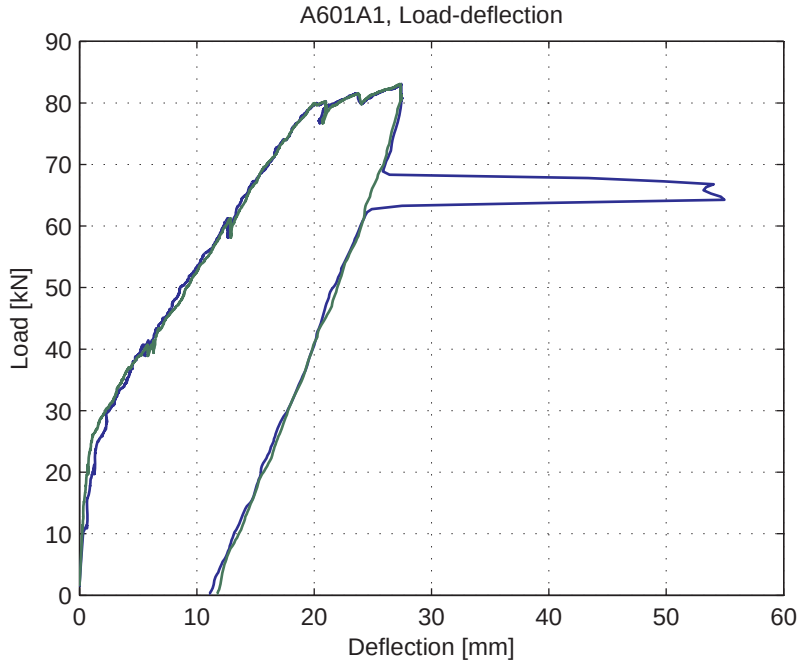


Fig. 5.31.2. Load-deflection curve

5.32. A601A2

5.32.1. Test properties

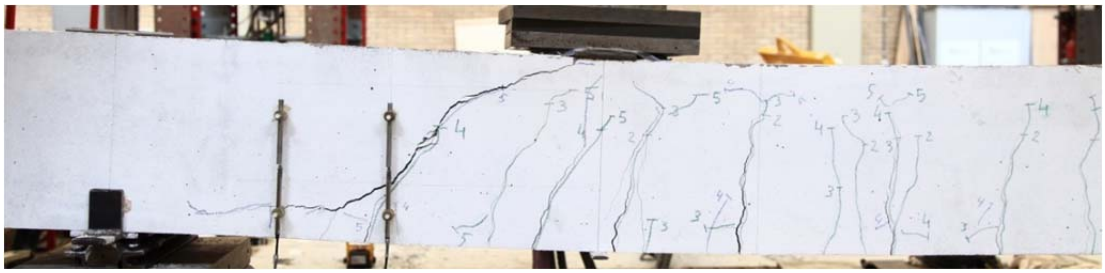


Fig. 5.32.1. Crack pattern after failure north side

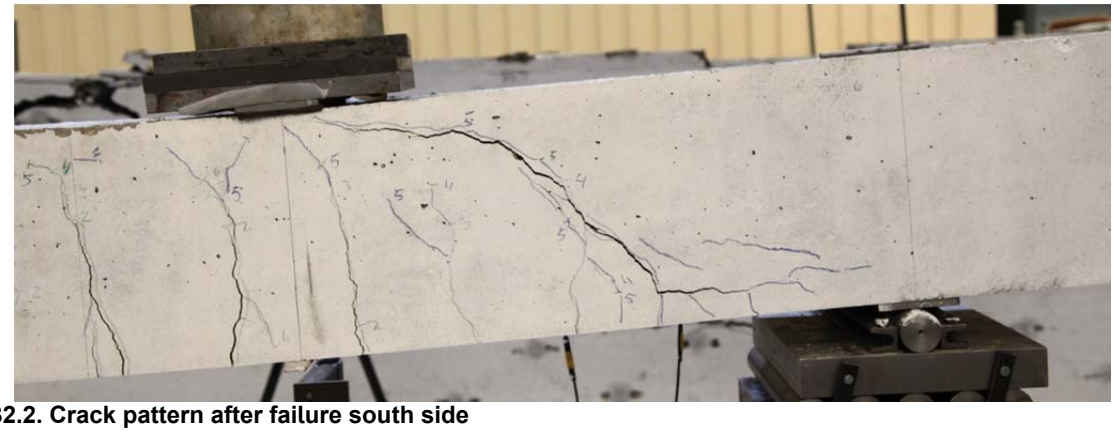


Fig. 5.32.2. Crack pattern after failure south side

Table 5.32.1. Beam properties

Date of test	29-04-2015
Reinforcement	2Ø16 + 1Ø10
Reinforcement ratio	0.58%
a	750 mm
a / *d*	2.72
Concrete cube strength at testing	78.5 MPa
Peak load	102.1 kN
Failure mode	Flexural

Table 5.32.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	Placed LVDT's 1-2
5	102	
6	114.4	Flexural failure, close to shear

Table 5.32.3. Location LVDT's used for crack opening measurements

LVDT	Distance from support [mm]	Distance from bottom beam [mm]
1	255	50
2	420	50

5.32.2. Measurement results

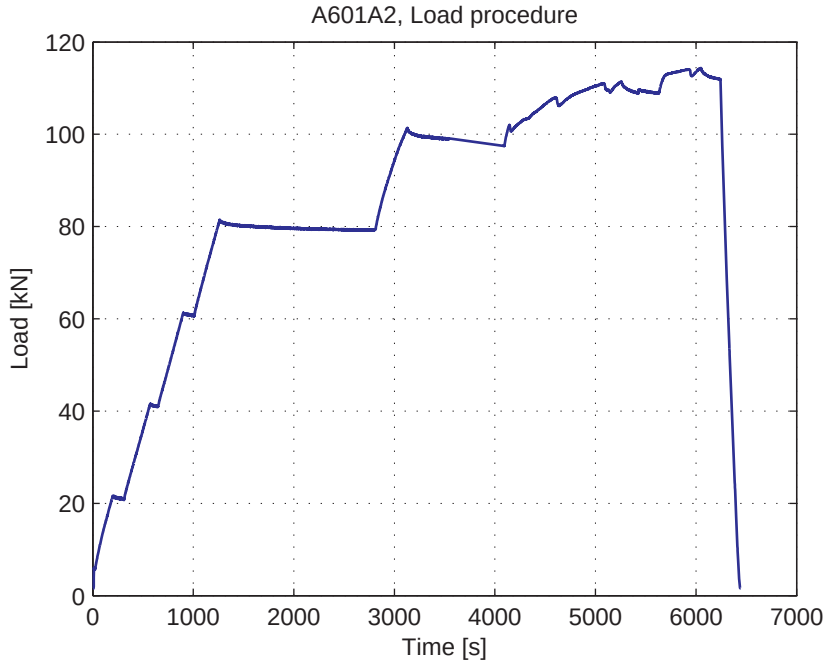


Fig. 5.32.3. Load-Time curve

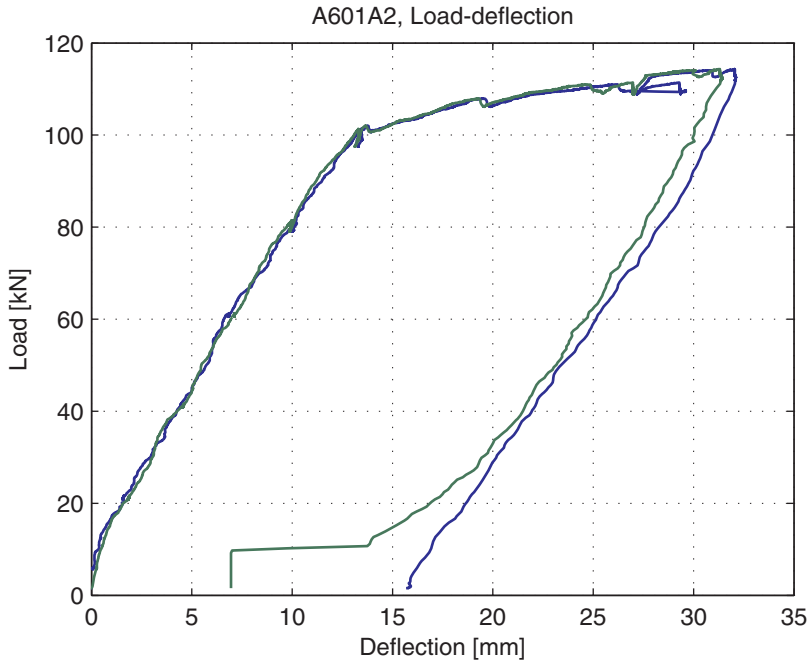


Fig. 5.32.4. Load-deflection curve

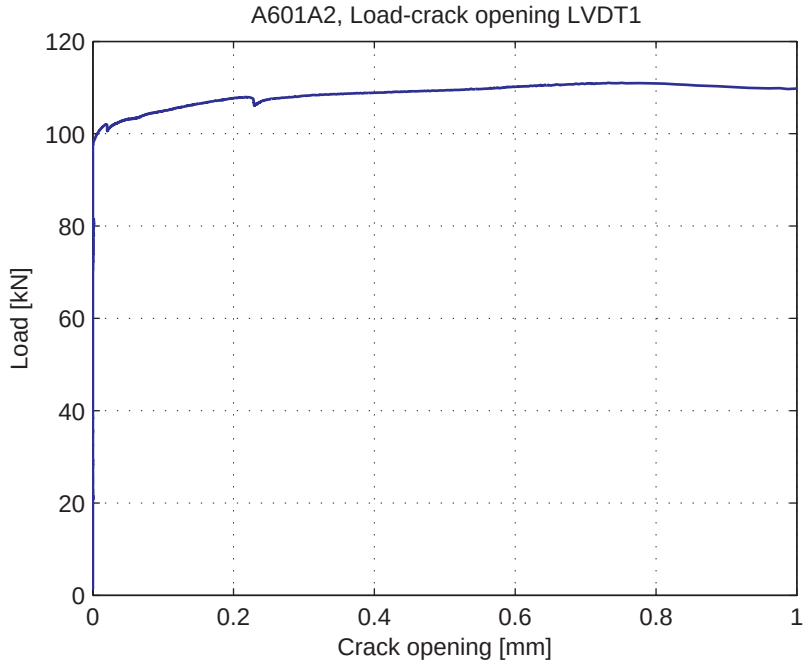


Fig. 5.32.5. Load-Crack opening for LVDT1

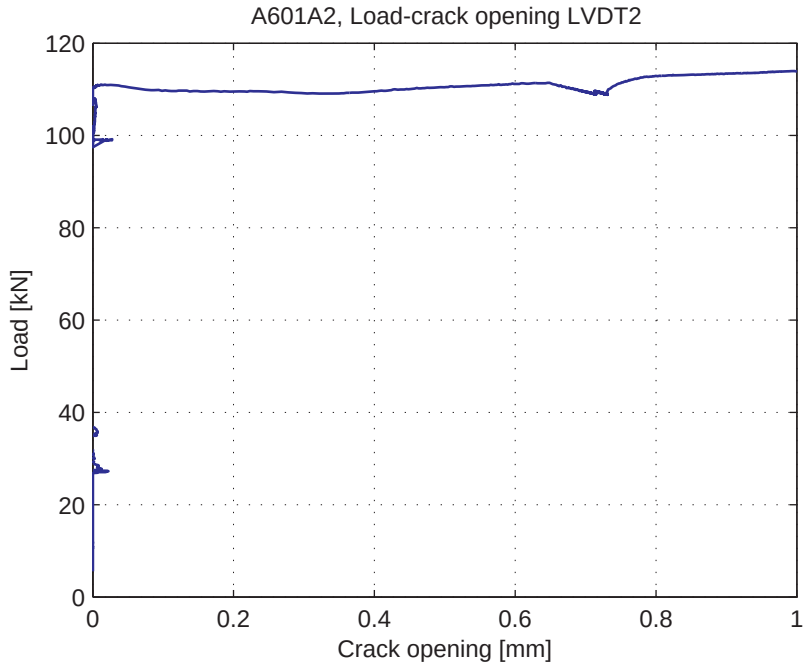


Fig. 5.32.6. Load-Crack opening for LVDT2

5.33. A601B1

5.33.1. Test properties

Fig. 5.33.1. Crack pattern after failure north side

Fig. 5.33.2. Crack pattern after failure south side

Table 5.33.1. Beam properties

Date of test	29-04-2015
Reinforcement	2Ø16 + 1Ø10
Reinforcement ratio	0.58%
a	700 mm
a / *d*	2.54
Concrete cube strength at testing	78.5 MPa
Peak load flexural / shear	106.4 kN / 118.7 kN
Failure mode	Flexural and shear

Table 5.33.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	Placed LVDT's 1-3
5	100	Paused test to change memory card of camera
6	106.4	Crack width for shear of 6 mm, for flexural 1 mm
7	118.7	Shear failure

5.33.2. Measurement results

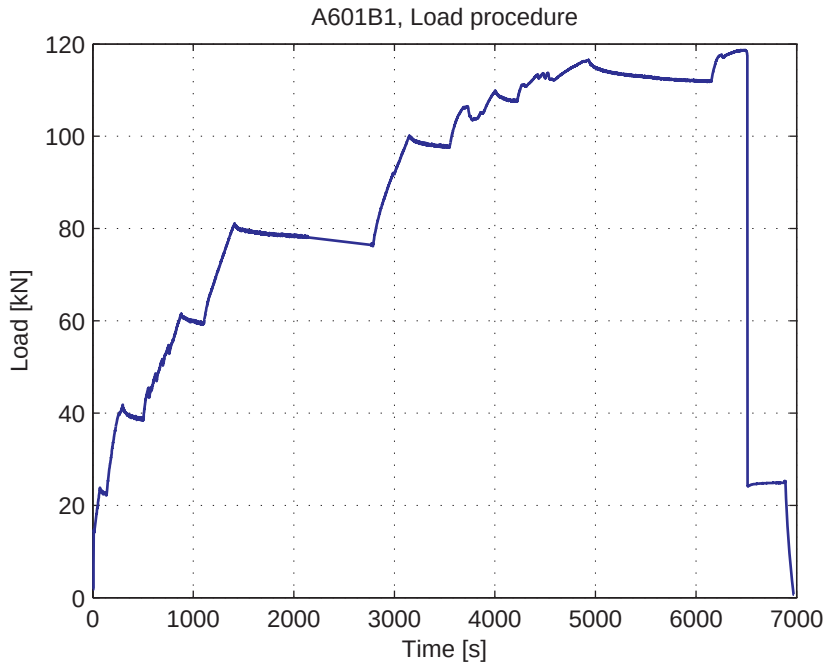


Fig. 5.33.3. Load-Time curve

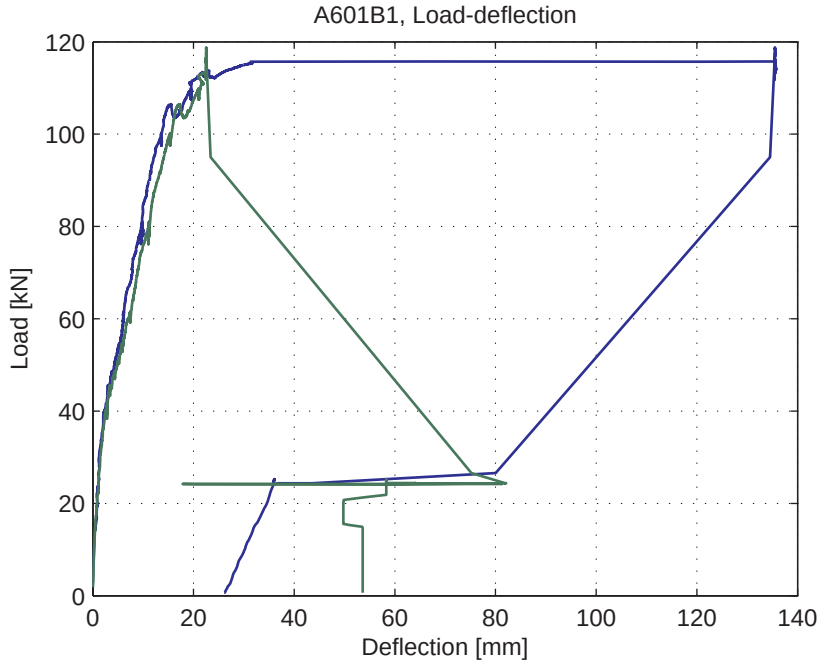


Fig. 5.33.4. Load-deflection curve

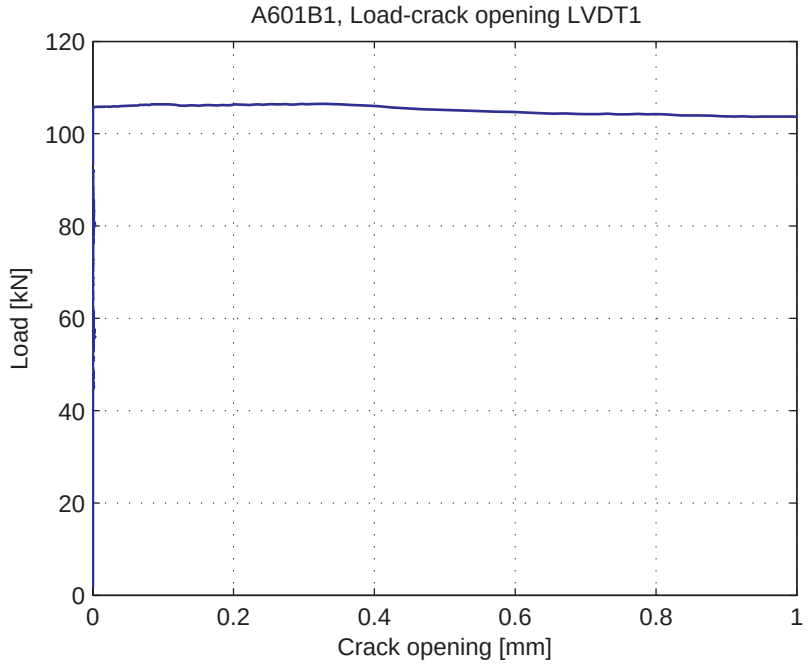


Fig. 5.33.5. Load-Crack opening for LVDT1

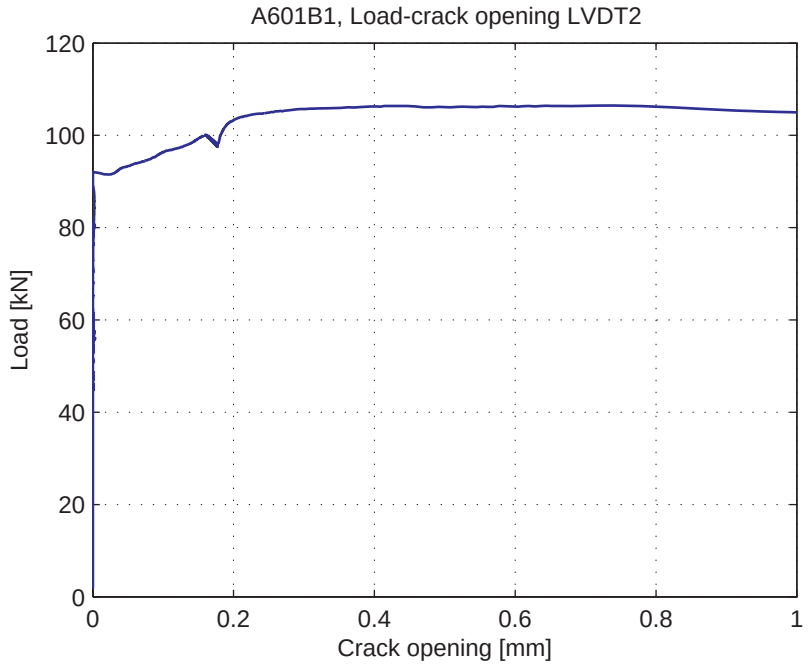


Fig. 5.33.6. Load-Crack opening for LVDT2

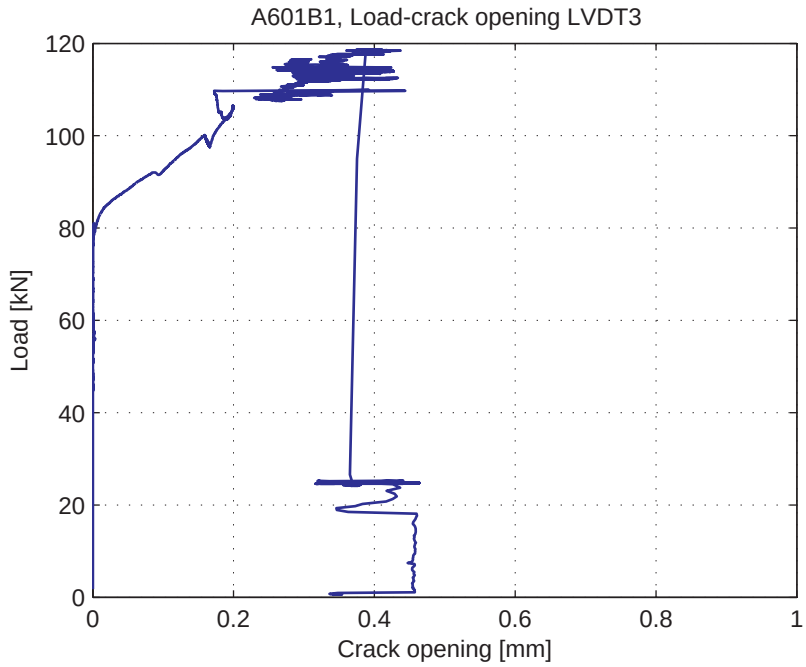


Fig. 5.33.7. Load-Crack opening for LVDT3

5.34. A601B2

5.34.1. Test properties

Fig. 5.34.1. Crack pattern after failure north side

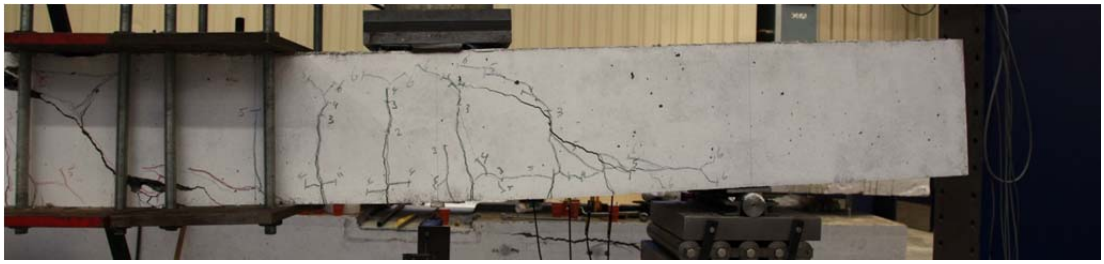


Fig. 5.34.2. Crack pattern after failure south side

Table 5.34.1. Beam properties

Date of test	30-04-2015
Reinforcement	2Ø16 + 1Ø10
Reinforcement ratio	0.58%
a	650 mm
a / *d*	2.36
Concrete cube strength at testing	78.5 MPa
flexural / shear	123.2 kN / 114.2 kN
Failure mode	Flexural failure with flexural shear crack

Table 5.34.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Old crack of previous test prestressed with plates and M24 bolts
1	40	
2	60	
3	80	Placed LVDT's 1-3
4	100	Placed LVDT 5
5	114.3	Shear cracks 1.5 mm, flexural cracks 2 mm. Stopped after jack displacement of 40 mm. No shear failure

5.34.2. Measurement results

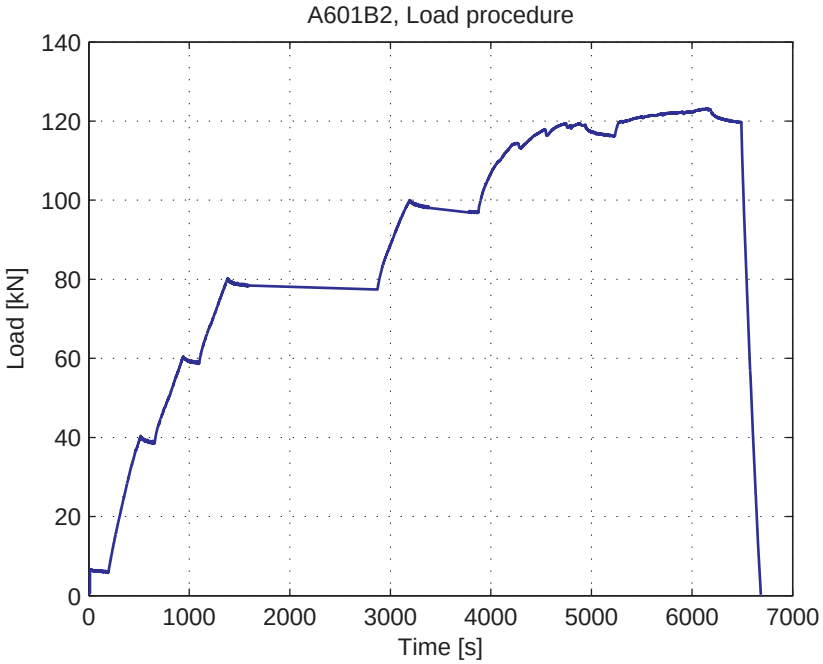


Fig. 5.34.3. Load-Time curve

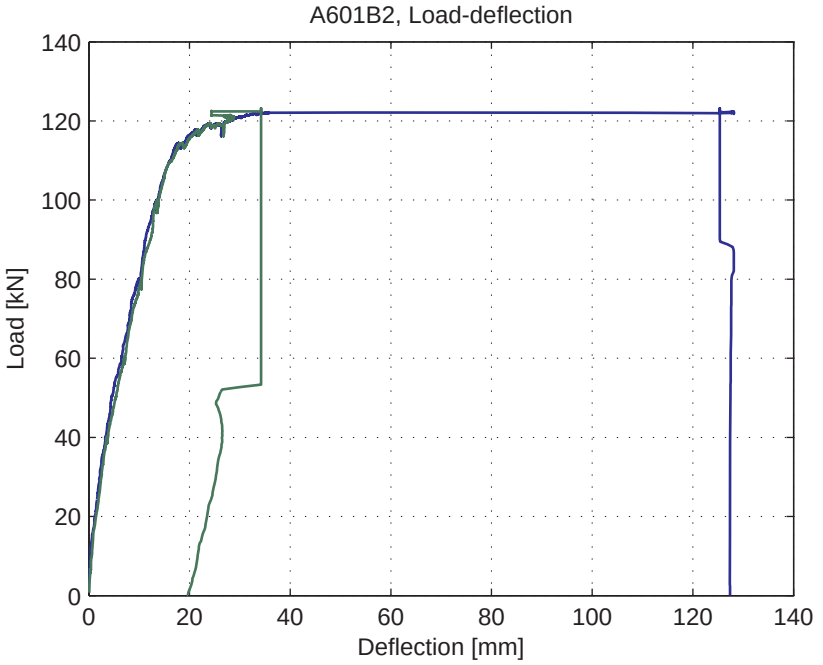


Fig. 5.34.4. Load-deflection curve

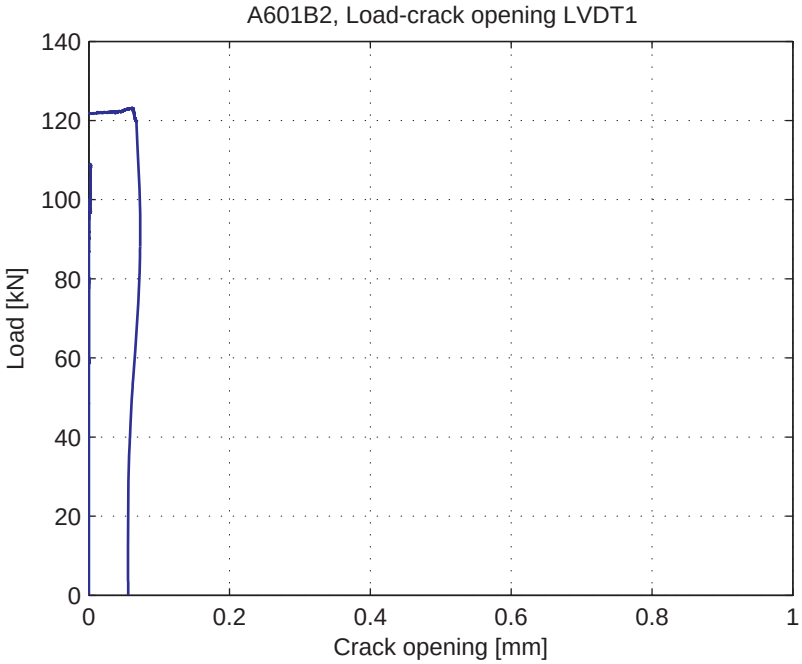


Fig. 5.34.5. Load-Crack opening for LVDT1

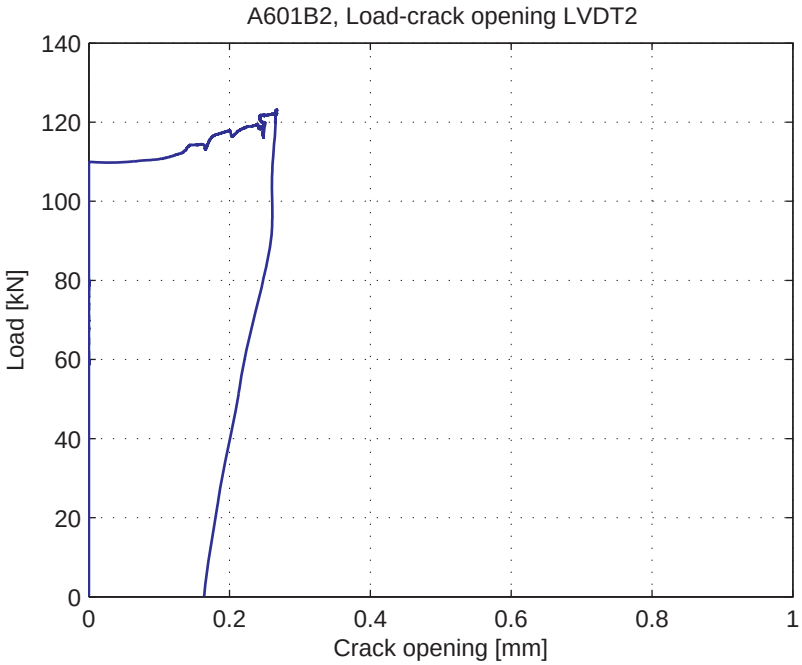


Fig. 5.34.6. Load-Crack opening for LVDT2

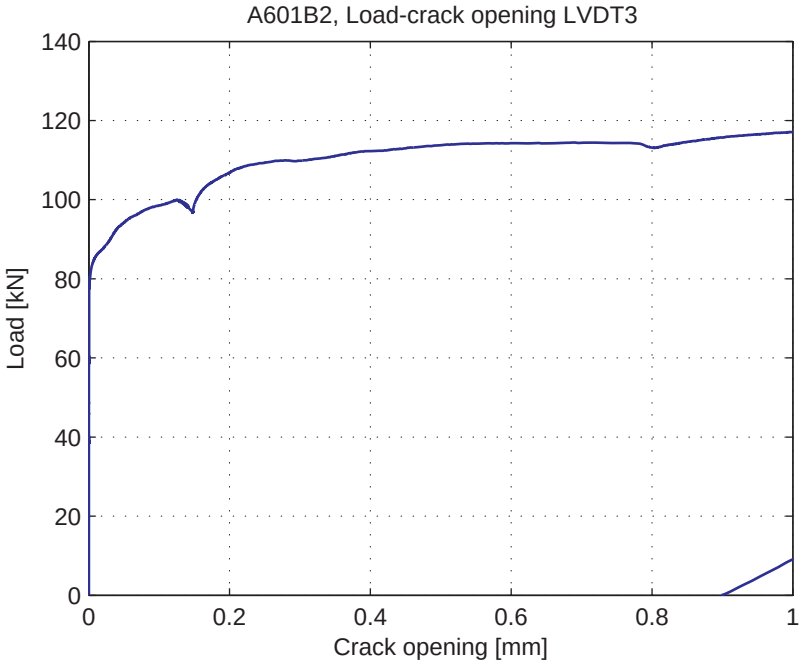


Fig. 5.34.7. Load-Crack opening for LVDT3

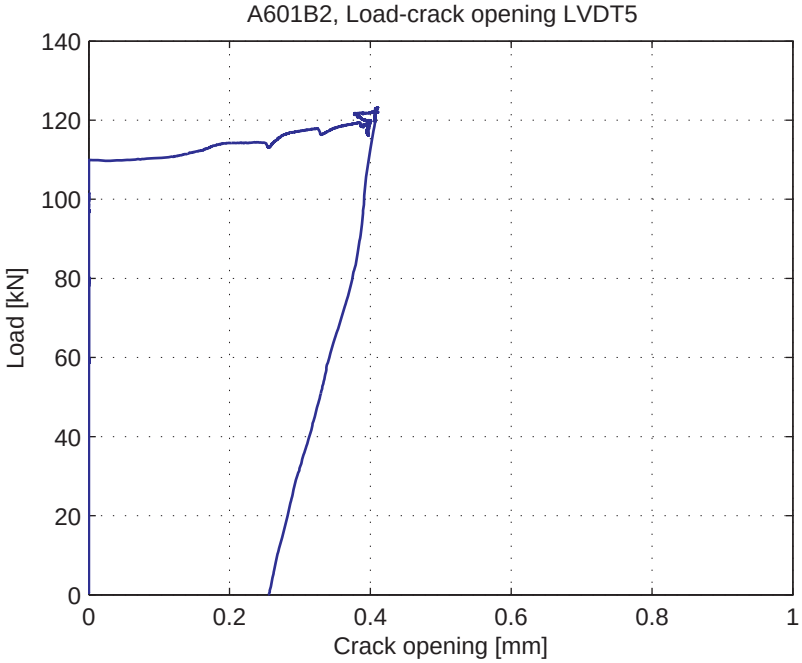


Fig. 5.34.8. Load-Crack opening for LVDT5

5.35. A602A1

5.35.1. Test properties

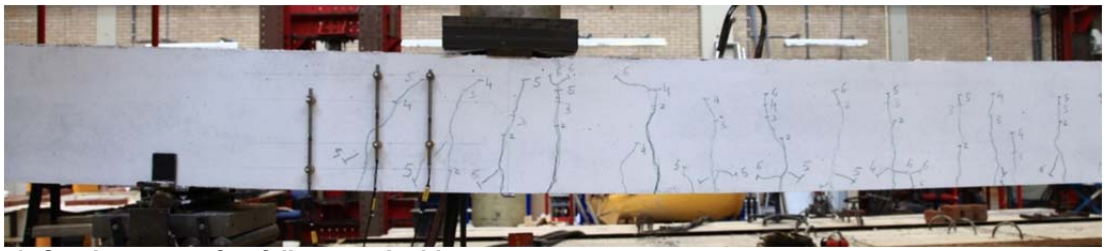


Fig. 5.35.1. Crack pattern after failure north side

Fig. 5.35.2. Crack pattern after failure south side

Table 5.35.1. Beam properties

Date of test	22-05-2015
Reinforcement	2Ø16 + 1Ø10
Reinforcement ratio	0.59%
a	750 mm
a / *d*	2.75
Concrete cube strength at testing	78.5 MPa
Peak load	98.8 kN
Failure mode	Flexural

Table 5.35.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	
4	80	Placed LVDT's 1-3
5	100	
6	105.4	Stopped after jack displacement of 30 mm

Table 5.35.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	325	50
2	North	Vertical	475	100
3	North	Vertical	585	100

5.35.2. Measurement results

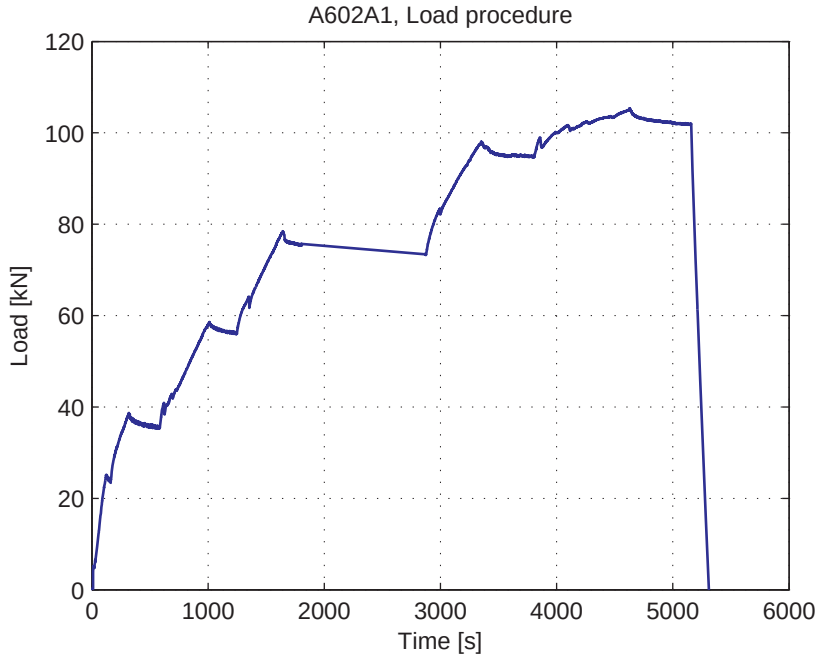


Fig. 5.35.3. Load-Time curve

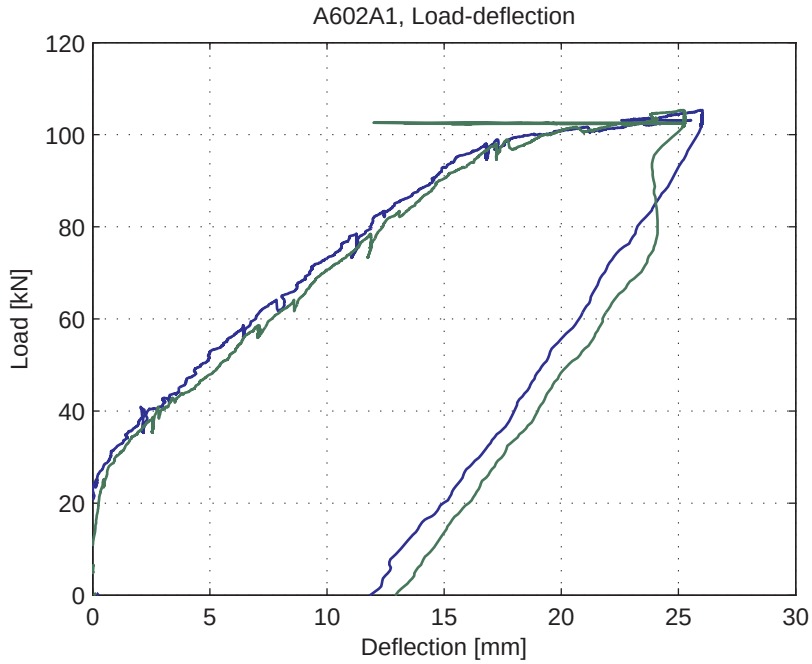


Fig. 5.35.4. Load-deflection curve

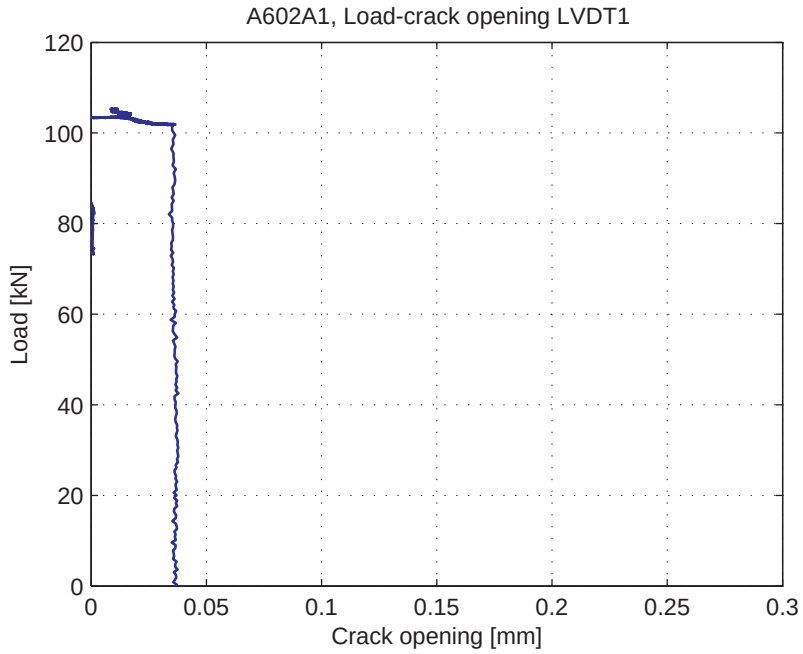


Fig. 5.35.5. Load-Crack opening for LVDT1

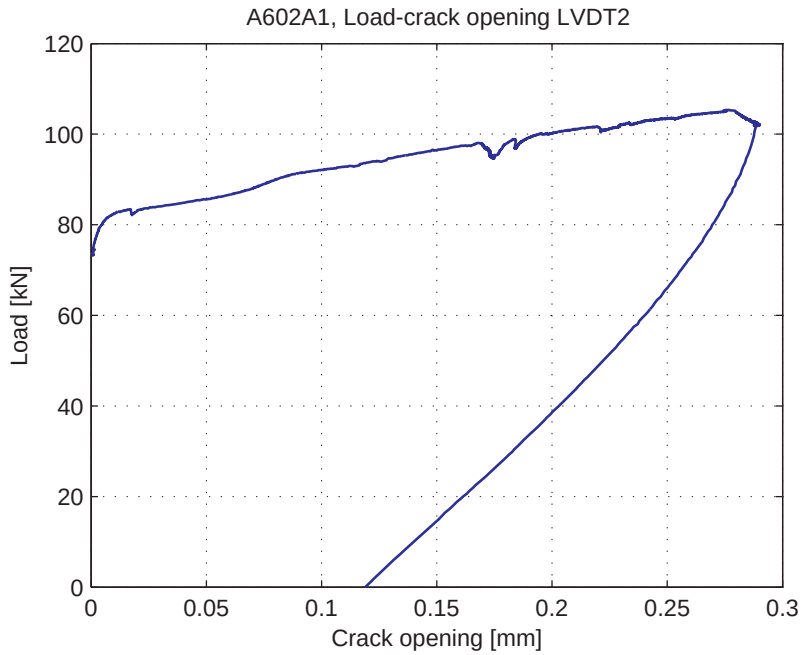


Fig. 5.35.6. Load-Crack opening for LVDT2

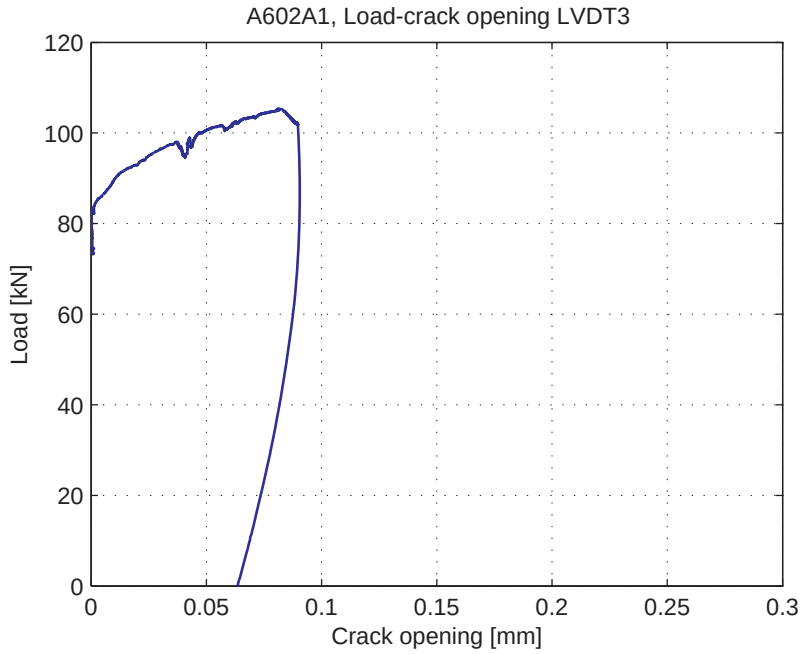


Fig. 5.35.7. Load-Crack opening for LVDT3

5.36. A602A2

5.36.1. Test properties

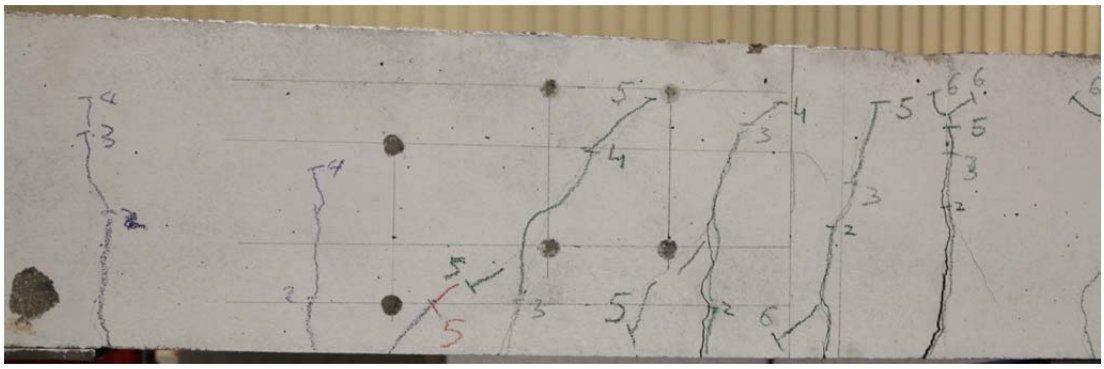


Fig. 5.36.1. Crack pattern after failure north side. (Picture taken after test A602A3.)

Fig. 5.36.2. Crack pattern after failure south side. (Picture taken after test A602A3.)

Table 5.36.1. Beam properties

Date of test	26-05-2015
Reinforcement	2Ø16 + 1Ø10
Reinforcement ratio	0.59%
a	700 mm
a / *d*	2.57
Concrete cube strength at testing	78.5 MPa
Peak load	112.8 kN
Failure mode	Flexural

Table 5.36.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	60	
3	80	
4	100	
5	119.6	Stopped after jack displacement of 30 mm

Table 5.36.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	325	50
2	North	Vertical	475	100
3	North	Vertical	585	100

5.36.2. Measurement results

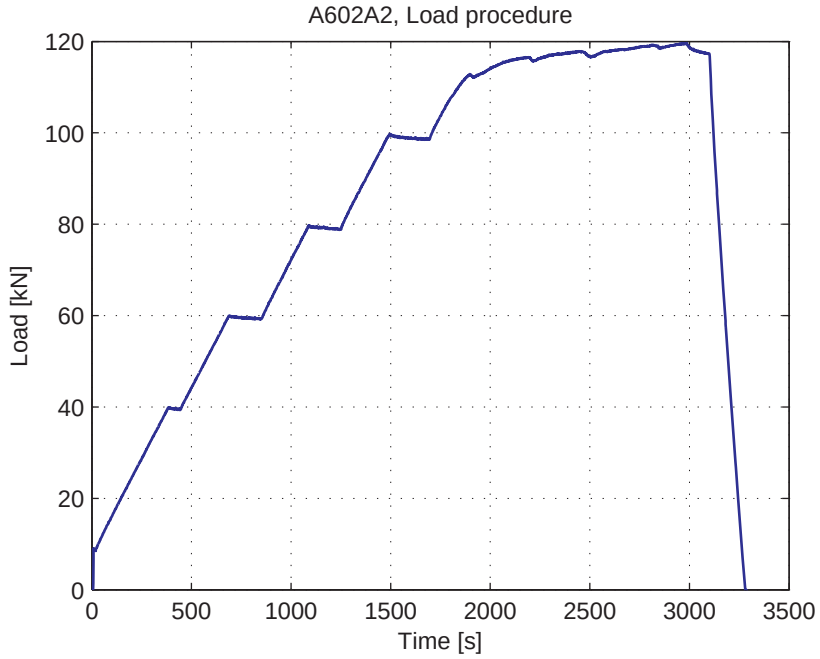


Fig. 5.36.3. Load-Time curve

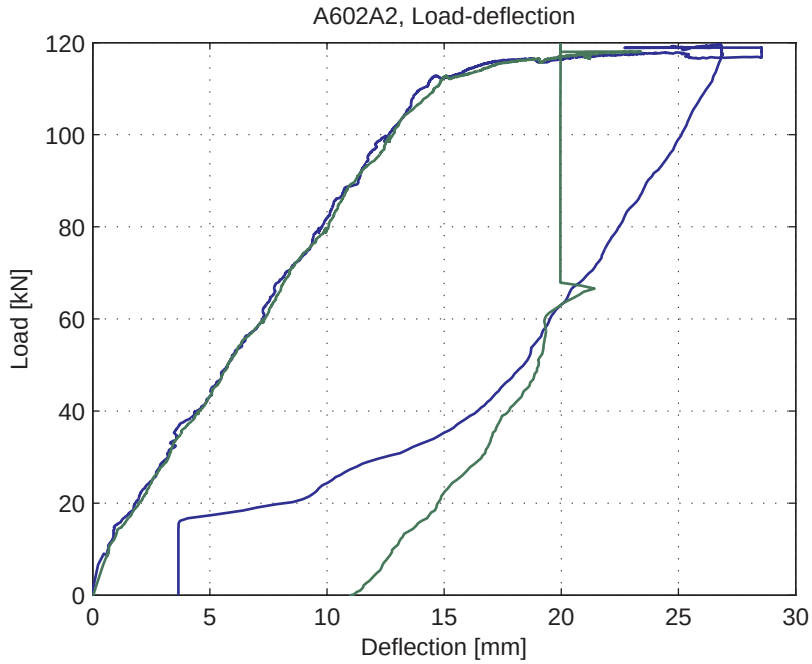


Fig. 5.36.4. Load-deflection curve

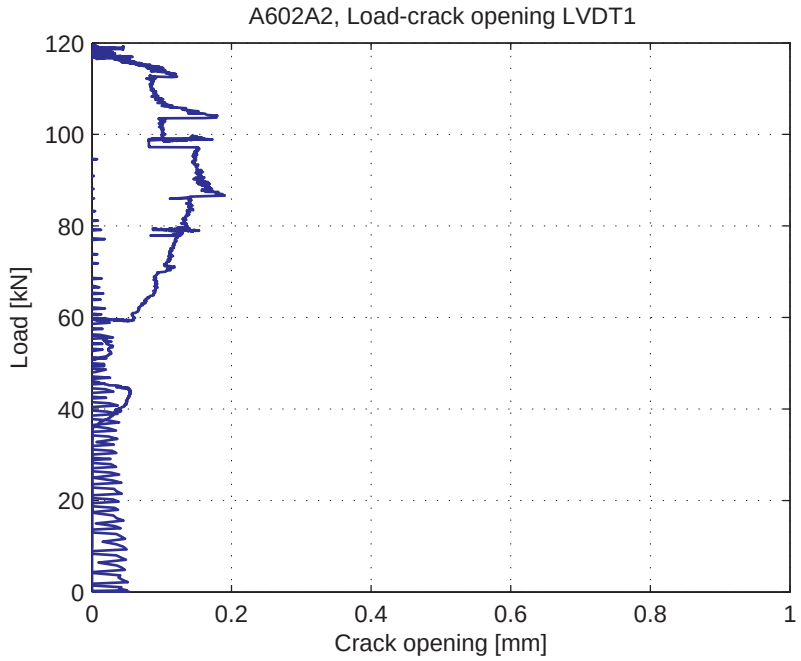


Fig. 5.36.5. Load-Crack opening for LVDT1

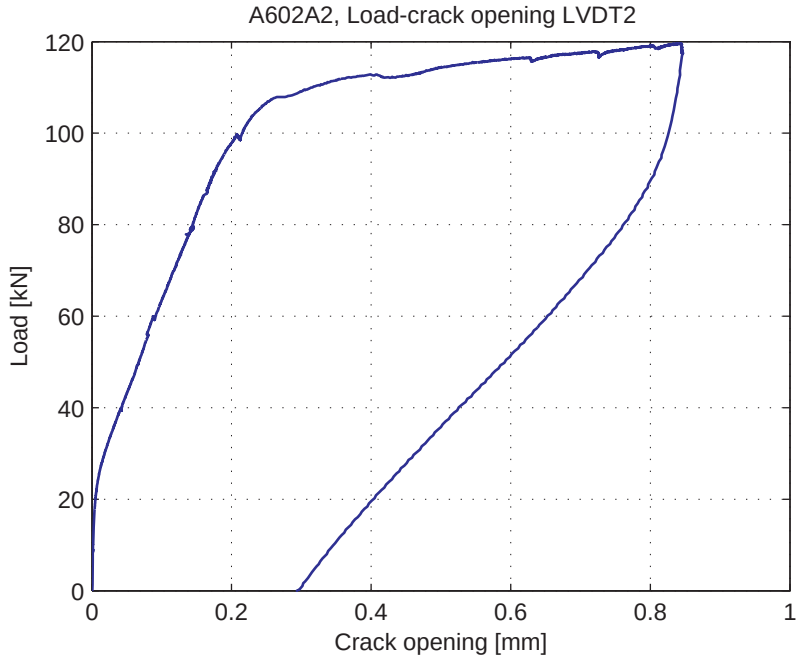


Fig. 5.36.6. Load-Crack opening for LVDT2

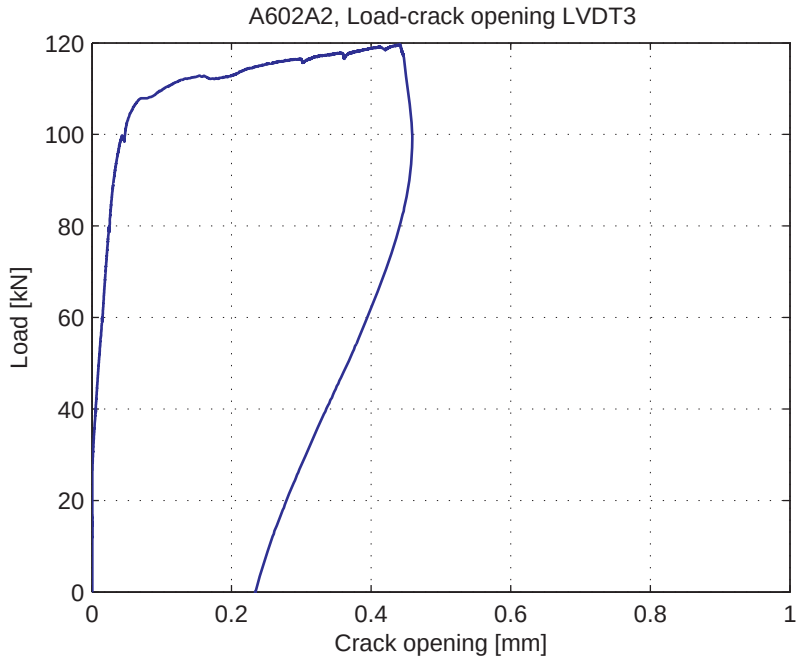


Fig. 5.36.7. Load-Crack opening for LVDT3

5.37. A602A3

5.37.1. Test properties

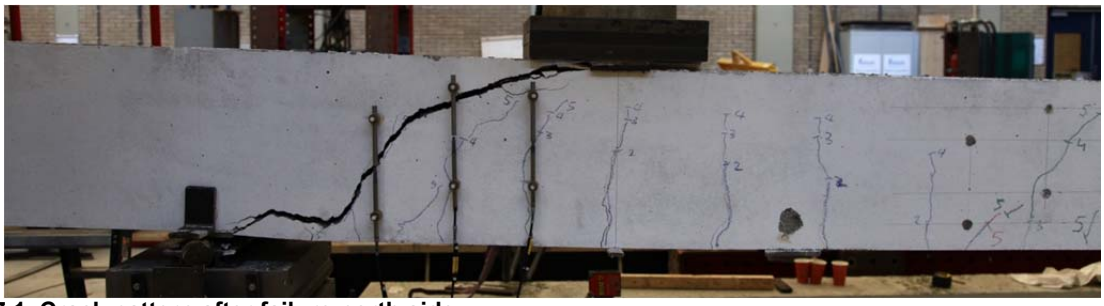


Fig. 5.37.1. Crack pattern after failure north side

Fig. 5.37.2. Crack pattern after failure south side

Table 5.37.1. Beam properties

Date of test	27-05-2015
Reinforcement	2Ø16 + 1Ø10
Reinforcement ratio	0.59%
a	695 mm
a / *d*	2.55
Concrete cube strength at testing	78.5 MPa
Peak load flexural / shear	107.9 kN / 114.2 kN
Failure mode	Flexural and shear

Table 5.37.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	60	
3	80	Placed LVDT's 1-3
4	100	Measurements stopped, laser2 and laser 4 shifted
5	114.2	Yielding at 114 kN, Shear at 112 kN

Table 5.37.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
1	North	Vertical	290	50
2	North	Vertical	420	100
3	North	Vertical	550	100

5.37.2. Measurement results

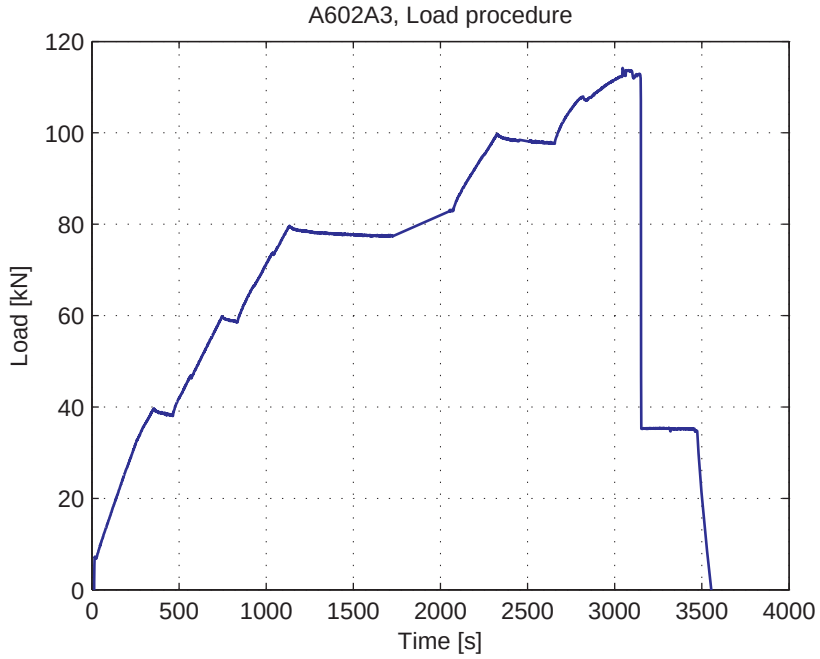


Fig. 5.37.3. Load-Time curve

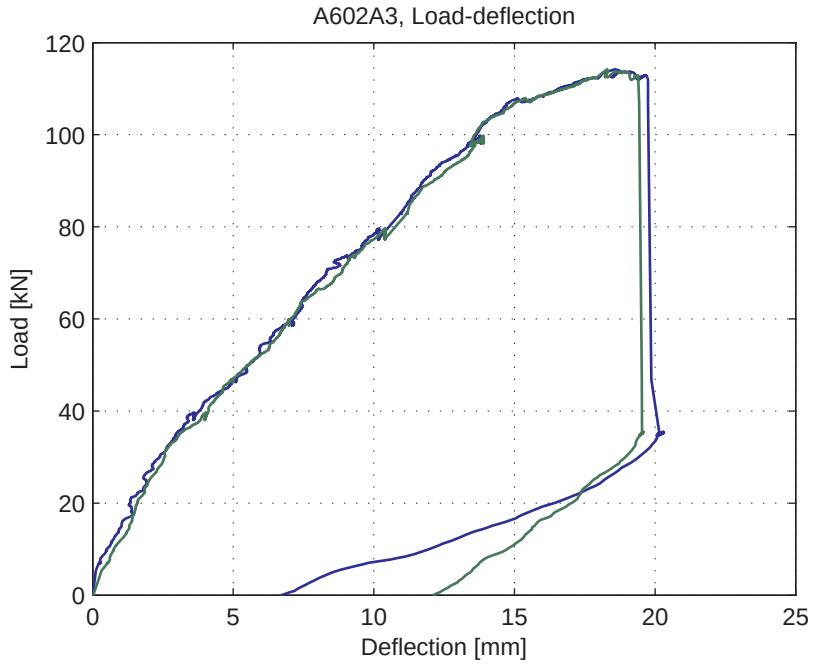


Fig. 5.37.4. Load-deflection curve

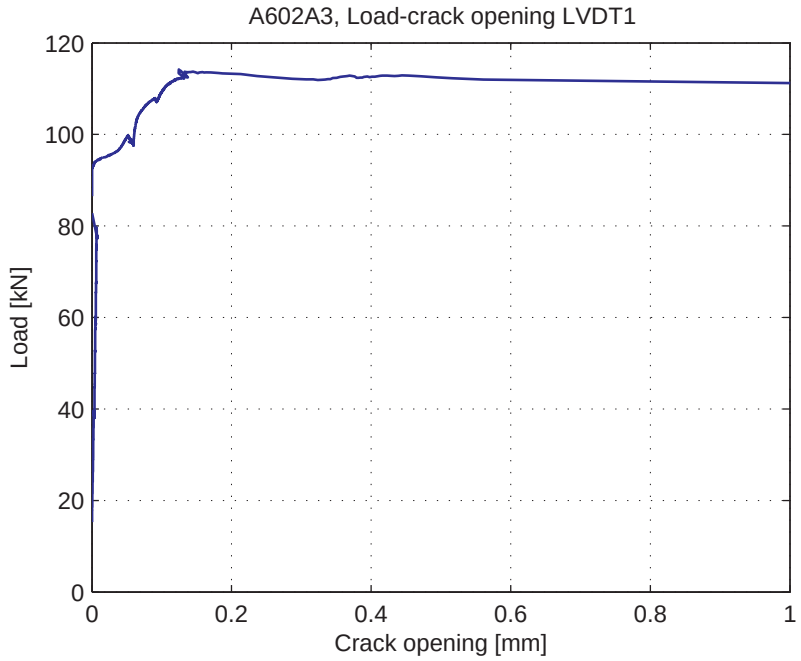


Fig. 5.37.5. Load-Crack opening for LVDT1

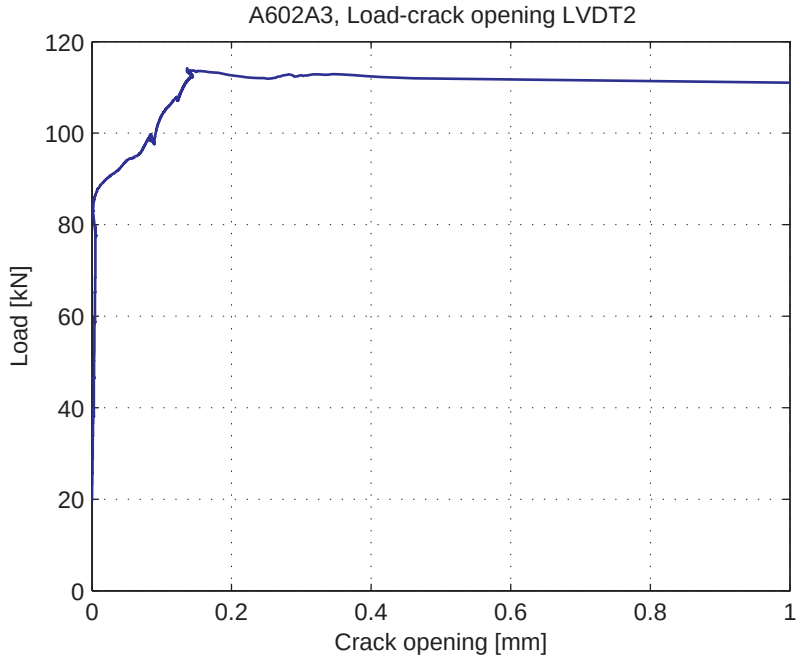


Fig. 5.37.6. Load-Crack opening for LVDT2

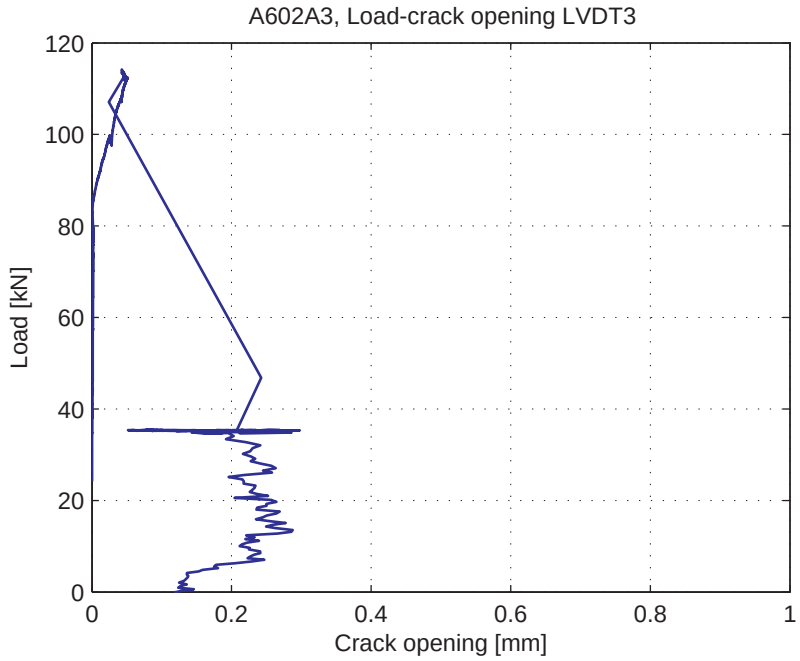


Fig. 5.37.7. Load-Crack opening for LVDT3

5.38. A602B1

5.38.1. Test properties

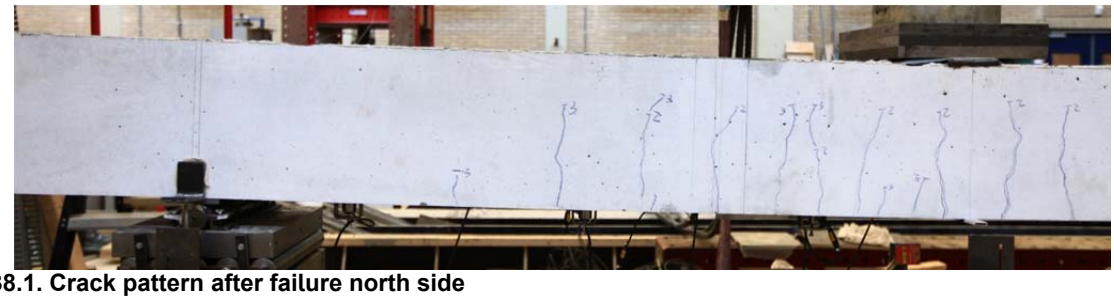


Fig. 5.38.1. Crack pattern after failure north side

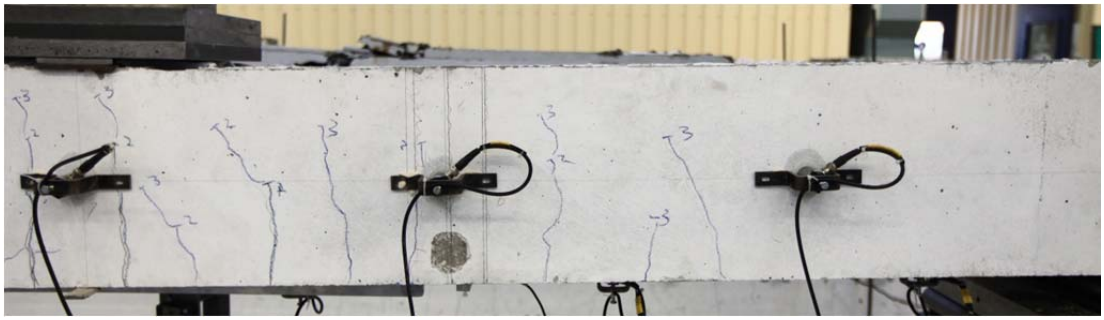


Fig. 5.38.2. Crack pattern after failure south side

Fig. 5.38.3. Sensors used for Acoustic Emission measurements

Table 5.38.1. Beam properties

Date of test	03-07-2015
Reinforcement	2Ø16 + 1Ø10
Reinforcement ratio	0.59%
a	1500 mm
a / *d*	5.50
Concrete cube strength at testing	78.5 MPa
Peak load	58.0 kN
Failure mode	Flexural

Table 5.38.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	All LVDT's replaced by new LVDT's. Lasers on supports replaced by LVDT1 and LVDT2. Laser 1 and 2 are under the load. LVDT3 measures over 1000 mm under the load. For this test load cycles are performed for Acoustic emission measurements.
1	20	
2	0	
3	20	
4	2	
5	20	
6	2	
7	40	
8	2	
9	40	
10	2	
11	40	
12	2	
13	60.5	LVDT3 out of range. Stopped after jack displacement of 35 mm.

5.38.2. Measurement results

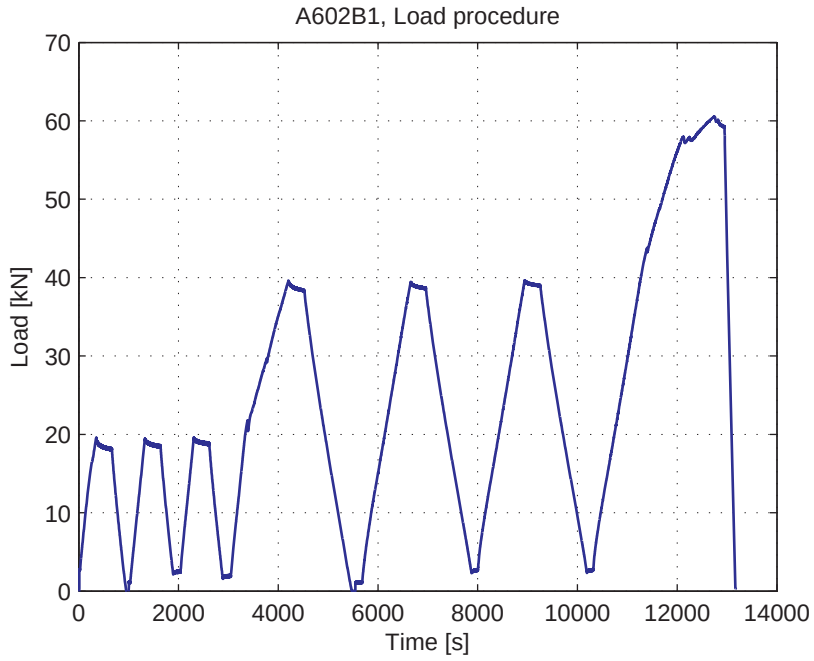


Fig. 5.38.4. Load-Time curve

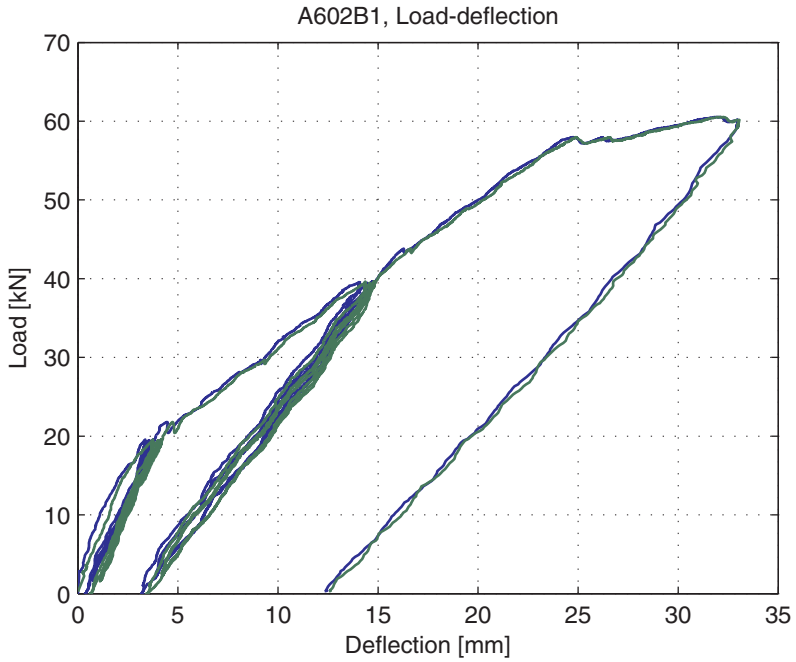


Fig. 5.38.5. Load-deflection curve

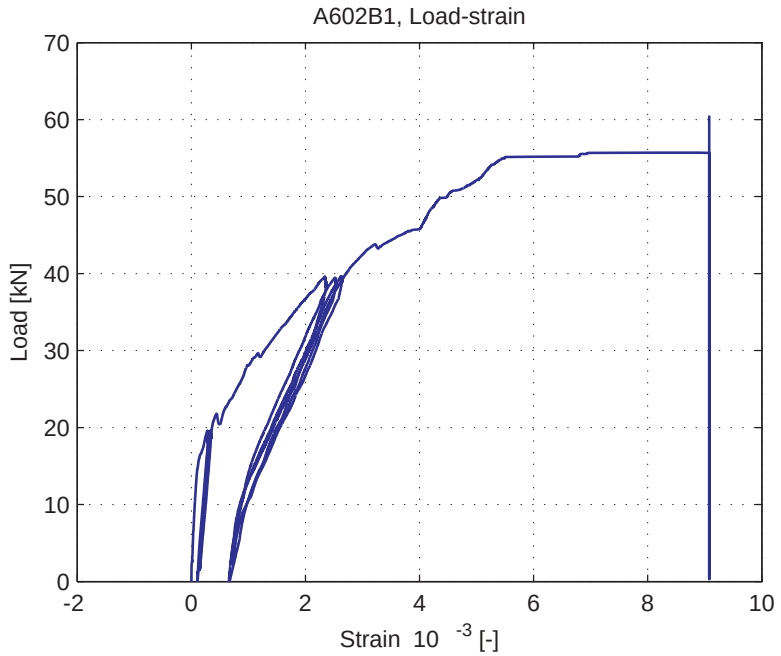


Fig. 5.38.6. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.39. A602B2

5.39.1. Test properties

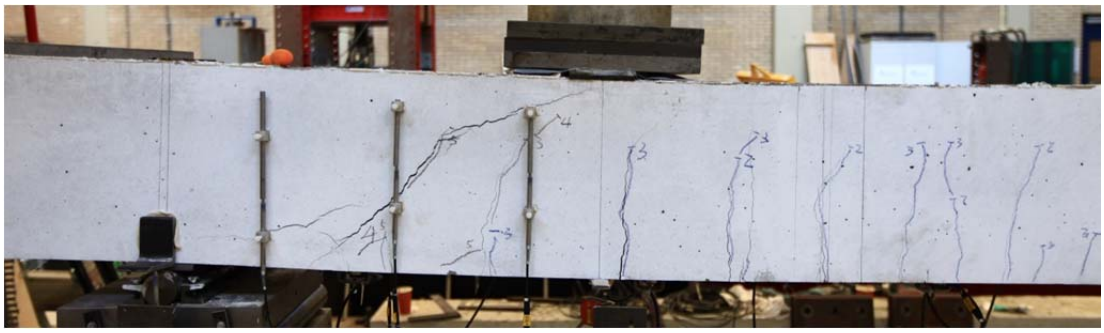


Fig. 5.39.1. Crack pattern after failure north side

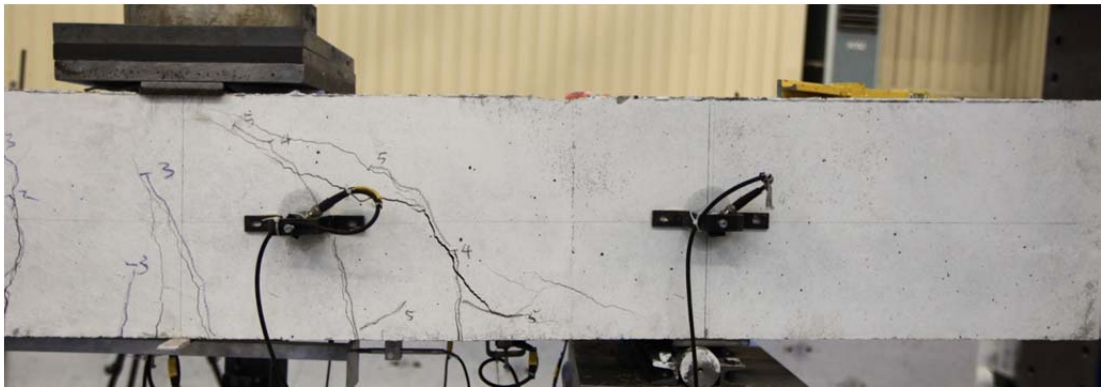


Fig. 5.39.2. Crack pattern after failure south side

Table 5.39.1. Beam properties

Date of test	06-07-2015
Reinforcement	2Ø16 + 1Ø10
Reinforcement ratio	0.59%
a	650 mm
a / *d*	2.39
Concrete cube strength at testing	78.5 MPa
Peak load flexural / shear	107.4 kN / 110.9 kN
Failure mode	Flexural and shear

Table 5.39.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements
1	40	
2	2	
3	40	
4	2	
5	40	
6	2	
7	60	
8	2	
9	60	
10	2	
11	60	
12	2	
13	80	Stopped at 61 kN to place LVDT's 4-6
14	2	
15	80	
16	2	
17	80	
18	2	
19	80	Stopped to contact Yuguang
20	100	Stopped for crack marking
	107.4	opening of inclined crack
	110.9	yielding of reinforcement.
21	117.5	Stopped test at jack displacement of 26 mm

Table 5.39.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	145	50
5	North	Vertical	345	100
6	North	Vertical	545	100

5.39.2. Measurement results

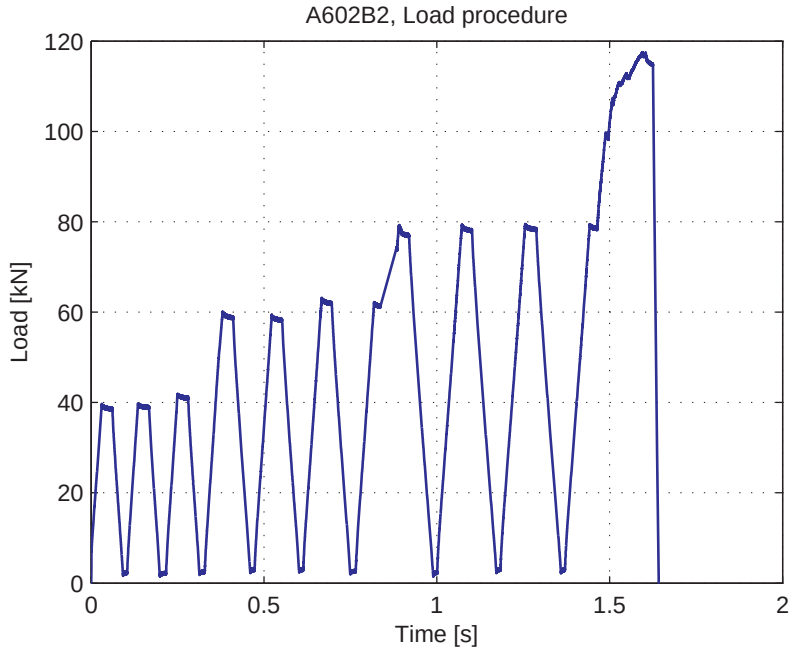


Fig. 5.39.3. Load-Time curve

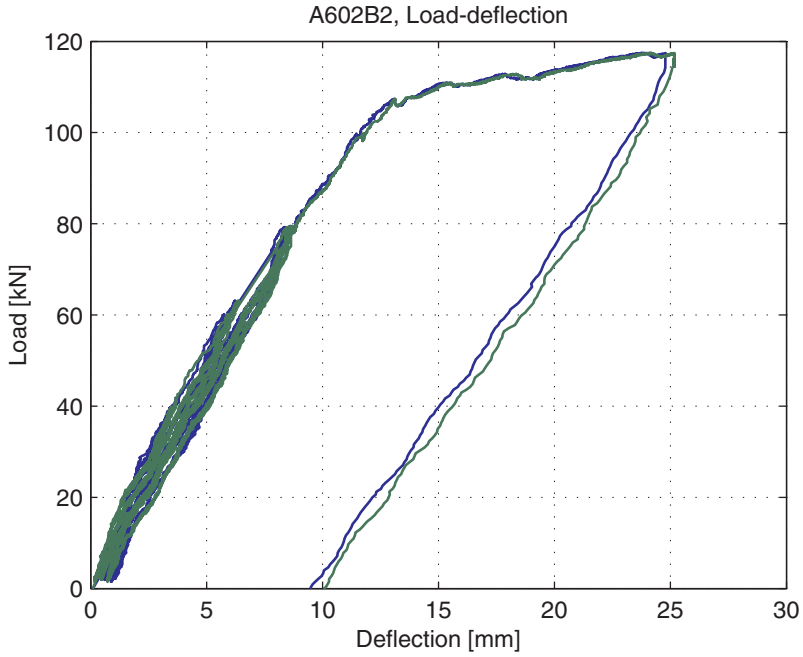


Fig. 5.39.4. Load-deflection curve

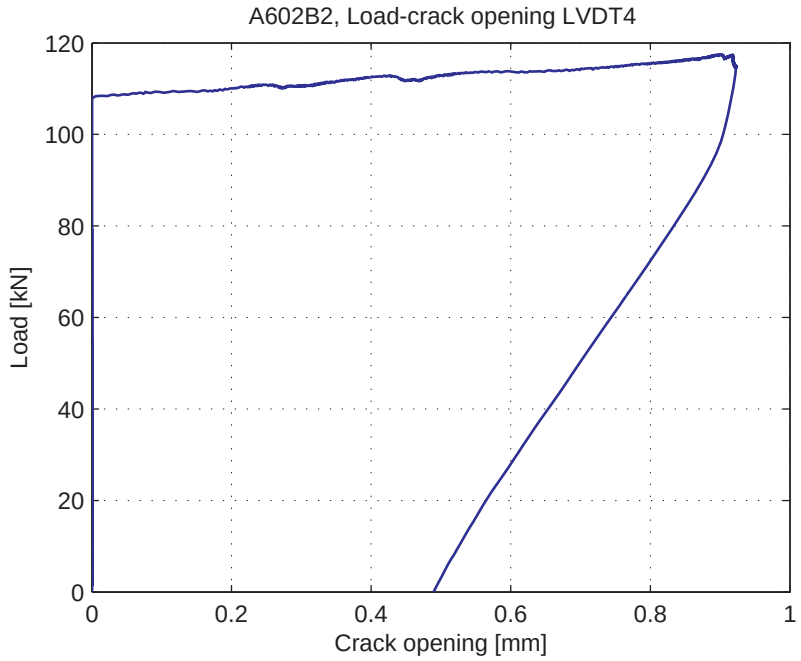


Fig. 5.39.5. Load-Crack opening for LVDT4

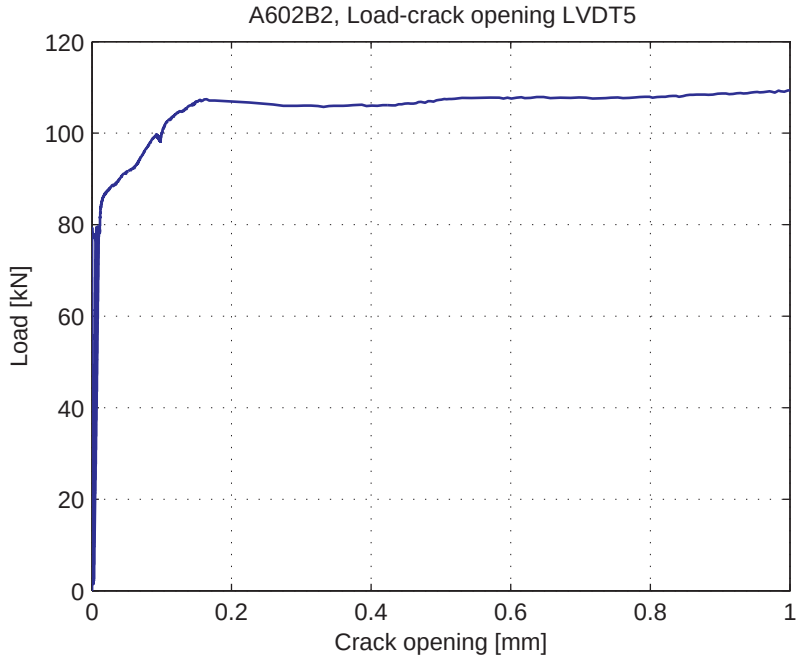


Fig. 5.39.6. Load-Crack opening for LVDT5

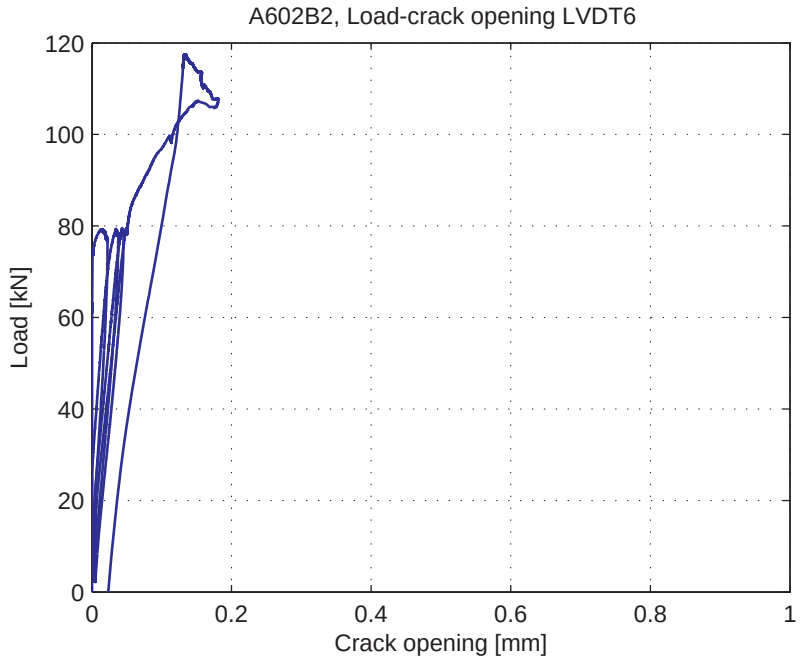


Fig. 5.39.7. Load-Crack opening for LVDT6

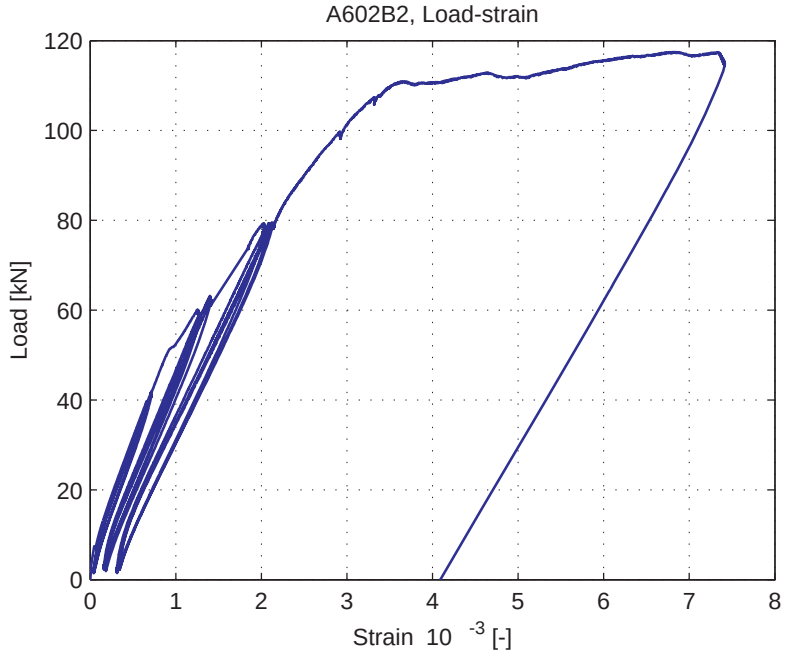


Fig. 5.39.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.40. B701A1

5.40.1. Test properties

Fig. 5.40.1. Crack pattern after failure north side

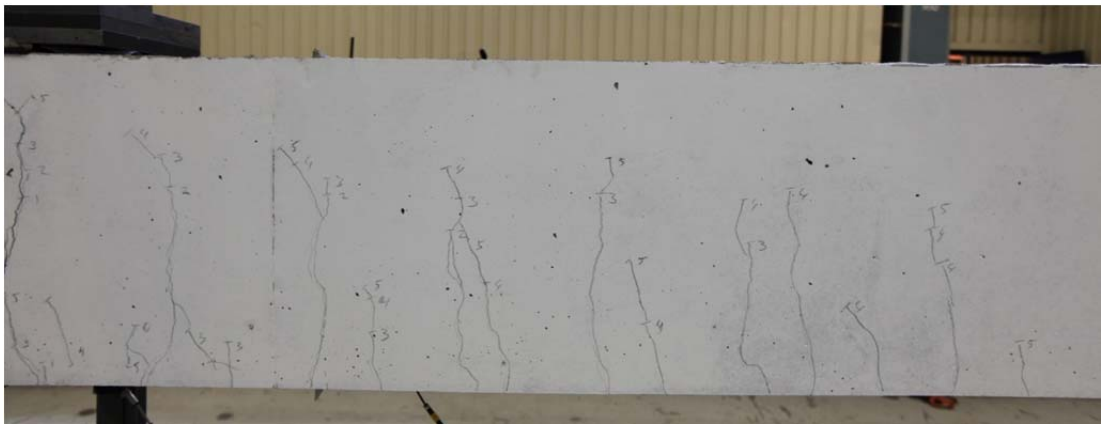


Fig. 5.40.2. Crack pattern after failure south side

Table 5.40.1. Beam properties

Date of test	08-07-2015
Reinforcement	3Ø20
Reinforcement ratio	0.67%
a	2250 mm
a / *d*	4.77
Concrete cube strength at testing	81.0 MPa
Peak load	175.5 kN
Failure mode	Flexural

Table 5.40.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	First test at h =500 mm beam
1	55	First cracks observed
2	80	
3	120	
4	160	
5	181.7	Yielding at 175 kN, stopped after jack displacement of 35 mm.

5.40.2. Measurement results

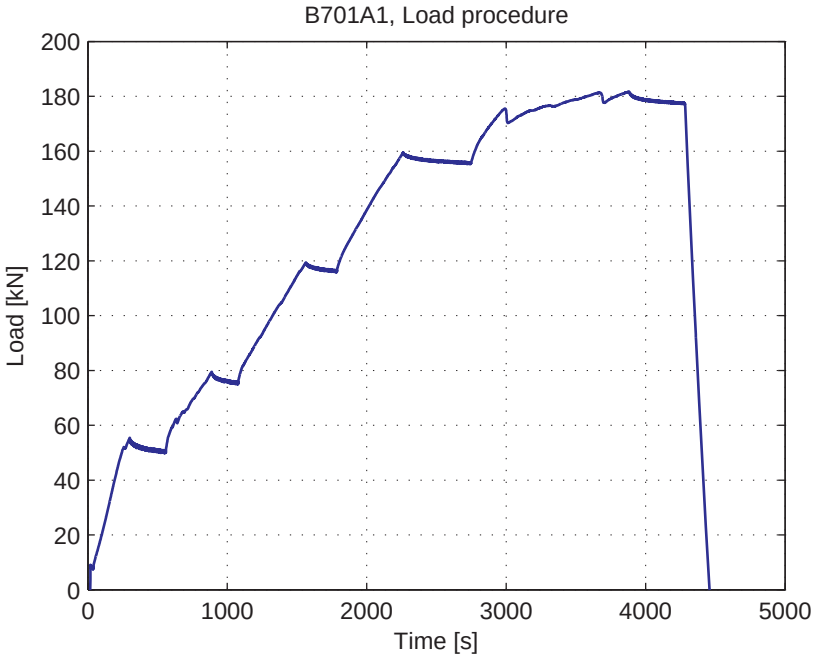


Fig. 5.40.3. Load-Time curve

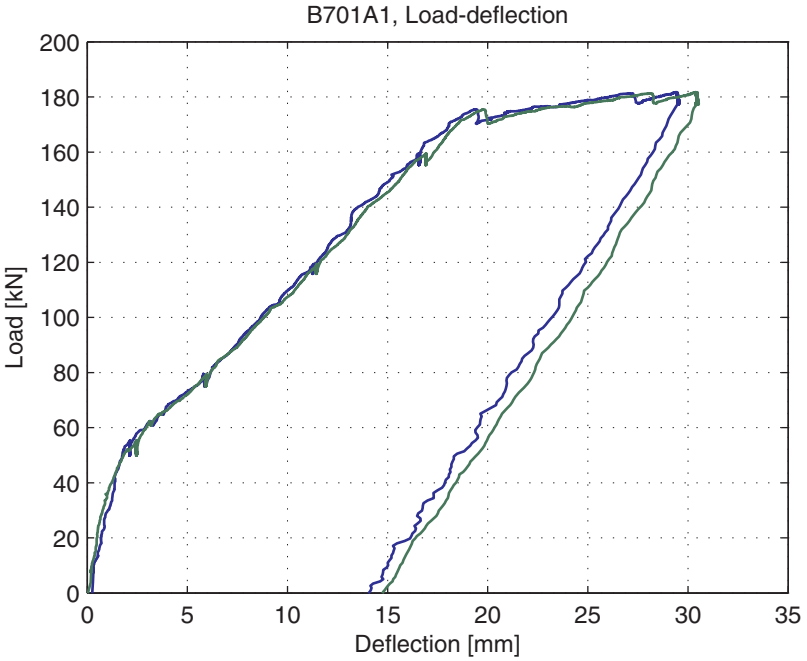


Fig. 5.40.4. Load-deflection curve

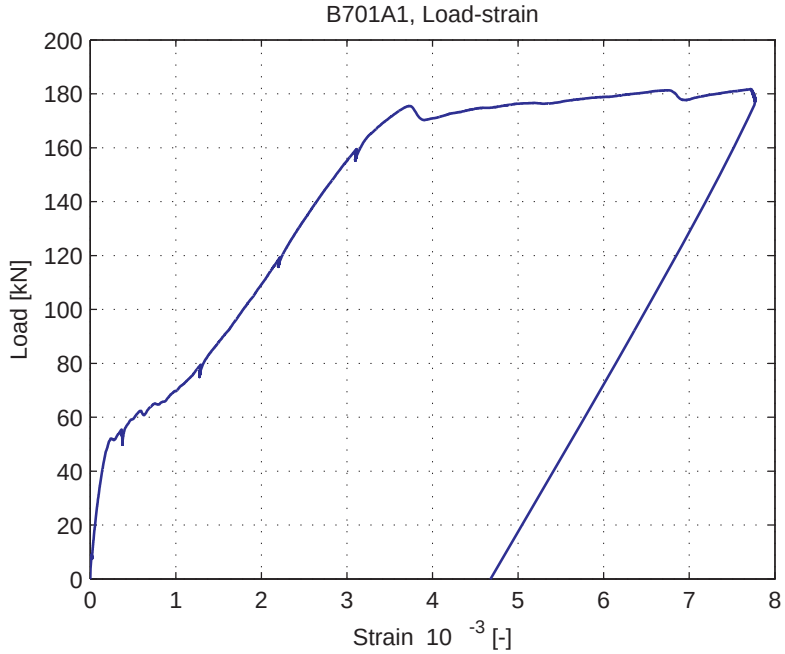


Fig. 5.40.5. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.41. B701A2

5.41.1. Test properties

Fig. 5.41.1. Crack pattern after failure north side

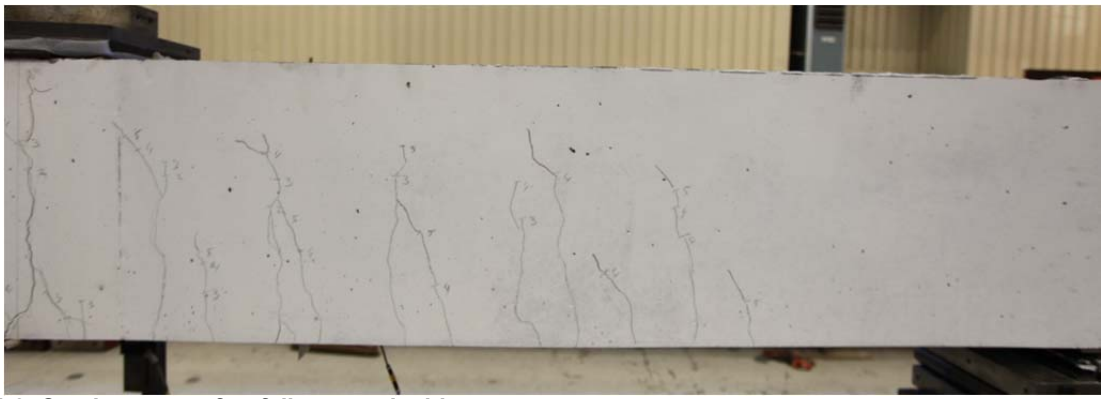


Fig. 5.41.2. Crack pattern after failure south side

Table 5.41.1. Beam properties

Date of test	10-07-2015
Reinforcement	3Ø20
Reinforcement ratio	0.67%
a	2000 mm
a / *d*	4.24
Concrete cube strength at testing	81.0 MPa
Peak load	179.5 kN
Failure mode	Flexural

Table 5.41.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	80	
3	120	
4	160	
5	187.6	Yielding at 179 kN. Stopped after jack displacement of 28.5 mm

5.41.2. Measurement results

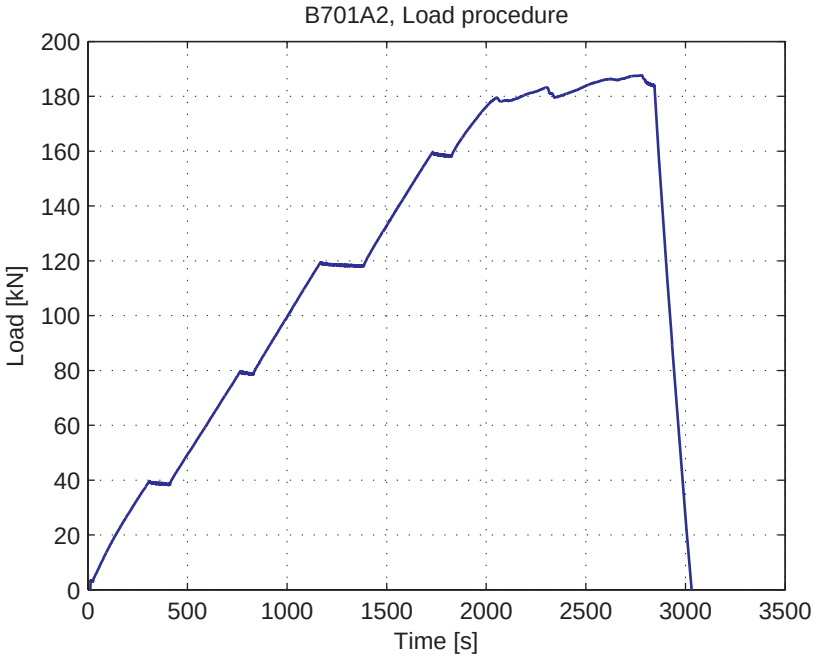


Fig. 5.41.3. Load-Time curve

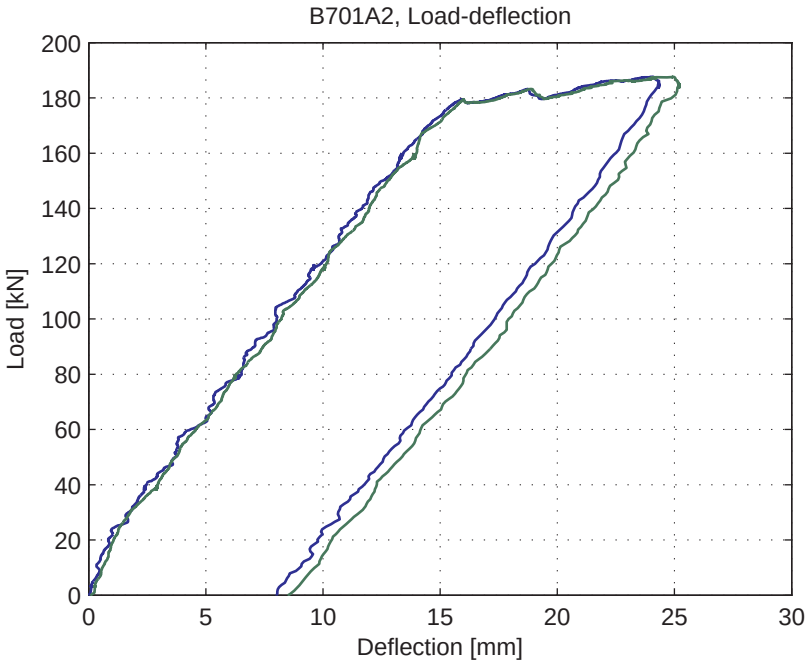


Fig. 5.41.4. Load-deflection curve

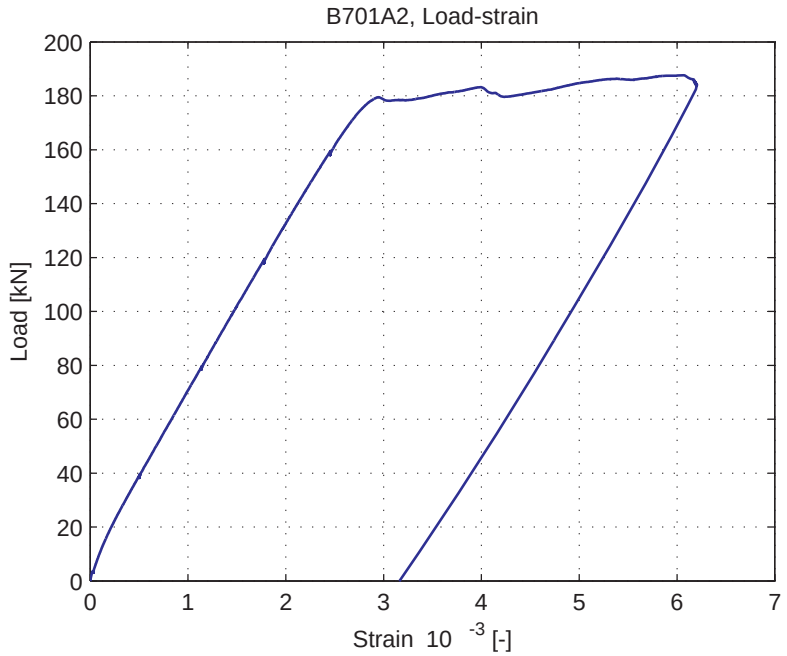


Fig. 5.41.5. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.42. B701A3

5.42.1. Test properties

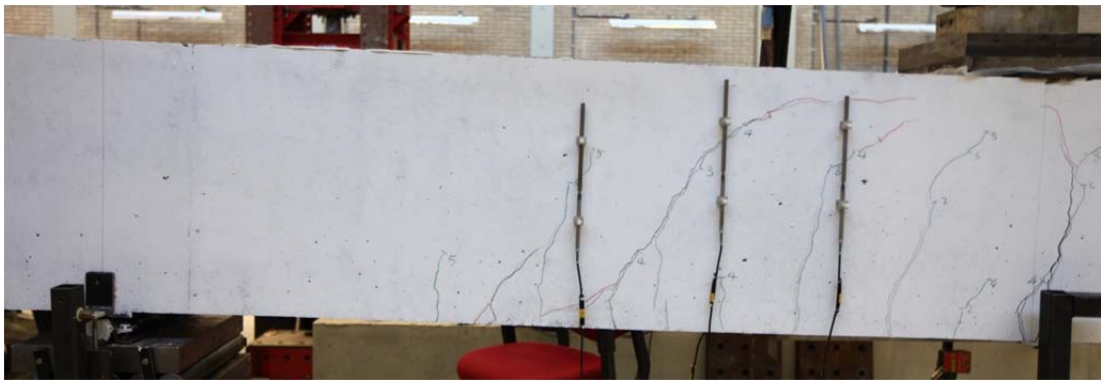


Fig. 5.42.1. Crack pattern after failure north side

Fig. 5.42.2. Crack pattern after failure south side

Table 5.42.1. Beam properties

Date of test	10-07-2015
Reinforcement	3Ø20
Reinforcement ratio	0.67%
a	1750 mm
a / *d*	3.71
Concrete cube strength at testing	81.0 MPa
Peak load	185.7 kN
Failure mode	Flexural

Table 5.42.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Placed LVDT's 4-6
1	40	
2	80	
3	120	
4	160	
5	199.1	Yielding at 185 kN. Stopped after jack displacement of 30 mm.

Table 5.42.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	880	200
5	North	Vertical	1145	250
6	North	Vertical	1375	250

5.42.2. Measurement results

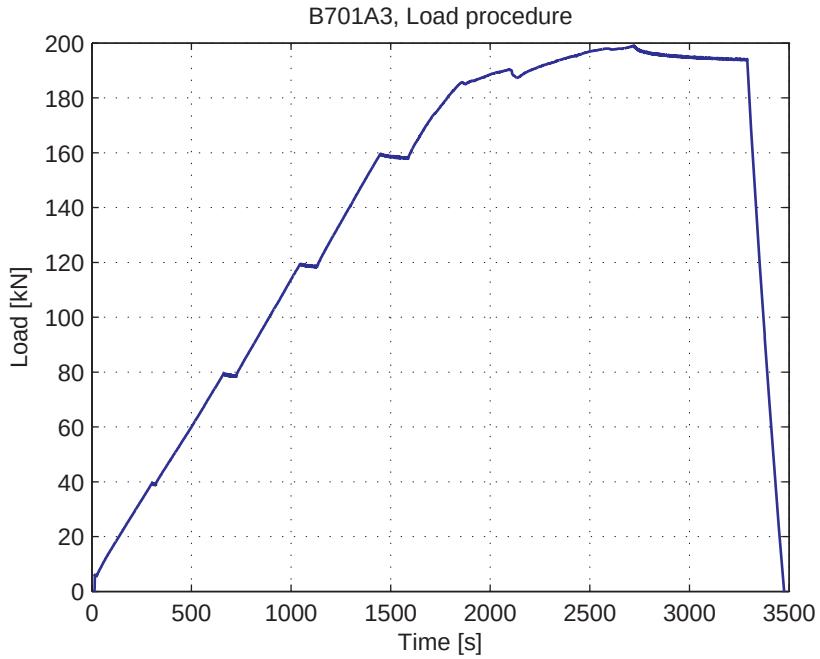


Fig. 5.42.3. Load-Time curve

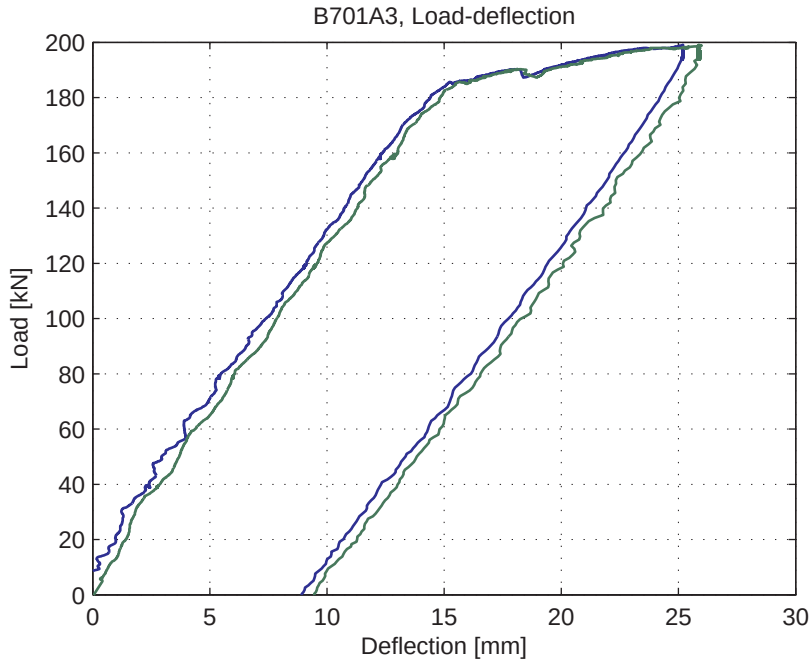


Fig. 5.42.4. Load-deflection curve

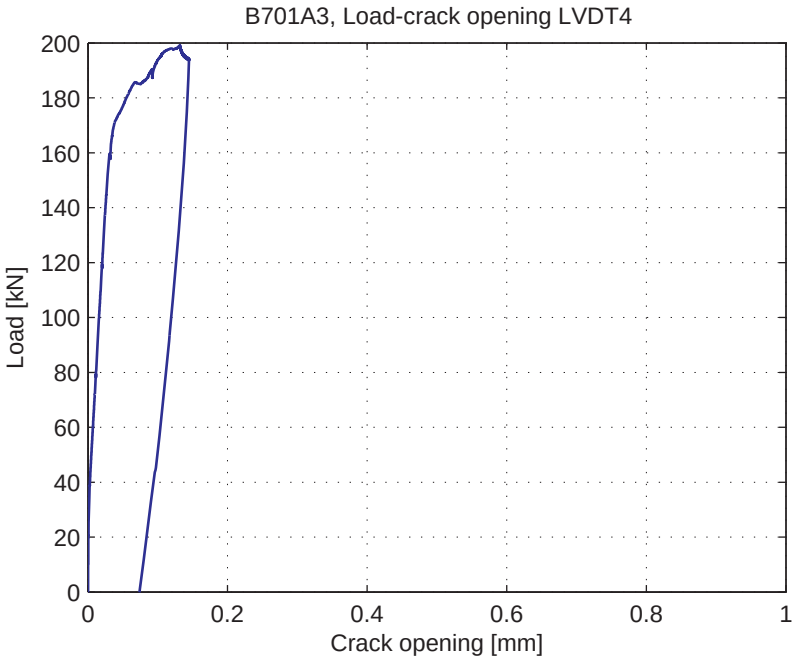


Fig. 5.42.5. Load-Crack opening for LVDT4

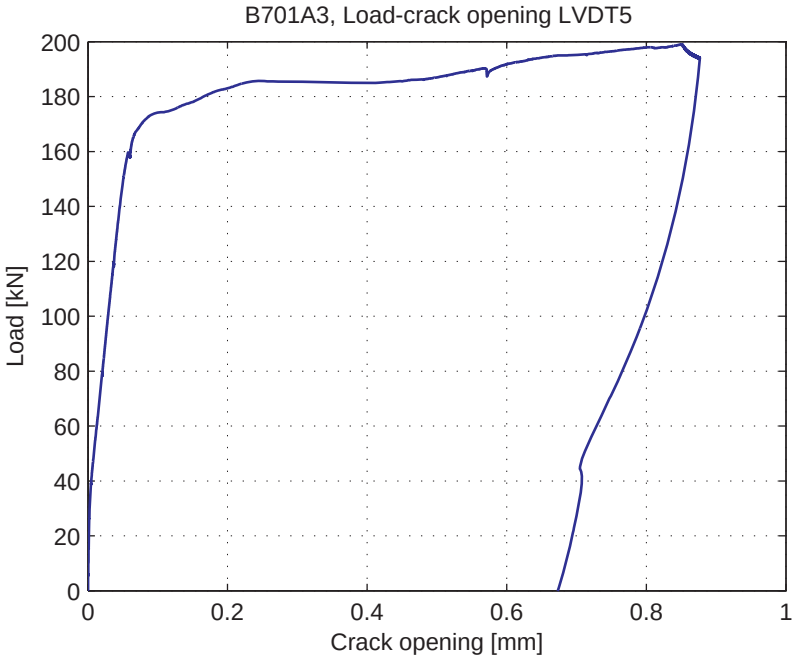


Fig. 5.42.6. Load-Crack opening for LVDT5

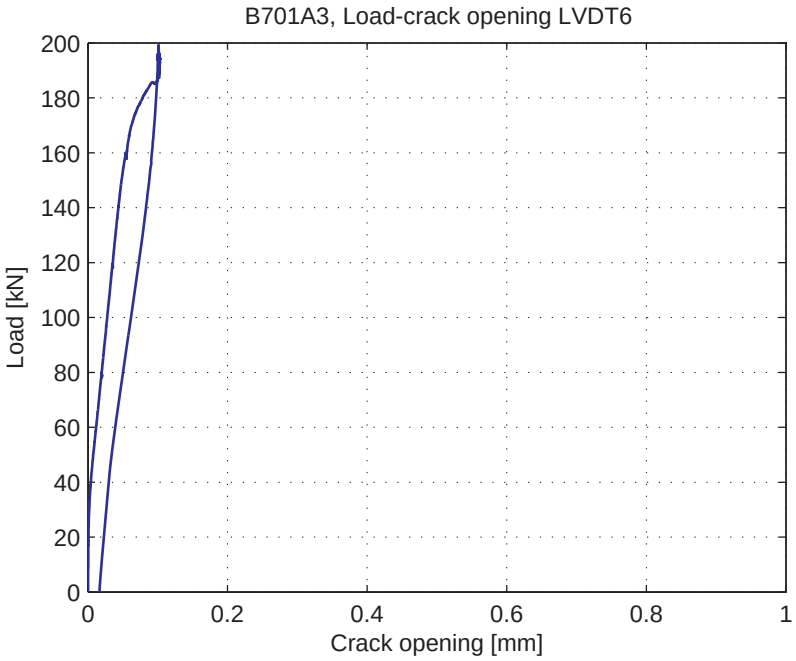


Fig. 5.42.7. Load-Crack opening for LVDT6

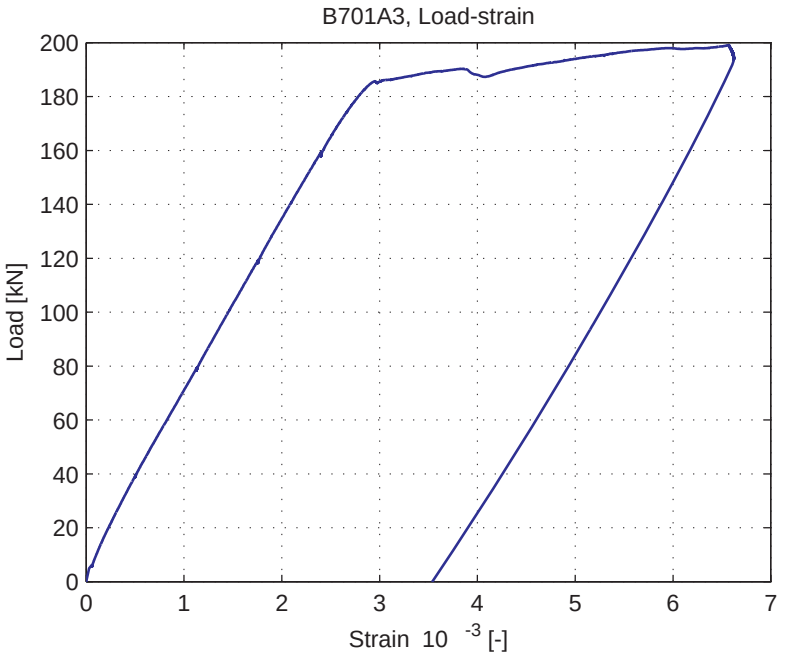


Fig. 5.42.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.43. B701B1

5.43.1. Test properties

Fig. 5.43.1. Crack pattern after failure north side

Fig. 5.43.2. Crack pattern after failure south side

Table 5.43.1. Beam properties

Date of test	14-07-2015
Reinforcement	3Ø20
Reinforcement ratio	0.67%
a	1700 mm
a / *d*	3.61
Concrete cube strength at testing	81.1 MPa
Peak load	193.6 kN
Failure mode	Flexural

Table 5.43.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	85	
3	120	LVDT3 was not started correct, out of range before 120 kN. Unloaded to 0 kN. Added LVDT's 4-6
4	160	Added LVDT 7
5	197.7kN	Yielding at 193 kN. Stopped after jack displacement of 25 mm

Table 5.43.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	970	200
5	North	Vertical	1135	250
6	North	Vertical	1310	250
7	North	Vertical	825	150

5.43.2. Measurement results

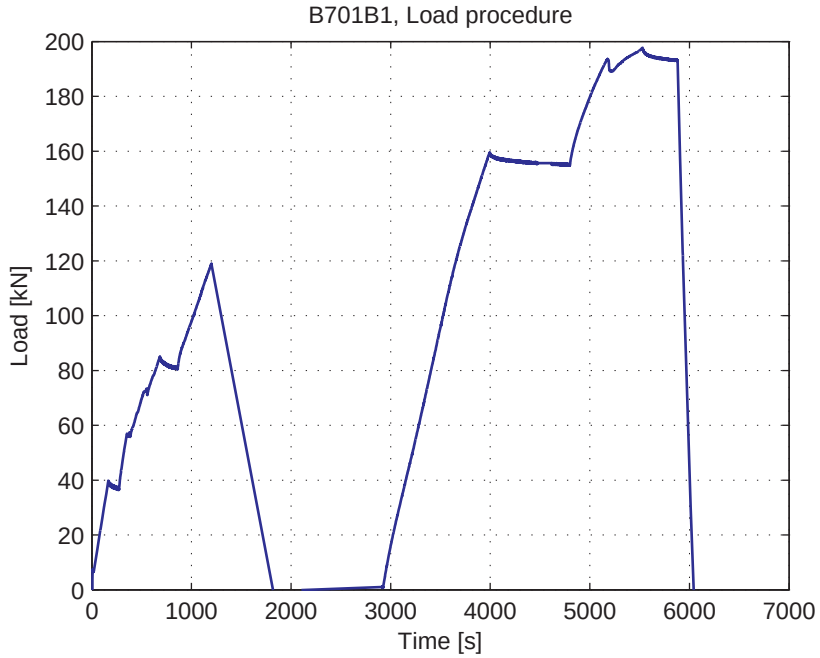


Fig. 5.43.3. Load-Time curve

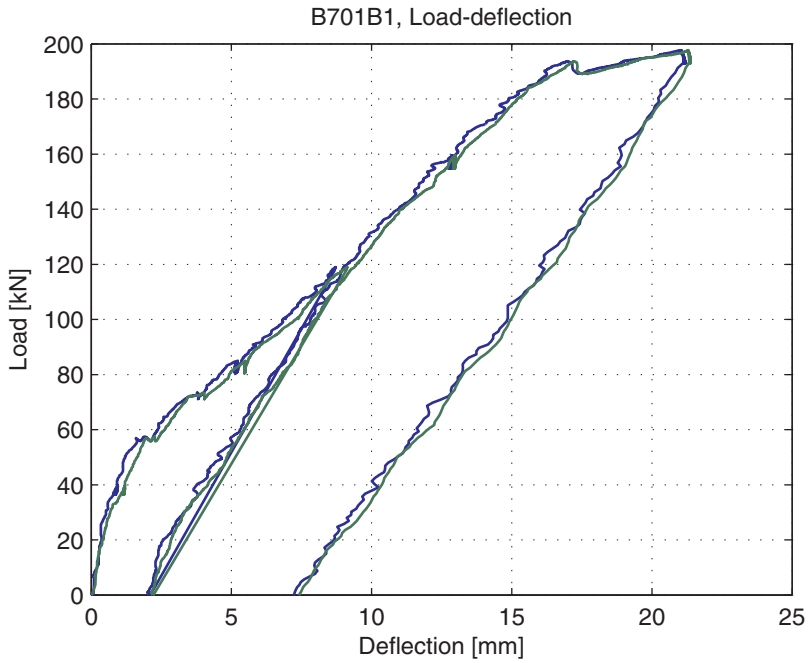


Fig. 5.43.4. Load-deflection curve

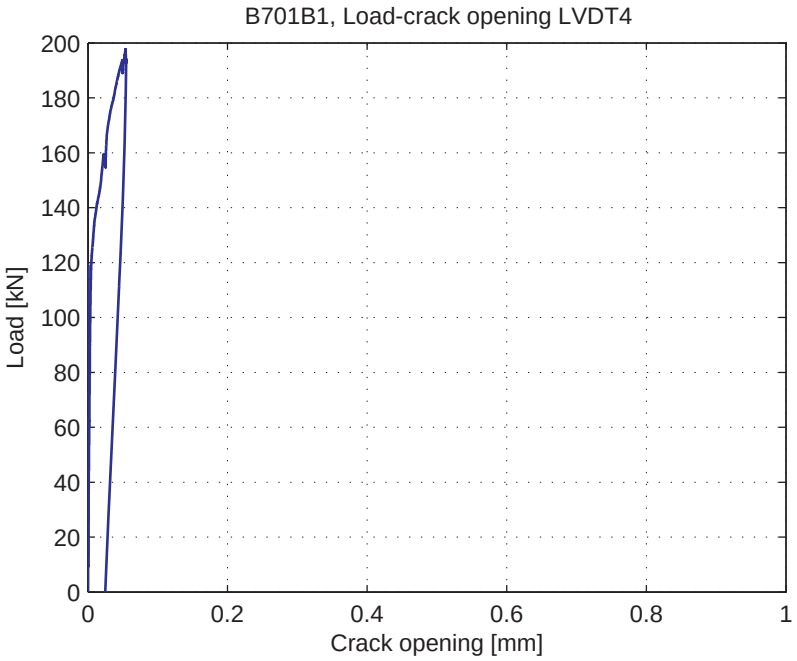


Fig. 5.43.5. Load-Crack opening for LVDT4

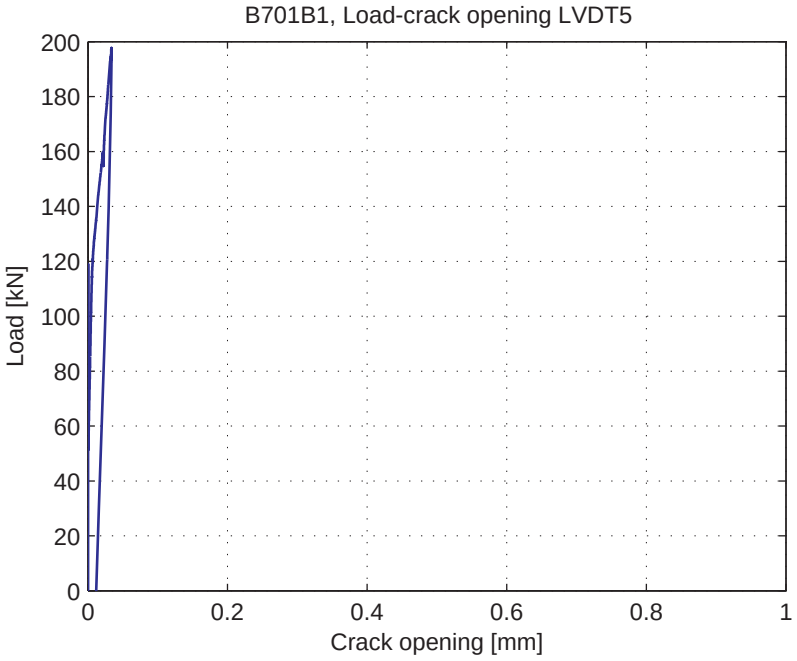


Fig. 5.43.6. Load-Crack opening for LVDT5

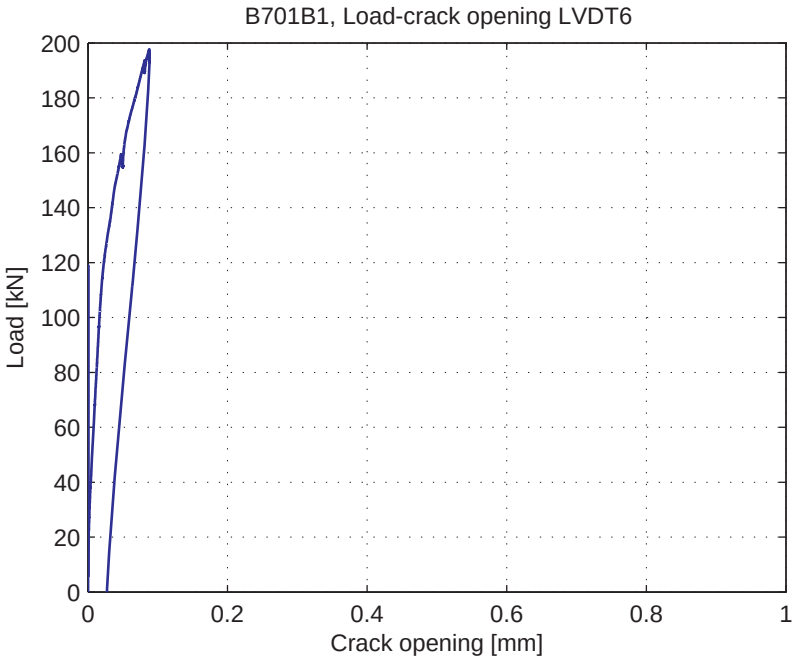


Fig. 5.43.7. Load-Crack opening for LVDT6

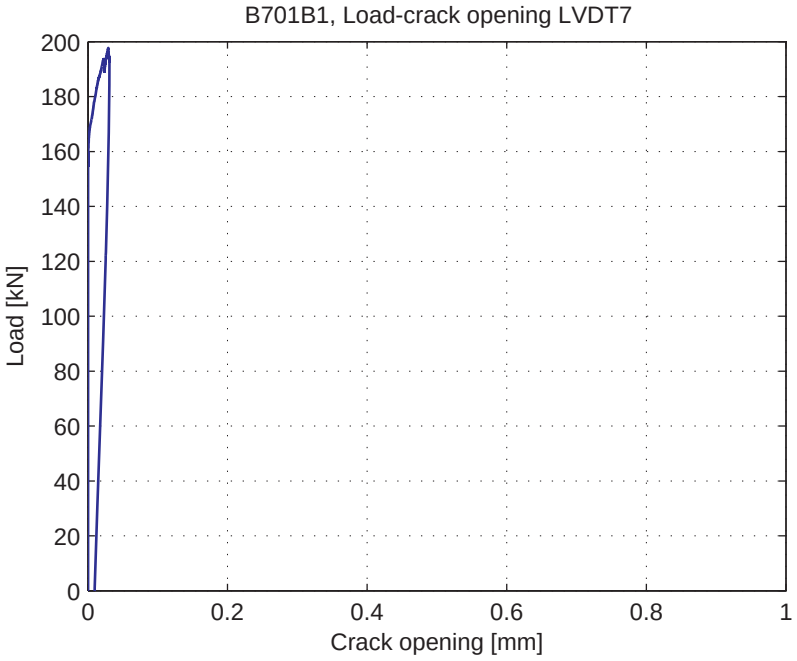


Fig. 5.43.8. Load-Crack opening for LVDT7

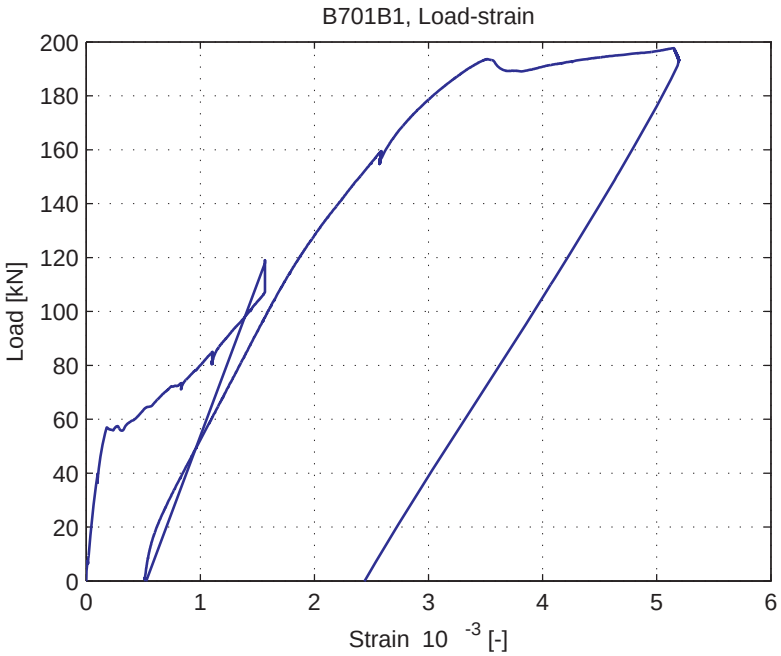


Fig. 5.43.9. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.44. B701B2

5.44.1. Test properties

Fig. 5.44.1. Crack pattern after failure north side

Fig. 5.44.2. Crack pattern after failure south side

Table 5.44.1. Beam properties

Date of test	14-07-2015
Reinforcement	3Ø20
Reinforcement ratio	0.67%
a	1500 mm
a / *d*	3.18
Concrete cube strength at testing	81.1 MPa
Peak load	202.4 kN
Failure mode	Shear

Table 5.44.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	80	
3	120	
4	160	
5	202.4	Shear failure

Table 5.44.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	970	200
5	North	Vertical	1135	250
6	North	Vertical	1310	250
7	North	Vertical	825	150

5.44.2. Measurement results

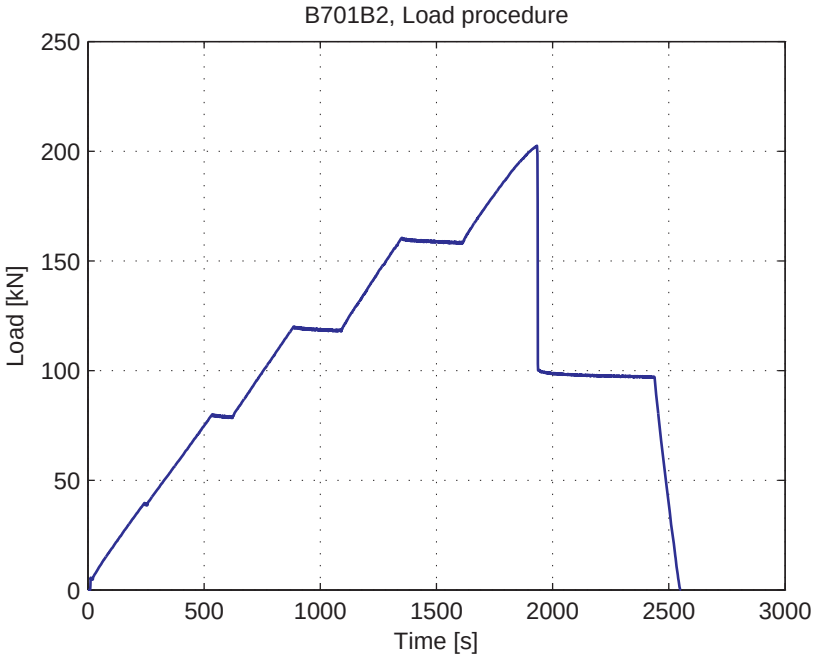


Fig. 5.44.3. Load-Time curve

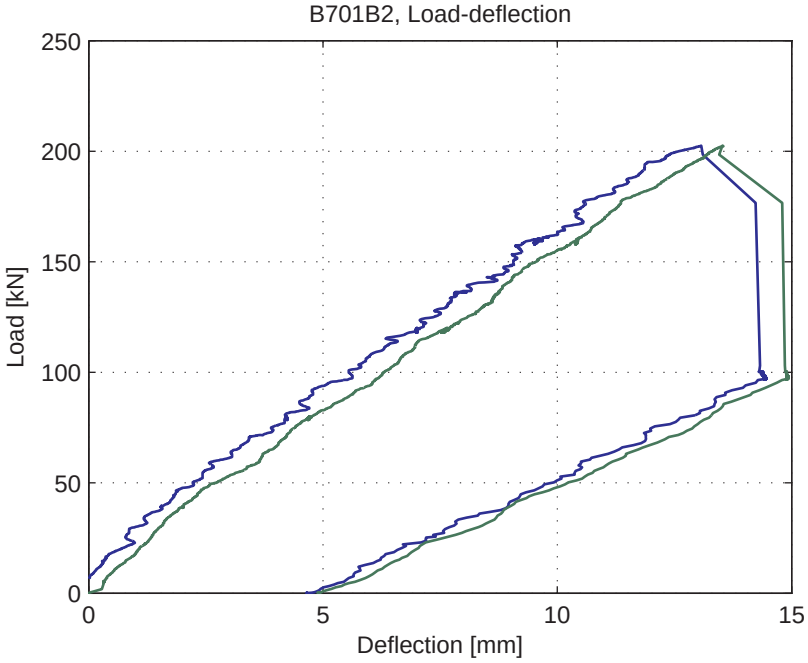


Fig. 5.44.4. Load-deflection curve

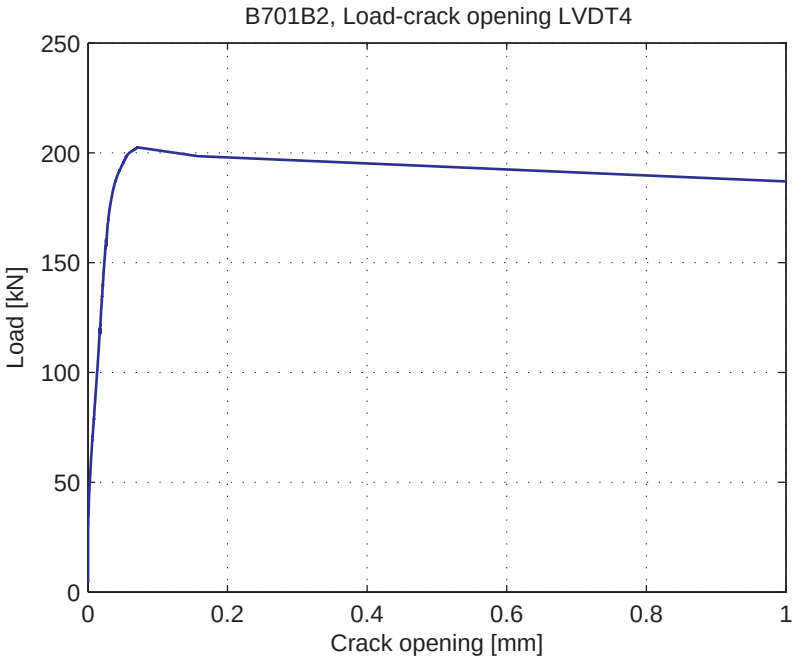


Fig. 5.44.5. Load-Crack opening for LVDT4

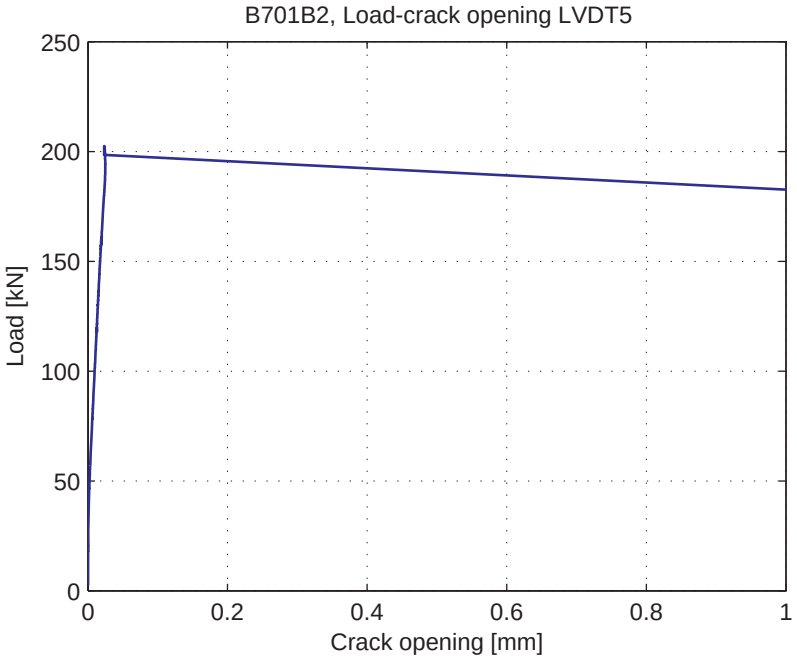


Fig. 5.44.6. Load-Crack opening for LVDT5

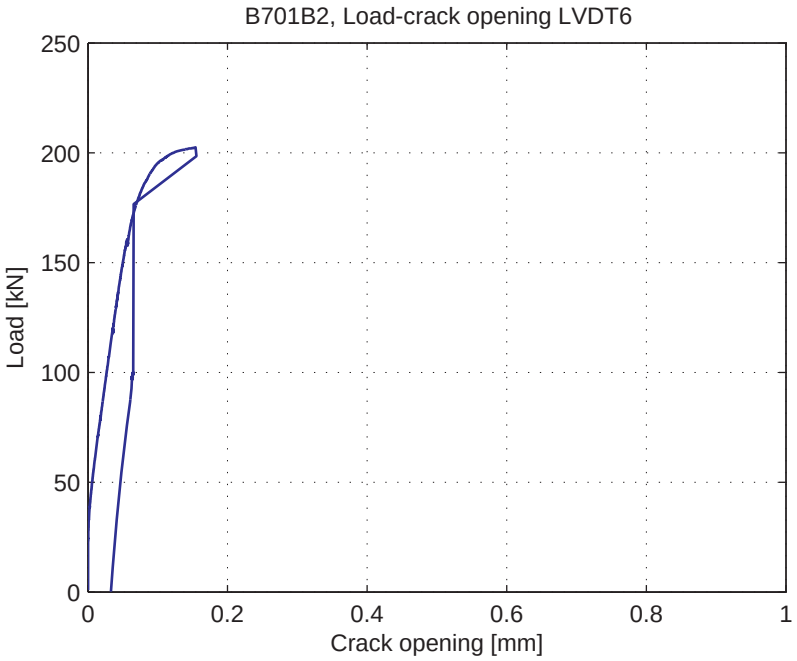


Fig. 5.44.7. Load-Crack opening for LVDT6

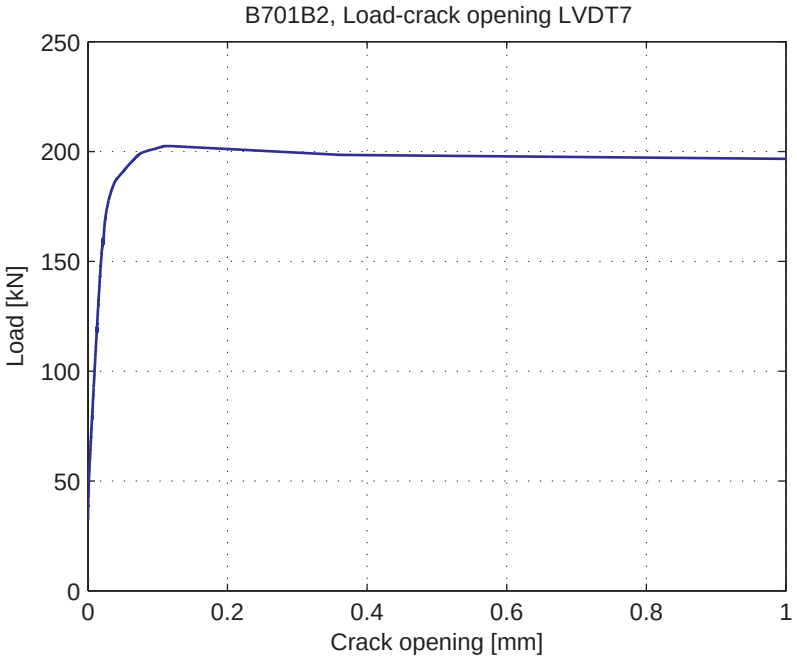


Fig. 5.44.8. Load-Crack opening for LVDT7

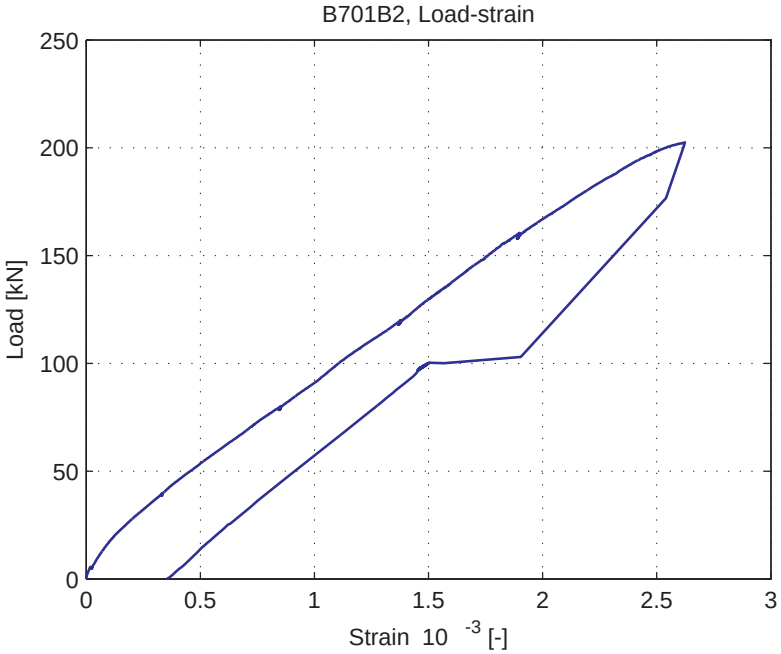


Fig. 5.44.9. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.45. B702A1

5.45.1. Test properties

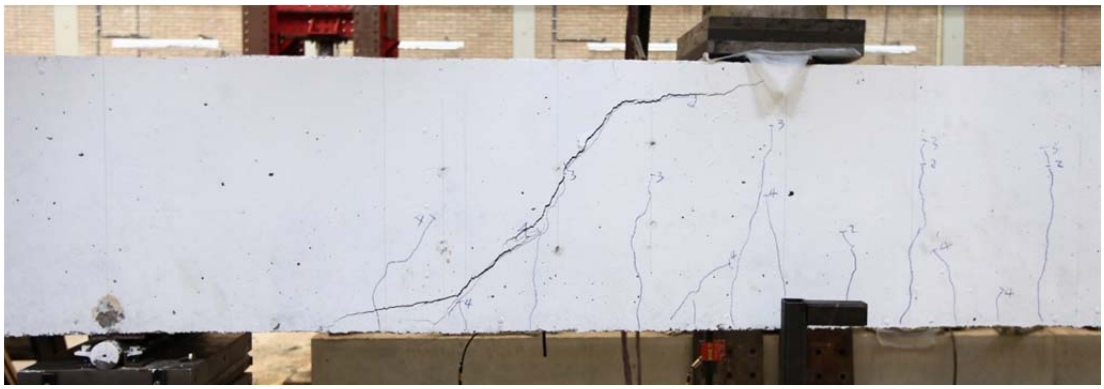


Fig. 5.45.1. Crack pattern after failure north side

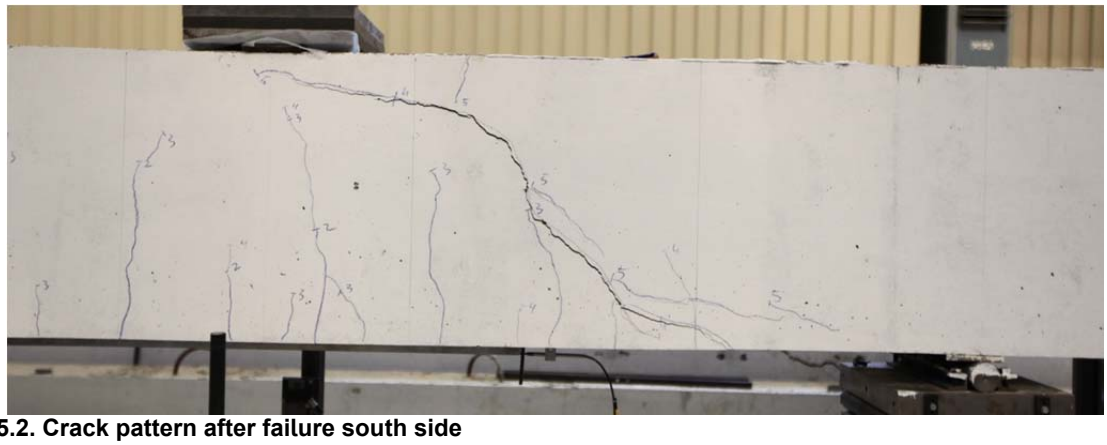


Fig. 5.45.2. Crack pattern after failure south side

Table 5.45.1. Beam properties

Date of test	12-08-2015
Reinforcement	3Ø20
Reinforcement ratio	0.67%
a	1250 mm
a / *d*	2.65
Concrete cube strength at testing	81.7 MPa
Peak load	183.2 kN
Failure mode	Shear

Table 5.45.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	60	
2	80	
3	120	Placed LVDT's 4-6. Stopped for video
4	170	
5	183.2	Shear failure

Table 5.45.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	705	150
5	North	Vertical	920	150
6	North	Vertical	1095	200

5.45.2. Measurement results

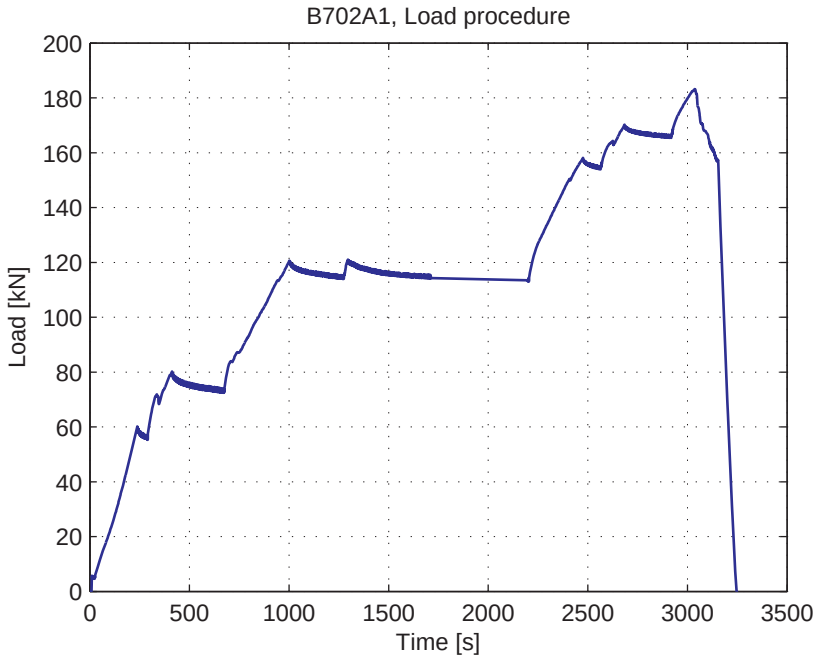


Fig. 5.45.3. Load-Time curve

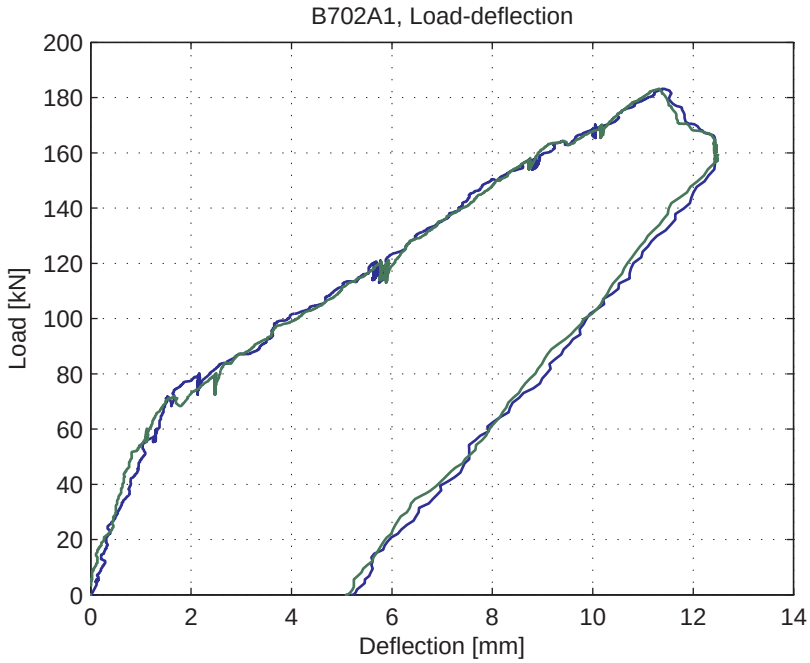


Fig. 5.45.4. Load-deflection curve

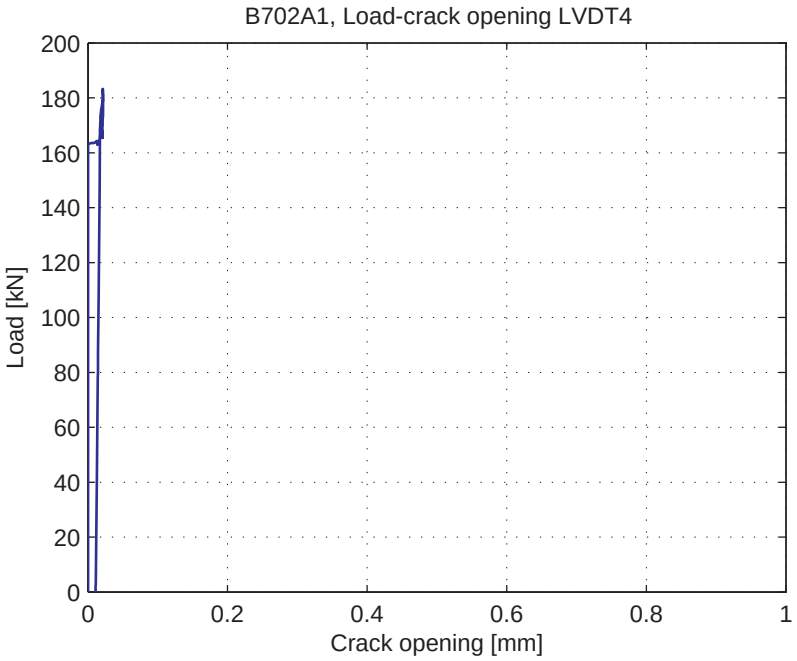


Fig. 5.45.5. Load-Crack opening for LVDT4

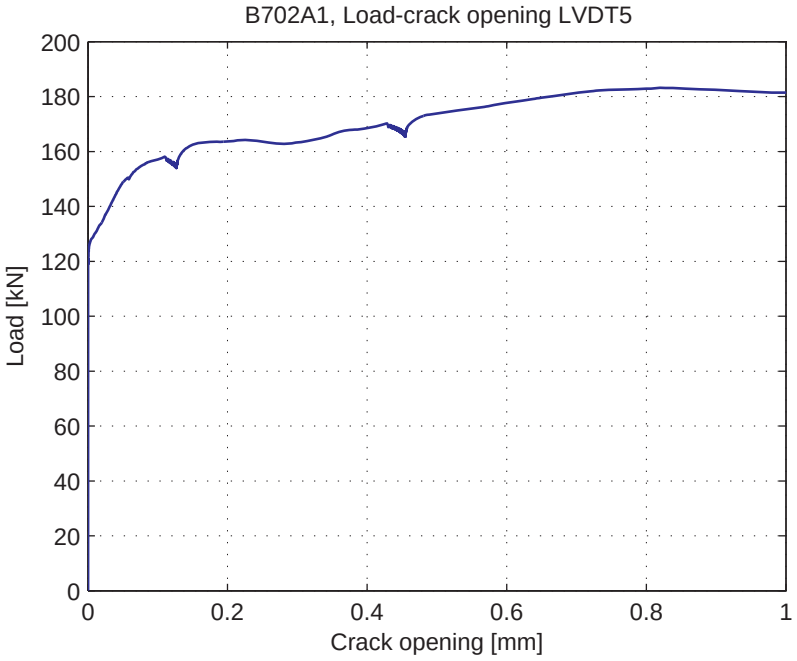


Fig. 5.45.6. Load-Crack opening for LVDT5

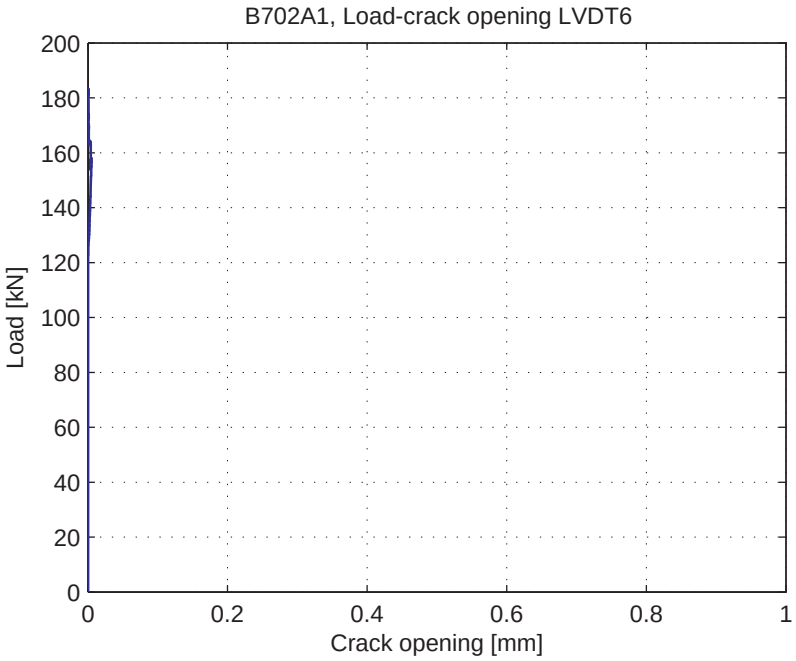


Fig. 5.45.7. Load-Crack opening for LVDT6

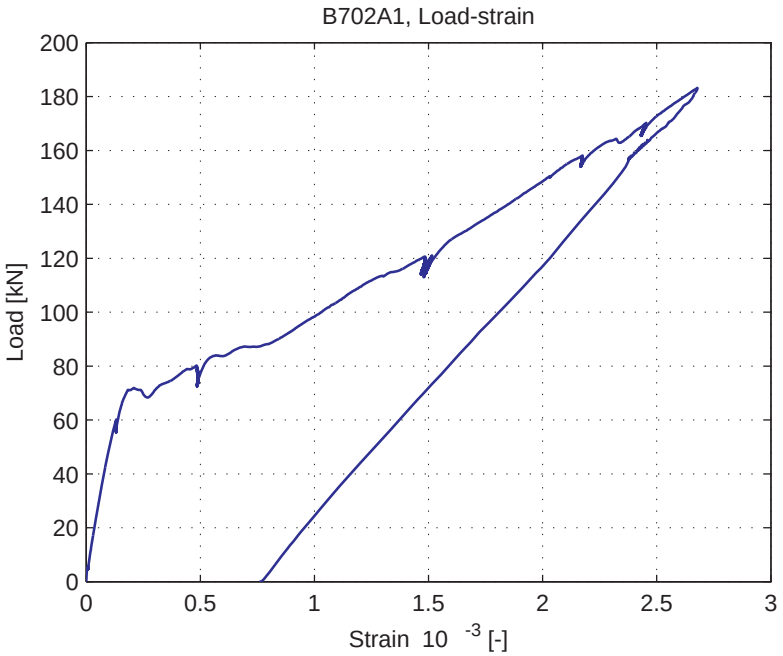


Fig. 5.45.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.46. B702B1

5.46.1. Test properties

Fig. 5.46.1. Crack pattern after failure north side

Fig. 5.46.2. Crack pattern after failure south side

Table 5.46.1. Beam properties

Date of test	12-08-2015
Reinforcement	3Ø20
Reinforcement ratio	0.67%
a	1450 mm
a / *d*	3.08
Concrete cube strength at testing	81.7 MPa
Peak load	164.9 kN
Failure mode	Shear

Table 5.46.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	80	
2	120	Placed LVDT's 4-6
3	160	
4	164.9	Shear failure

Table 5.46.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	750	100
5	North	Vertical	990	150
6	North	Vertical	1240	200

5.46.2. Measurement results

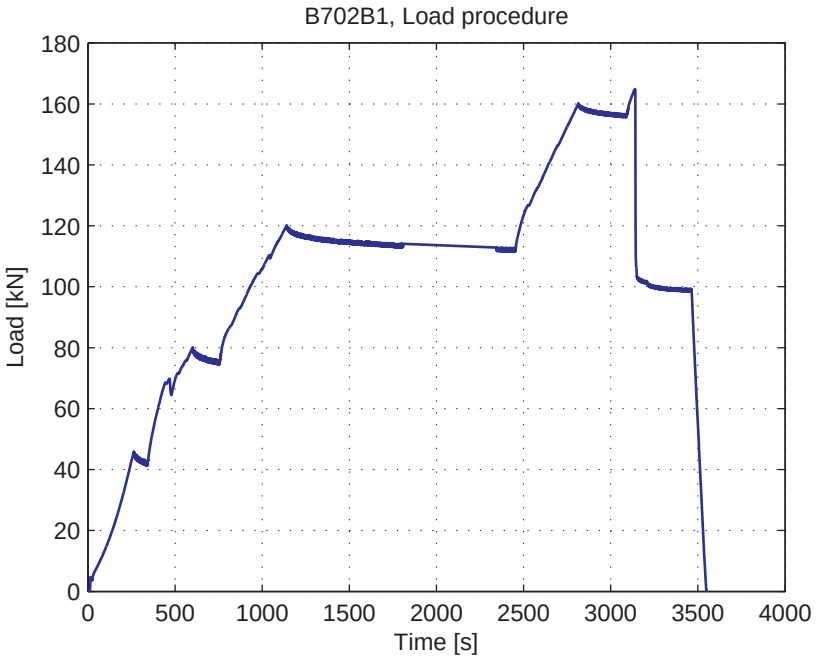


Fig. 5.46.3. Load-Time curve

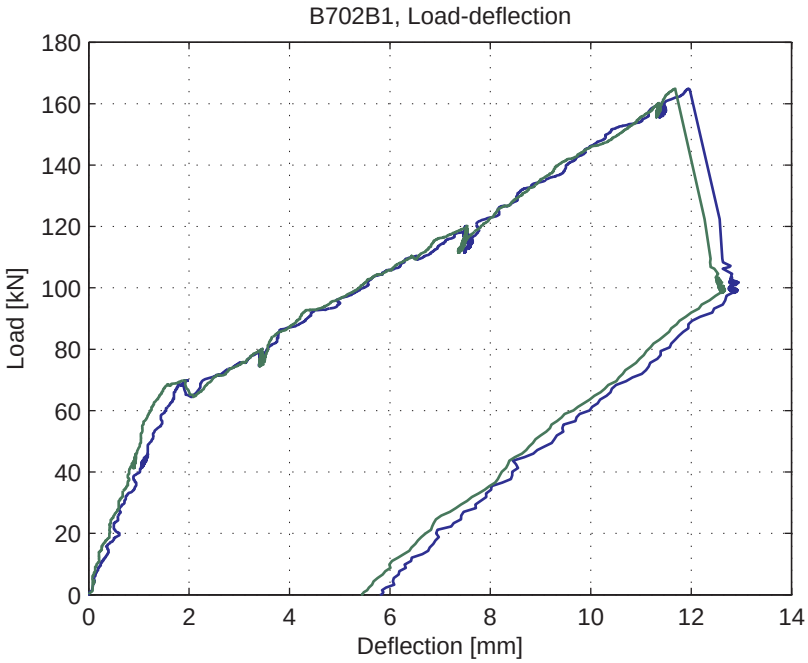


Fig. 5.46.4. Load-deflection curve

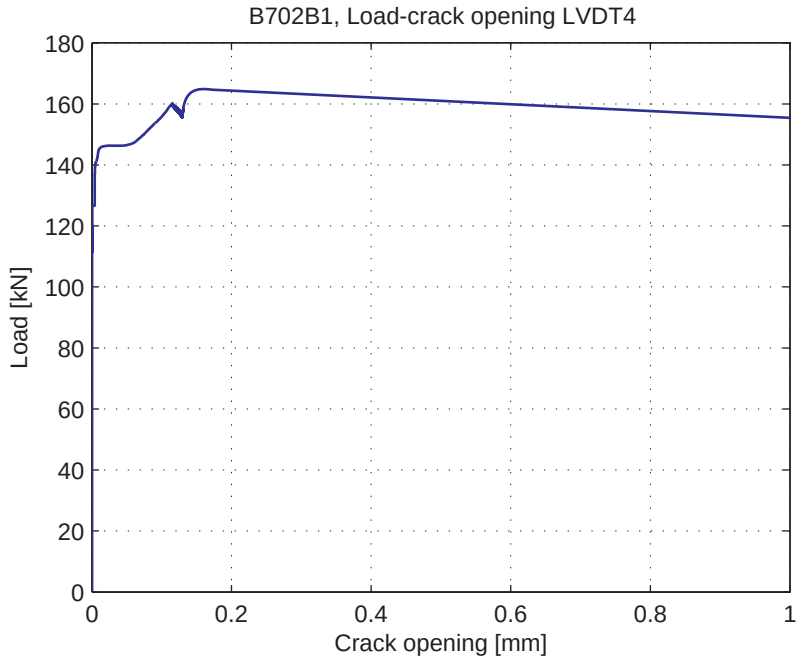


Fig. 5.46.5. Load-Crack opening for LVDT4

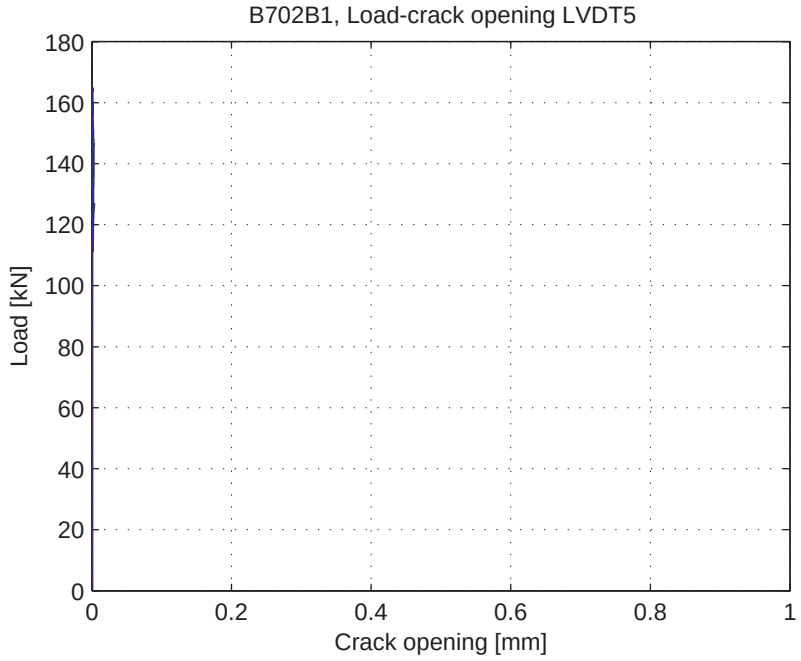


Fig. 5.46.6. Load-Crack opening for LVDT5

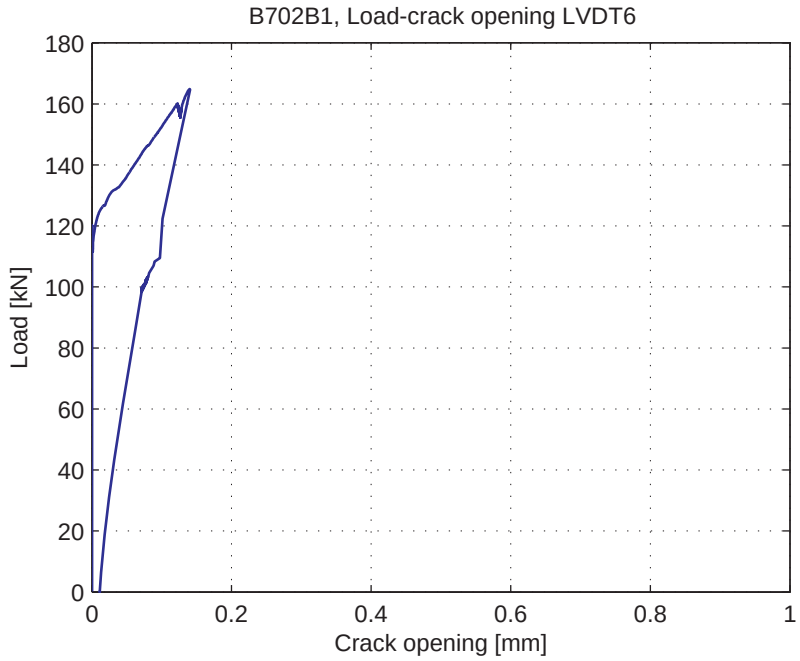


Fig. 5.46.7. Load-Crack opening for LVDT6

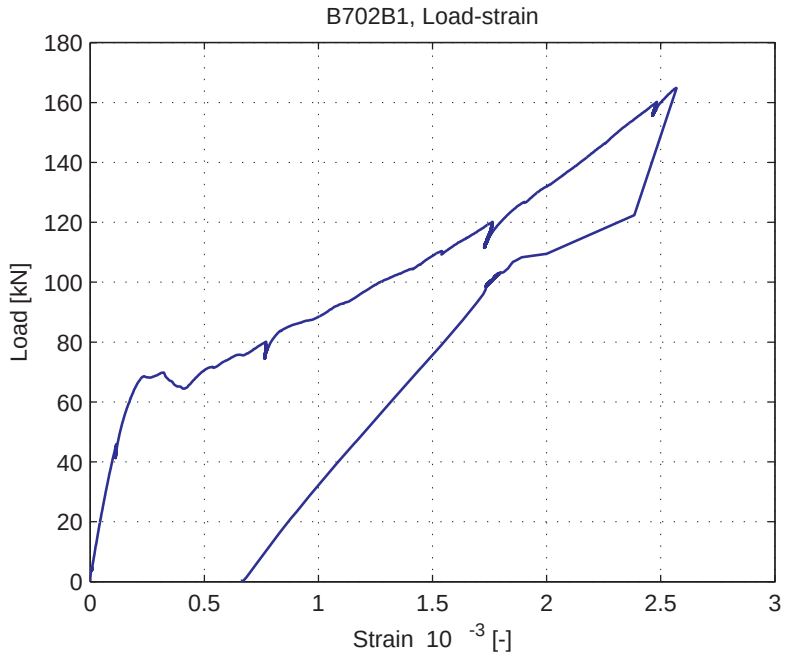


Fig. 5.46.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.47. B501A1

5.47.1. Test properties

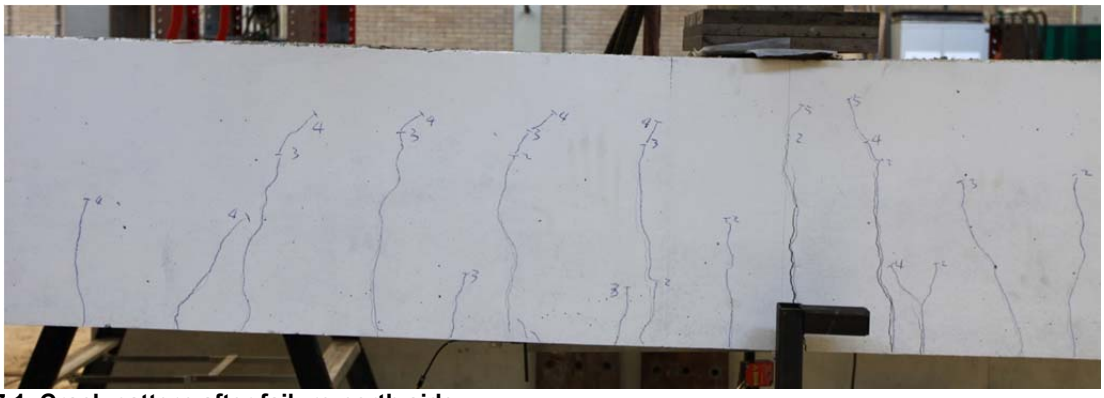


Fig. 5.47.1. Crack pattern after failure north side

Fig. 5.47.2. Crack pattern after failure south side

Table 5.47.1. Beam properties

Date of test	13-08-2015
Reinforcement	2Ø20 + 1Ø16
Reinforcement ratio	0.59%
a	2000 mm
a / *d*	4.24
Concrete cube strength at testing	81.8 MPa
Peak load	168.5 kN
Failure mode	Flexural

Table 5.47.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	80	
3	120	
4	160	
5	172.3	First yielding at 168.5 kN. Stopped after jack displacement of 30 mm

5.47.2. Measurement results

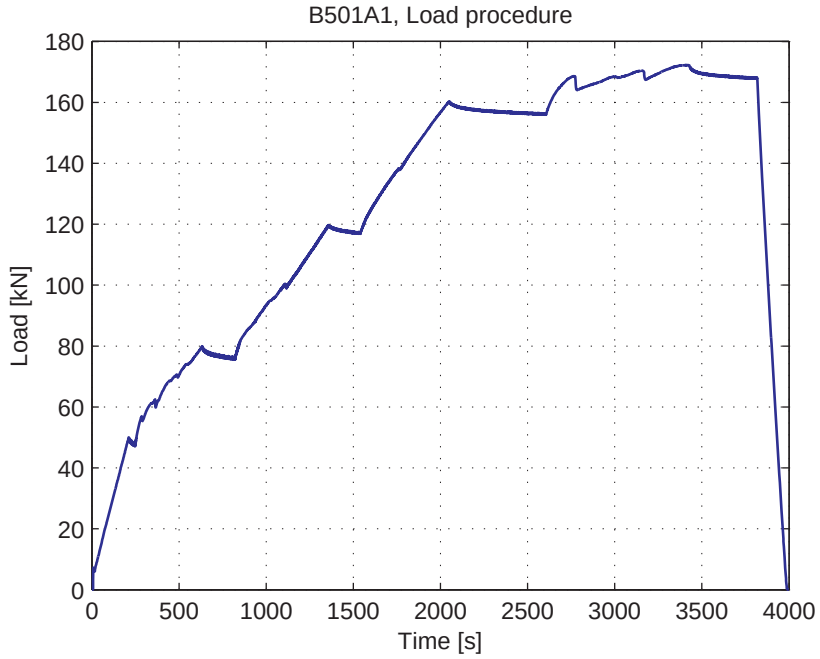


Fig. 5.47.3. Load-Time curve

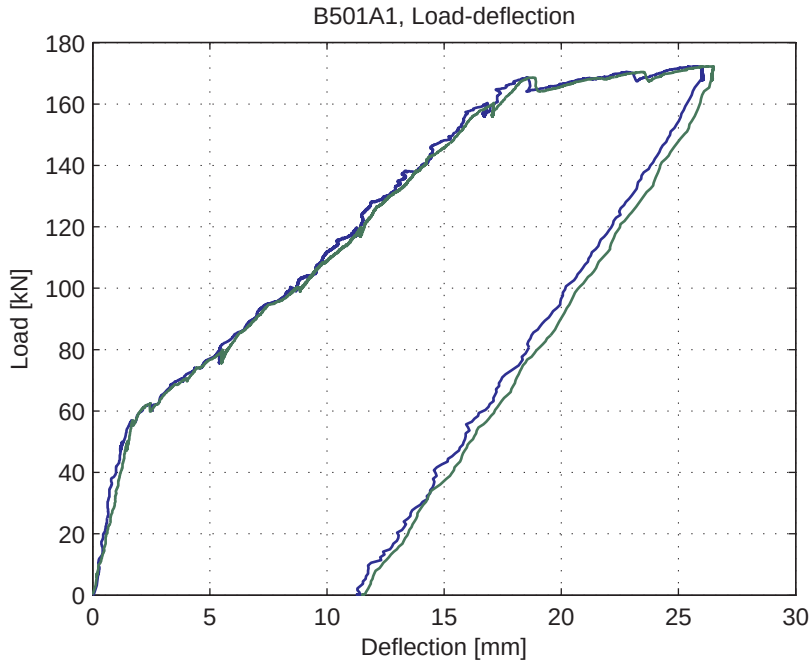


Fig. 5.47.4. Load-deflection curve

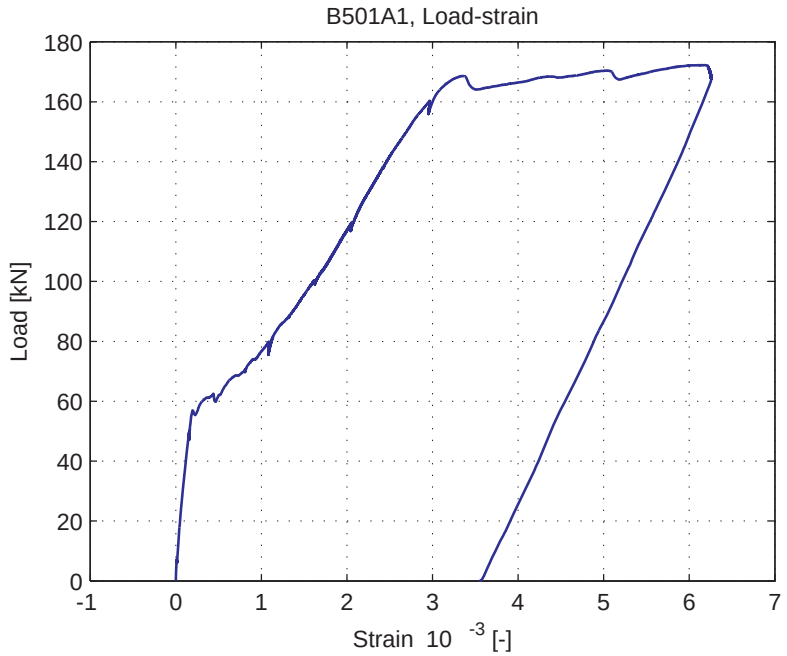


Fig. 5.47.5. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.48. B501A2

5.48.1. Test properties

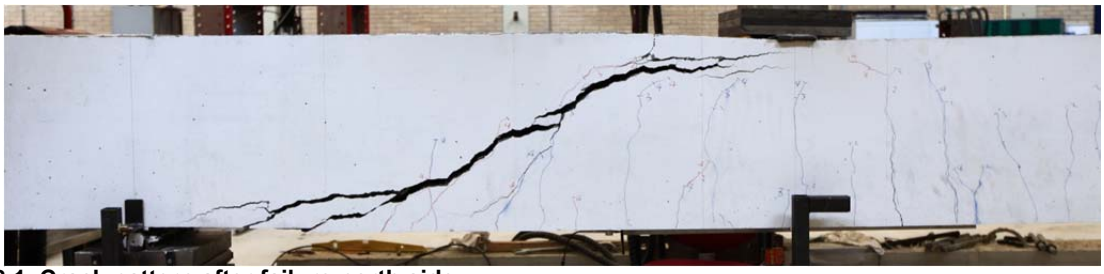


Fig. 5.48.1. Crack pattern after failure north side

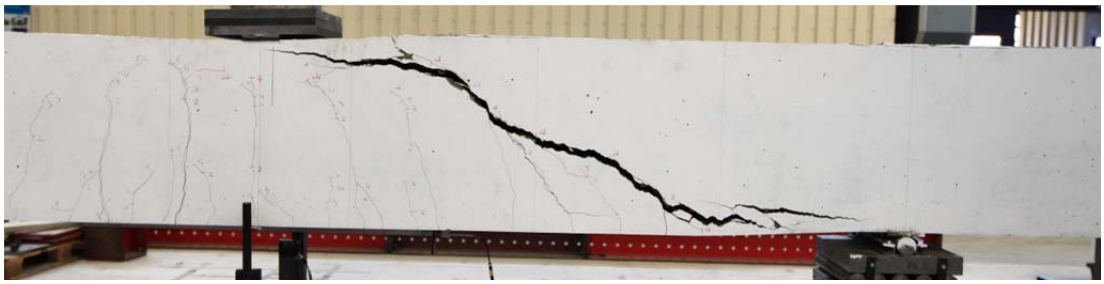


Fig. 5.48.2. Crack pattern after failure south side

Table 5.48.1. Beam properties

Date of test	14-08-2015
Reinforcement	2Ø20 + 1Ø16
Reinforcement ratio	0.59%
a	1750 mm
a / *d*	3.71
Concrete cube strength at testing	81.8 MPa
Peak load	166.4 kN
Failure mode	Shear

Table 5.48.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	80	
3	120	
4	166.4	Shear failure

5.48.2. Measurement results

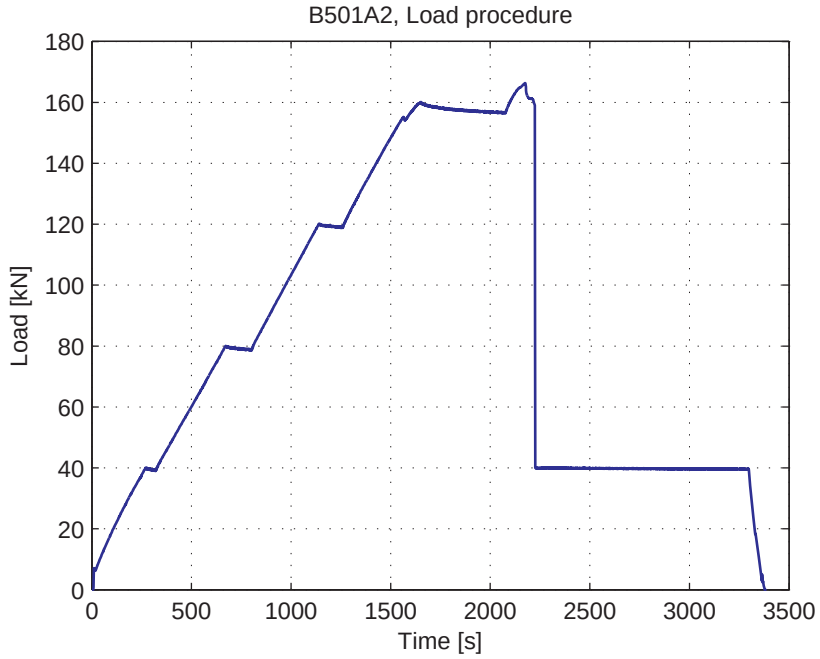


Fig. 5.48.3. Load-Time curve

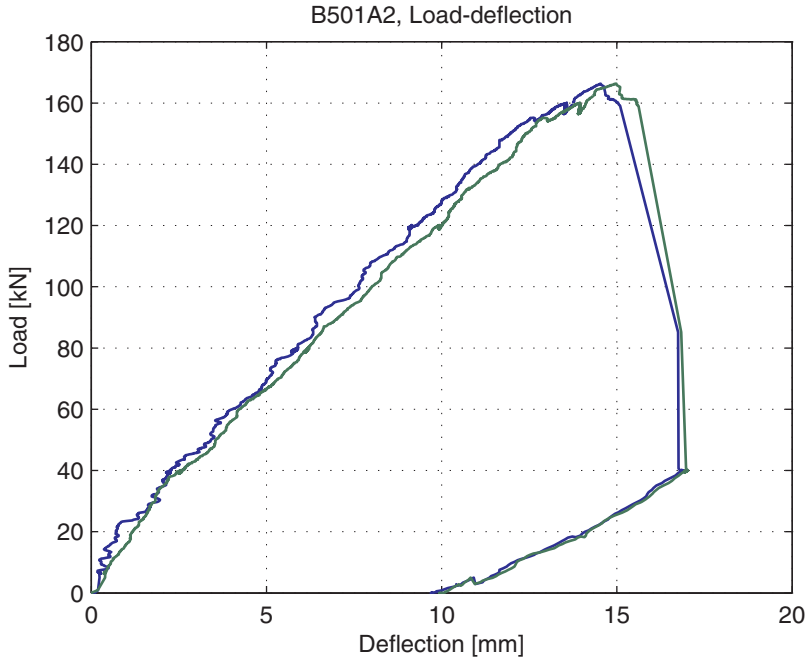


Fig. 5.48.4. Load-deflection curve

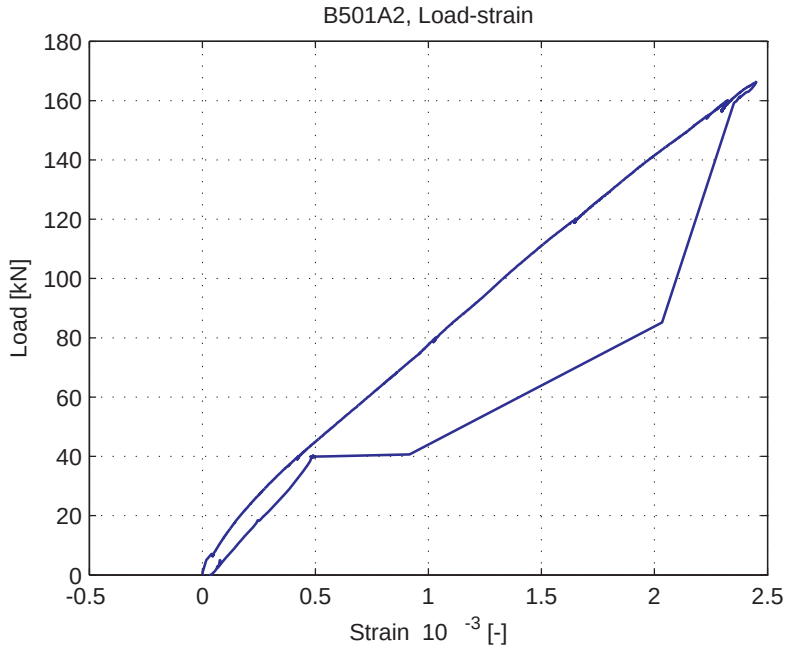


Fig. 5.48.5. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.49. B501B1

5.49.1. Test properties

Fig. 5.49.1. Crack pattern after failure north side

Fig. 5.49.2. Crack pattern after failure south side

Table 5.49.1. Beam properties

Date of test	17-08-2015
Reinforcement	2Ø20 + 1Ø16
Reinforcement ratio	0.59%
a	1800 mm
a / *d*	3.82
Concrete cube strength at testing	81.8 MPa
Peak load	165.7 kN
Failure mode	Shear

Table 5.49.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	80	
3	120	Placed LVDT's 4-6
4	160	
5	165.7	Shear failure

Table 5.49.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	670	100
5	North	Vertical	980	150
6	North	Vertical	1260	200

5.49.2. Measurement results

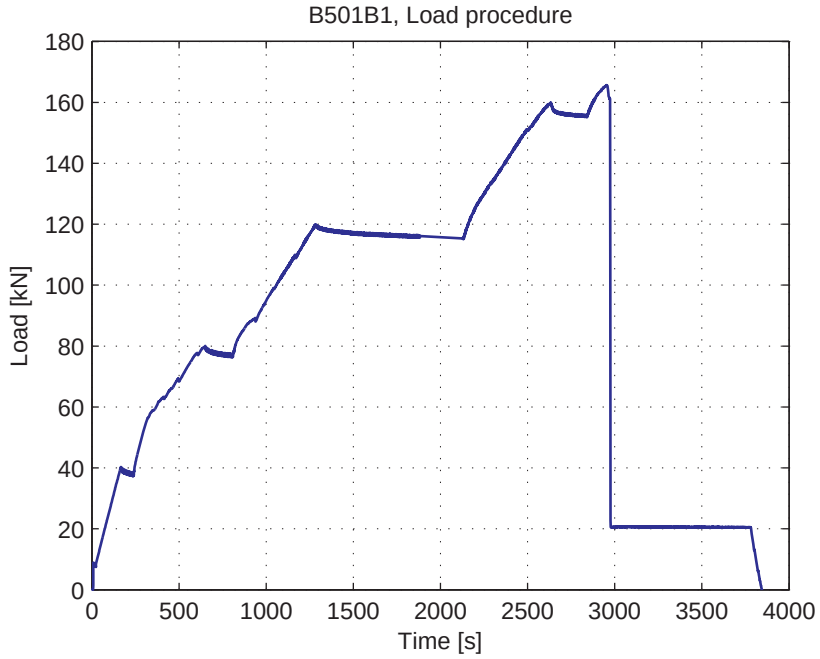


Fig. 5.49.3. Load-Time curve

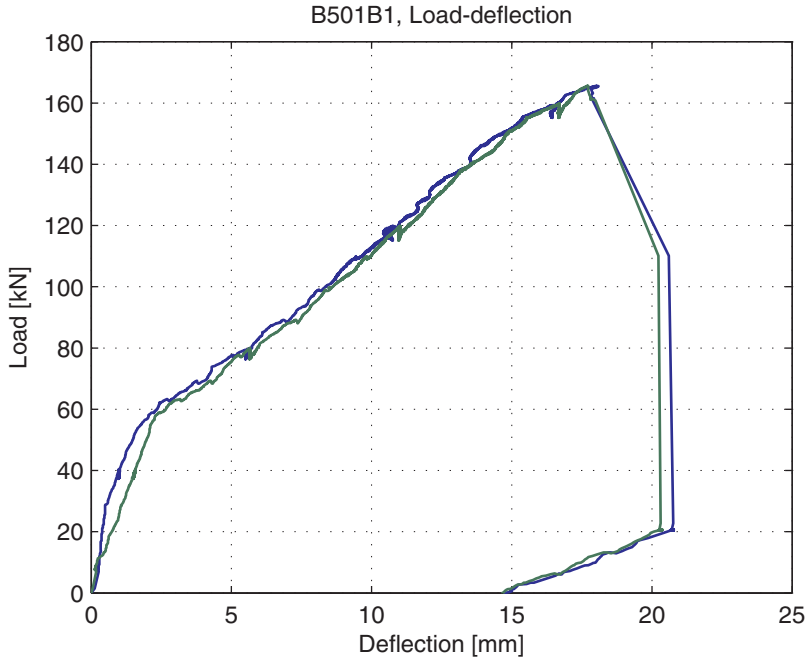


Fig. 5.49.4. Load-deflection curve

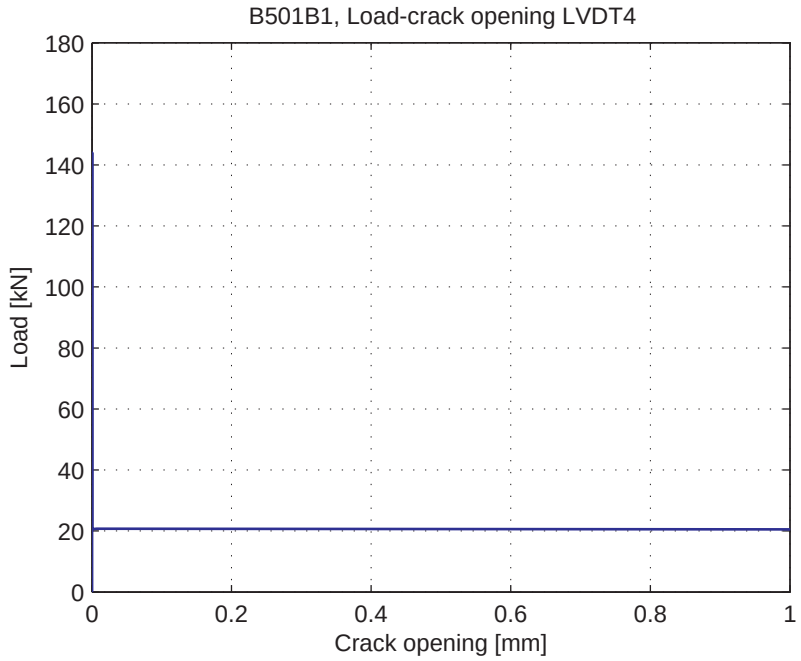


Fig. 5.49.5. Load-Crack opening for LVDT4

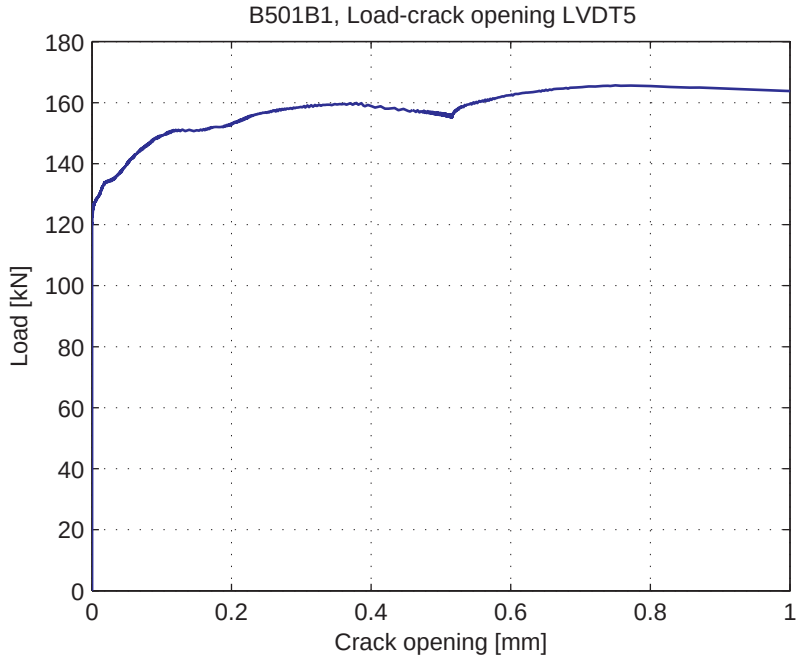


Fig. 5.49.6. Load-Crack opening for LVDT5

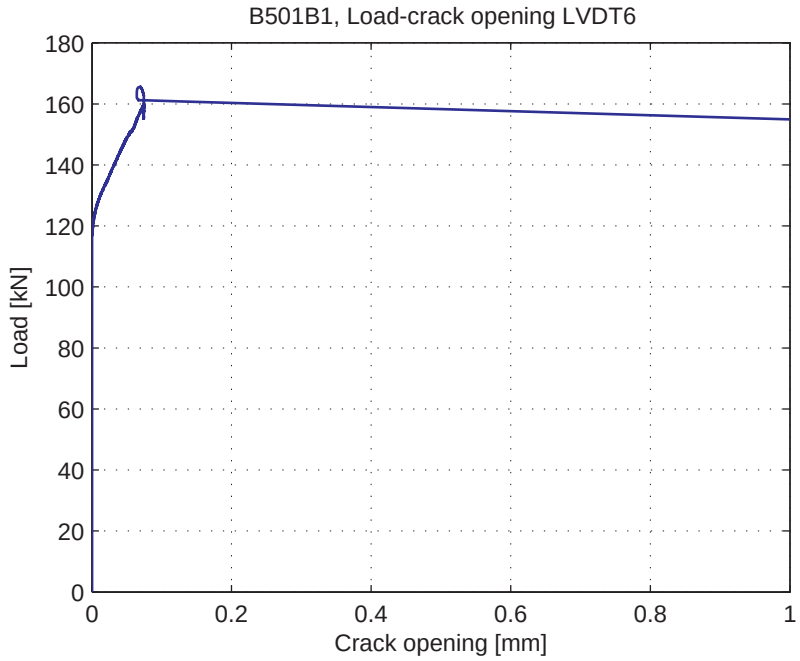


Fig. 5.49.7. Load-Crack opening for LVDT6

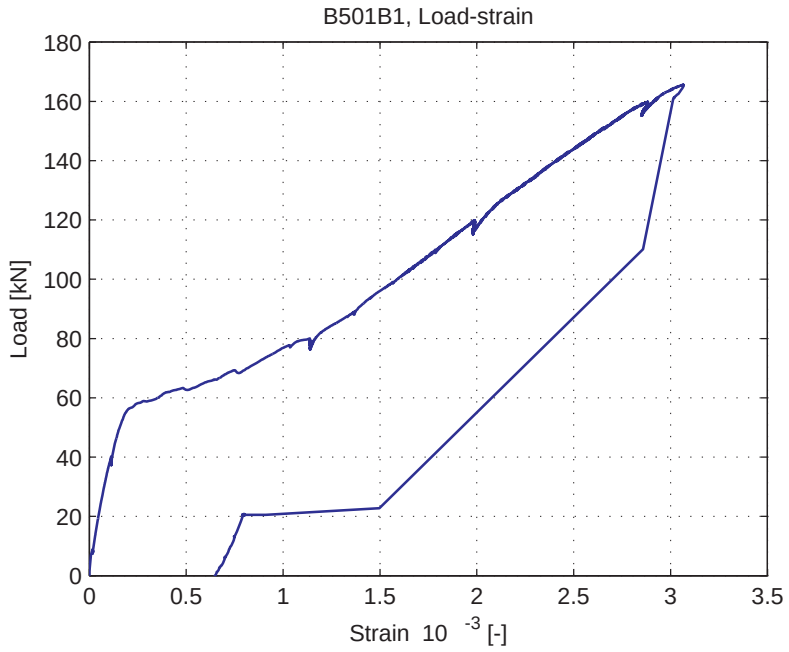


Fig. 5.49.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.50. B502A1

5.50.1. Test properties

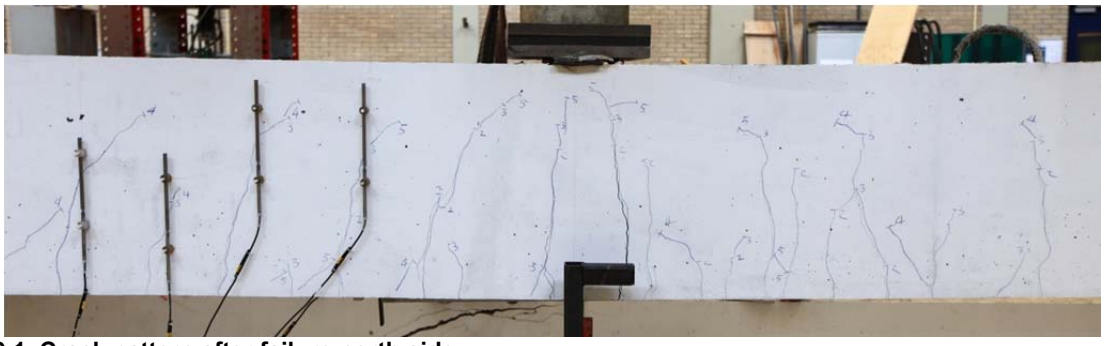


Fig. 5.50.1. Crack pattern after failure north side

Fig. 5.50.2. Crack pattern after failure south side

Table 5.50.1. Beam properties

Date of test	18-08-2015
Reinforcement	2Ø20 + 1Ø16
Reinforcement ratio	0.59%
a	1900 mm
a / *d*	4.03
Concrete cube strength at testing	81.9 MPa
Peak load	166.9 kN
Failure mode	Flexural

Table 5.50.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	80	
3	120	Placed LVDT's 4-6
4	160	
5	174.5	First yielding at 166 kN. Stopped after jack displacement of 30 mm

Table 5.50.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	1040	100
5	North	Vertical	1235	250
6	North	Vertical	1455	250
7	North	Vertical	870	150

5.50.2. Measurement results

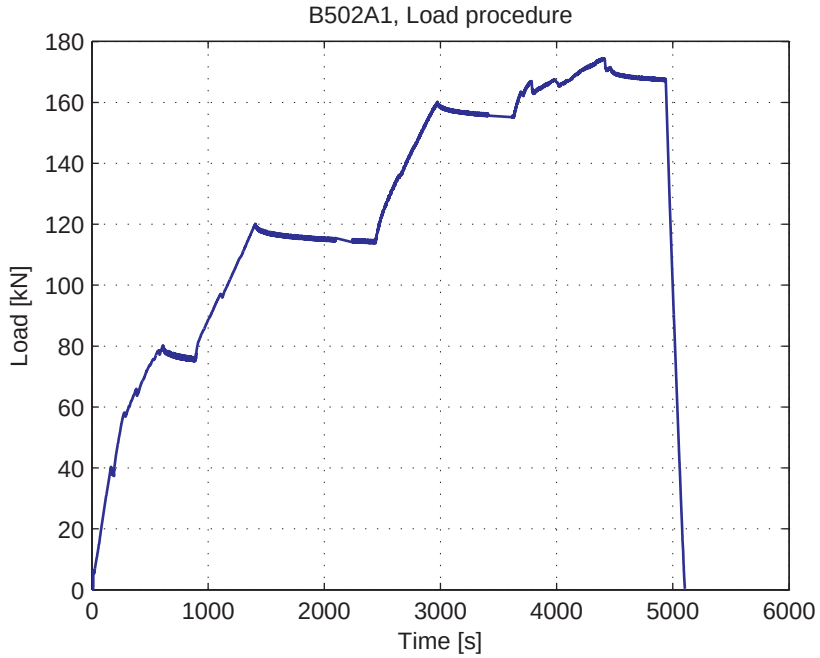


Fig. 5.50.3. Load-Time curve

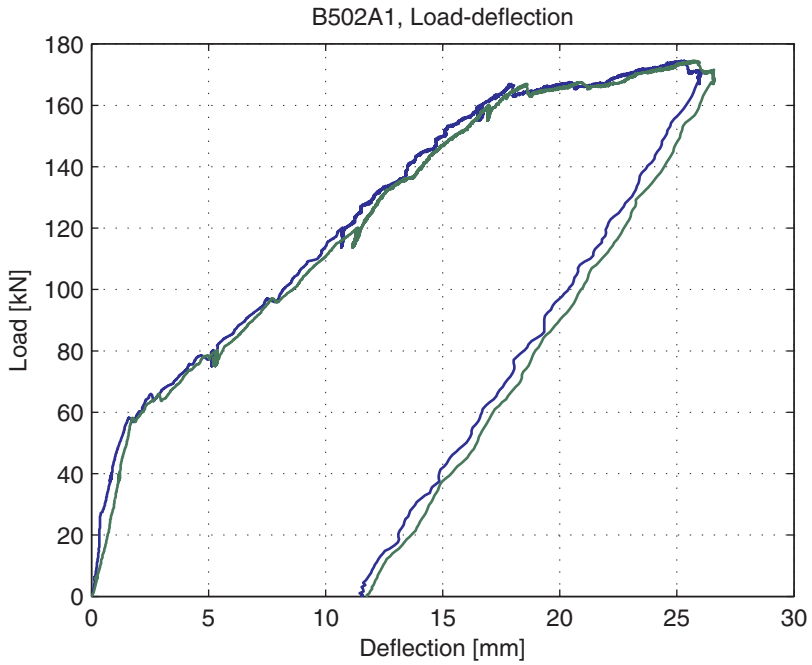


Fig. 5.50.4. Load-deflection curve

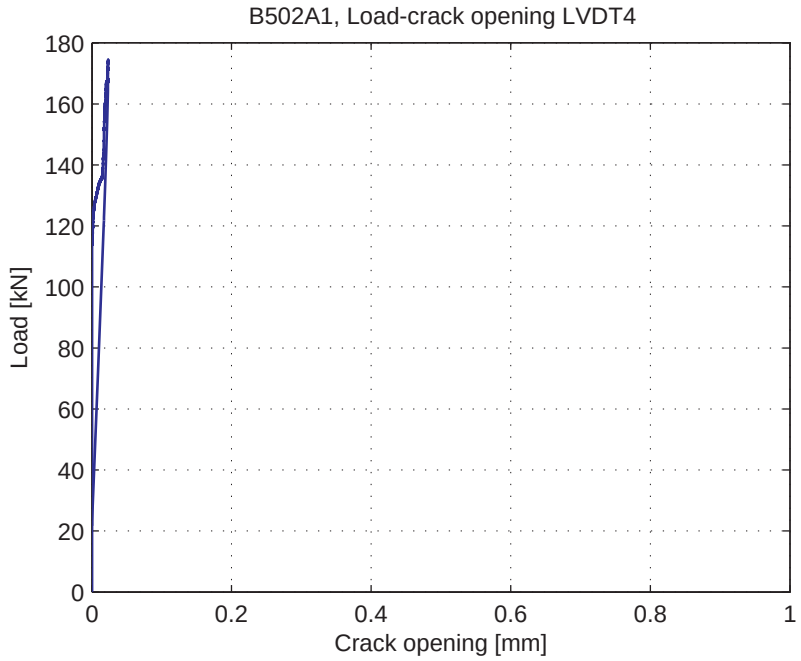


Fig. 5.50.5. Load-Crack opening for LVDT4

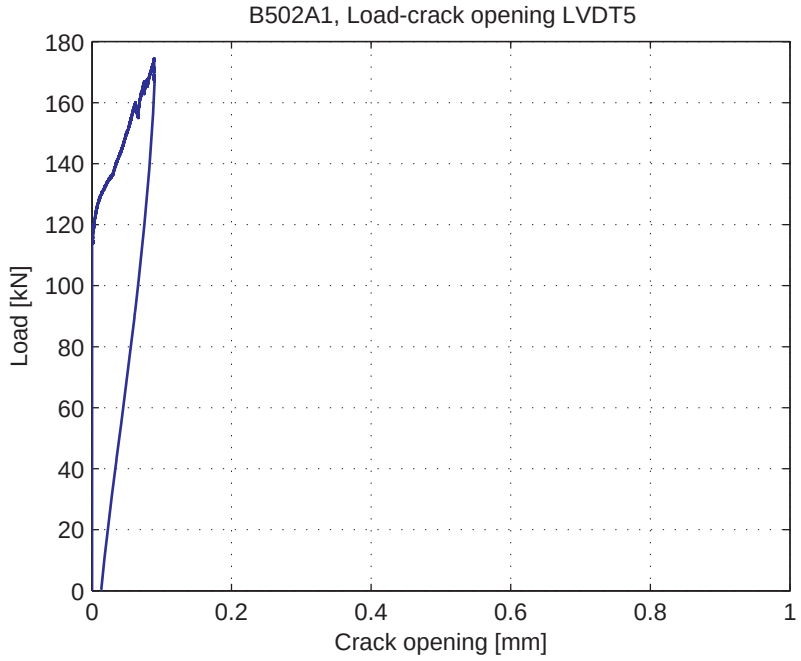


Fig. 5.50.6. Load-Crack opening for LVDT5

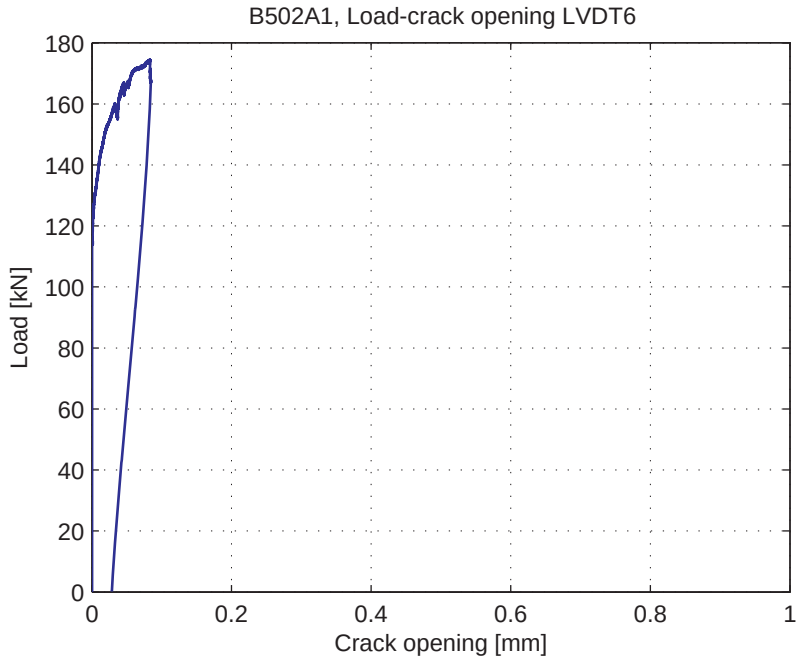


Fig. 5.50.7. Load-Crack opening for LVDT6

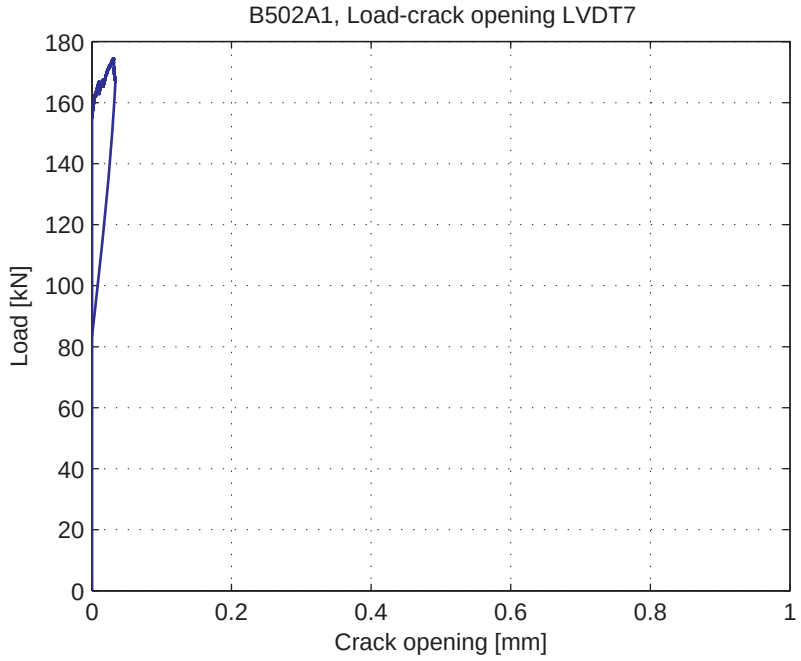


Fig. 5.50.8. Load-Crack opening for LVDT7

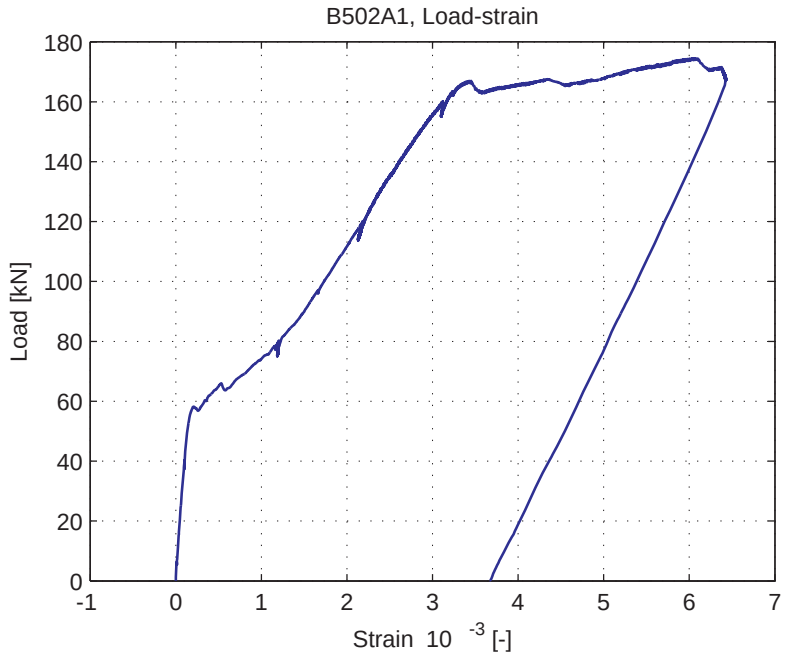


Fig. 5.50.9. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.51. B502A2

5.51.1. Test properties

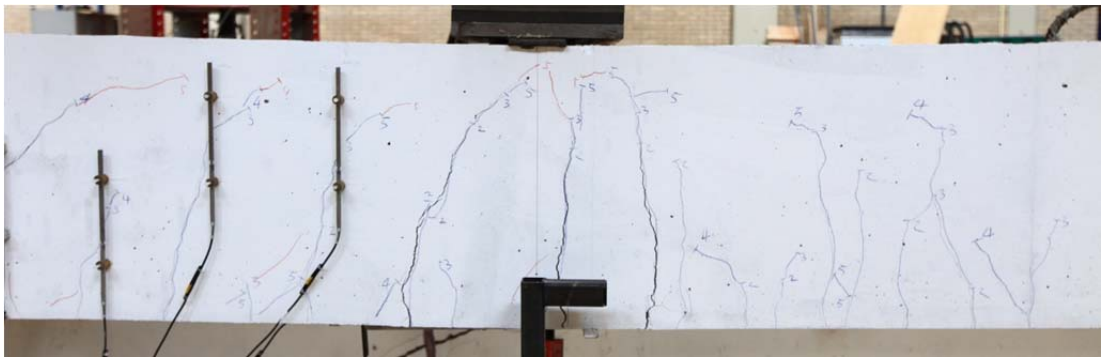


Fig. 5.51.1. Crack pattern after failure north side

Fig. 5.51.2. Crack pattern after failure south side

Table 5.51.1. Beam properties

Date of test	18-08-2015
Reinforcement	2Ø20 + 1Ø16
Reinforcement ratio	0.59%
a	1800 mm
a / *d*	3.81
Concrete cube strength at testing	81.9 MPa
Peak load	175.1 kN
Failure mode	Flexural

Table 5.51.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	160	
2	181.2	Yielding at 175 kN. Stoppefter at jack displacement of 30 mm.

Table 5.51.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	1040	100
5	North	Vertical	1235	250
6	North	Vertical	1455	250
7	North	Vertical	870	150

5.51.2. Measurement results

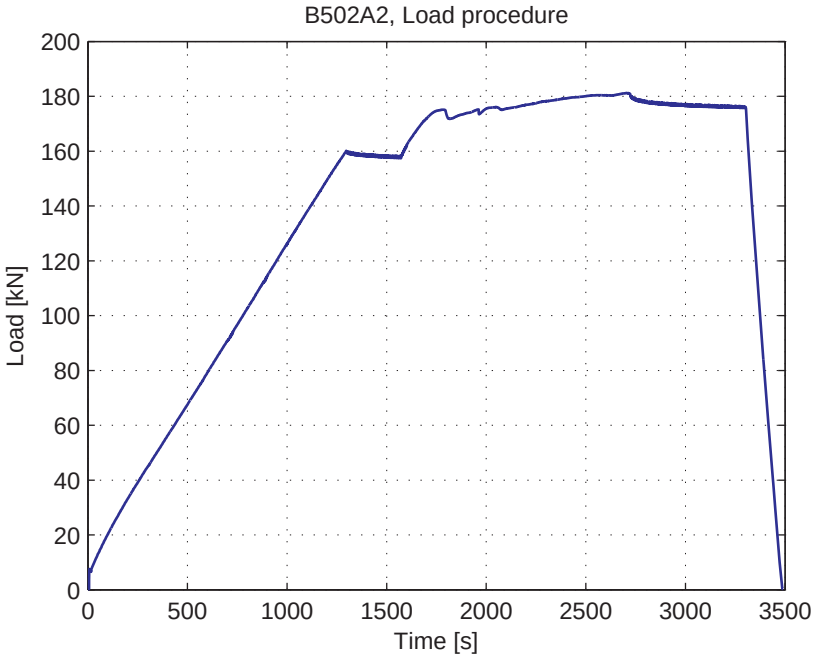


Fig. 5.51.3. Load-Time curve

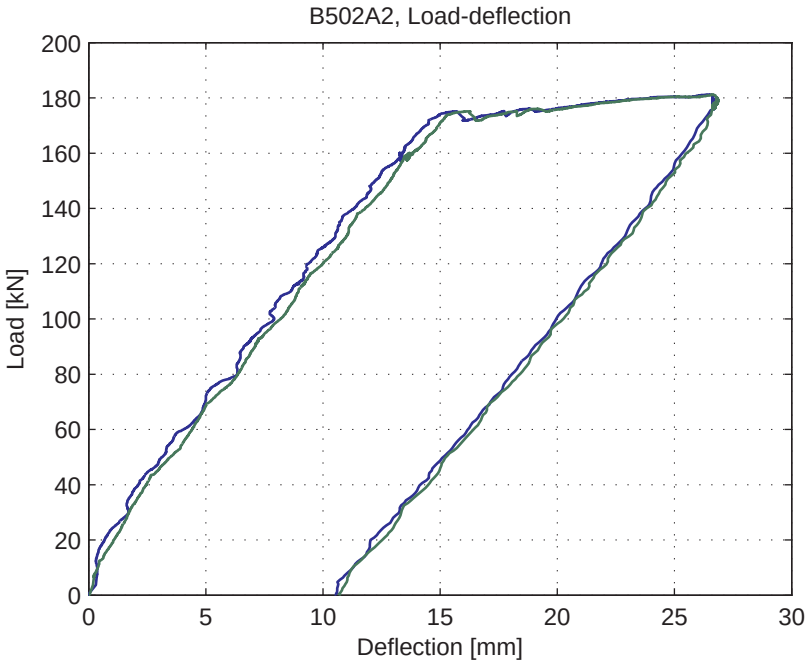


Fig. 5.51.4. Load-deflection curve

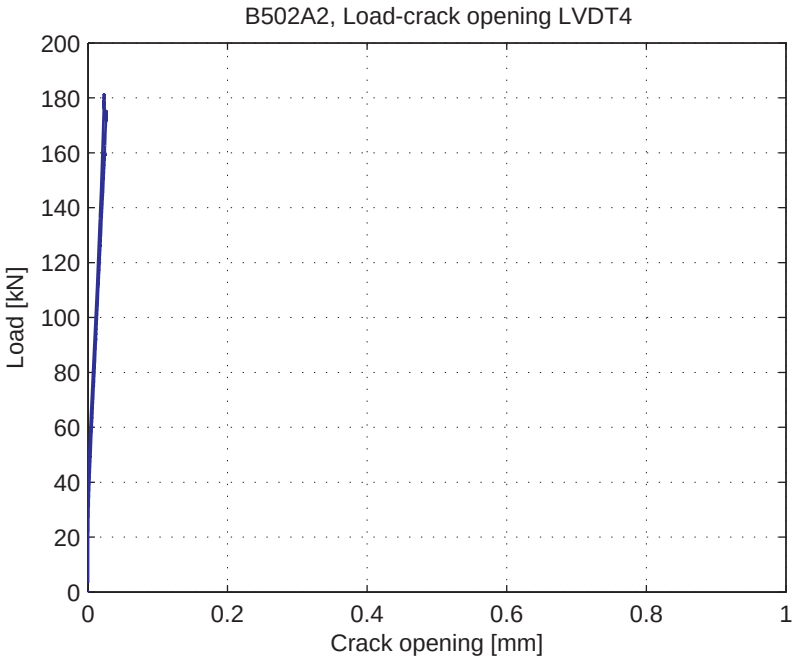


Fig. 5.51.5. Load-Crack opening for LVDT4

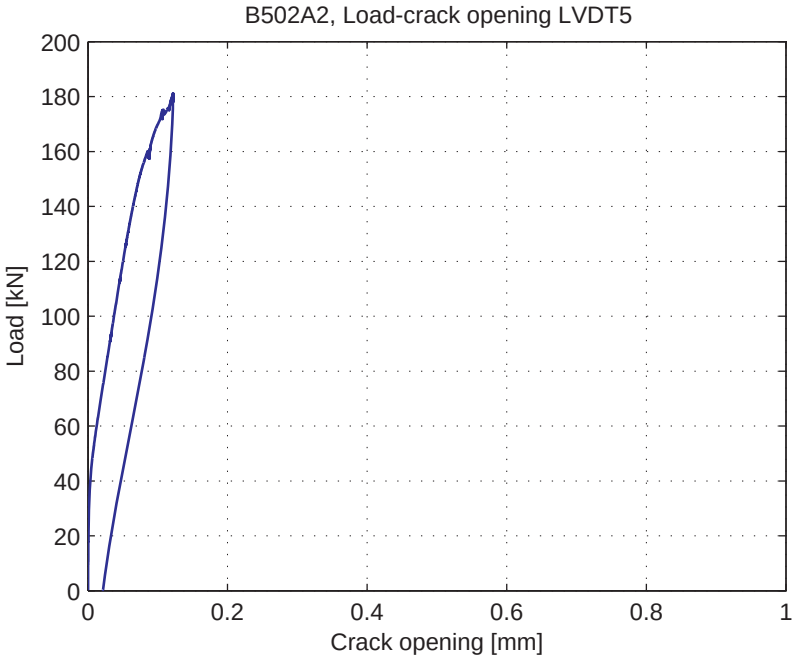


Fig. 5.51.6. Load-Crack opening for LVDT5

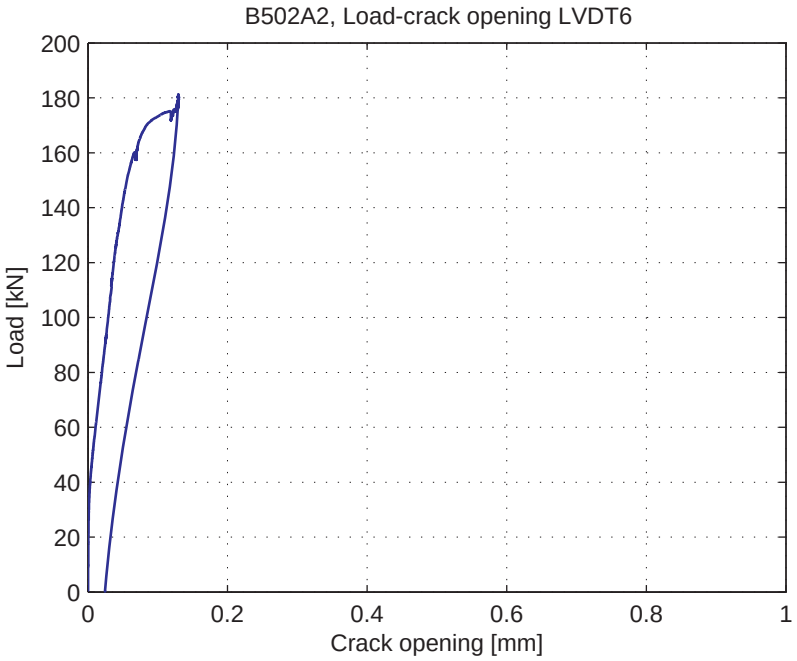


Fig. 5.51.7. Load-Crack opening for LVDT6

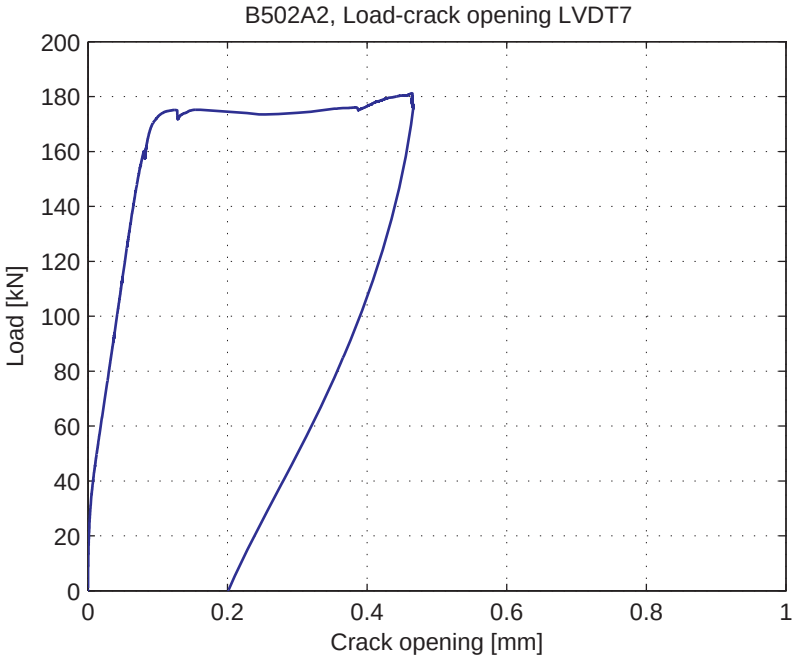


Fig. 5.51.8. Load-Crack opening for LVDT7

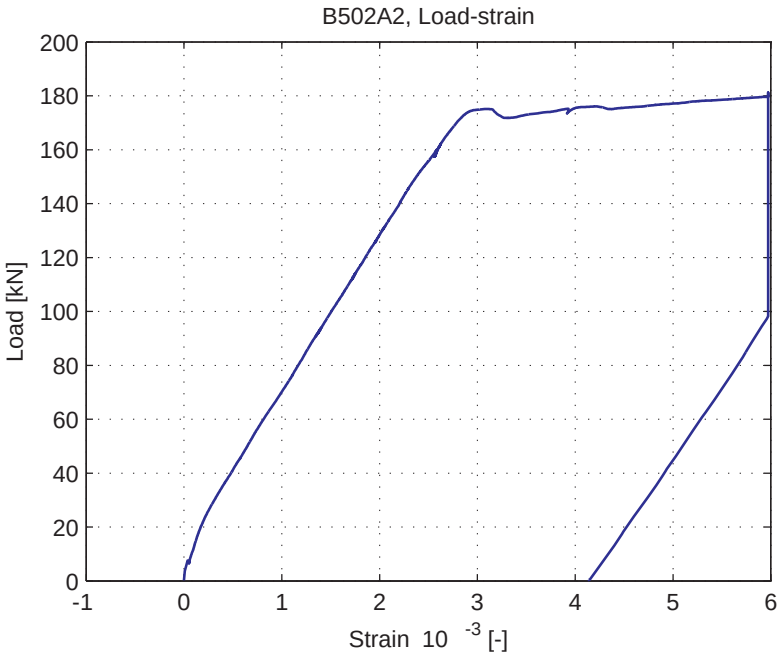


Fig. 5.51.9. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.52. B502A3

5.52.1. Test properties

Fig. 5.52.1. Crack pattern after failure north side

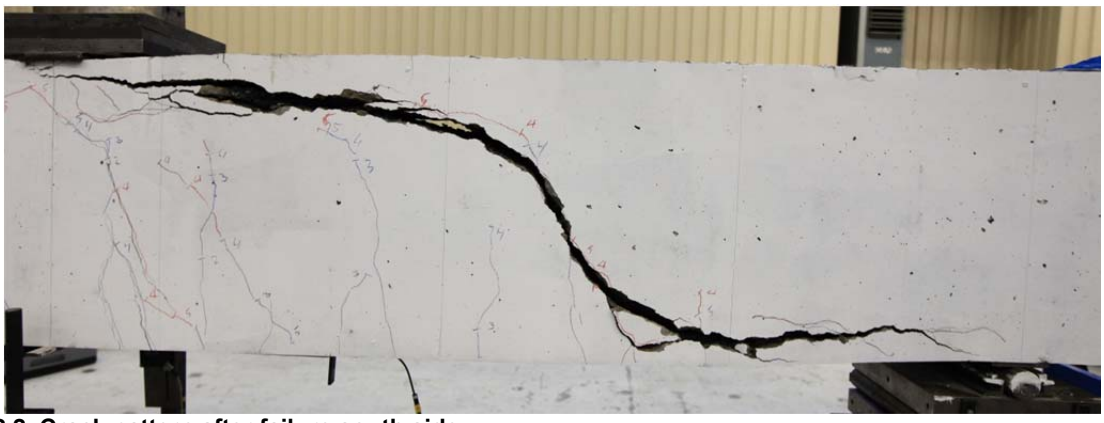


Fig. 5.52.2. Crack pattern after failure south side

Table 5.52.1. Beam properties

Date of test	19-08-2015
Reinforcement	2Ø20 + 1Ø16
Reinforcement ratio	0.59%
a	1700 mm
a / *d*	3.60
Concrete cube strength at testing	81.9 MPa
Peak load	173.6 kN
Failure mode	Shear

Table 5.52.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	120	
2	160	
3	173.6	Shear failure

Table 5.52.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	1040	100
5	North	Vertical	1235	250
6	North	Vertical	1455	250
7	North	Vertical	870	150

5.52.2. Measurement results

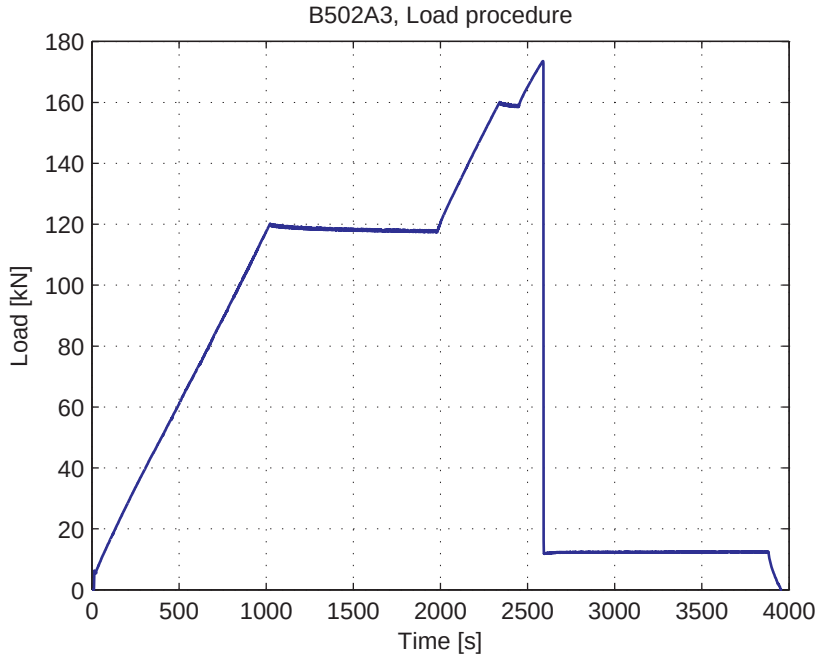


Fig. 5.52.3. Load-Time curve

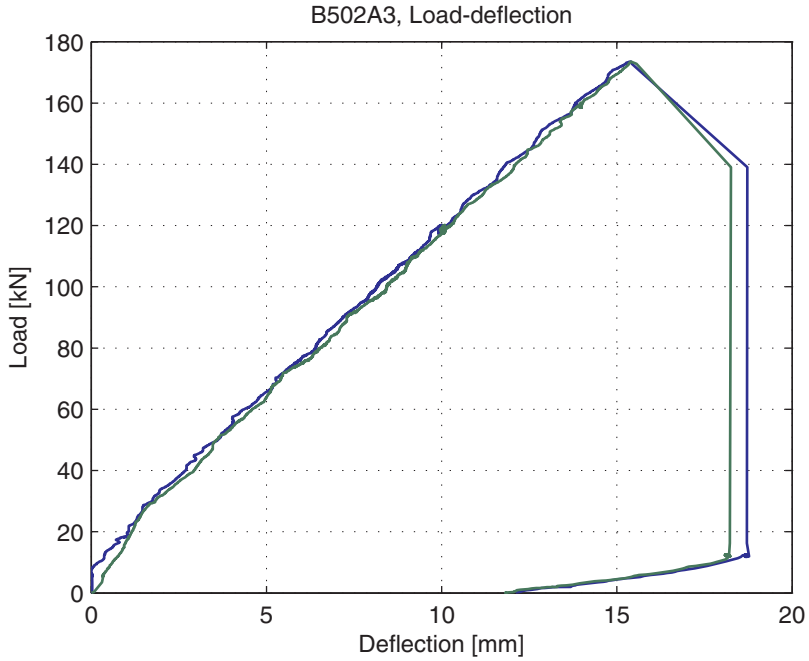


Fig. 5.52.4. Load-deflection curve

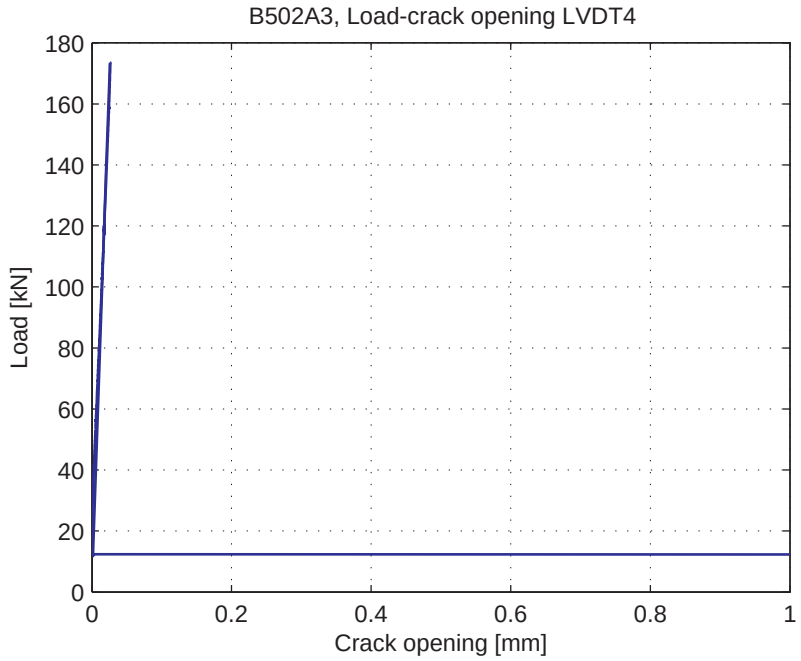


Fig. 5.52.5. Load-Crack opening for LVDT4

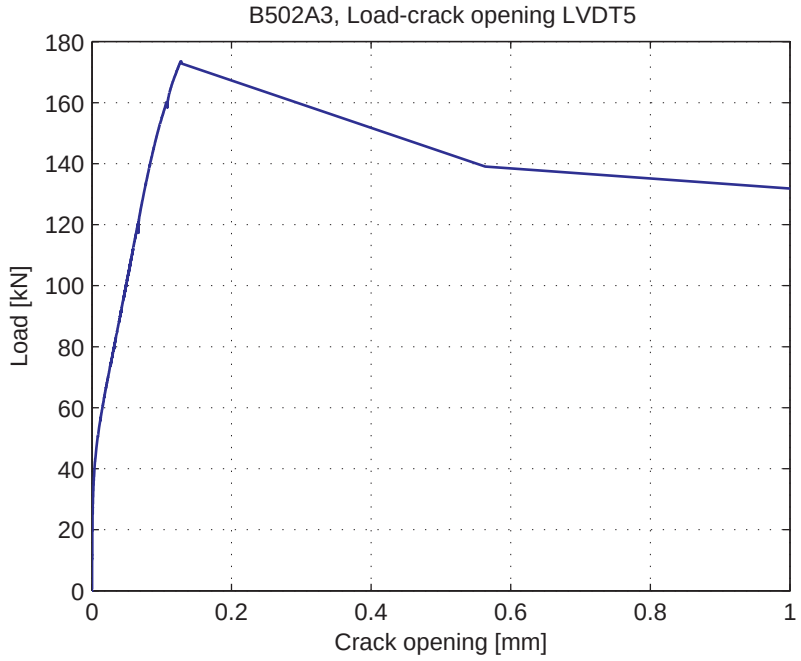


Fig. 5.52.6. Load-Crack opening for LVDT5

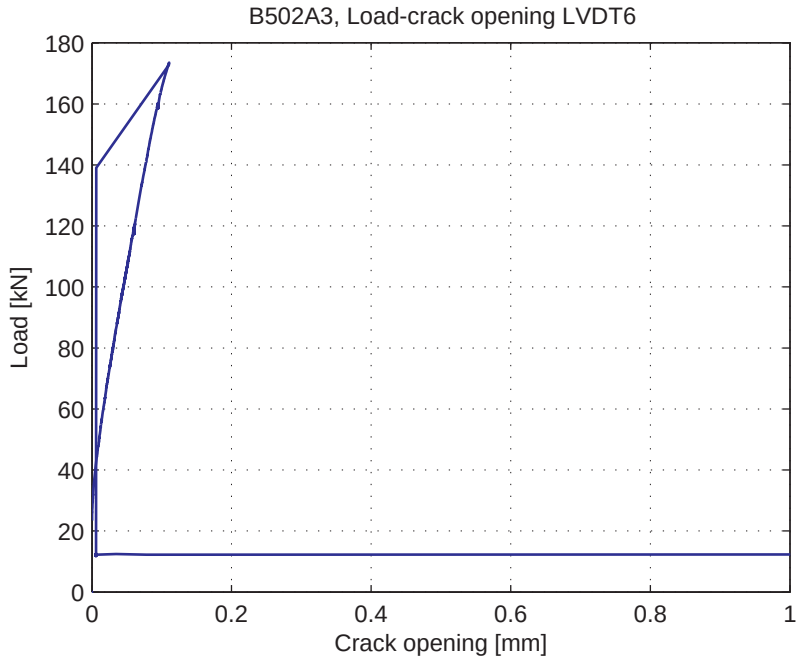


Fig. 5.52.7. Load-Crack opening for LVDT6

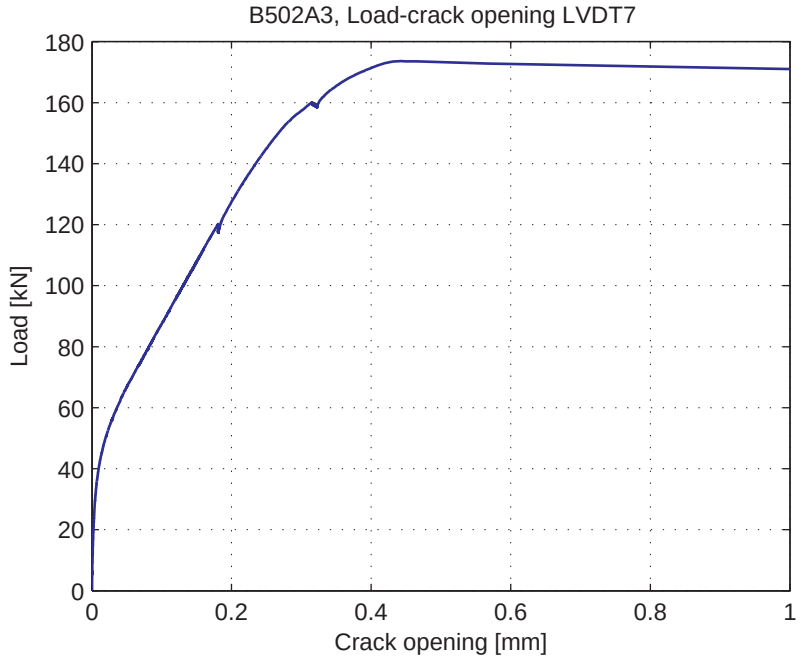


Fig. 5.52.8. Load-Crack opening for LVDT7

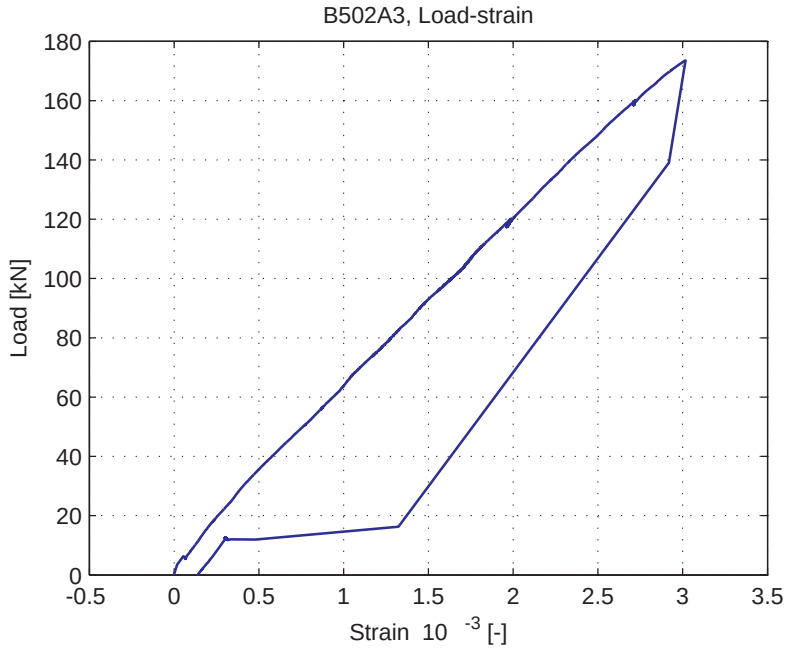


Fig. 5.52.9. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.53. B502B1

5.53.1. Test properties

Fig. 5.53.1. Crack pattern after failure north side

Fig. 5.53.2. Crack pattern after failure south side

Table 5.53.1. Beam properties

Date of test	20-08-2015
Reinforcement	2Ø20 + 1Ø16
Reinforcement ratio	0.59%
a	1700 mm
a / *d*	3.60
Concrete cube strength at testing	81.9 MPa
Peak load	173.2 kN
Failure mode	Shear

Table 5.53.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	40	
2	80	
3	120	
4	130	Placed LVDT's 4-6. Returned to 0 kN for beginning of crack
5	160	Added LVDT 7
6	173.2	Shear failure

Table 5.53.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	890	200
5	North	Vertical	1145	250
6	North	Vertical	1395	250
7	North	Vertical	600	50

5.53.2. Measurement results

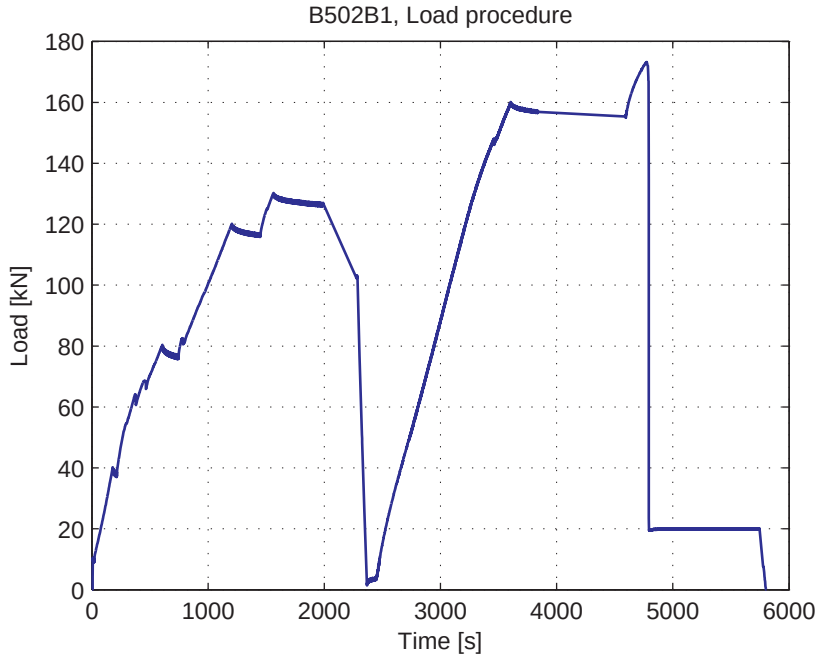


Fig. 5.53.3. Load-Time curve

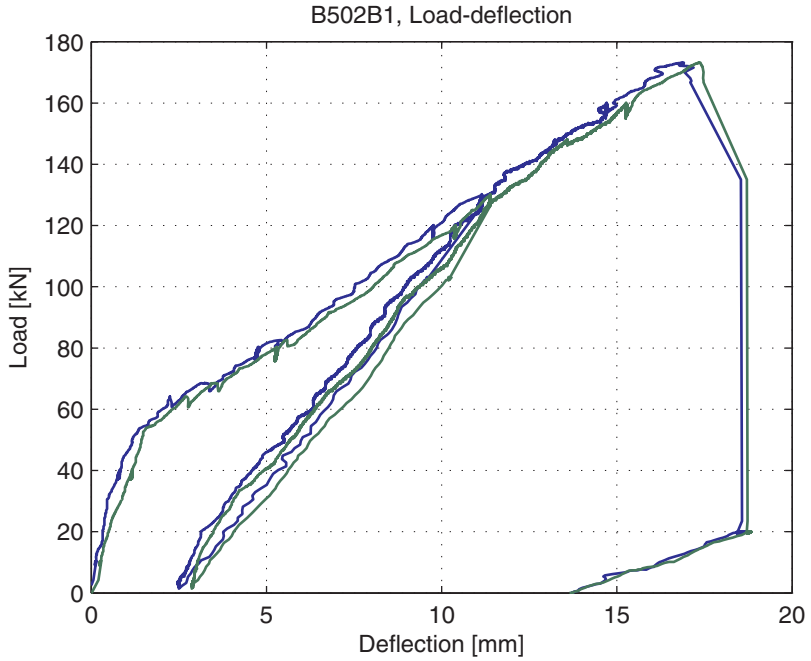


Fig. 5.53.4. Load-deflection curve

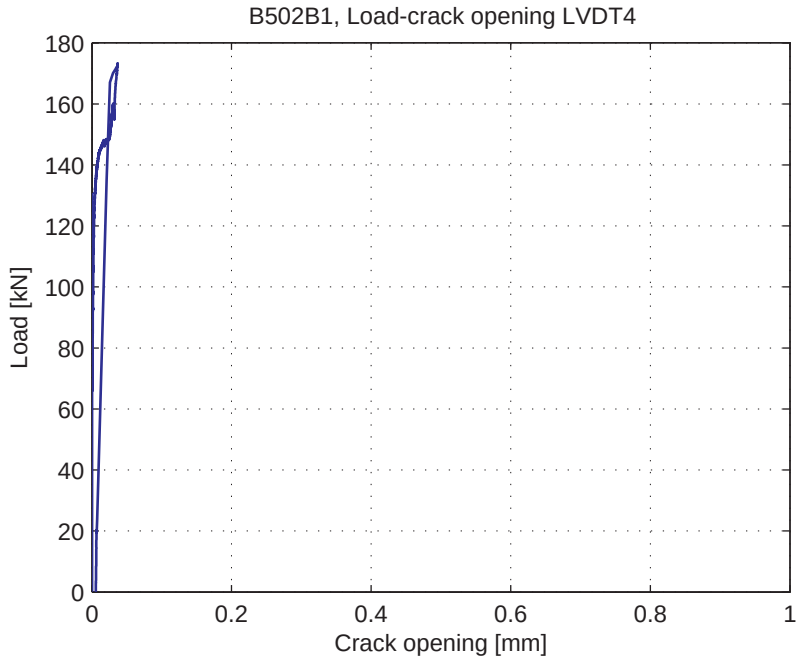


Fig. 5.53.5. Load-Crack opening for LVDT4

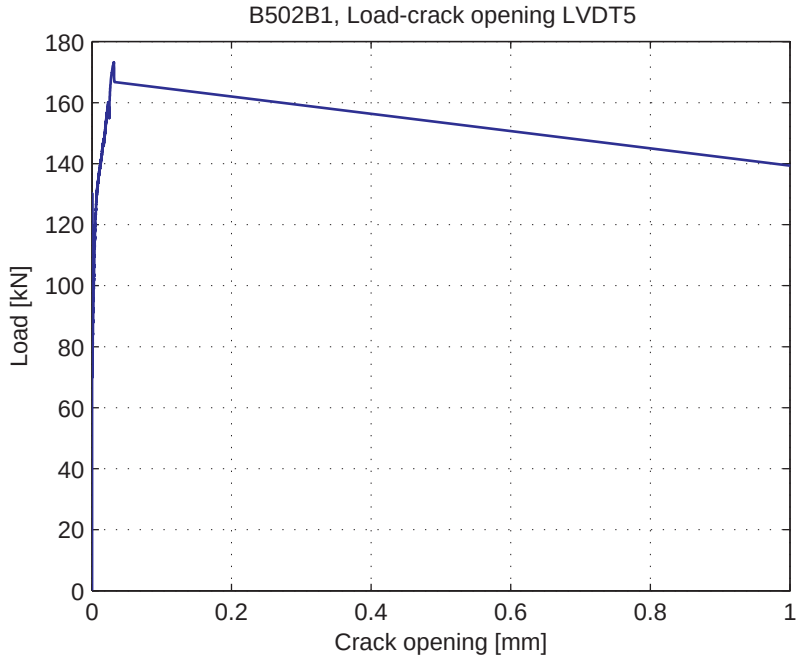


Fig. 5.53.6. Load-Crack opening for LVDT5

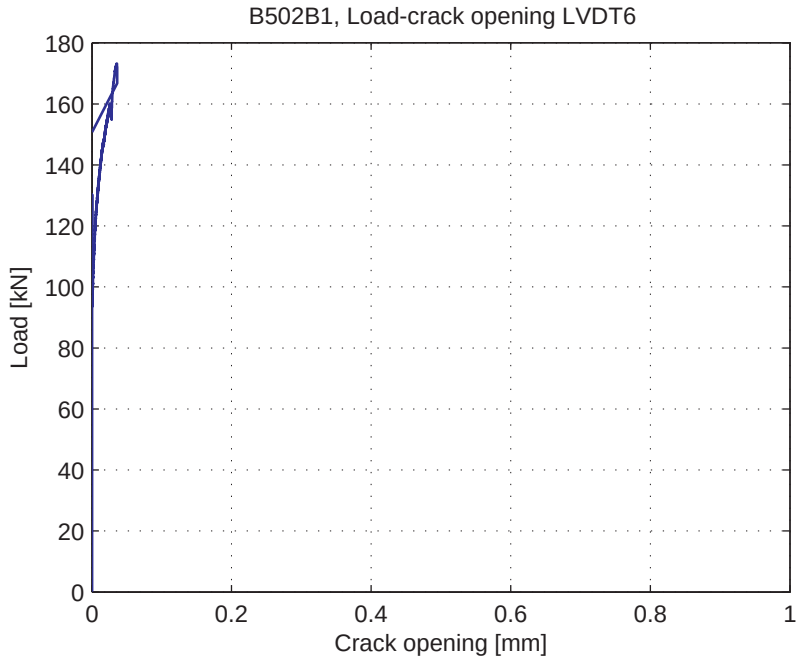


Fig. 5.53.7. Load-Crack opening for LVDT6

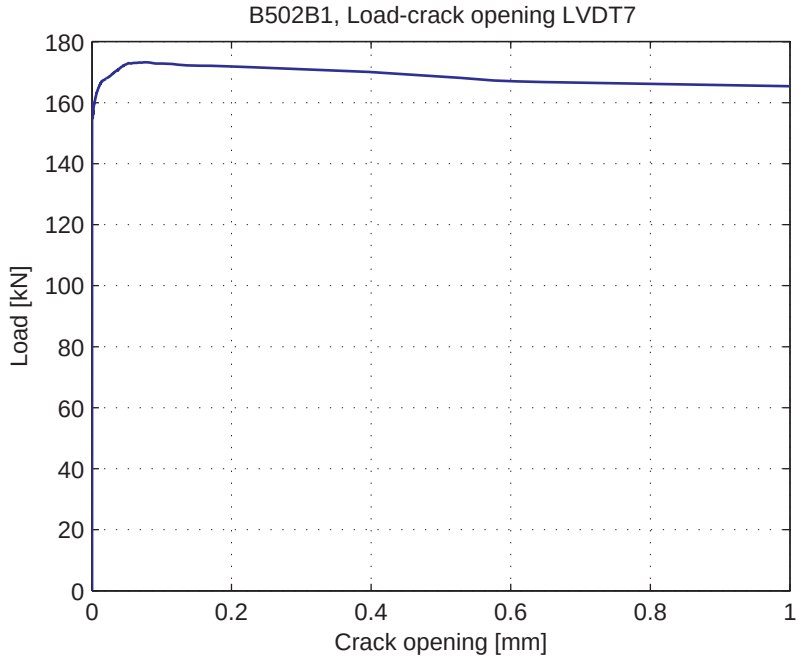


Fig. 5.53.8. Load-Crack opening for LVDT7

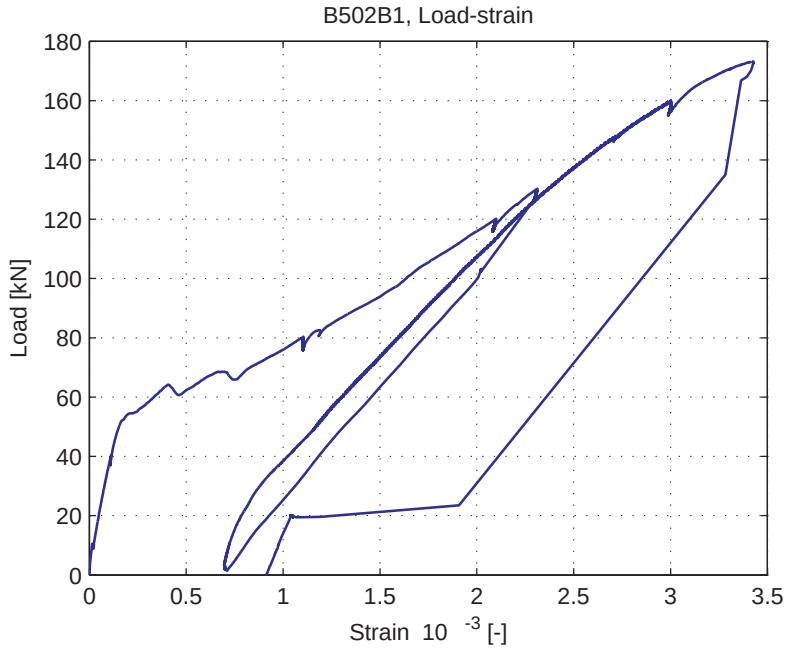


Fig. 5.53.9. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.54. C901A1

5.54.1. Test properties

Table 5.54.1. Beam properties

Date of test	22-09-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.91%
a	1250 mm
a / *d*	4.60
Concrete cube strength at testing	23.7 MPa
Peak load	98.5 kN
Failure mode	Flexural

Table 5.54.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Load cycles are performed for Acoustic Emission measurements
1	20	
2	2	
3	20	
4	2	
5	20	
6	2	
7	40	
8	2	
9	40	
10	2	
11	40	
12	2	
13	60	
14	2	
15	60	
16	2	
17	60	
18	2	Placed LVDT's 4-6
19	80	LVDT1 re-zeroed
20	99.8	Yielding, stopped after jack displacement of 38 mm

Table 5.54.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	565	100
5	North	Vertical	750	100
6	North	Vertical	880	100

5.54.2. Measurement results

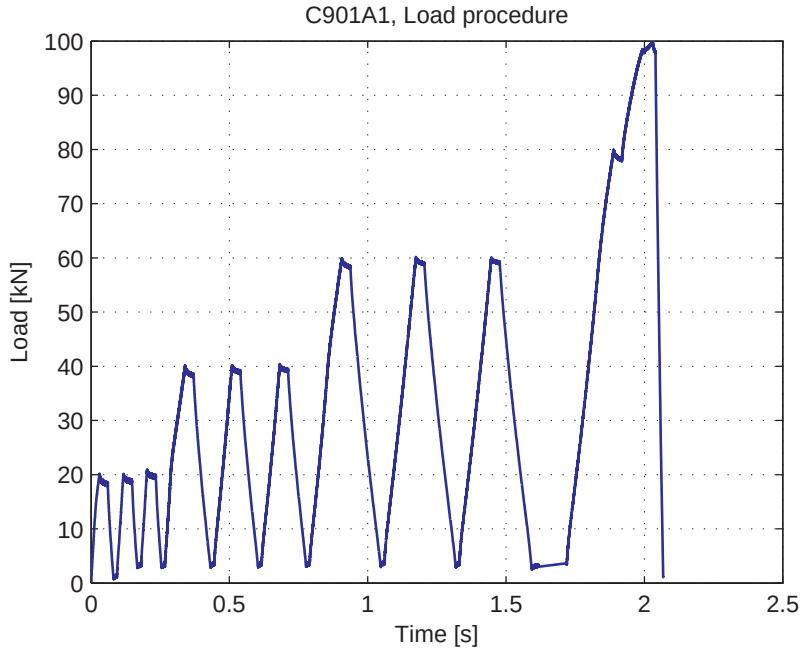


Fig. 5.54.1. Load-Time curve

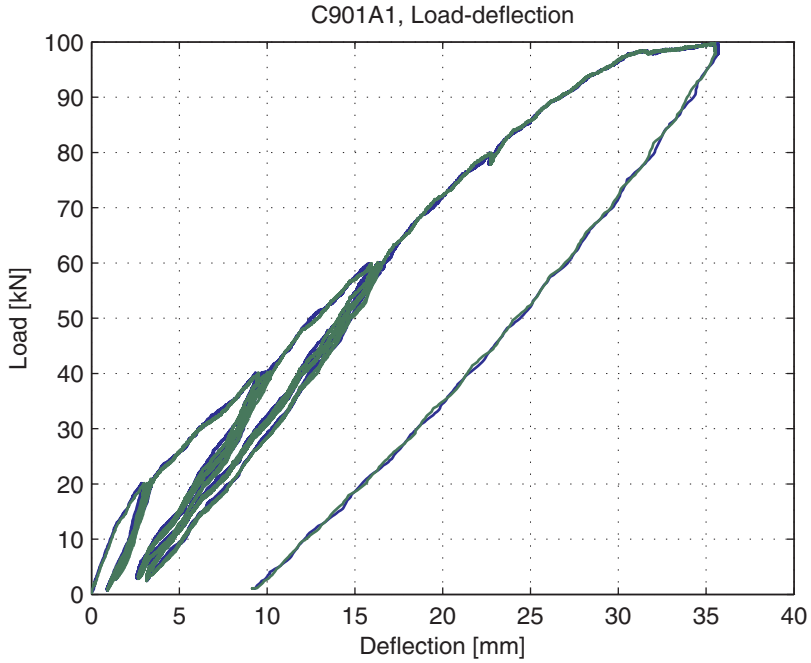


Fig. 5.54.2. Load-deflection curve

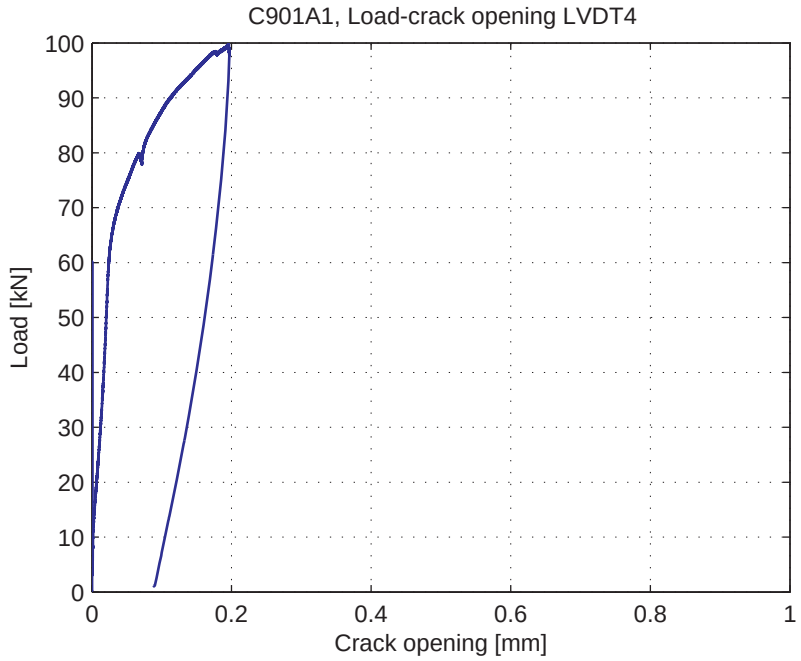


Fig. 5.54.3. Load-Crack opening for LVDT4

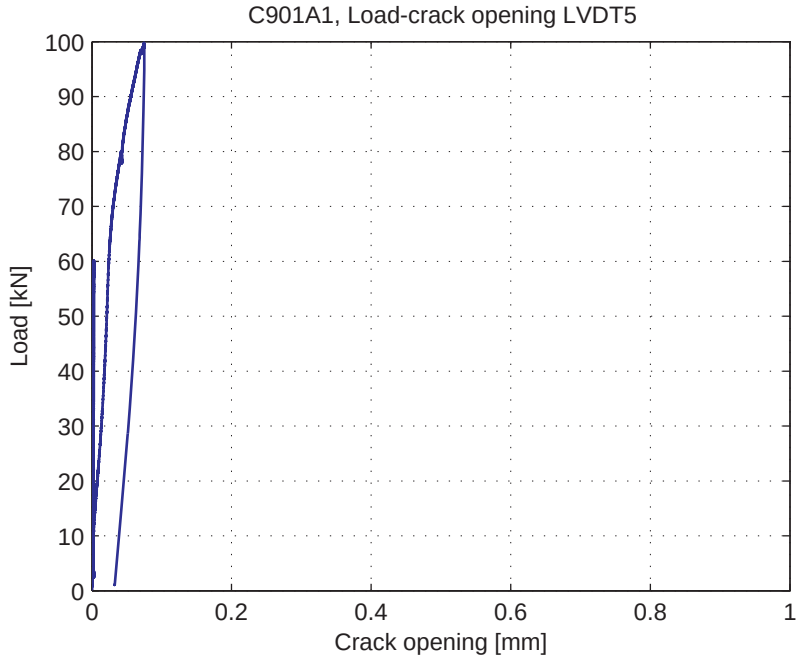


Fig. 5.54.4. Load-Crack opening for LVDT5

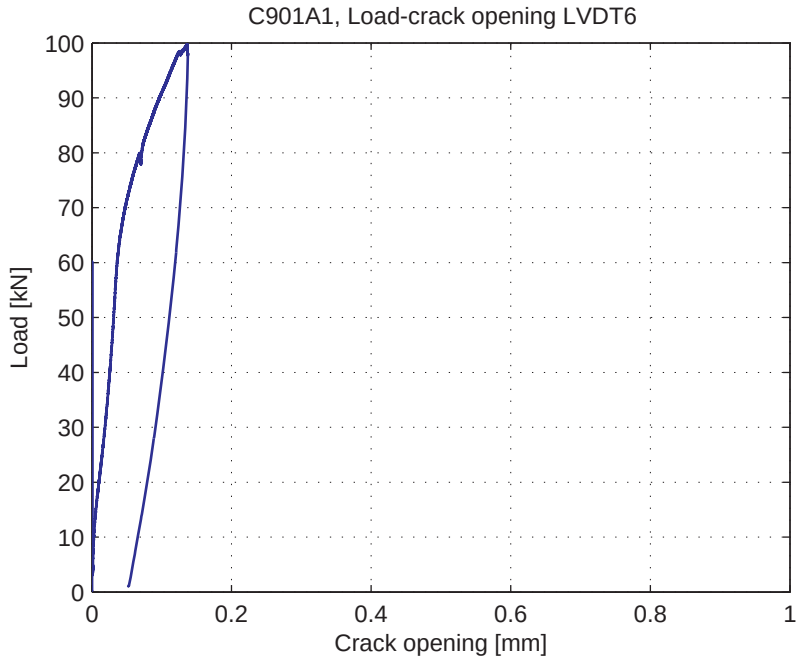


Fig. 5.54.5. Load-Crack opening for LVDT6

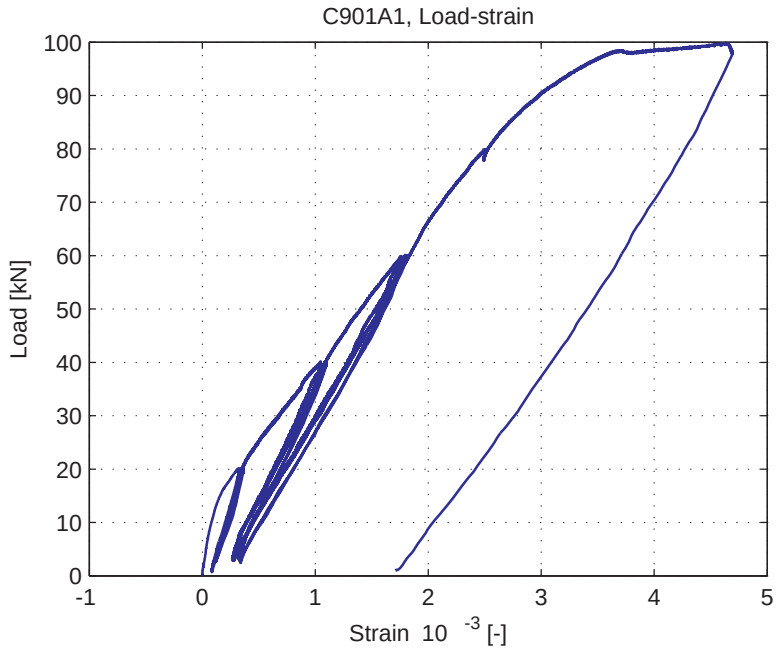


Fig. 5.54.6. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.55. C901A2

5.55.1. Test properties

Fig. 5.55.1. Crack pattern after failure north side

Fig. 5.55.2. Crack pattern after failure south side and sensors used for Acoustic Emission measurements

Table 5.55.1. Beam properties

Date of test	23-09-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.91%
a	1000 mm
a / *d*	3.68
Concrete cube strength at testing	23.7 MPa
Peak load	103.4 kN
Failure mode	Shear

Table 5.55.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Added LVDT 7. Applied load cycles for Acoustic Emission measurements
1	20	
2	2	
3	20	
4	2	
5	20	
6	2	
7	60	
8	2	
9	60	
10	2	
11	60	
12	2	
13	80	
14	2	
15	80	
16	2	
17	80	
18	2	
19	103.4	opening of flexural shear crack started at 100.1 kN, force going down. Shear failure.

Table 5.55.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	565	100
5	North	Vertical	750	100
6	North	Vertical	880	100
7	North	Vertical	425	50

5.55.2. Measurement results

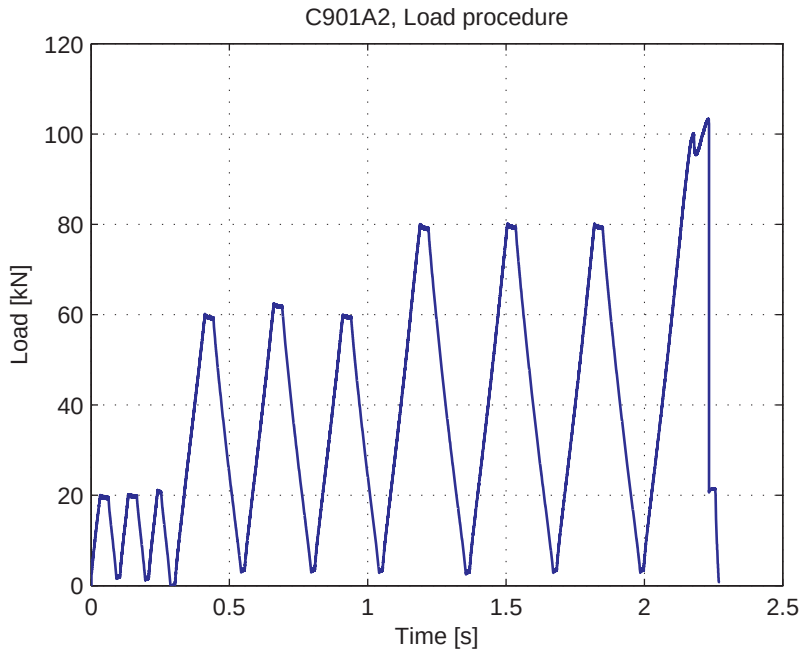


Fig. 5.55.3. Load-Time curve

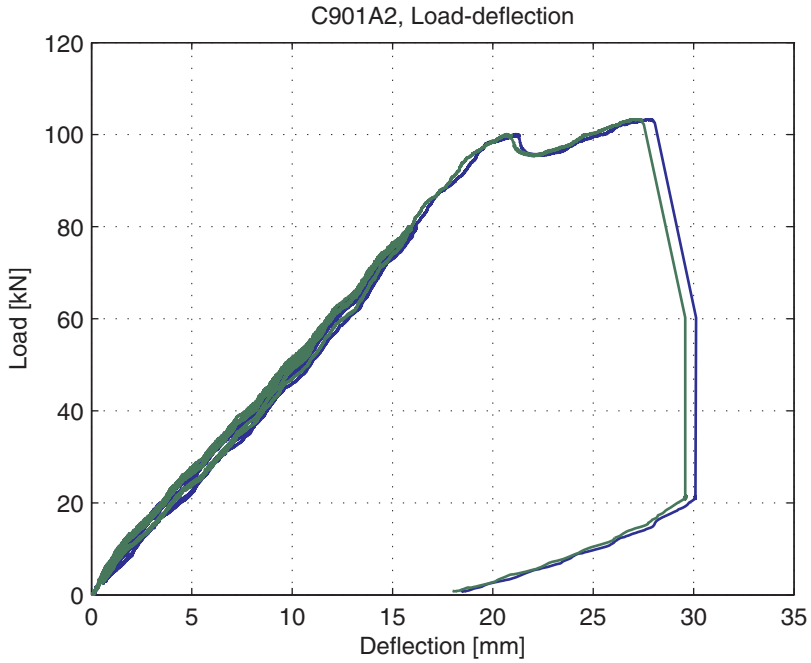


Fig. 5.55.4. Load-deflection curve

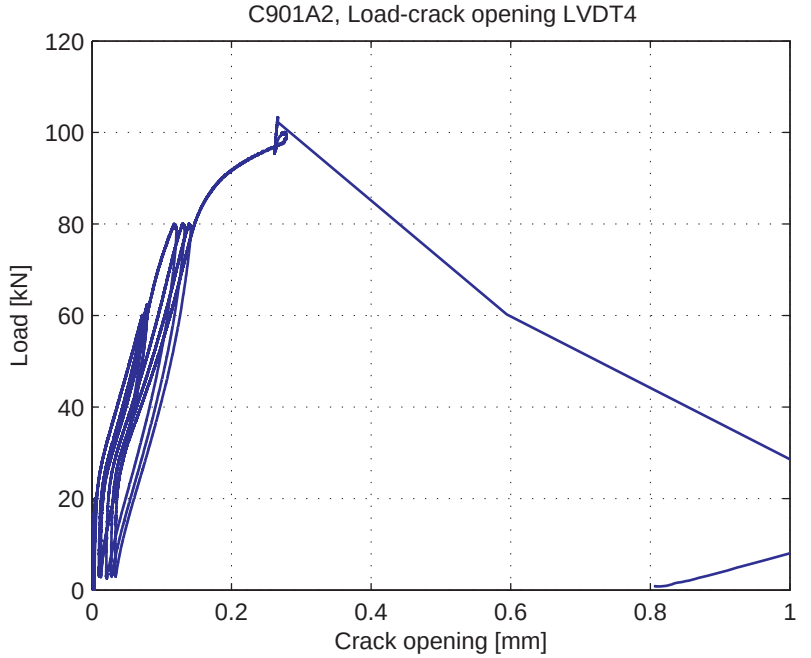


Fig. 5.55.5. Load-Crack opening for LVDT4

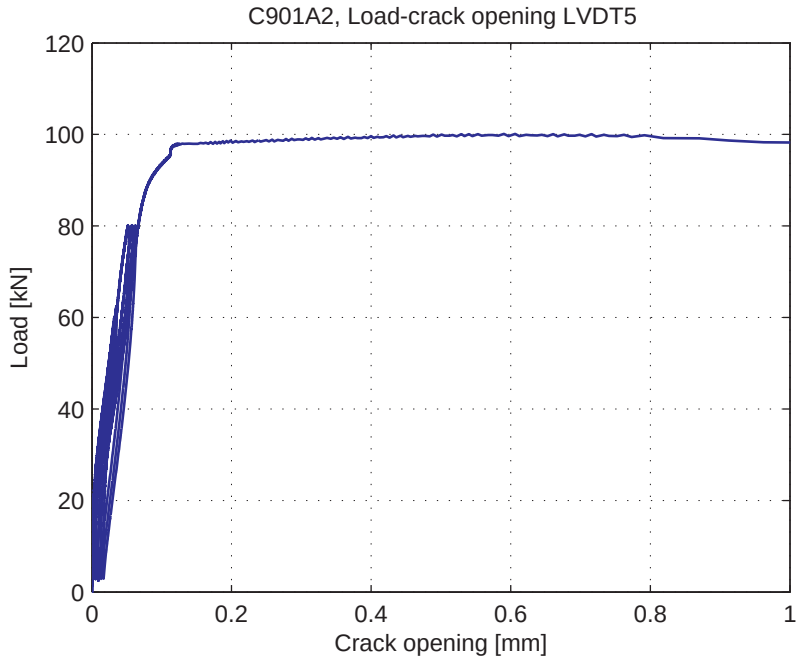


Fig. 5.55.6. Load-Crack opening for LVDT5

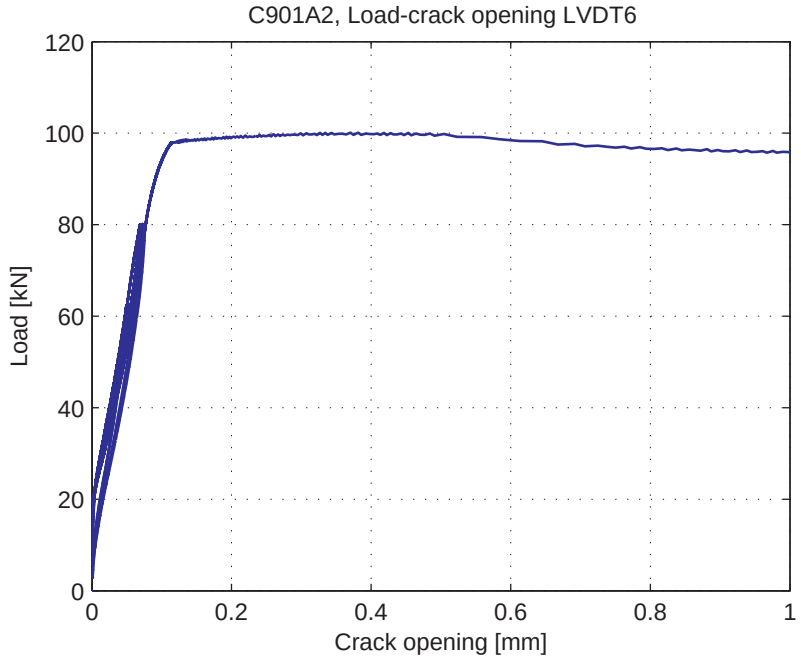


Fig. 5.55.7. Load-Crack opening for LVDT6

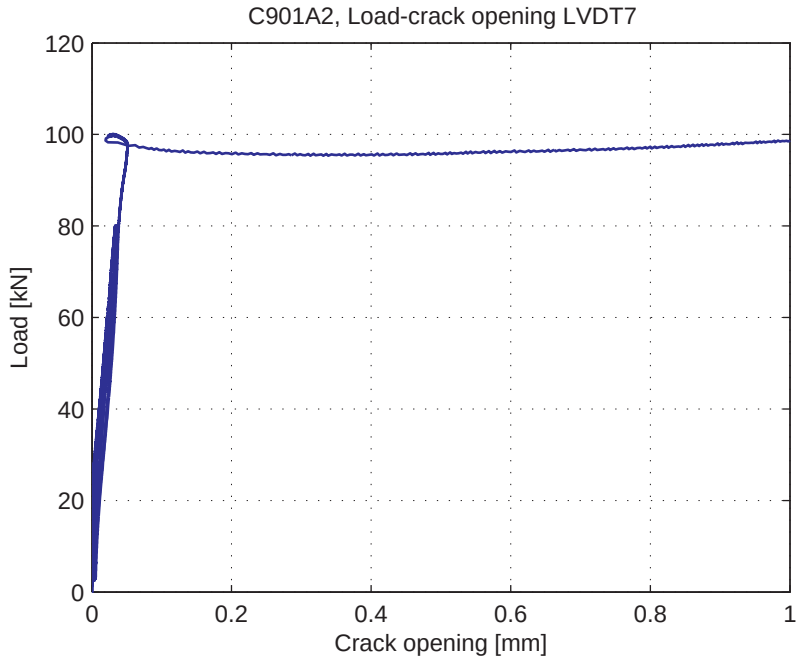


Fig. 5.55.8. Load-Crack opening for LVDT7

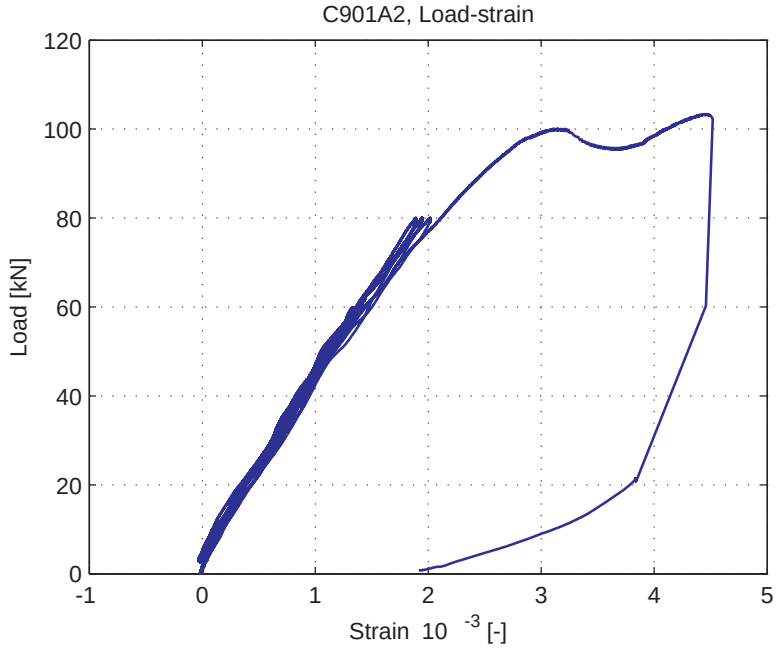


Fig. 5.55.9. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.56. C901A3

5.56.1. Test properties

Fig. 5.56.1. Crack pattern after failure north side

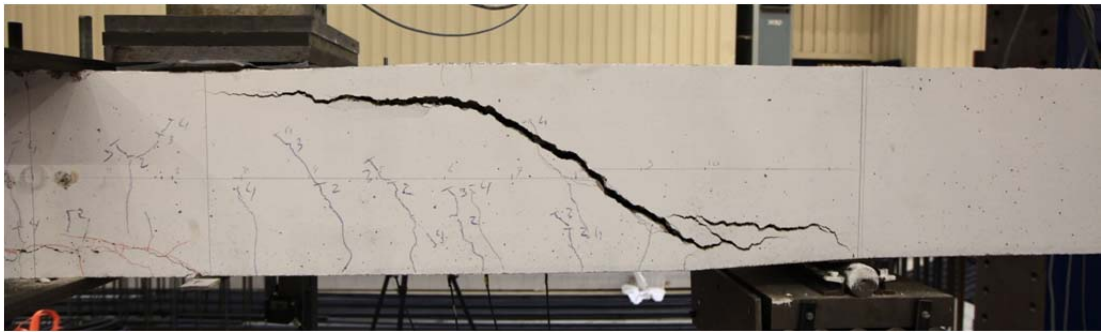


Fig. 5.56.2. Crack pattern after failure south side

Table 5.56.1. Beam properties

Date of test	24-09-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.91%
a	1000 mm
a / *d*	3.68
Concrete cube strength at testing	23.7 MPa
Peak load	84.1 kN
Failure mode	Shear

Table 5.56.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Shear crack from C091A2 clamped with two steel plates. LVDT 3 not placed due to steel plates
1	20	
2	40	
3	60	Placed LVDT's 4-7
4	80	
5	84.1	Shear failure

Table 5.56.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	470	100
5	North	Vertical	595	100
6	North	Vertical	660	100
7	North	Vertical	800	100

5.56.2. Measurement results

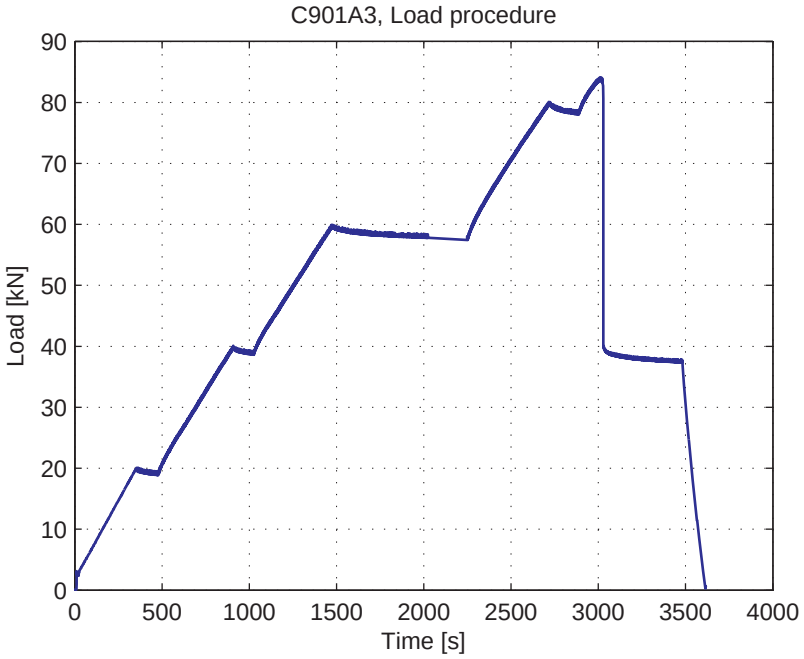


Fig. 5.56.3. Load-Time curve

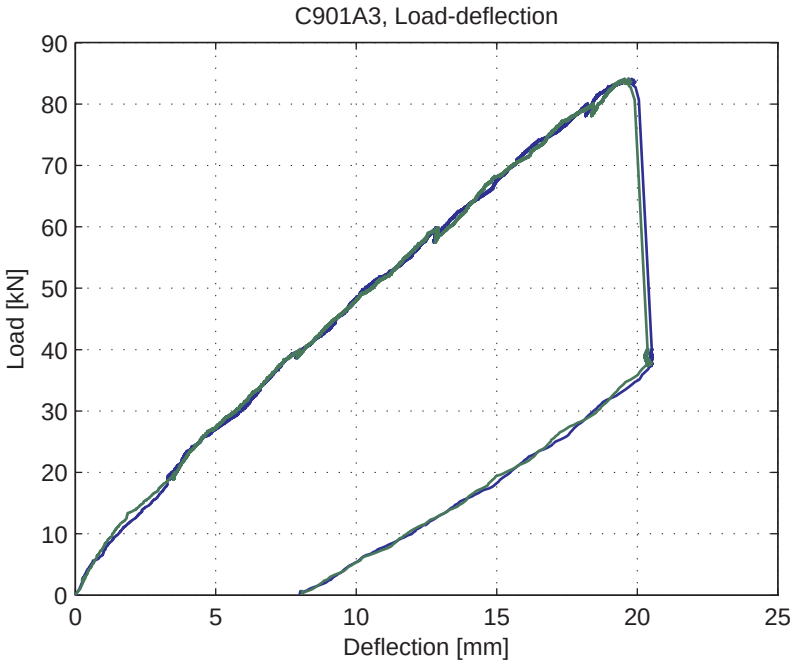


Fig. 5.56.4. Load-deflection curve

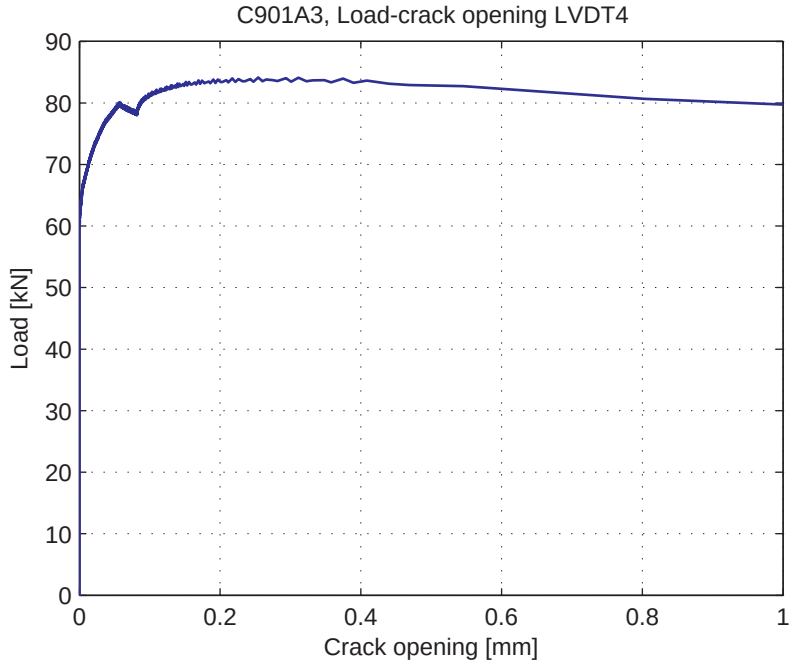


Fig. 5.56.5. Load-Crack opening for LVDT4

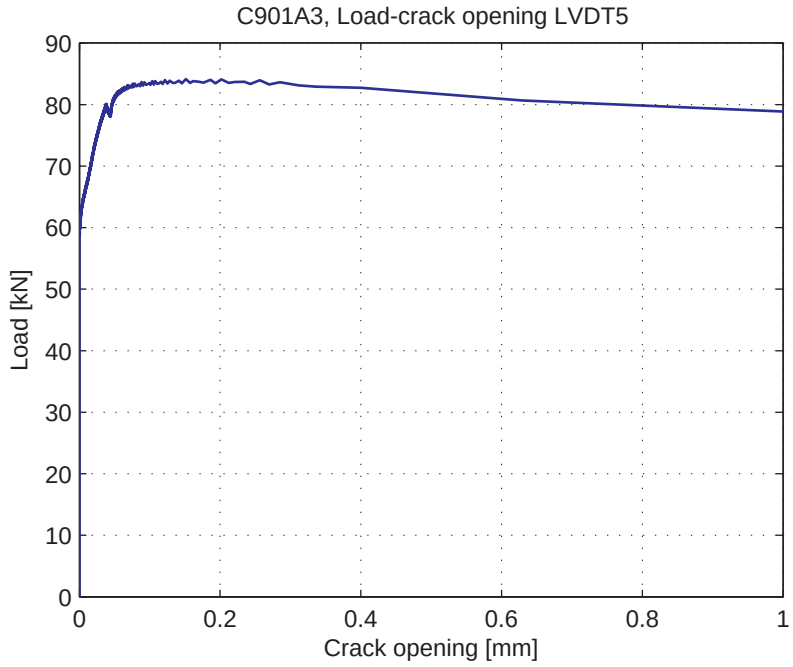


Fig. 5.56.6. Load-Crack opening for LVDT5

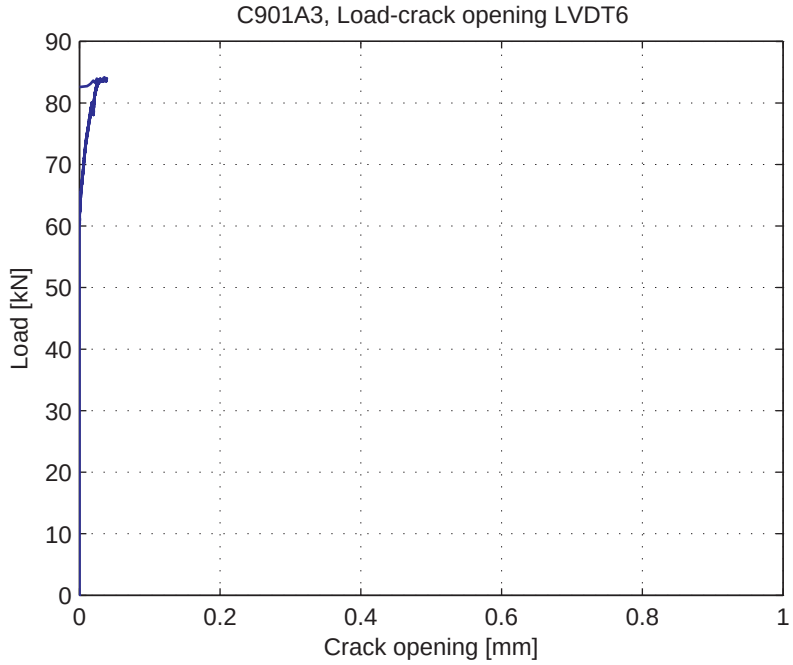


Fig. 5.56.7. Load-Crack opening for LVDT6

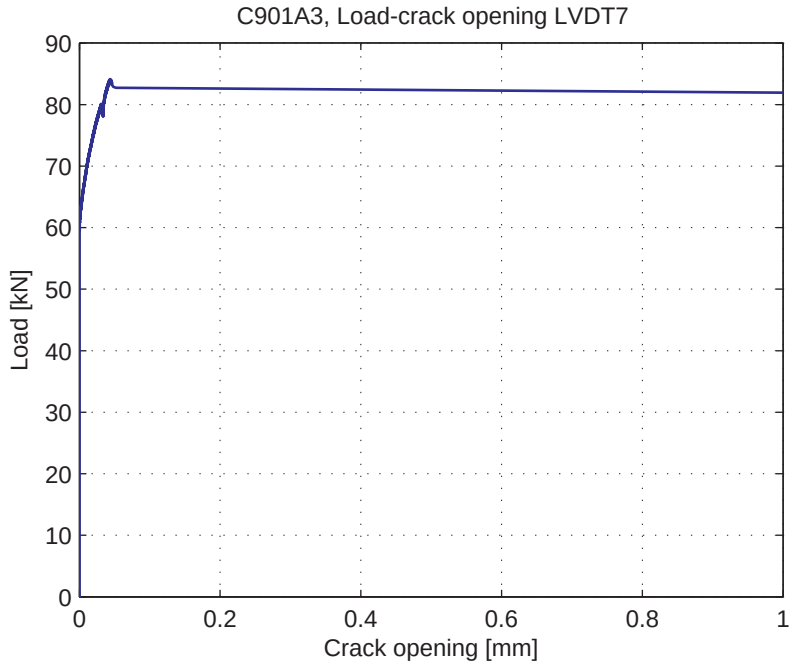


Fig. 5.56.8. Load-Crack opening for LVDT7

5.57. C901B1

5.57.1. Test properties

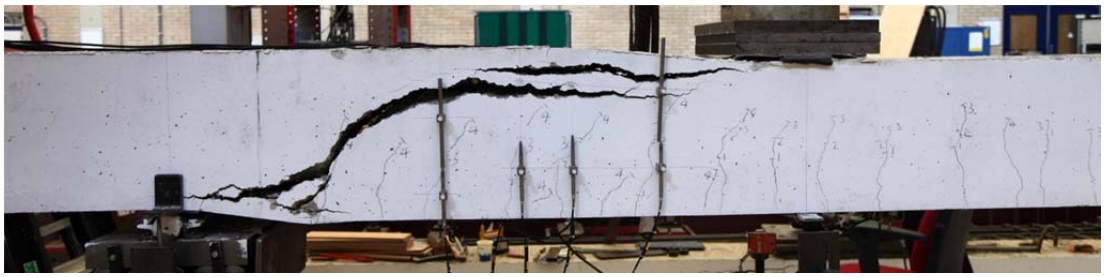


Fig. 5.57.1. Crack pattern after failure north side

Fig. 5.57.2. Crack pattern after failure south side

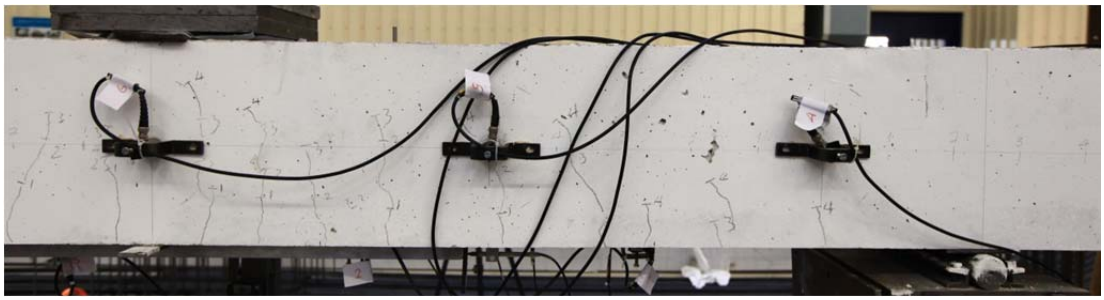


Fig. 5.57.3. Sensors used for Acoustic Emission measurements at side beam

Fig. 5.57.4. Sensors used for Acoustic Emission measurements at bottom beam

Table 5.57.1. Beam properties

Date of test	25-09-2015
Reinforcement	2Ø20 + 1Ø12
Reinforcement ratio	0.91%
a	1250 mm
a / *d*	4.60
Concrete cube strength at testing	23.7 Mpa
Peak load	101.7 kN
Failure mode	Shear

Table 5.57.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements
1	20	
2	2	
3	25	
4	2	
5	25	
6	2	
7	40	
8	2	
9	40	
10	2	
11	40	
12	2	
13	60	
14	2	
15	60	
16	2	
17	60	
18	2	Placed LVDT's 4-7
19	80	
20	2	
21	80	
22	2	
23	80	
24	2	
25	101.7	Shear failure

Table 5.57.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	525	50
5	North	Vertical	680	100
6	North	Vertical	780	100
4	North	Vertical	950	100

5.57.2. Measurement results

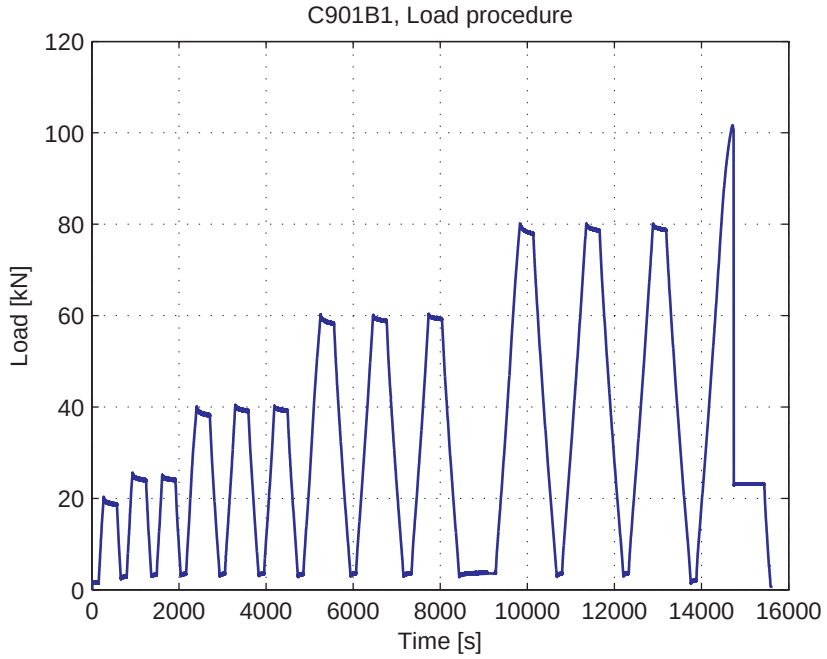


Fig. 5.57.5. Load-Time curve

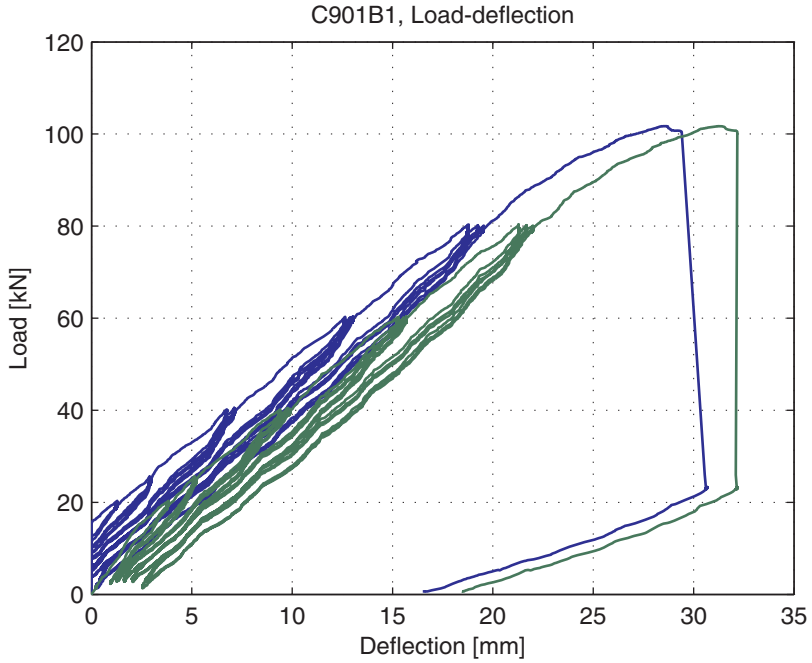


Fig. 5.57.6. Load-deflection curve

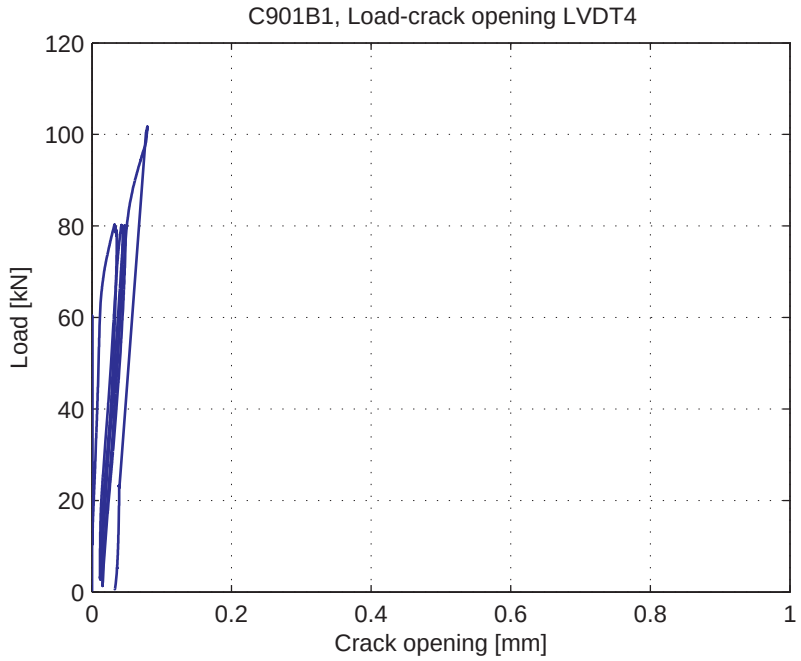


Fig. 5.57.7. Load-Crack opening for LVDT4

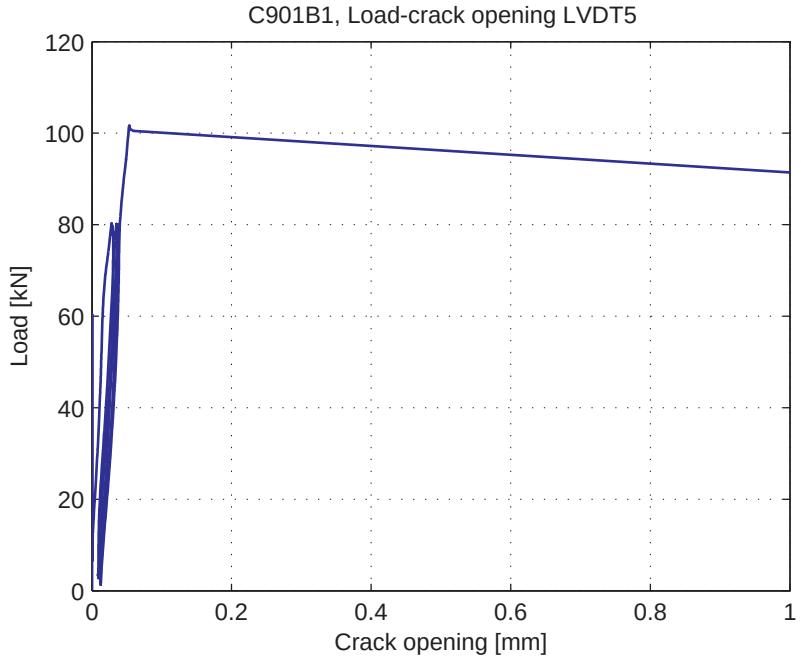


Fig. 5.57.8. Load-Crack opening for LVDT5

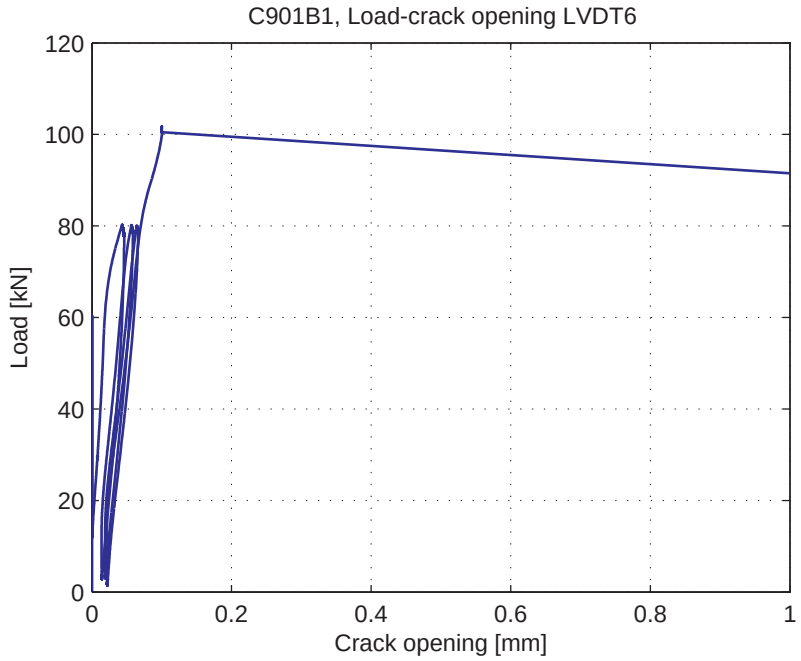


Fig. 5.57.9. Load-Crack opening for LVDT6

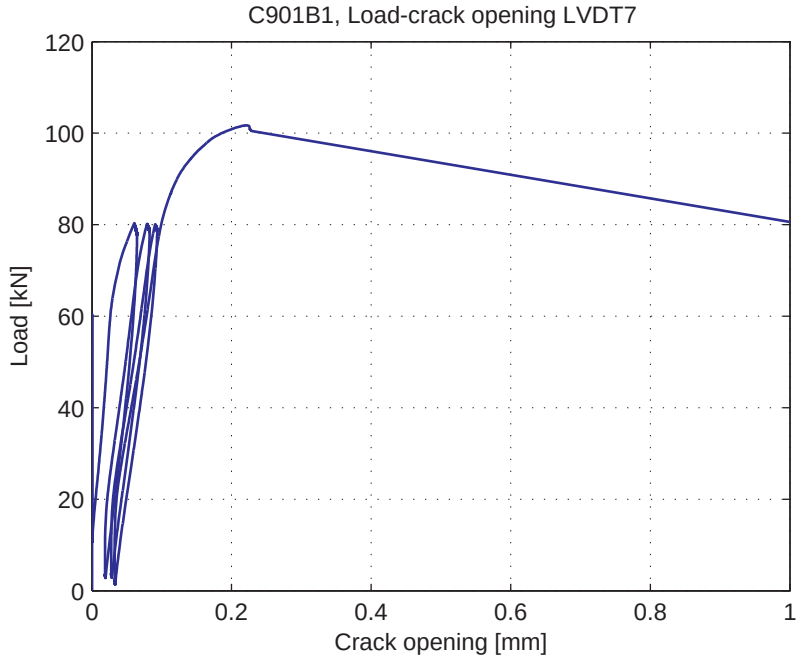


Fig. 5.57.10. Load-Crack opening for LVDT7

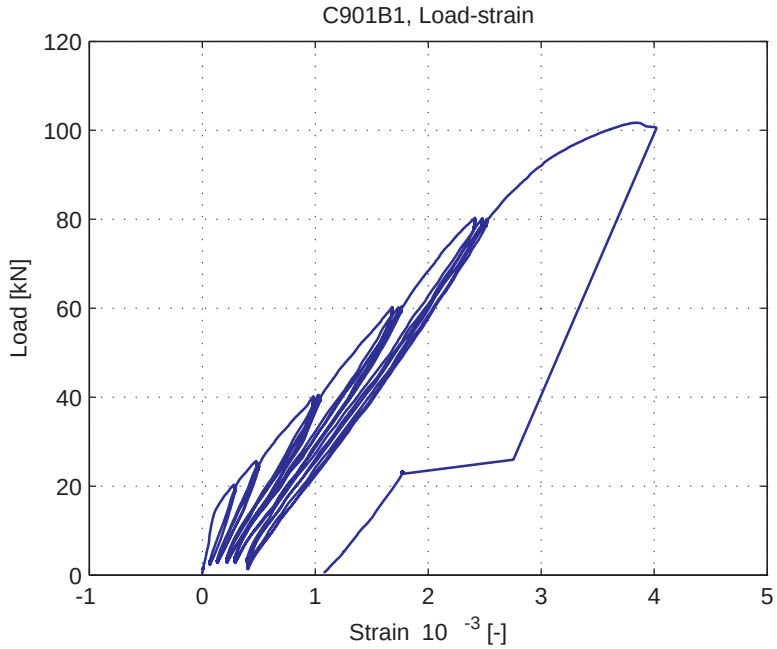


Fig. 5.57.11. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.58. C751A1

5.58.1. Test properties

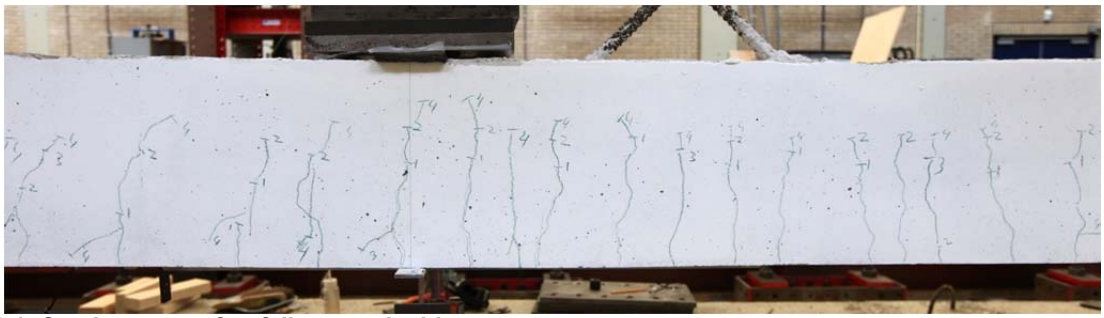


Fig. 5.58.1. Crack pattern after failure north side

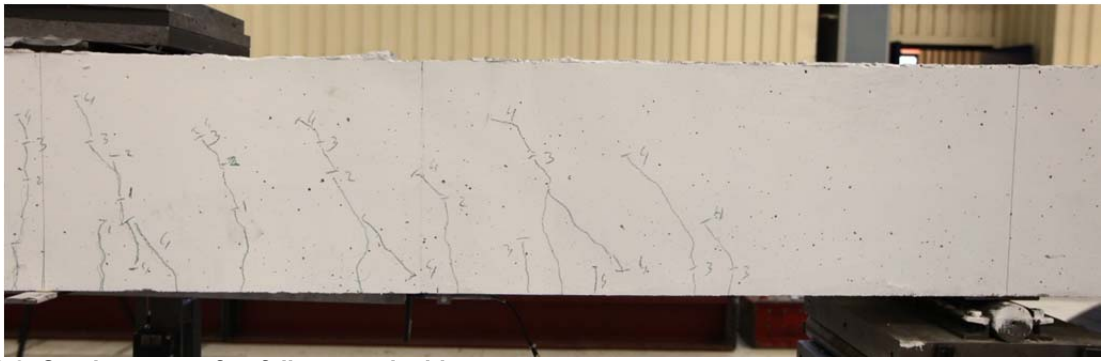


Fig. 5.58.2. Crack pattern after failure south side

Table 5.58.1. Beam properties

Date of test	17-09-2015
Reinforcement	3Ø16
Reinforcement ratio	0.74%
a	1250 mm
a / *d*	4.63
Concrete cube strength at testing	23.7 MPa
Peak load	76.5 kN
Failure mode	Flexural

Table 5.58.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	LVDT1 broken, replaced by LVDT 16, channel is the same
1	20	
2	40	
3	60	
4	76.5	Stopped after jack displacement of 35 mm

5.58.2. Measurement results

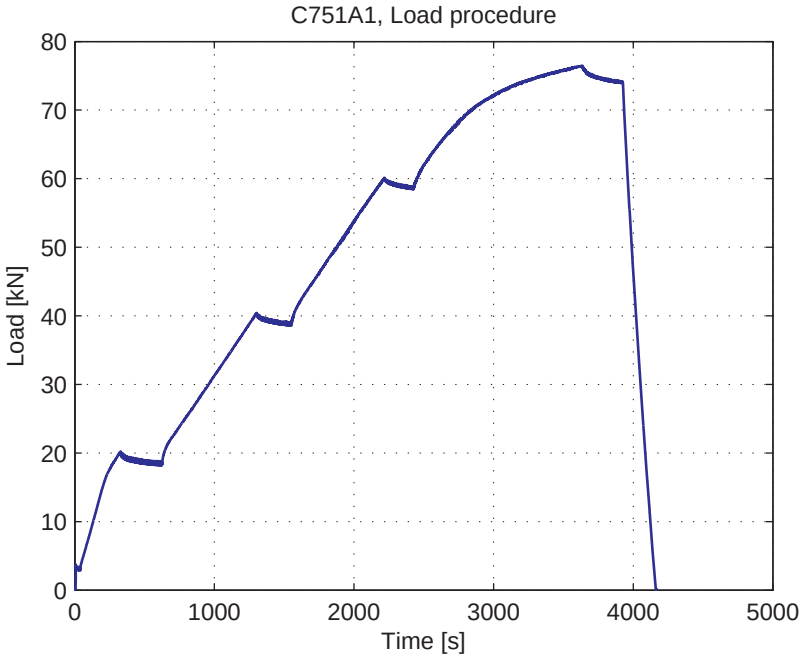


Fig. 5.58.3. Load-Time curve

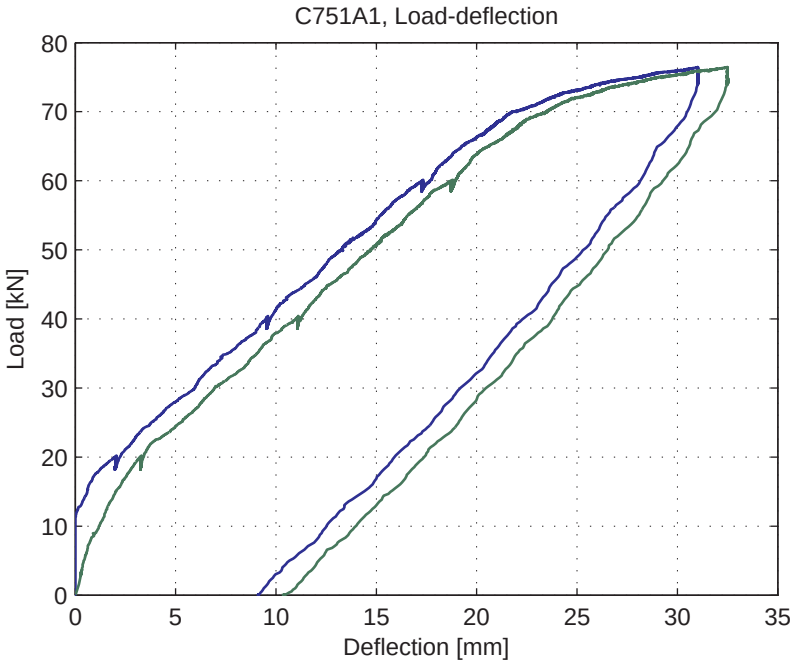


Fig. 5.58.4. Load-deflection curve

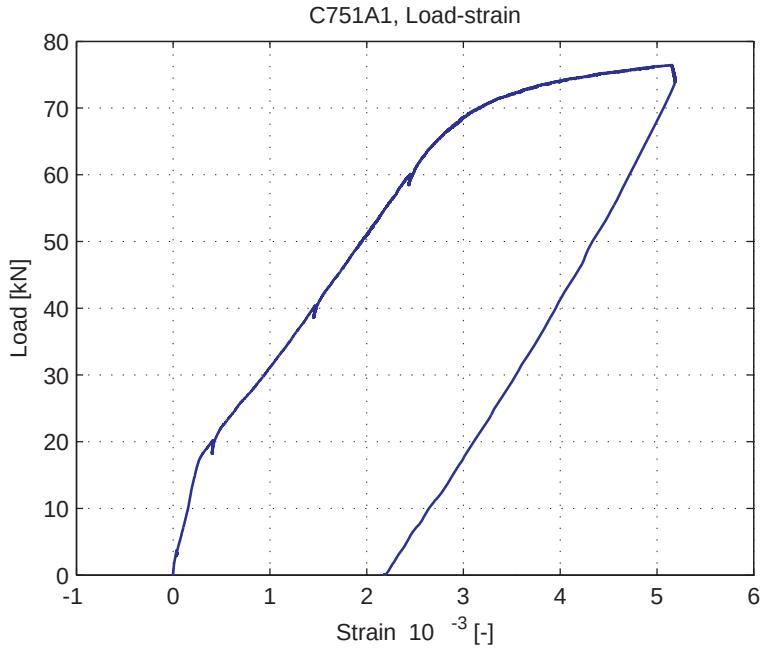


Fig. 5.58.5. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.59. C751A2

5.59.1. Test properties

Fig. 5.59.1. Crack pattern after failure north side

Fig. 5.59.2. Crack pattern after failure south side

Table 5.59.1. Beam properties

Date of test	17-09-2015
Reinforcement	3Ø16
Reinforcement ratio	0.74%
a	1000 mm
a / *d*	3.70
Concrete cube strength at testing	23.7 MPa
Peak load	84.5 kN
Failure mode	Shear

Table 5.59.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Placed LVDT's 4-6
1	20	
2	40	
3	60	
4	70	Waited for camera
5	80	
6	84.5	Shear failure

Table 5.59.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	410	100
5	North	Vertical	550	100
6	North	Vertical	735	100

5.59.2. Measurement results

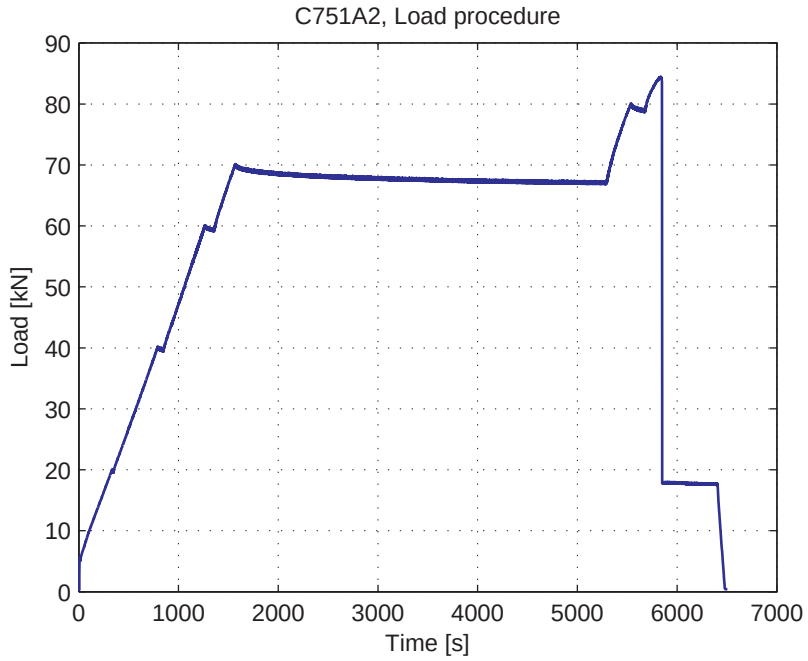


Fig. 5.59.3. Load-Time curve

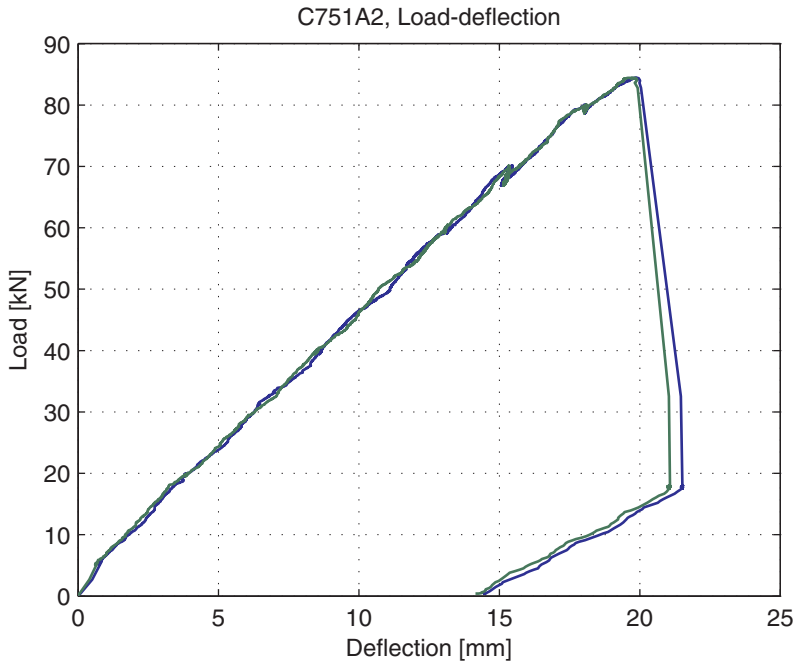


Fig. 5.59.4. Load-deflection curve

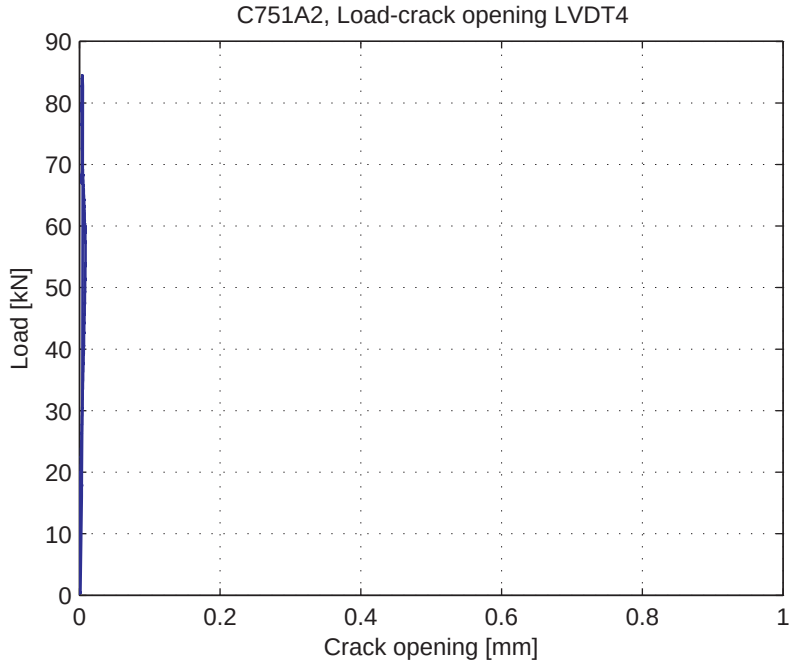


Fig. 5.59.5. Load-Crack opening for LVDT4

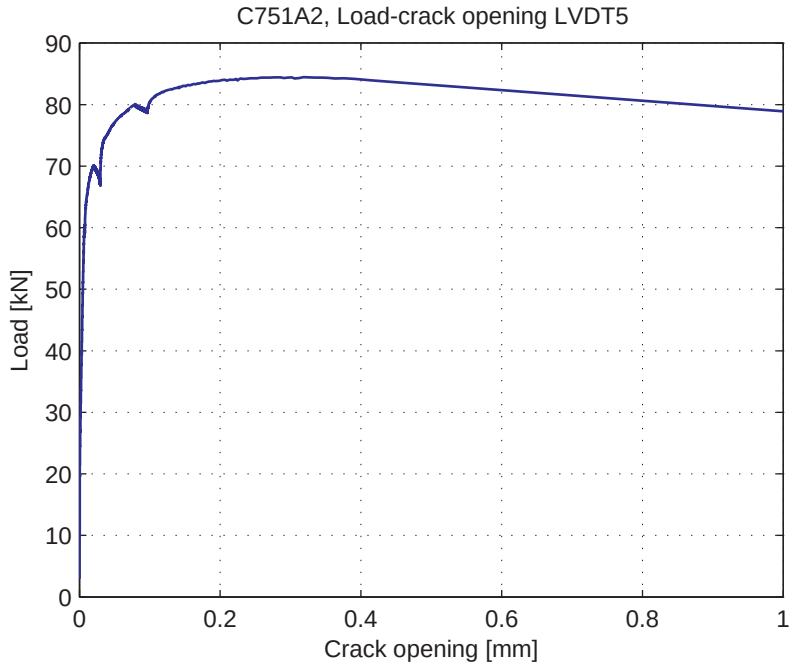


Fig. 5.59.6. Load-Crack opening for LVDT5

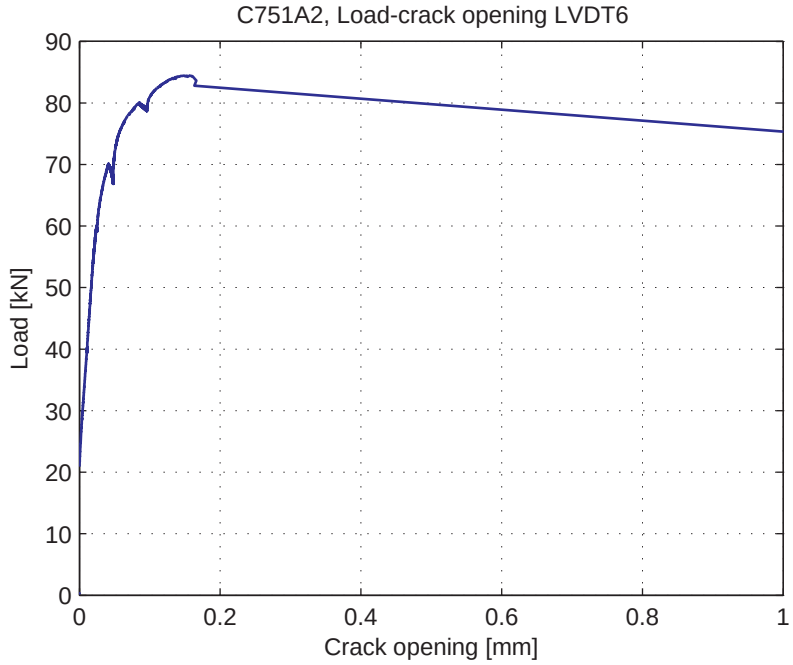


Fig. 5.59.7. Load-Crack opening for LVDT6

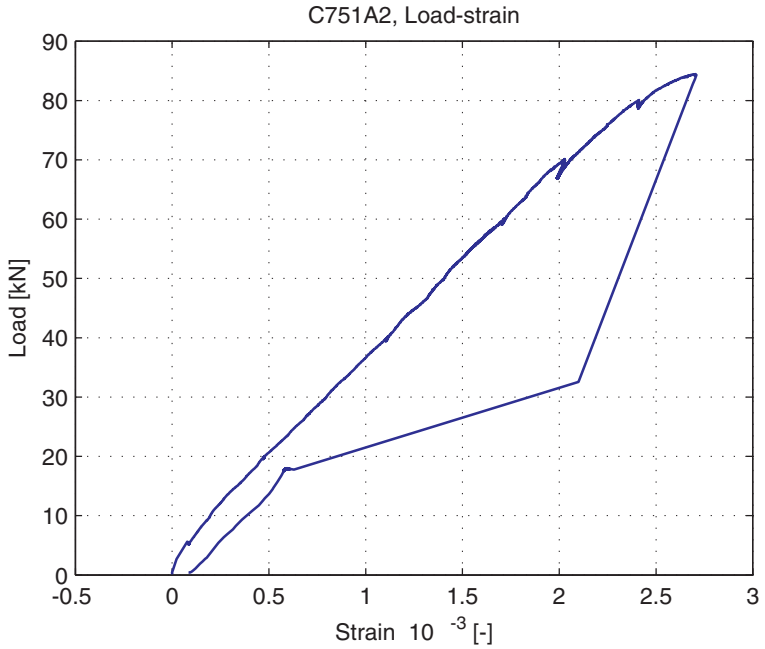


Fig. 5.59.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.60. C751A3

5.60.1. Test properties

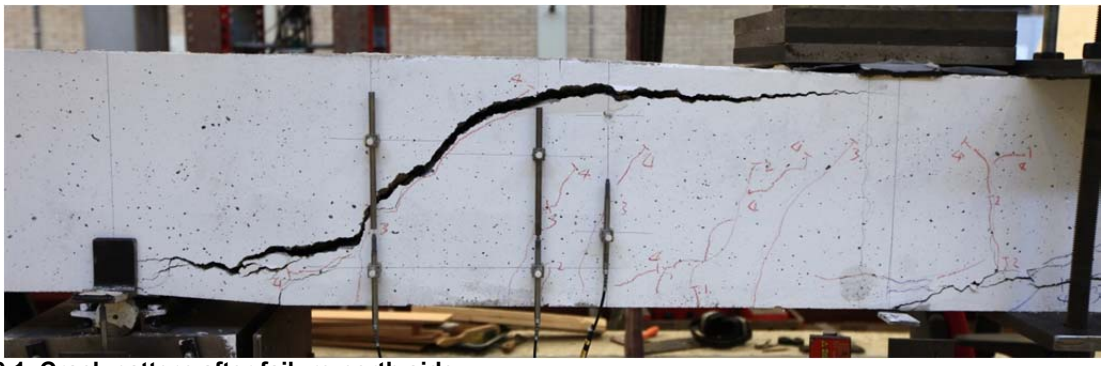


Fig. 5.60.1. Crack pattern after failure north side

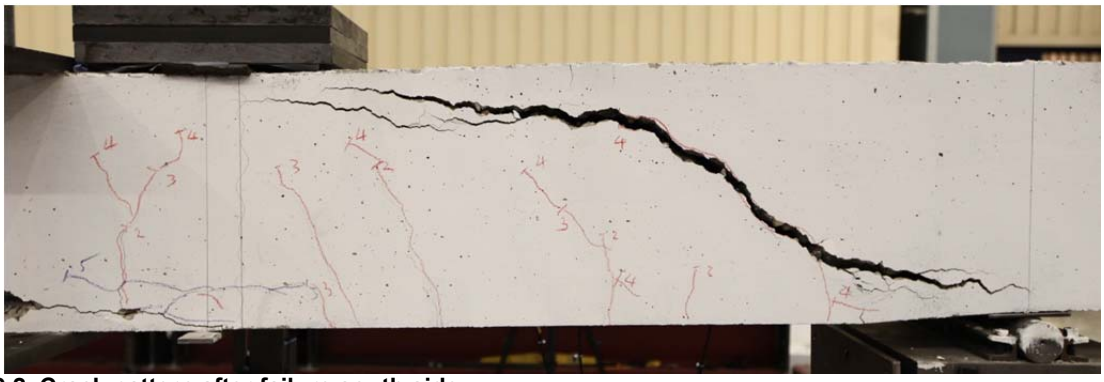


Fig. 5.60.2. Crack pattern after failure south side

Table 5.60.1. Beam properties

Date of test	18-09-2015
Reinforcement	3Ø16
Reinforcement ratio	0.74%
a	1000 mm
a / *d*	3.70
Concrete cube strength at testing	23.7 MPa
Peak load	86.7 kN
Failure mode	Shear

Table 5.60.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	60	Placed LVDT's 4-6
4	80	
5	86.7	Shear failure

Table 5.60.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	330	50
5	North	Vertical	535	50
6	North	Vertical	635	100

5.60.2. Measurement results

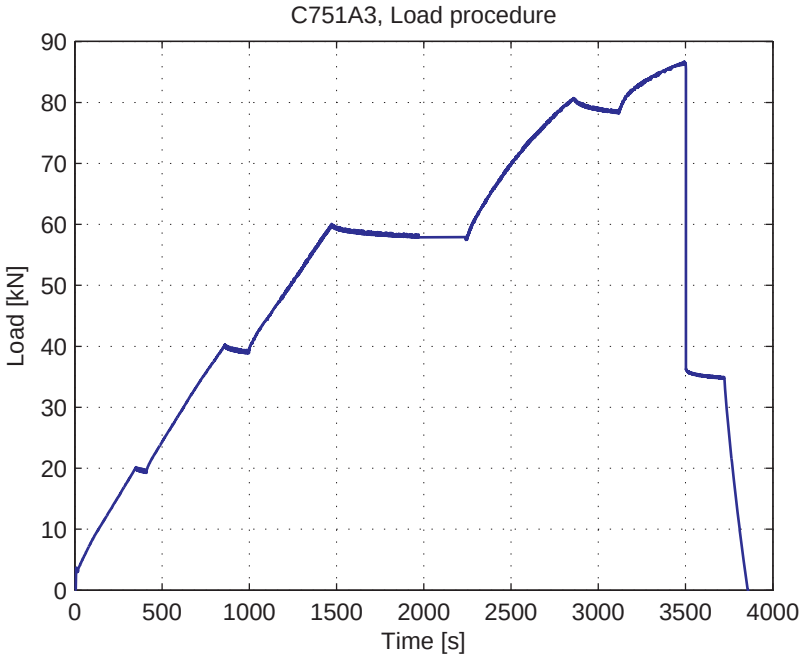


Fig. 5.60.3. Load-Time curve

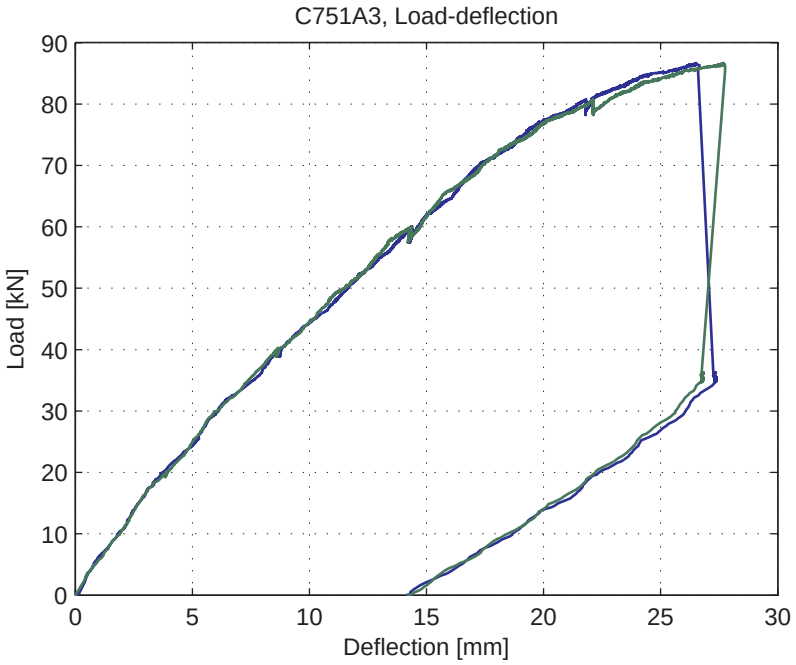


Fig. 5.60.4. Load-deflection curve

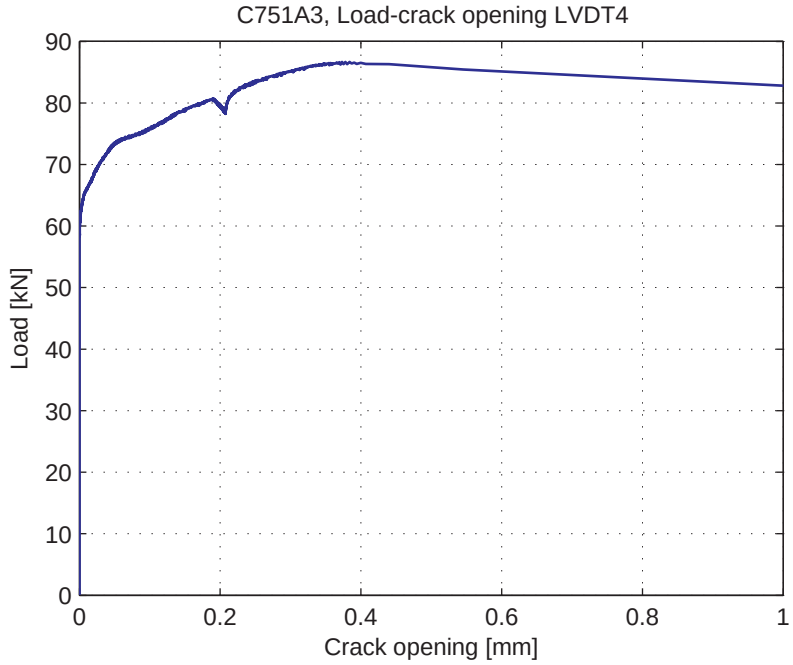


Fig. 5.60.5. Load-Crack opening for LVDT4

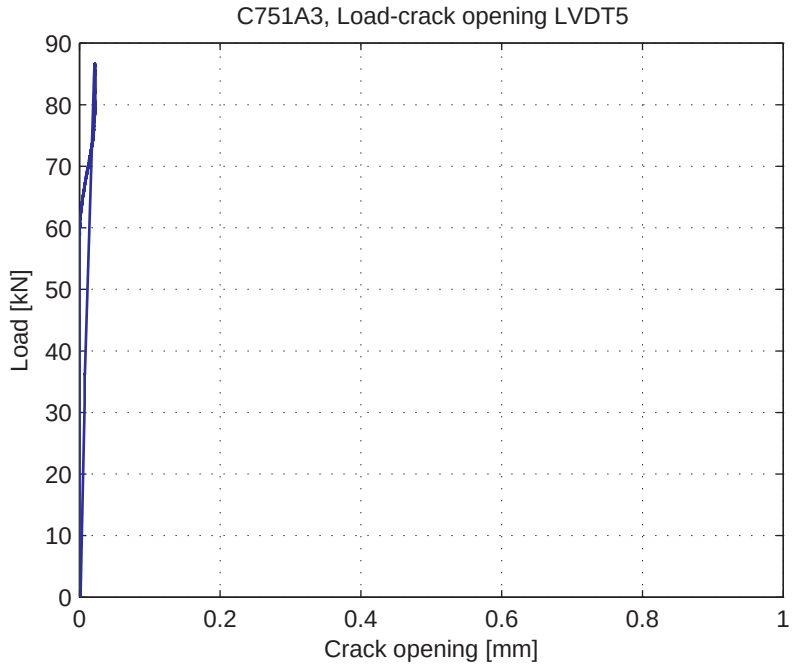


Fig. 5.60.6. Load-Crack opening for LVDT5

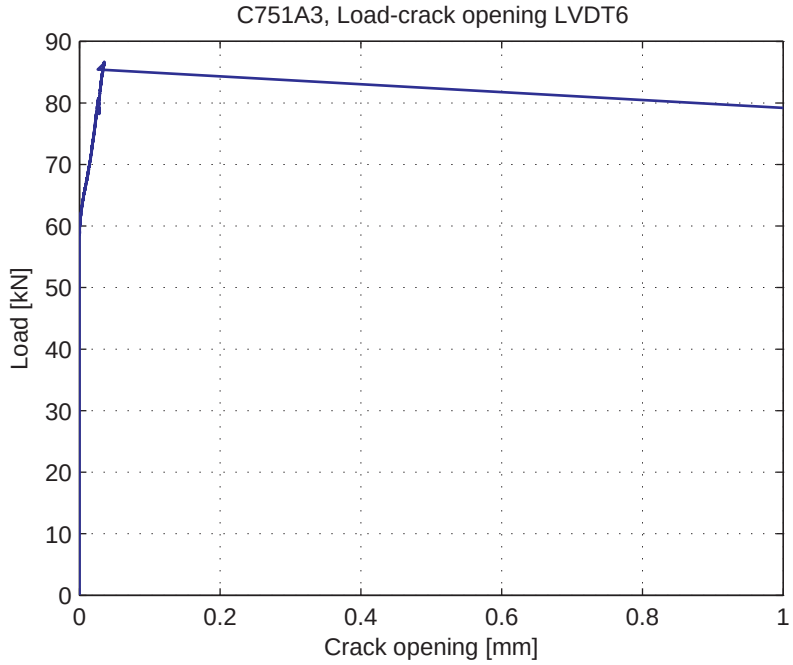


Fig. 5.60.7. Load-Crack opening for LVDT6

5.61. C751B1

5.61.1. Test properties

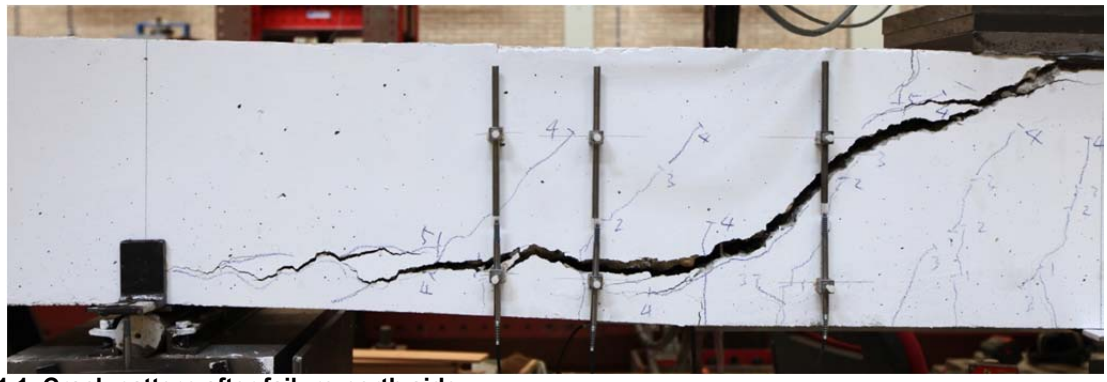


Fig. 5.61.1. Crack pattern after failure north side

Fig. 5.61.2. Crack pattern after failure south side

Table 5.61.1. Beam properties

Date of test	18-09-2015
Reinforcement	3Ø16
Reinforcement ratio	0.74%
a	1100 mm
a / *d*	4.15
Concrete cube strength at testing	23.7 MPa
flexural / shear	75.6 kN / 82.8 kN
Failure mode	Flexural and shear

Table 5.61.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	Placed LVDT's 4-5
3	60	
4	70	Placed LVDT 6
5	80	
6	82.8	Shear failure

Table 5.61.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	510	50
5	North	Vertical	775	50
6	North	Vertical	400	50

5.61.2. Measurement results

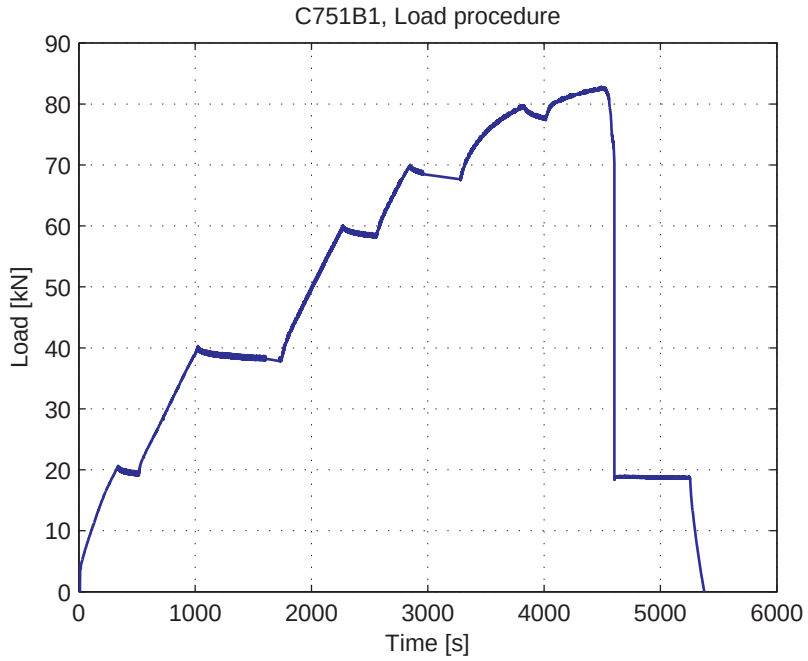


Fig. 5.61.3. Load-Time curve

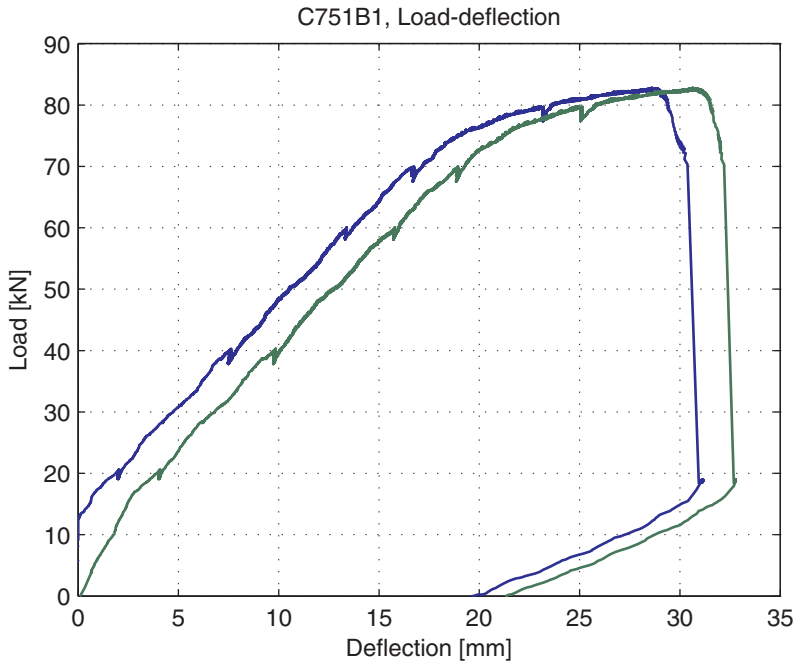


Fig. 5.61.4. Load-deflection curve

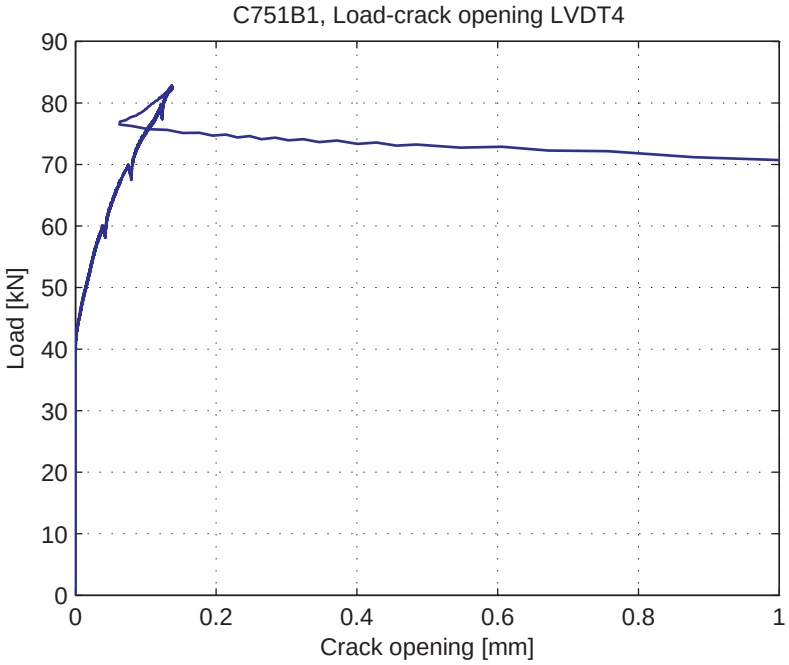


Fig. 5.61.5. Load-Crack opening for LVDT4

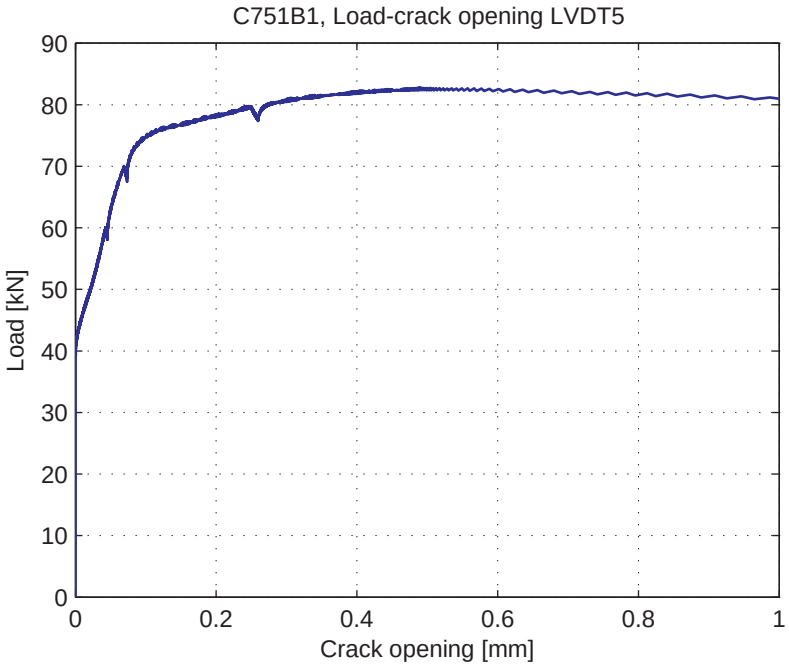


Fig. 5.61.6. Load-Crack opening for LVDT5

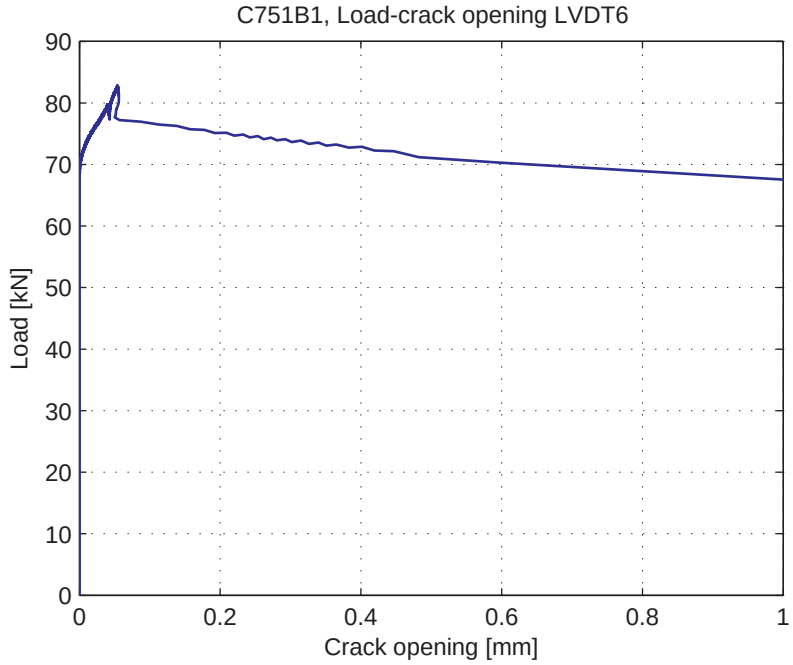


Fig. 5.61.7. Load-Crack opening for LVDT6

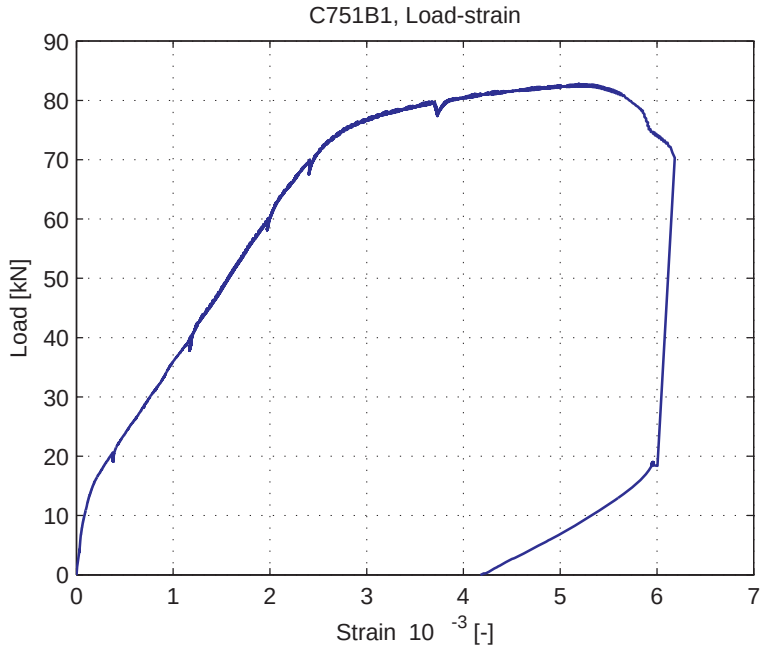


Fig. 5.61.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.62. C451A1

5.62.1. Test properties

Fig. 5.62.1. Crack pattern after failure north side

Fig. 5.62.2. Crack pattern after failure south side

Table 5.62.1. Beam properties

Date of test	09-09-2015
Reinforcement	3Ø12
Reinforcement ratio	0.42%
a	1250 mm
a / *d*	4.59
Concrete cube strength at testing	23.7 MPa
Peak load	41.4 kN
Failure mode	Flexural

Table 5.62.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40	
3	47.5	Yielding

5.62.2. Measurement results

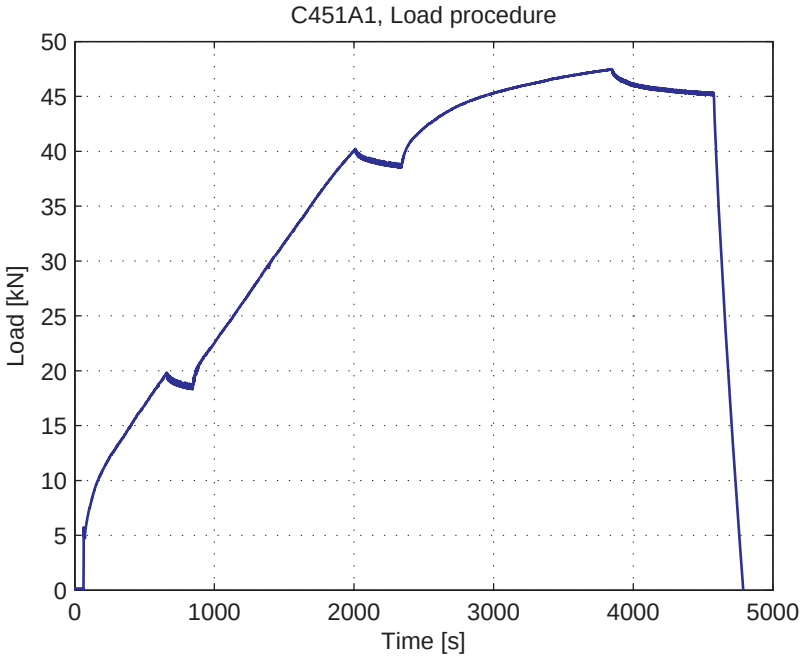


Fig. 5.62.3. Load-Time curve

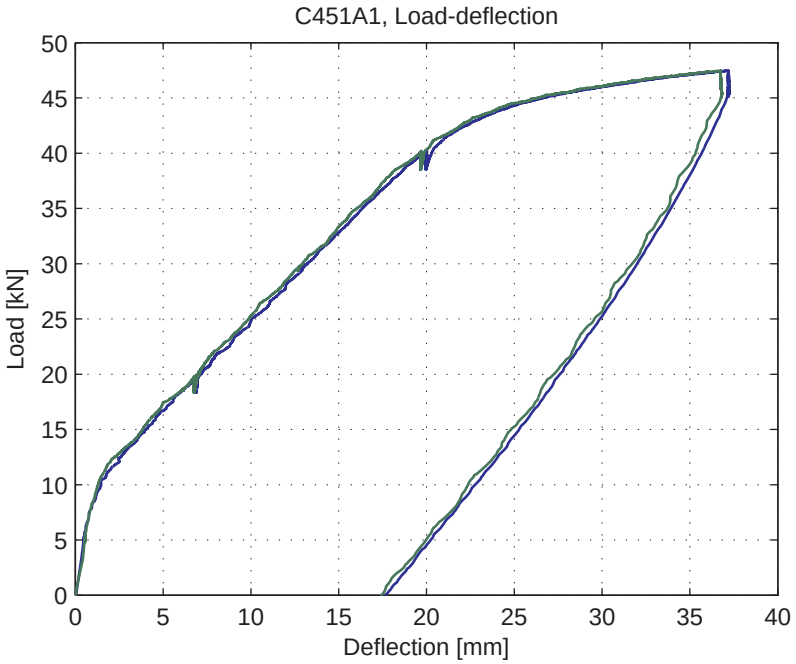


Fig. 5.62.4. Load-deflection curve

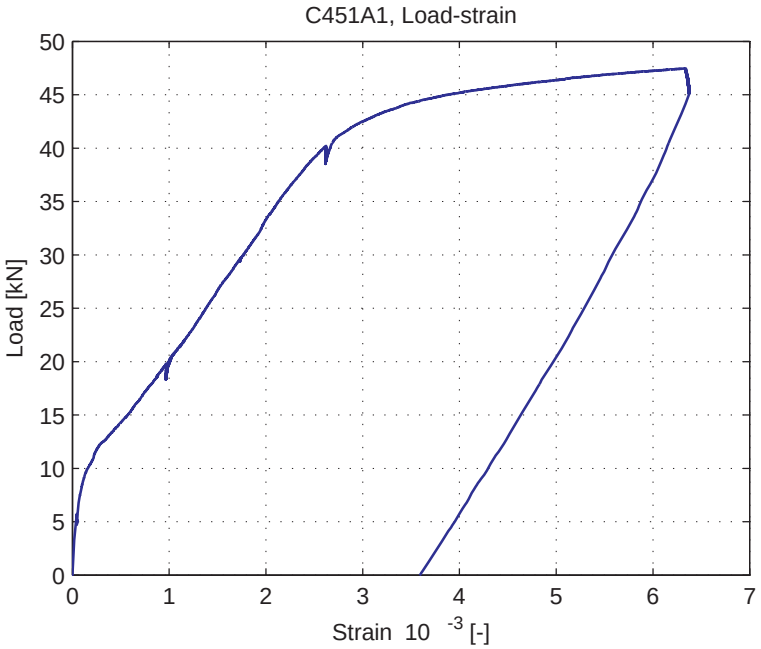


Fig. 5.62.5. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.63. C451A2

5.63.1. Test properties

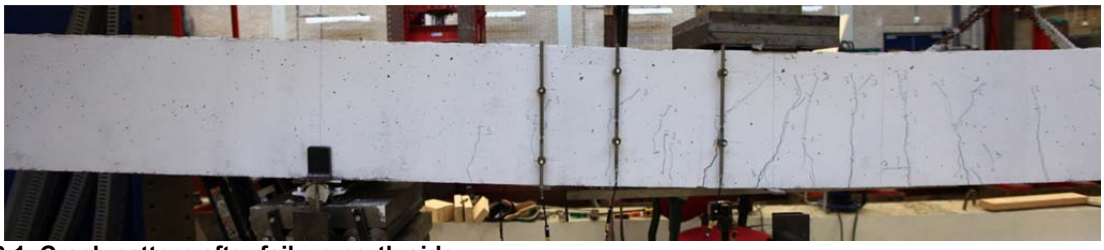


Fig. 5.63.1. Crack pattern after failure north side

Fig. 5.63.2. Crack pattern after failure south side

Table 5.63.1. Beam properties

Date of test	10-09-2015
Reinforcement	3Ø12
Reinforcement ratio	0.42%
a	1000 mm
a / *d*	3.67
Concrete cube strength at testing	23.7 MPa
Peak load	58.6 kN
Failure mode	Flexural

Table 5.63.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Placed LVDT's 4-6
1	20	
2	40	LVDT3 came in a hole of steel plate.
3	58.6	Yielding. Stopped after jack displacement of 35 mm.

Table 5.63.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	490	50
5	North	Vertical	650	100
6	North	Vertical	880	100

5.63.2. Measurement results

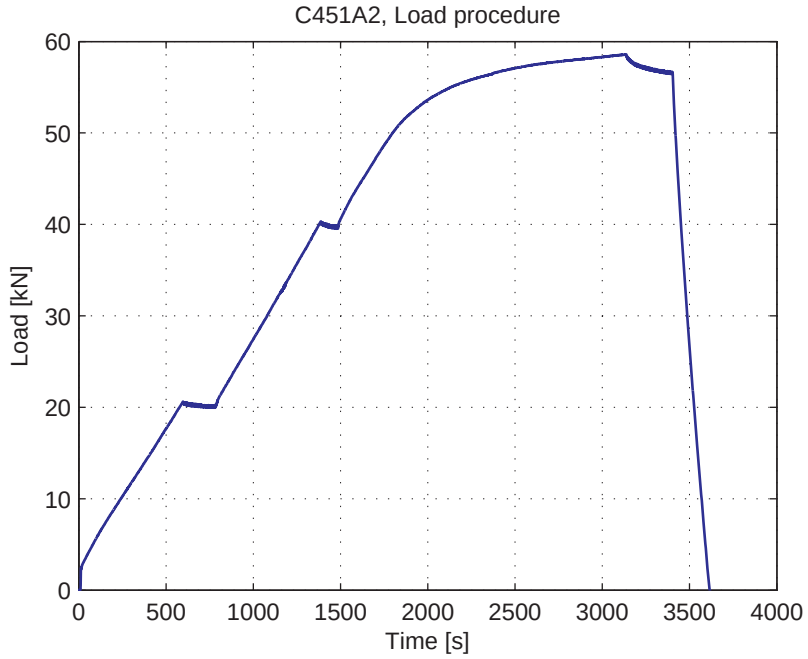


Fig. 5.63.3. Load-Time curve

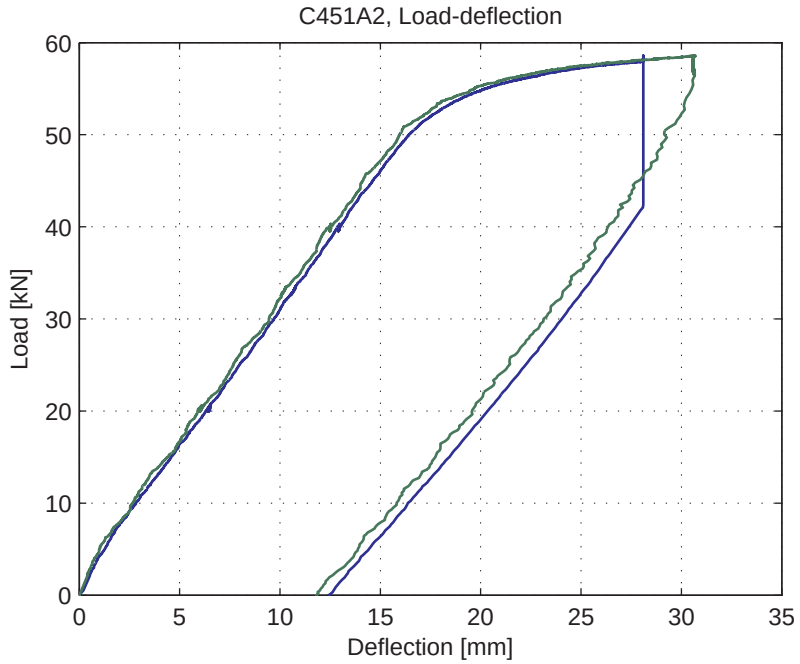


Fig. 5.63.4. Load-deflection curve

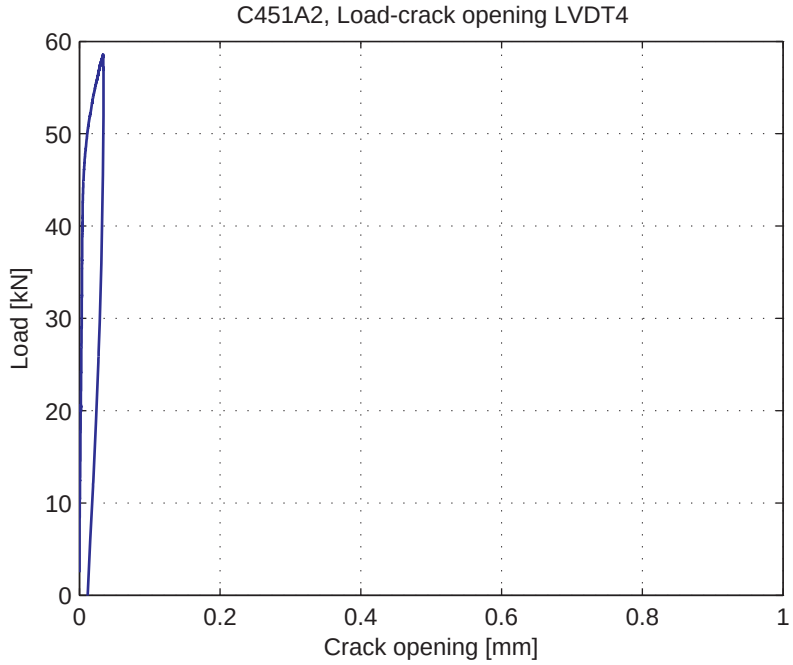


Fig. 5.63.5. Load-Crack opening for LVDT4

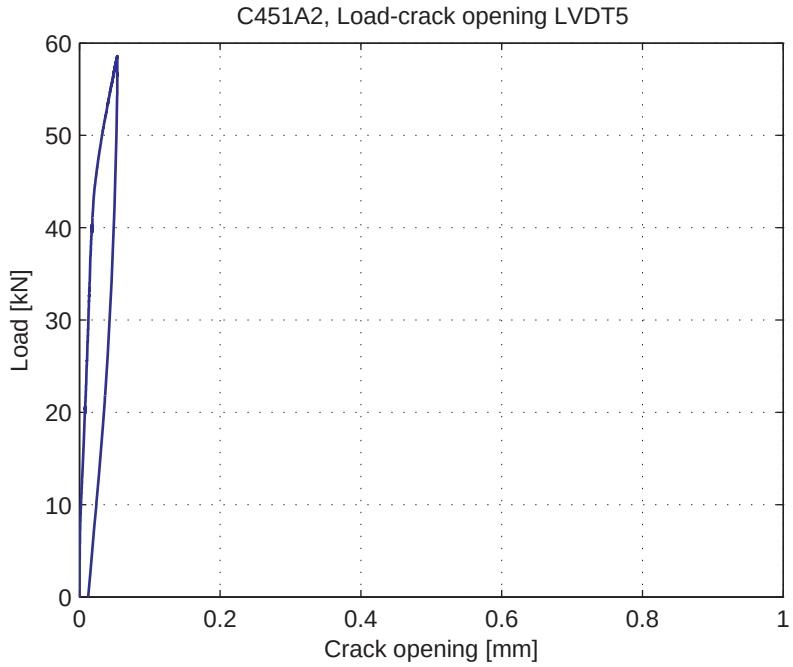


Fig. 5.63.6. Load-Crack opening for LVDT5

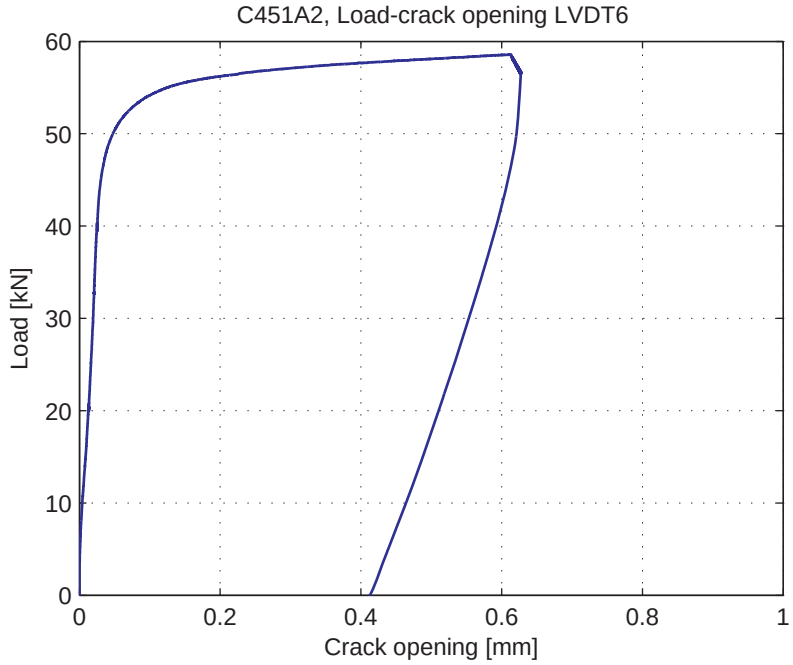


Fig. 5.63.7. Load-Crack opening for LVDT6

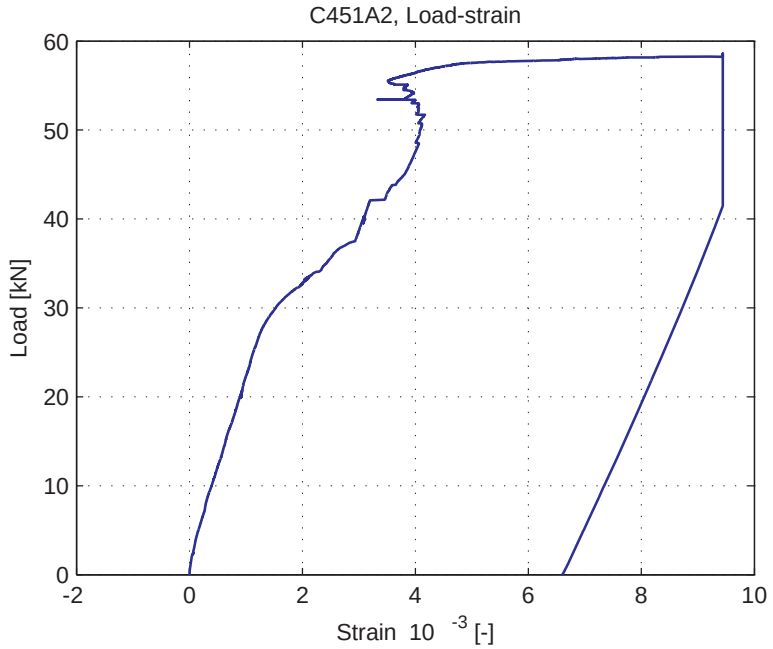


Fig. 5.63.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.64. C451A3

5.64.1. Test properties

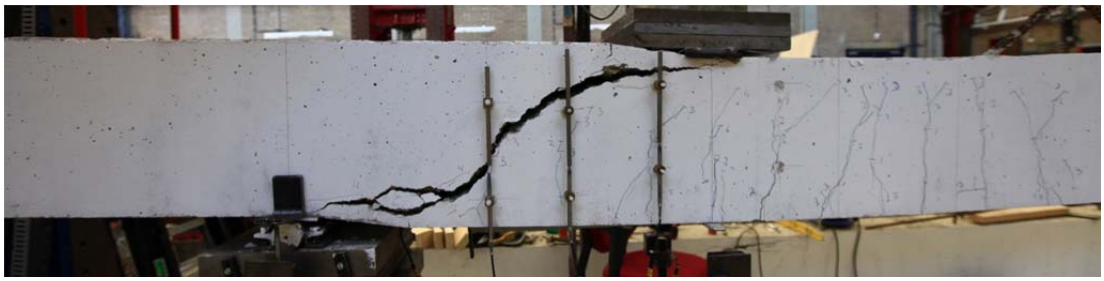


Fig. 5.64.1. Crack pattern after failure north side

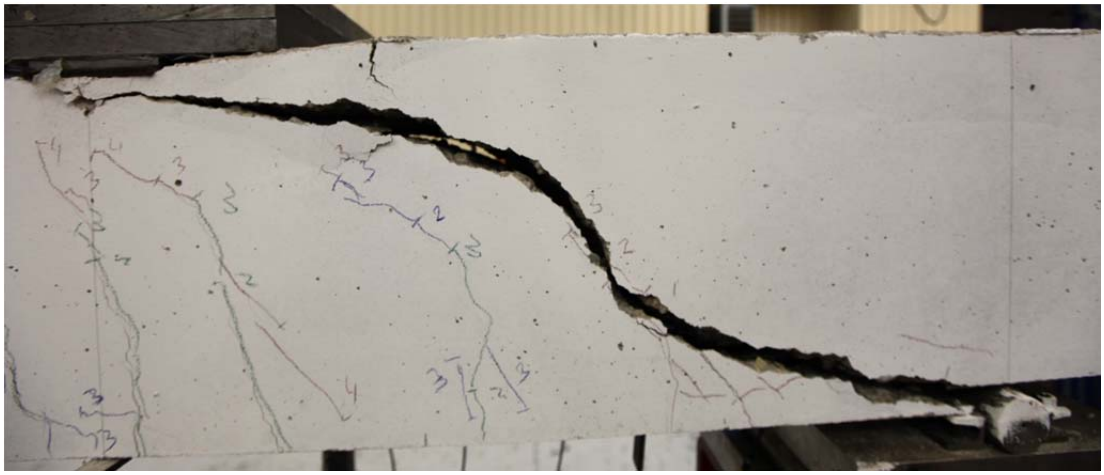


Fig. 5.64.2. Crack pattern after failure south side

Table 5.64.1. Beam properties

Date of test	11-09-2015
Reinforcement	3Ø12
Reinforcement ratio	0.42%
a	750 mm
a / *d*	2.75
Concrete cube strength at testing	23.7 MPa
Flexural / shear	68.4 kN / 73.5 kN (shear failure)
Failure mode	Flexural and shear

Table 5.64.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Replaced LVDT 6, Difficult to install LVDT 3, beam deformed a lot
1	20	
2	40	
3	60	
4	73.5	Shear failure under sustained load

Table 5.64.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	490	50
5	North	Vertical	650	100
6	North	Vertical	345	50

5.64.2. Measurement results

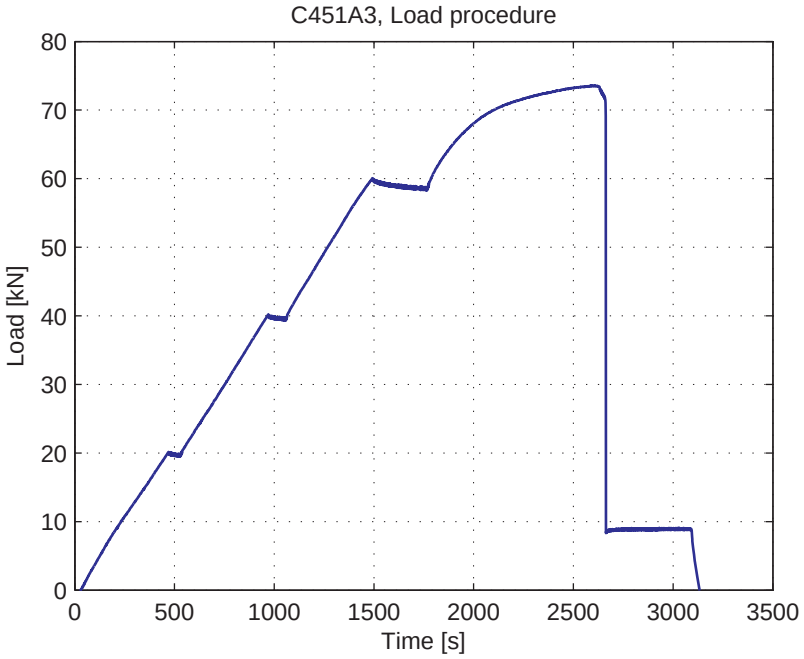


Fig. 5.64.3. Load-Time curve

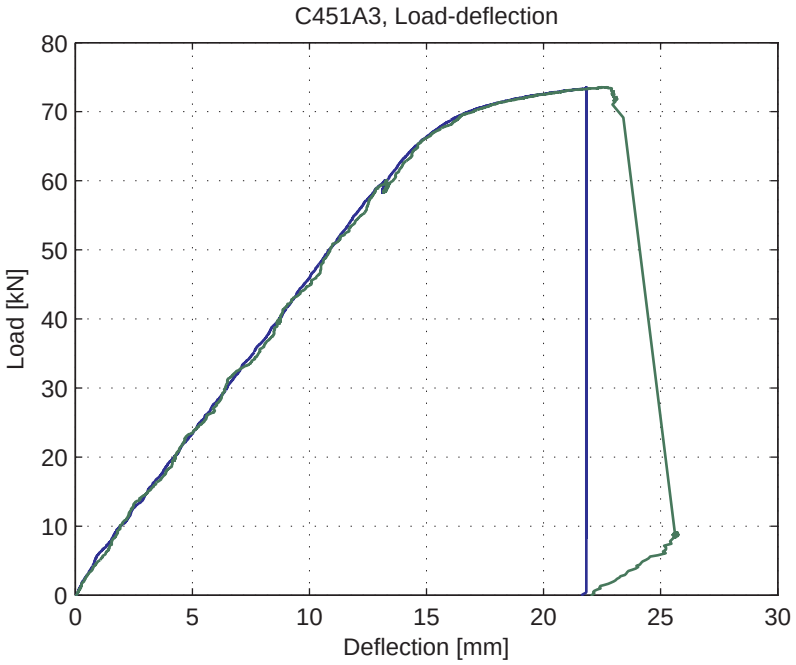


Fig. 5.64.4. Load-deflection curve

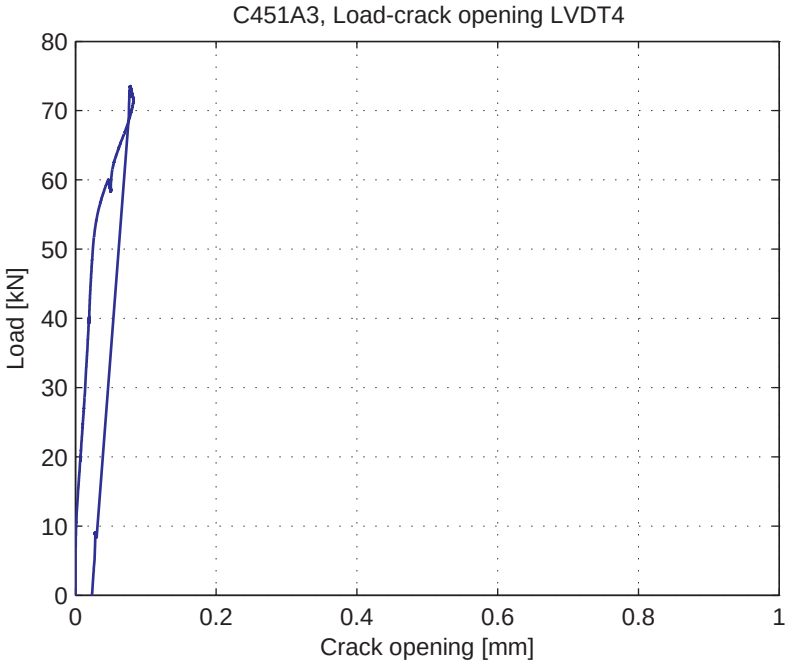


Fig. 5.64.5. Load-Crack opening for LVDT4

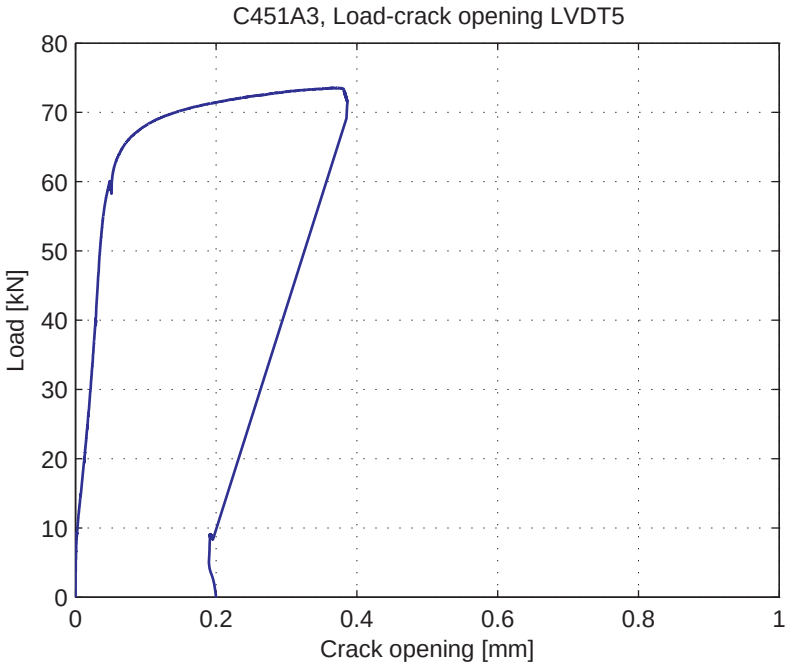


Fig. 5.64.6. Load-Crack opening for LVDT5

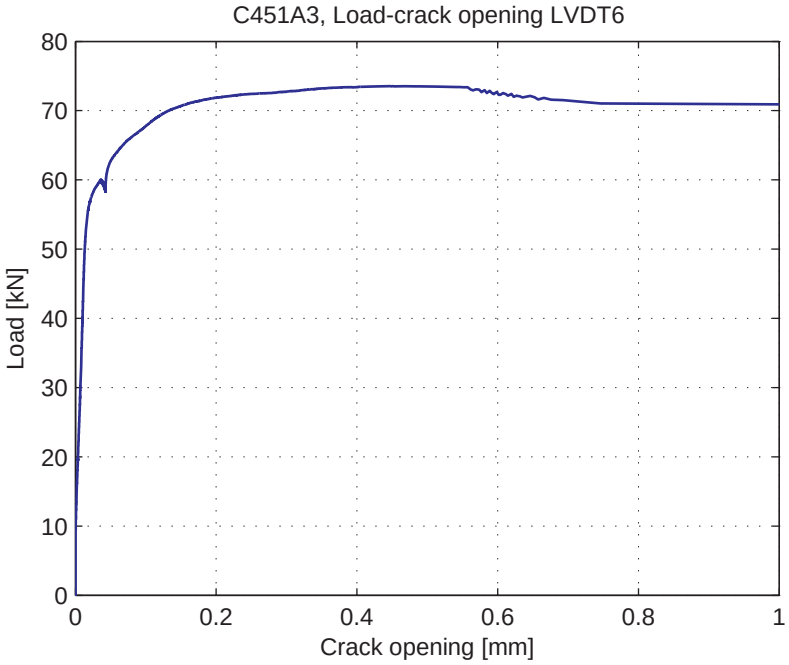


Fig. 5.64.7. Load-Crack opening for LVDT6

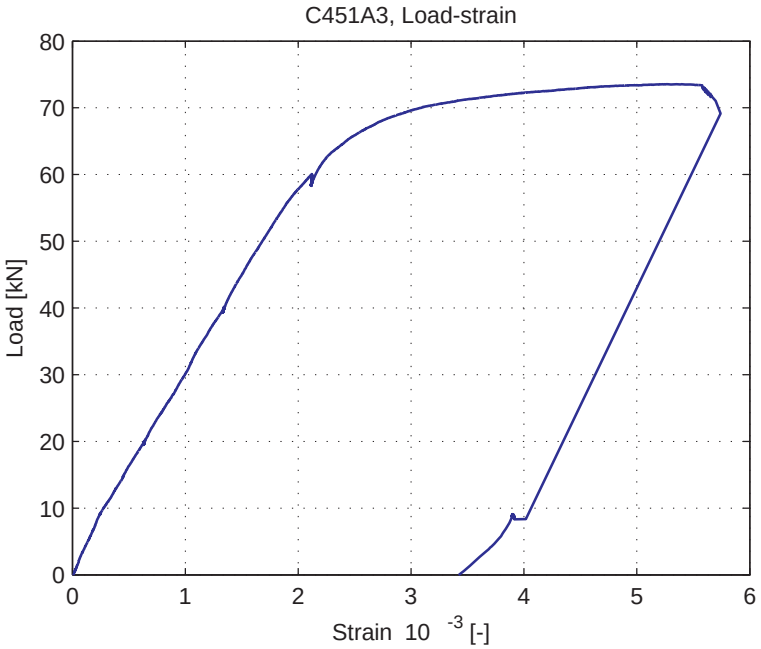


Fig. 5.64.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.65. C451A4

5.65.1. Test properties

Fig. 5.65.1. Crack pattern after failure north side

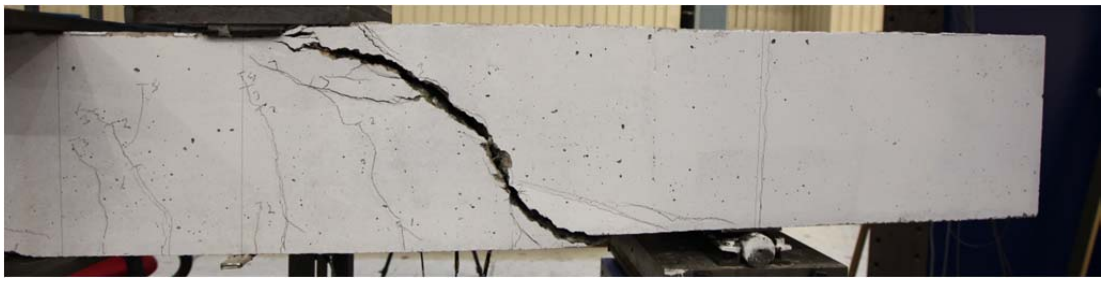


Fig. 5.65.2. Crack pattern after failure south side

Table 5.65.1. Beam properties

Date of test	11-09-2015
Reinforcement	3Ø12
Reinforcement ratio	0.42%
a	750 mm
a / *d*	2.75
Concrete cube strength at testing	23.7 MPa
Peak load	70.9 kN
Failure mode	Shear

Table 5.65.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Shear crack of 3th test fixed with two steel plates, prestressed. LVDT 3 cannot be placed due to steel plates
1	20	
2	40	Placed LVDT's 4-6
3	50	Stopped to check for new shear cracks
4	60	Stopped for video
5	70.8	Shear failure, slowly developed

Table 5.65.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	380	50
5	North	Vertical	470	50
6	North	Vertical	545	100

5.65.2. Measurement results

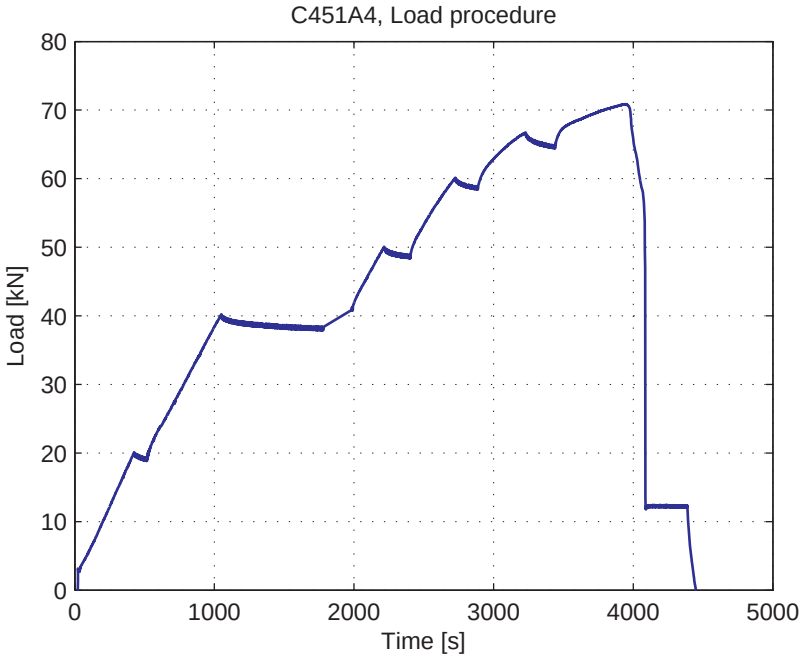


Fig. 5.65.3. Load-Time curve

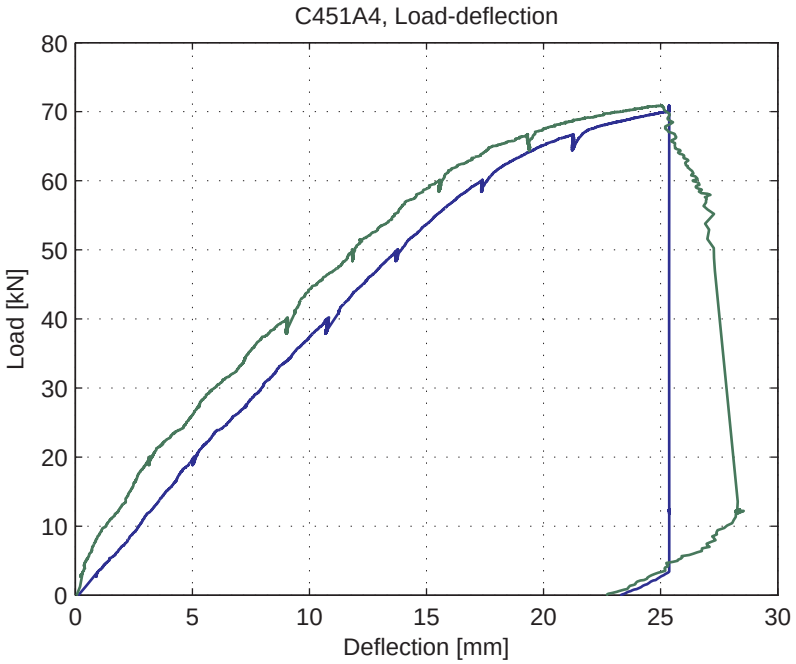


Fig. 5.65.4. Load-deflection curve

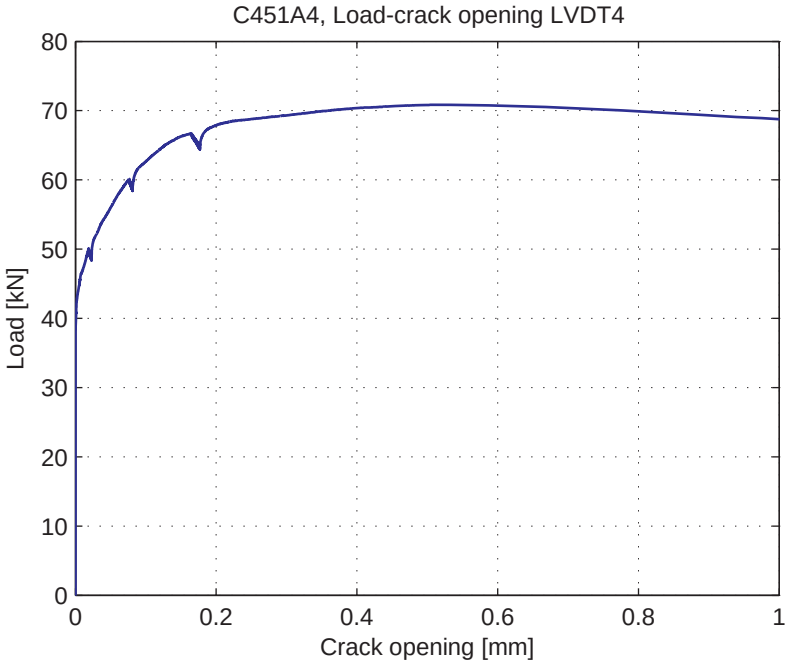


Fig. 5.65.5. Load-Crack opening for LVDT4

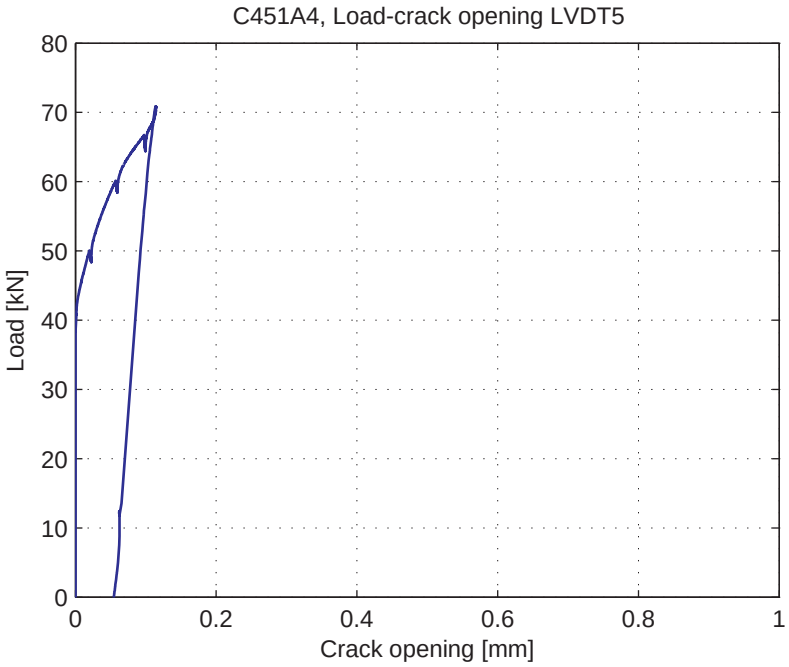


Fig. 5.65.6. Load-Crack opening for LVDT5

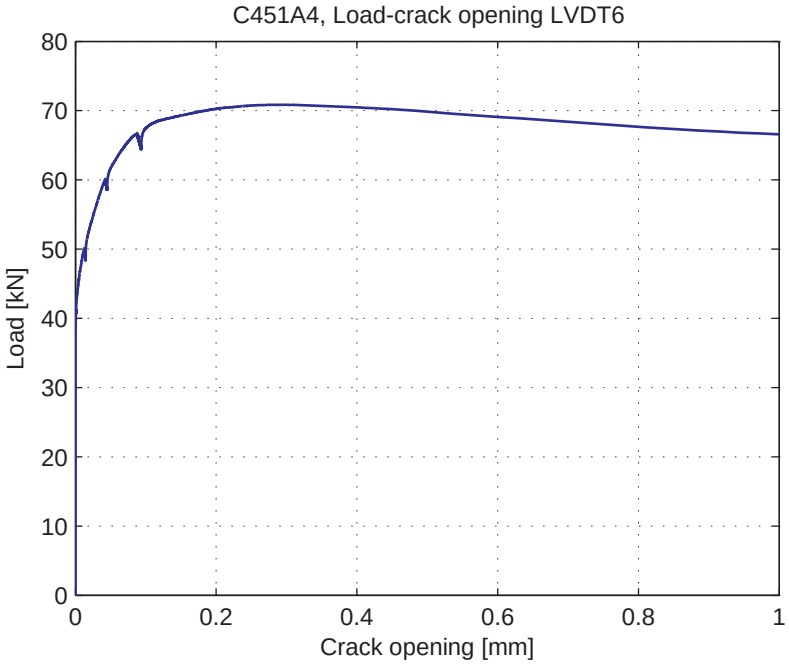


Fig. 5.65.7. Load-Crack opening for LVDT6

5.66. C451B0

5.66.1. Test properties

Table 5.66.1. Beam properties

Date of test	14-09-2015
Reinforcement	3Ø12
Reinforcement ratio	0.42%
a	850 mm
a / *d*	3.12
Concrete cube strength at testing	23.7 MPa
Peak load	-
Failure mode	-

Table 5.66.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	20	
2	40.2	It is observed that shear crack at unloaded side (side a) is opening. Test is halted and crack is closed by steel plates. Test is continued in C451B3. C451B2 only measured applying the steel plates.

5.66.2. Measurement results

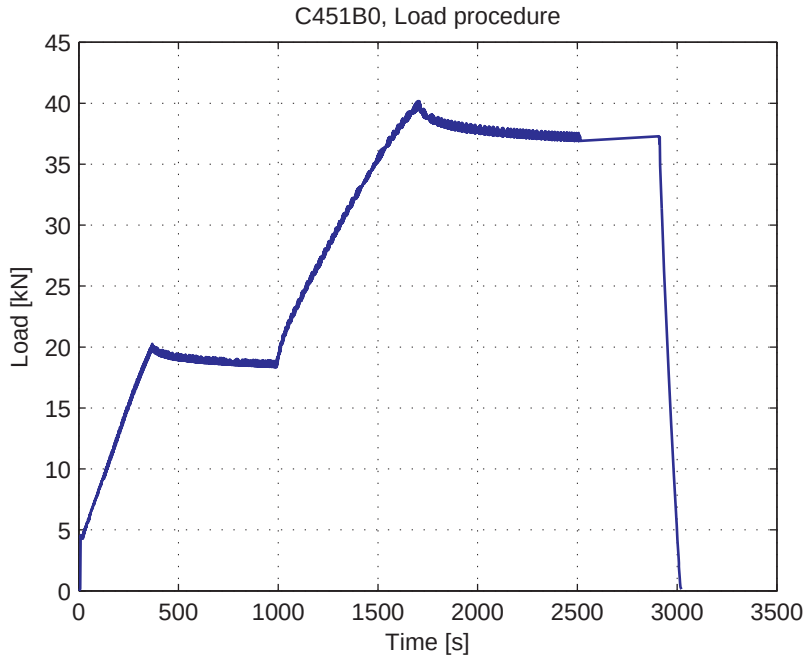


Fig. 5.66.1. Load-Time curve

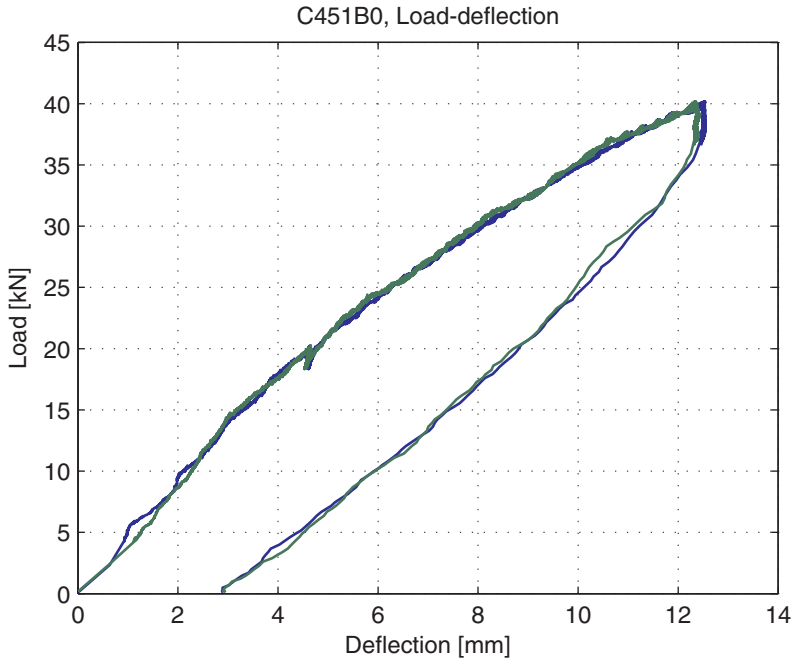


Fig. 5.66.2. Load-deflection curve

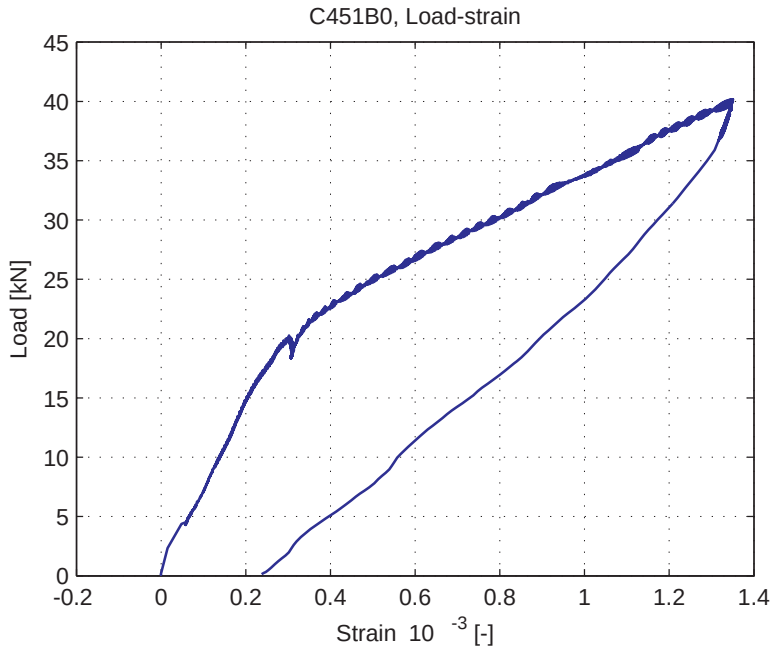


Fig. 5.66.3. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.67. C451B1

5.67.1. Test properties

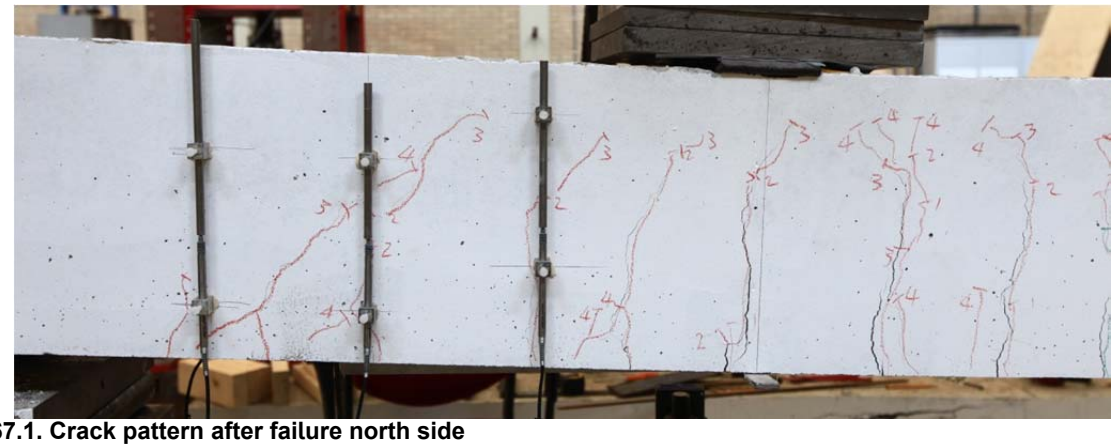


Fig. 5.67.1. Crack pattern after failure north side

Fig. 5.67.2. Crack pattern after failure south side

Table 5.67.1. Beam properties

Date of test	14-09-2015
Reinforcement	3Ø12
Reinforcement ratio	0.42%
a	800 mm
a / *d*	2.94
Concrete cube strength at testing	23.7 MPa
Peak load	58.5 kN
Failure mode	Flexural

Table 5.67.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Placed LVDT 4 and 5
1	40	
2	60	Added LVDT 6
3	66.3	Yielding, stopped after jack displacement of 40 mm

Table 5.67.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	460	50
5	North	Vertical	630	100
6	North	Vertical	300	50

5.67.2. Measurement results

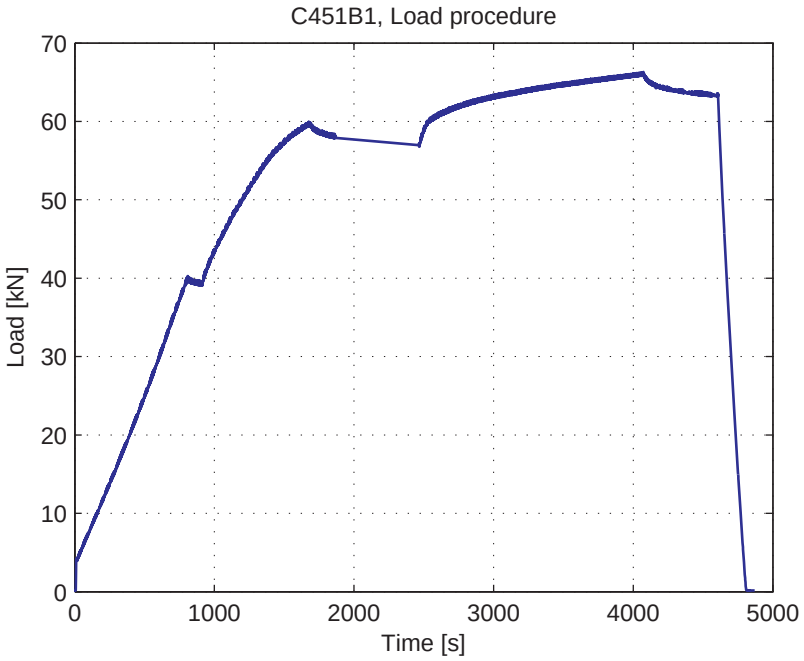


Fig. 5.67.3. Load-Time curve

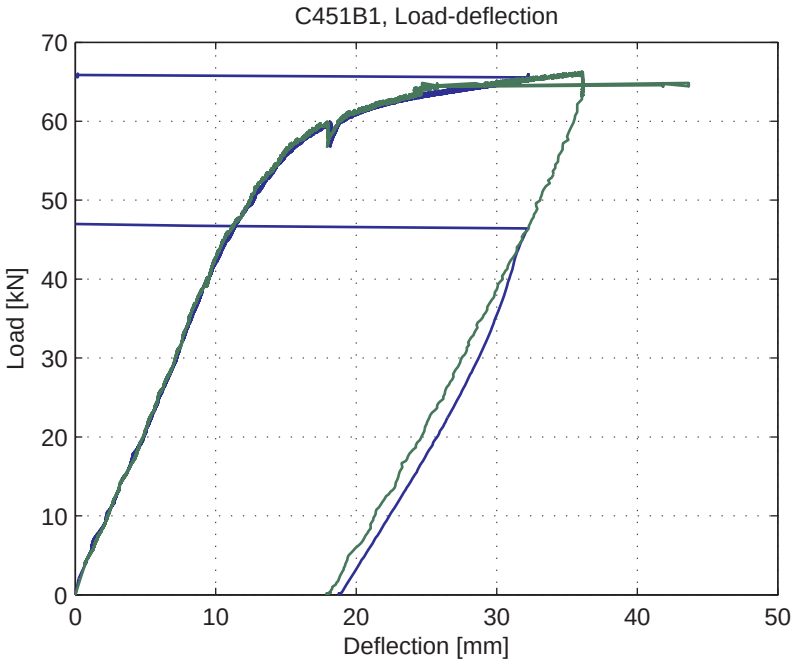


Fig. 5.67.4. Load-deflection curve

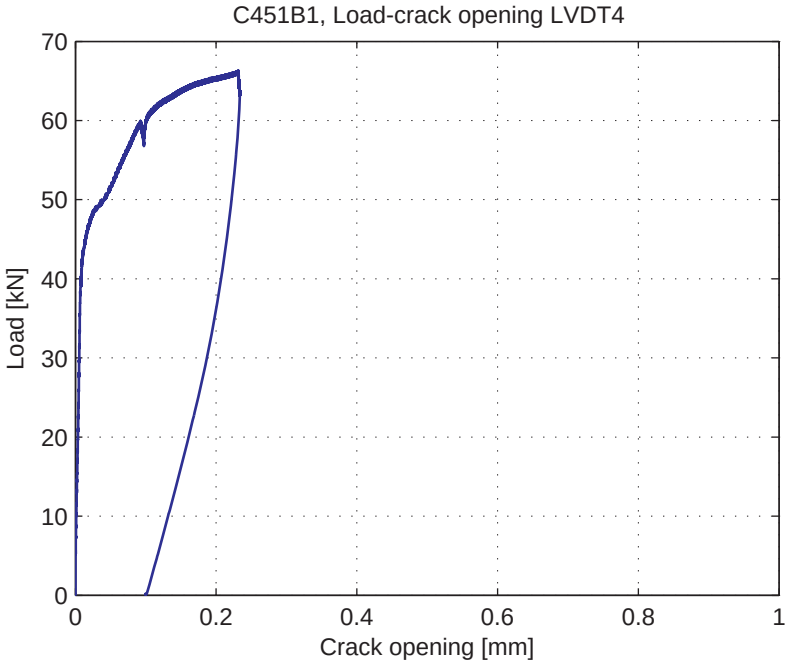


Fig. 5.67.5. Load-Crack opening for LVDT4

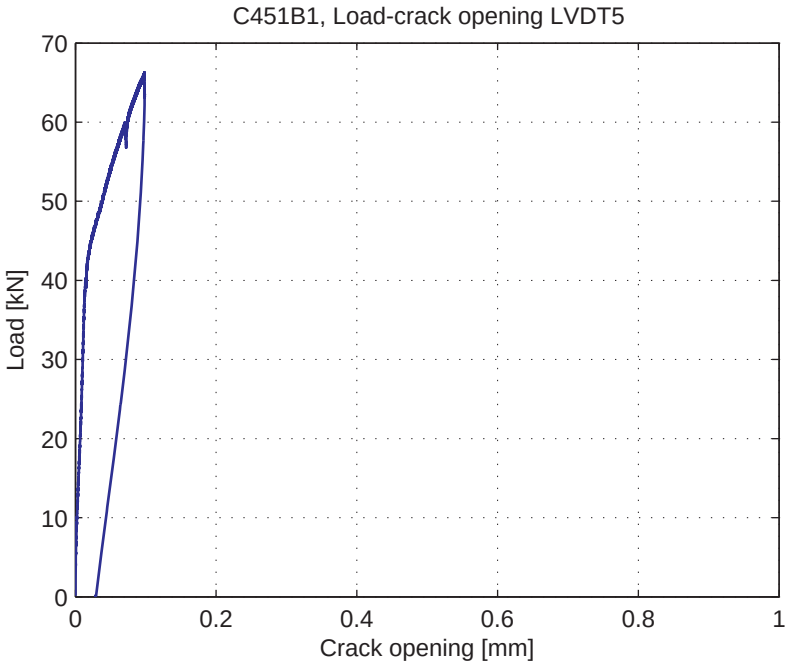


Fig. 5.67.6. Load-Crack opening for LVDT5

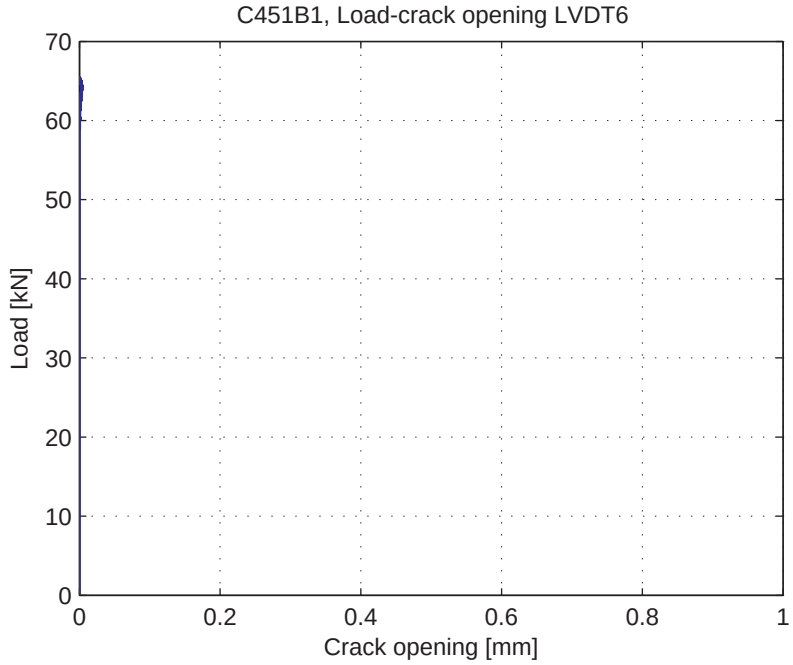


Fig. 5.67.7. Load-Crack opening for LVDT6

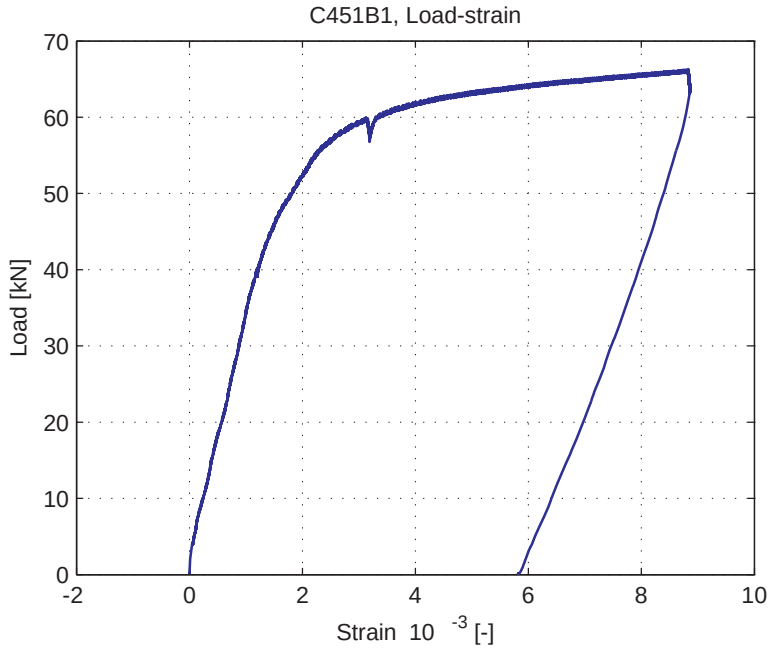


Fig. 5.67.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.68. C451B2

5.68.1. Test properties

Fig. 5.68.1. Crack pattern after failure north side

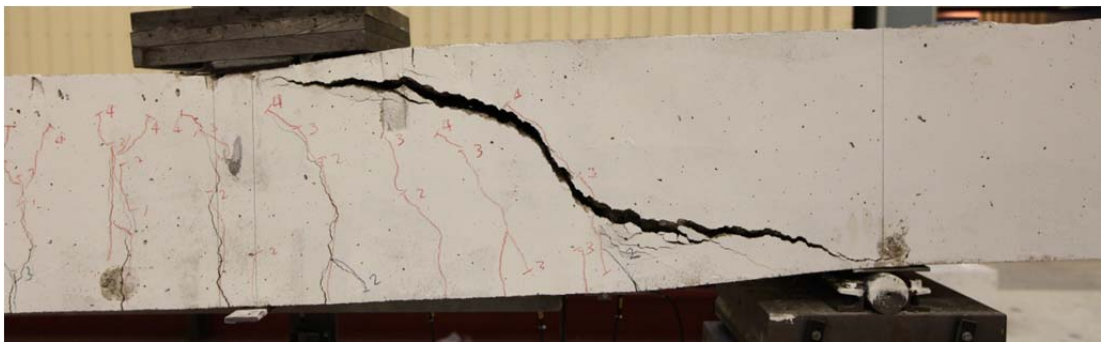


Fig. 5.68.2. Crack pattern after failure south side

Table 5.68.1. Beam properties

Date of test	15-09-2015
Reinforcement	3Ø12
Reinforcement ratio	0.42%
a	800 mm
a / *d*	2.94
Concrete cube strength at testing	23.7 MPa
Peak load	70.6 kN (shear failure shortly after yielding of reinforcement)
Failure mode	Flexural and shear

Table 5.68.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Steel for laser 1 and 2 changed, now 40 mm wide. LVDT 3 not replaced, still in old position
1	40	
2	60	Halted for video and Yuguang
3	70.6	Shear failure

Table 5.68.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
4	North	Vertical	460	50
5	North	Vertical	630	100
6	North	Vertical	300	50

5.68.2. Measurement results

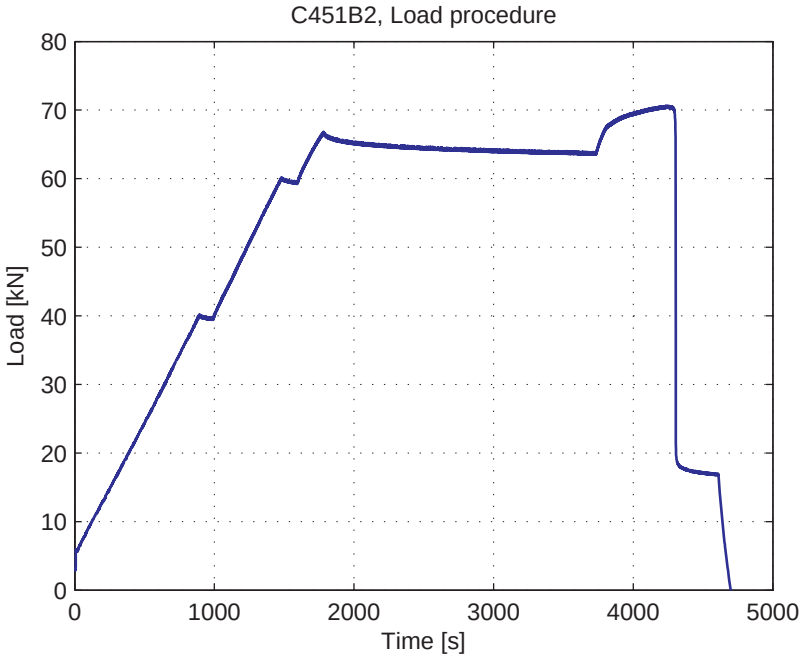


Fig. 5.68.3. Load-Time curve

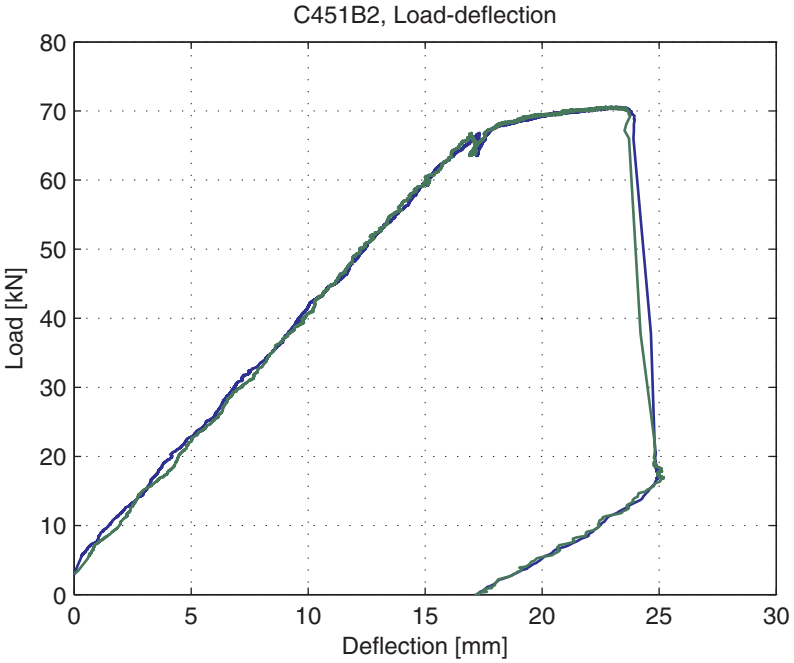


Fig. 5.68.4. Load-deflection curve

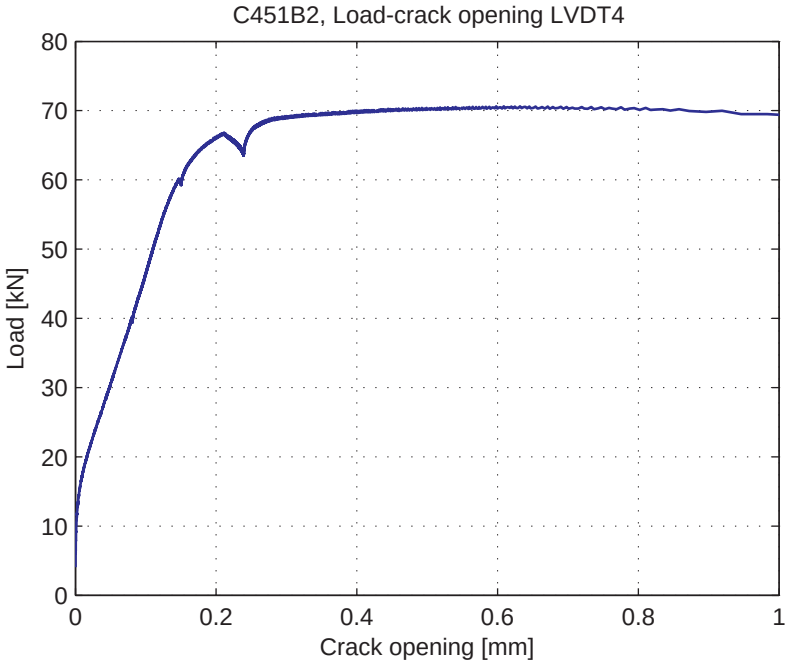


Fig. 5.68.5. Load-Crack opening for LVDT4

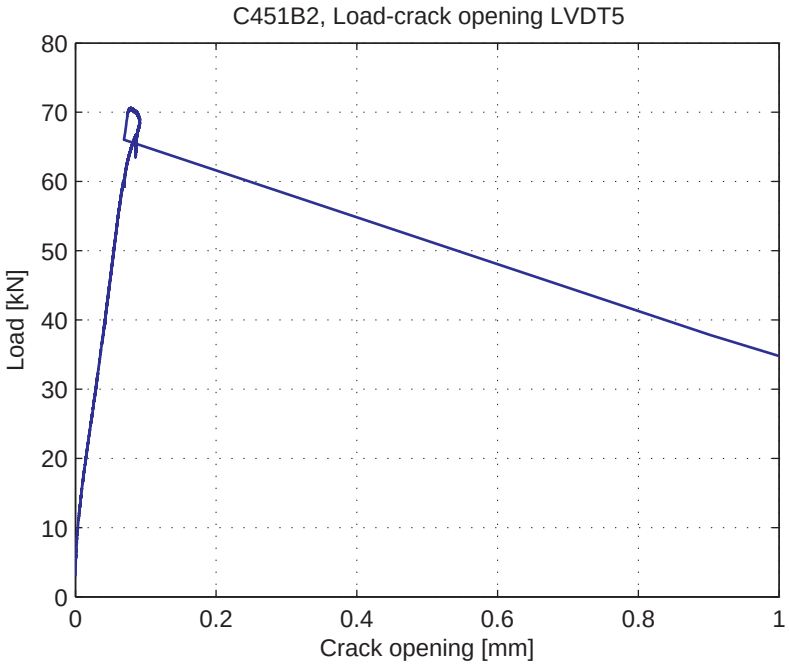


Fig. 5.68.6. Load-Crack opening for LVDT5

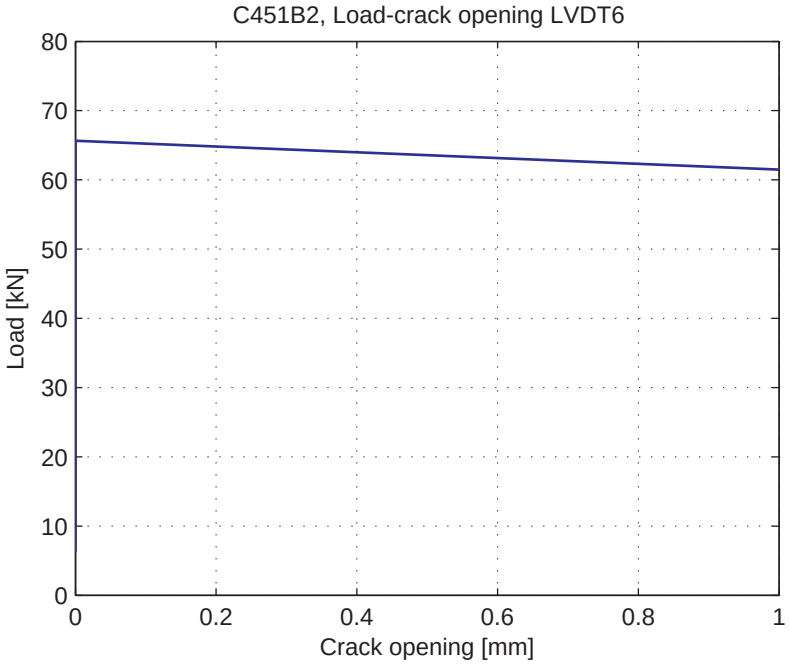


Fig. 5.68.7. Load-Crack opening for LVDT6

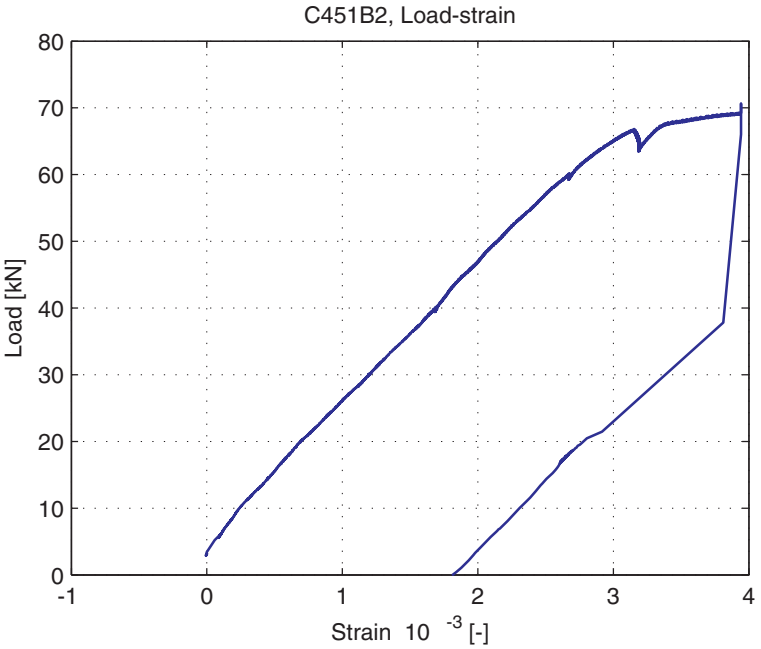


Fig. 5.68.8. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.69. C451B3

5.69.1. Test properties

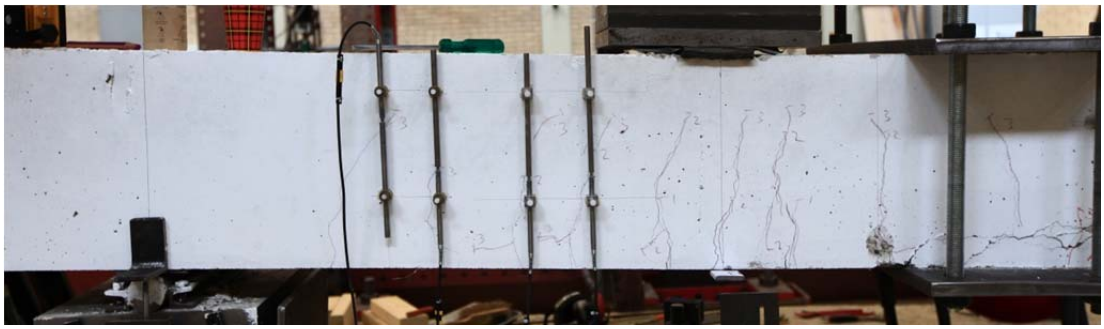


Fig. 5.69.1. Crack pattern after failure north side

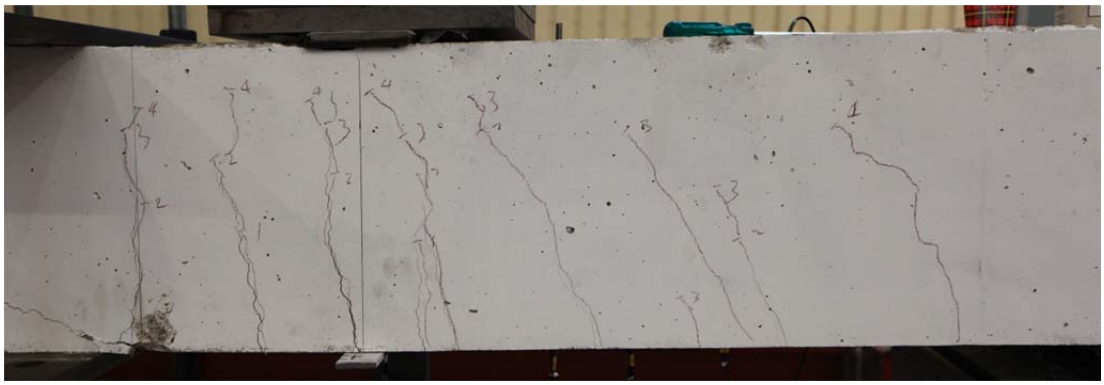


Fig. 5.69.2. Crack pattern after failure south side

Table 5.69.1. Beam properties

Date of test	15-09-2015
Reinforcement	3Ø12
Reinforcement ratio	0.42%
a	800
a / *d*	2.94
Concrete cube strength at testing	23.7 MPa
Peak load	67.1 kN
Failure mode	Flexural

Table 5.69.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Shear crack from previous test clamped by steel plates. LVDT 3 not placed due to steel plates. LVDT 1 not working, replaced by LVDT 7
1	20	
2	40	Placed LVDT's 4 and 5
3	60	Placed LVDT's 3 and 6
4	67.1	Stopped after jack displacement of 35.8 mm

Table 5.69.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
3	North	Vertical	320	100
4	North	Vertical	525	100
5	North	Vertical	610	100
6	North	Vertical	400	100

5.69.2. Measurement results

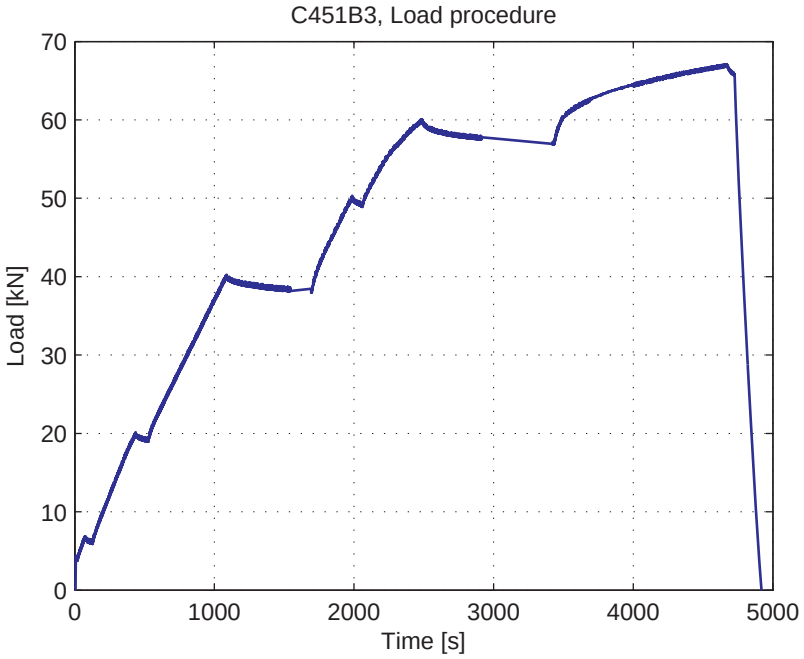


Fig. 5.69.3. Load-Time curve

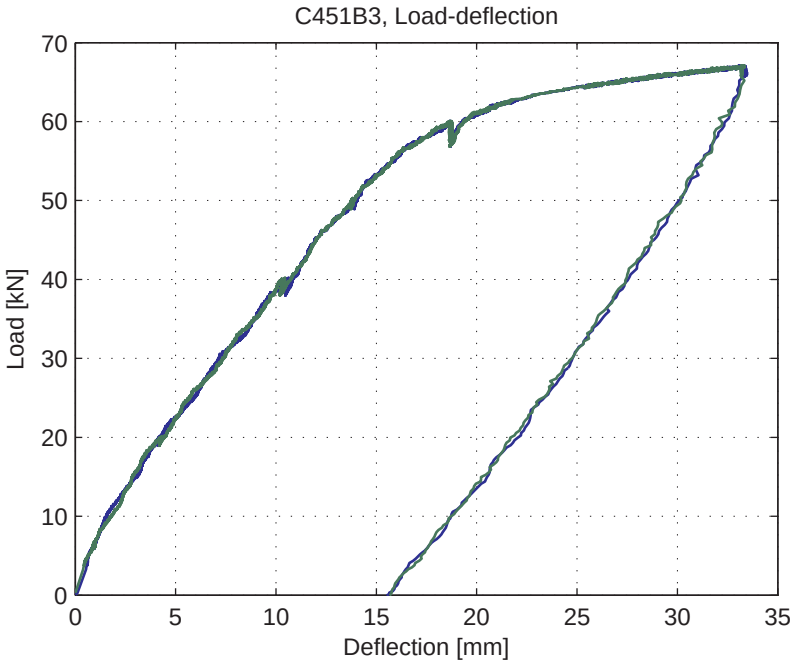


Fig. 5.69.4. Load-deflection curve

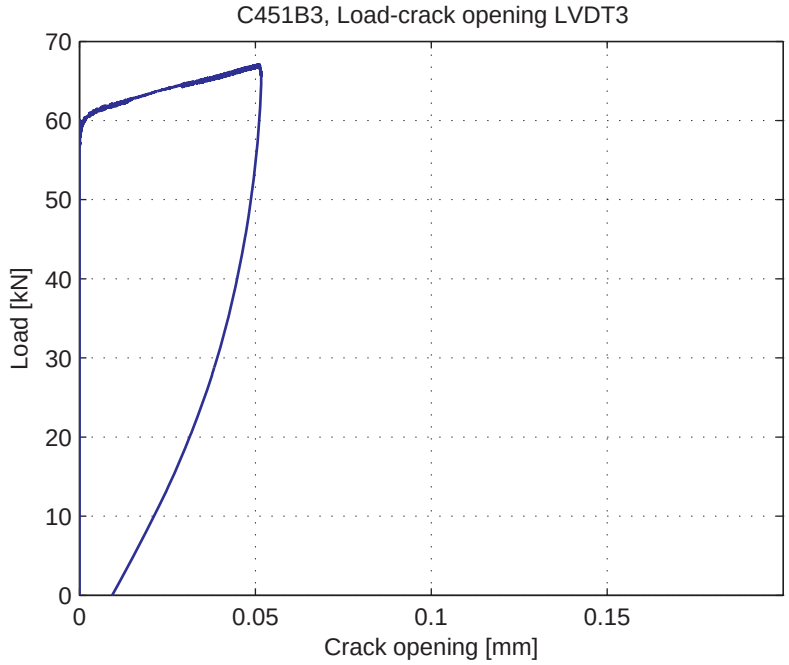


Fig. 5.69.5. Load-Crack opening for LVDT3

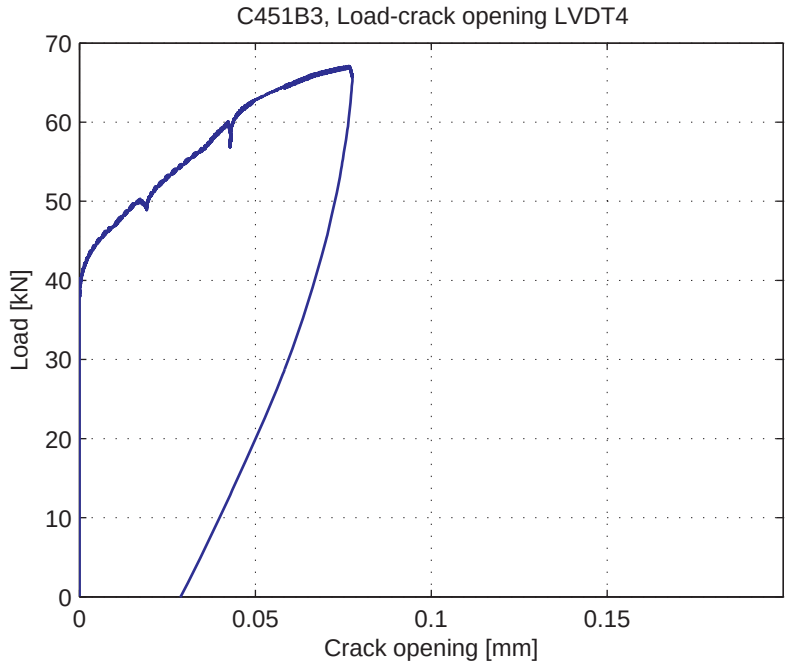


Fig. 5.69.6. Load-Crack opening for LVDT4

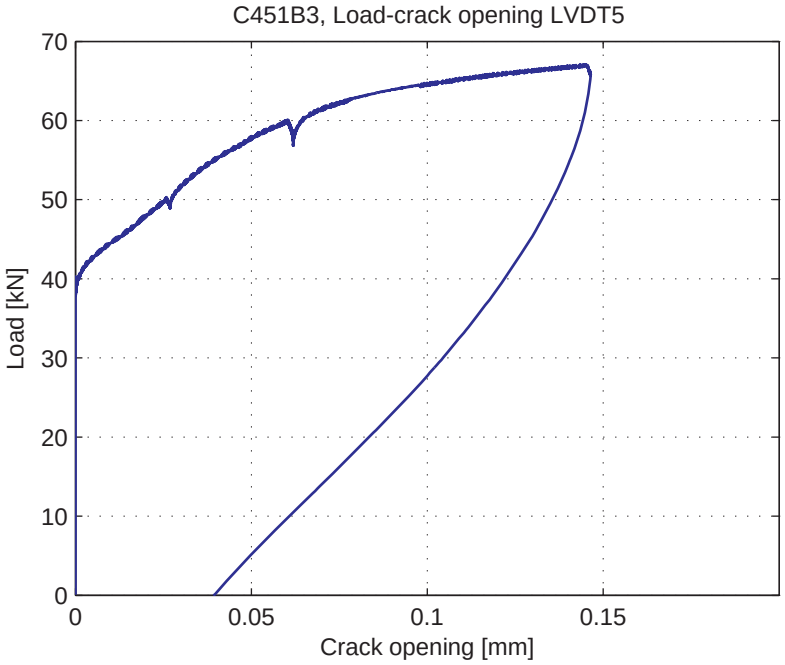


Fig. 5.69.7. Load-Crack opening for LVDT5

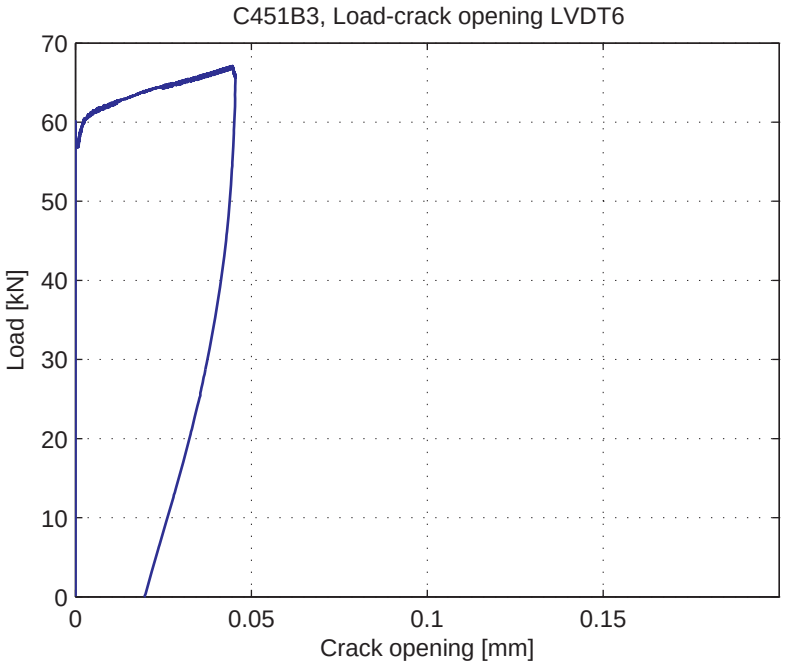


Fig. 5.69.8. Load-Crack opening for LVDT6

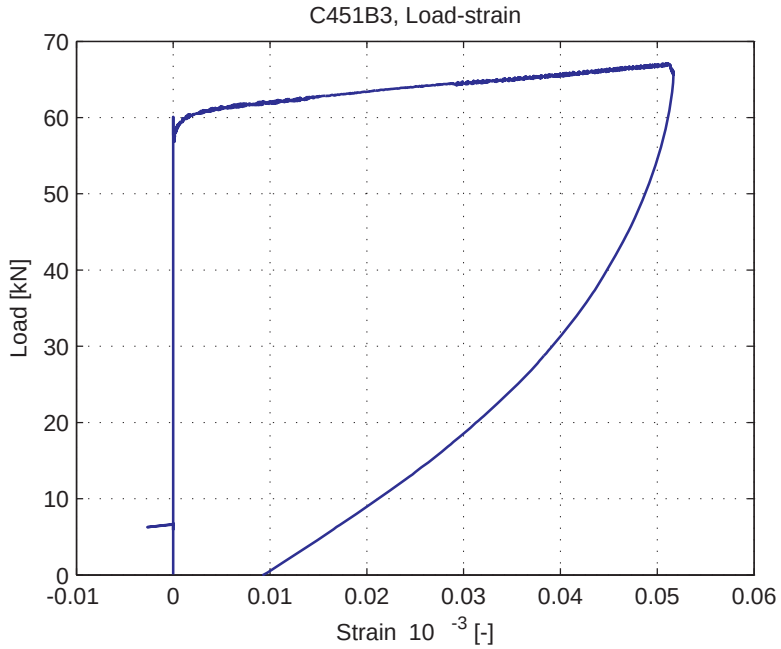


Fig. 5.69.9. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.70. C451B4

5.70.1. Test properties

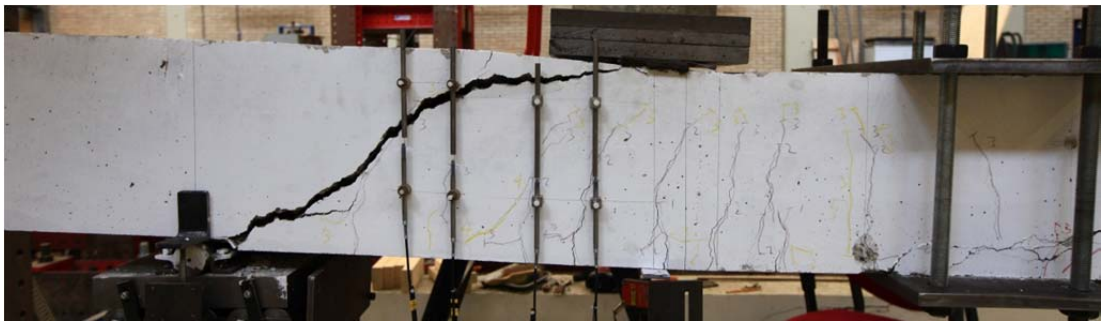


Fig. 5.70.1. Crack pattern after failure north side

Fig. 5.70.2. Crack pattern after failure south side

Table 5.70.1. Beam properties

Date of test	16-09-2015
Reinforcement	3Ø12
Reinforcement ratio	0.42%
a	700 mm
a / *d*	2.57
Concrete cube strength at testing	23.7 MPa
Peak load	77.2 kN
Failure mode	Shear

Table 5.70.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	LVDT 1 replaced by LVDT 7. All previous LVDT's are still in place
1	20	
2	40	
3	60	
4	70	
5	77.2	Shear failure

Table 5.70.3. Location LVDT's used for crack opening measurements

LVDT	Side	Orientation	Distance from support [mm]	Distance from bottom beam [mm]
3	North	Vertical	320	100
4	North	Vertical	525	100
5	North	Vertical	610	100
6	North	Vertical	400	100

5.70.2. Measurement results

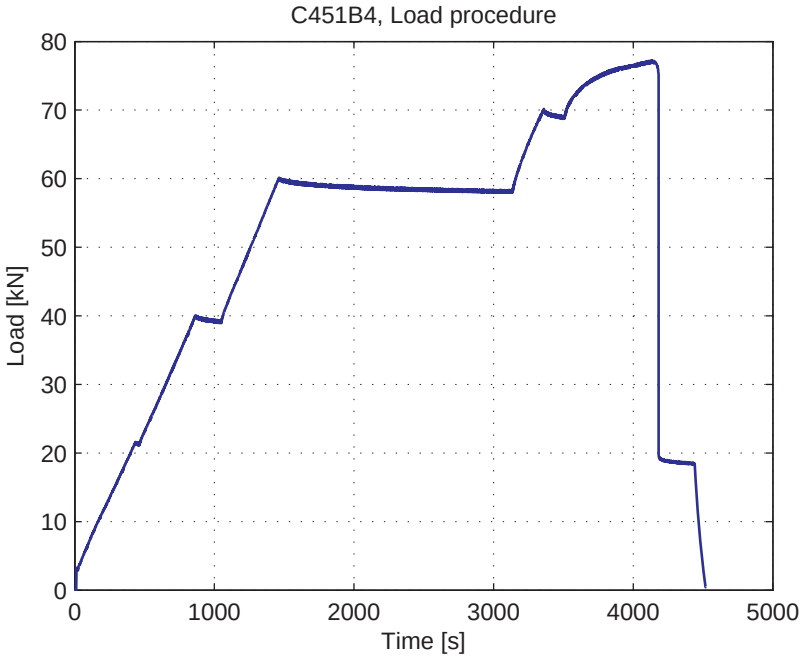


Fig. 5.70.3. Load-Time curve

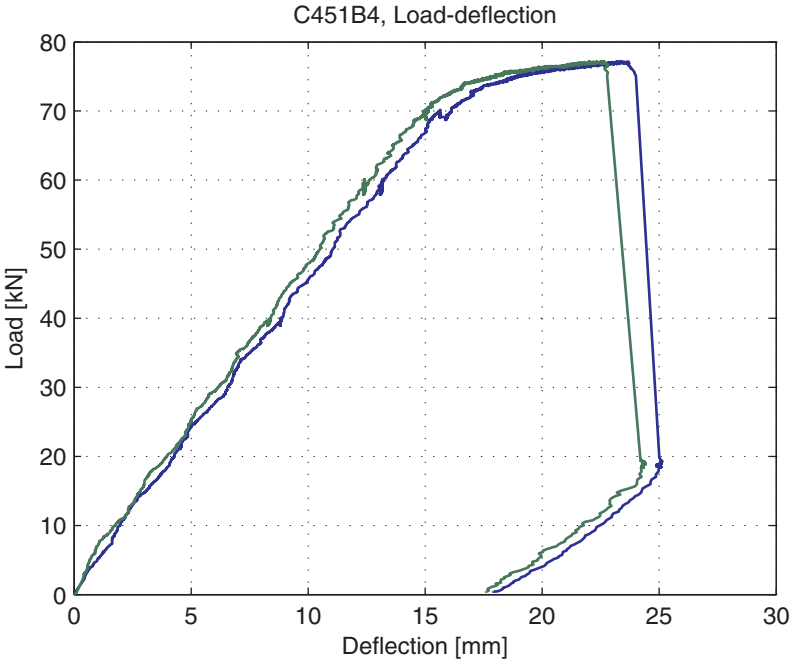


Fig. 5.70.4. Load-deflection curve

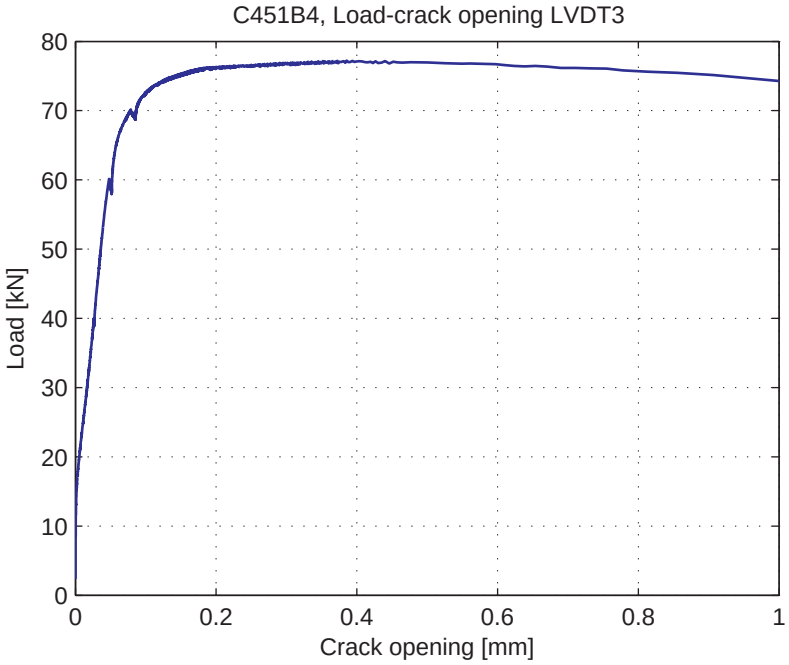


Fig. 5.70.5. Load-Crack opening for LVDT3

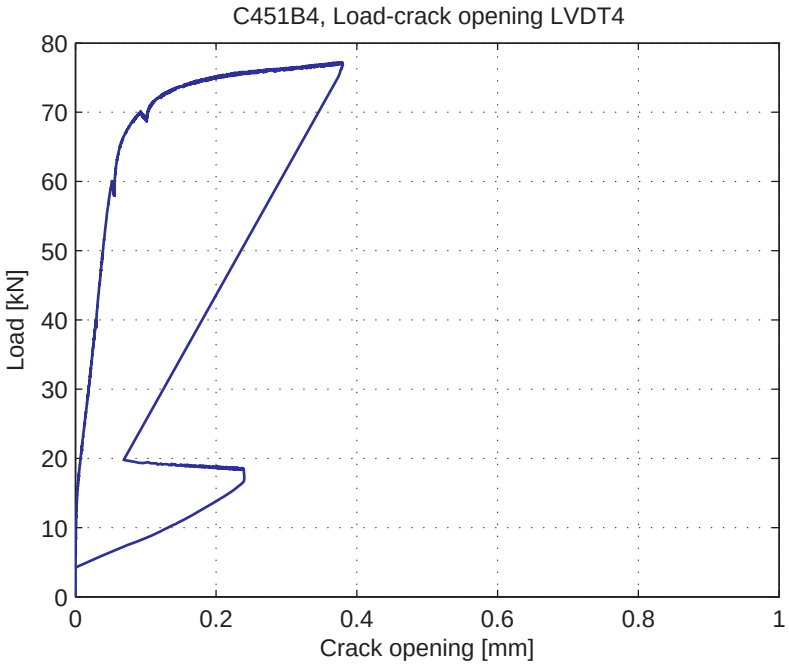


Fig. 5.70.6. Load-Crack opening for LVDT4

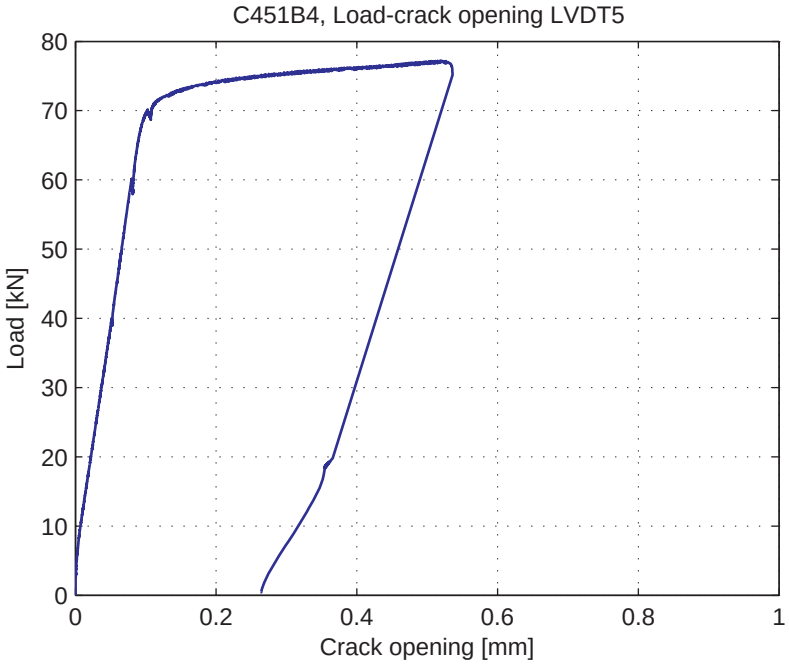


Fig. 5.70.7. Load-Crack opening for LVDT5

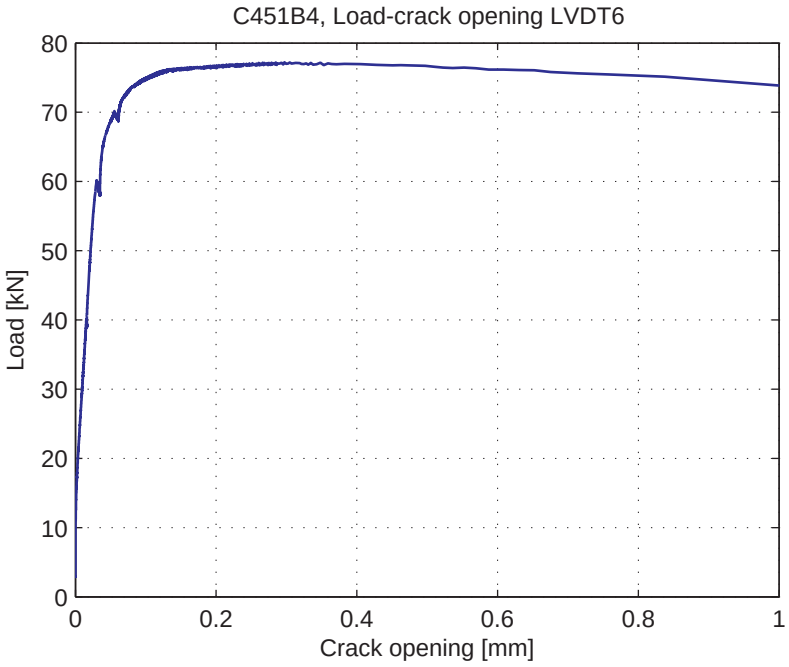


Fig. 5.70.8. Load-Crack opening for LVDT6

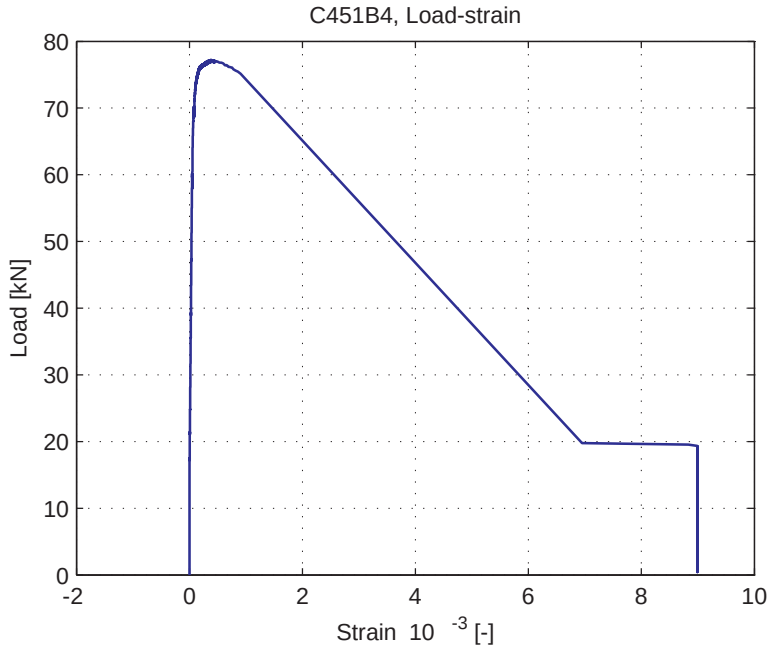


Fig. 5.70.9. Average strain over 1m length, measured at bottom of specimen (LVDT 3)

5.71. P301A1

5.71.1. Test properties

Fig. 5.71.1. Crack pattern after failure north side

Table 5.71.1. Beam properties

Date of test	21-01-2016
Reinforcement	3Ø20
Reinforcement ratio	1.19%
a	800 mm
a / *d*	3.02
Concrete cube strength at testing	80.5 MPa
Peak load	100.2 kN
Failure mode	Flexural

Table 5.71.2. Load steps

Load step	Load [kN]	Miscellaneous
0	50	
1	70	
2	100	

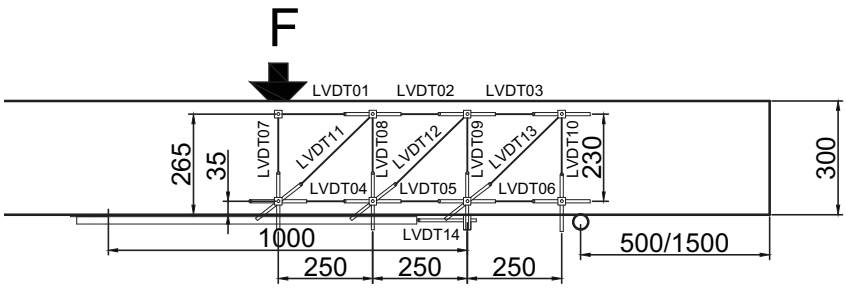


Fig. 5.71.2. LVDT layout and numbering for 300 mm deep beams

5.71.2. Measurement results

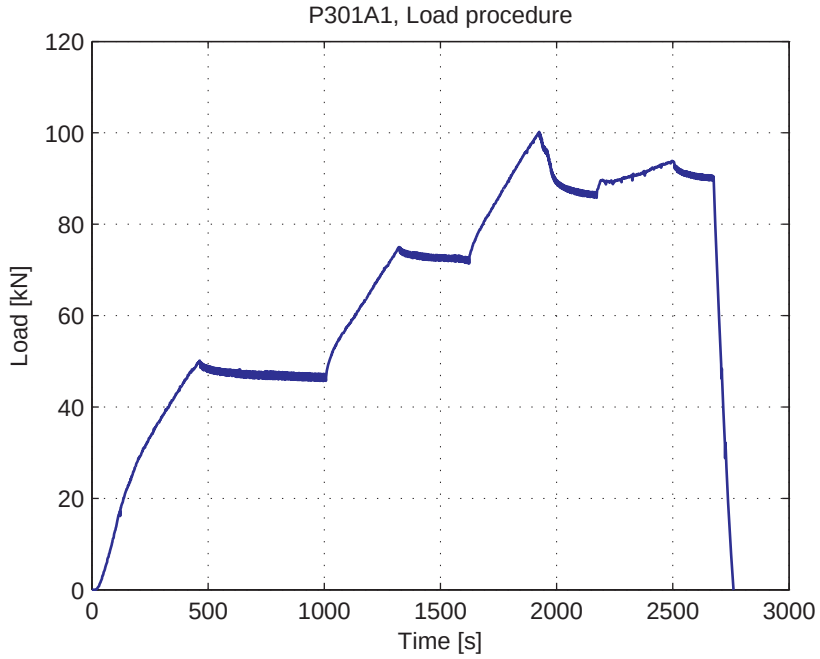


Fig. 5.71.3. Load-Time curve

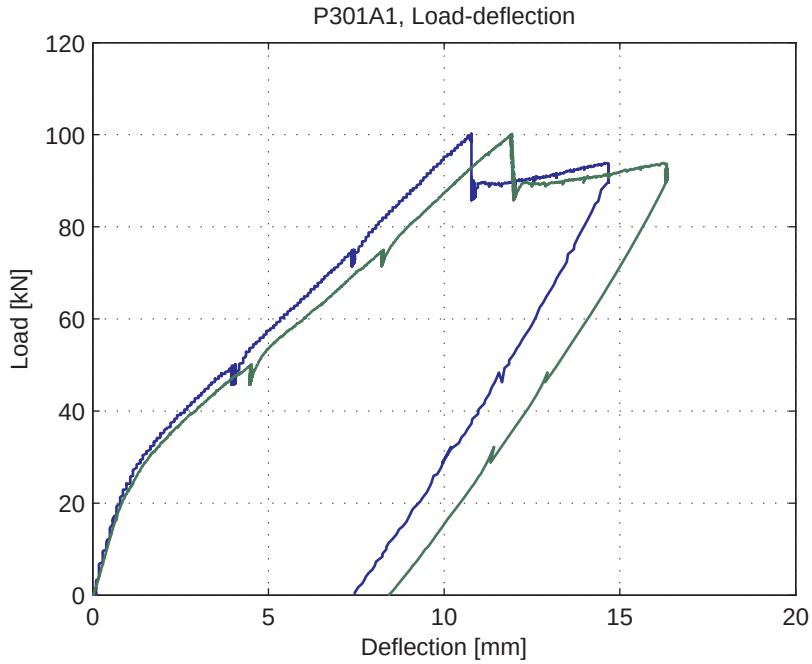


Fig. 5.71.4. Load-deflection curve

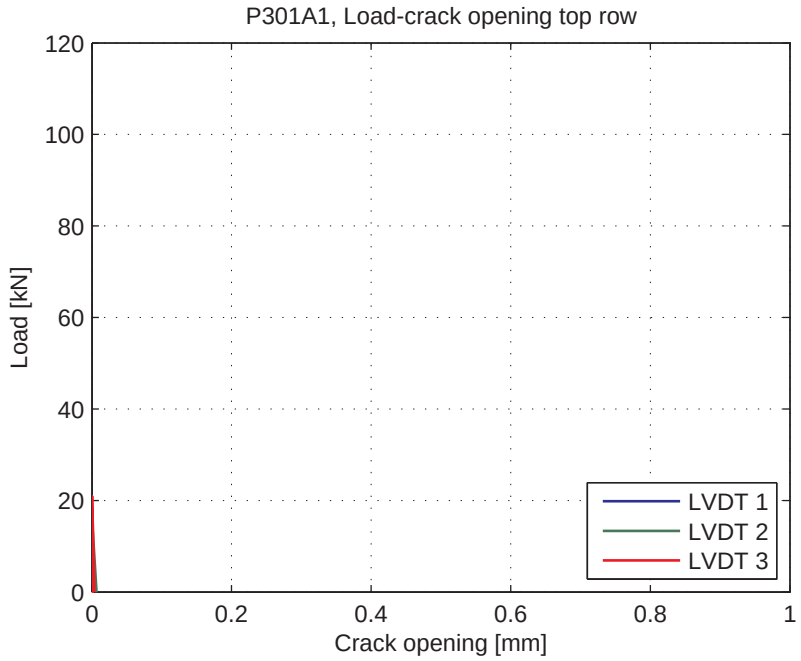


Fig. 5.71.5. Load-Crack opening for LVDT's 1-3 (top row)

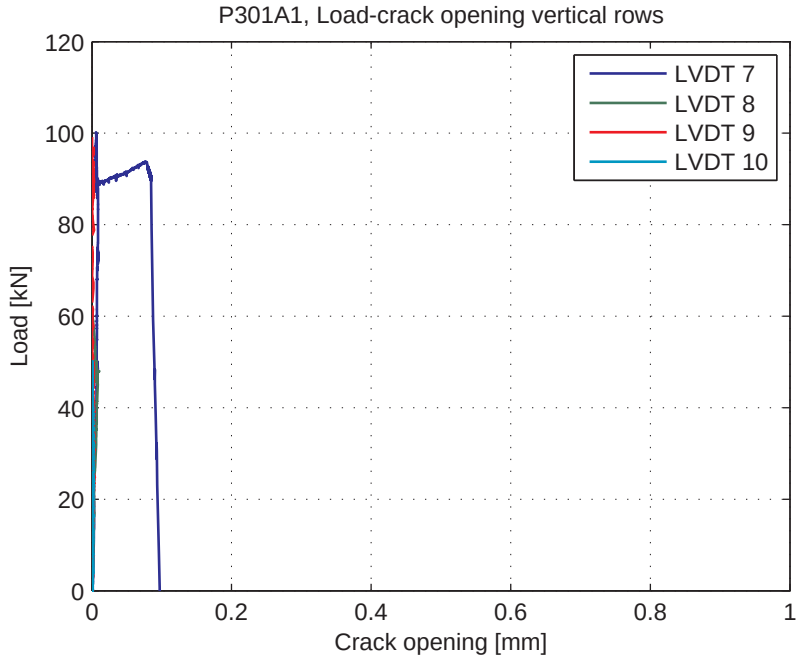


Fig. 5.71.6. Load-Crack opening for LVDT's 7-10 (vertical LVDT's)

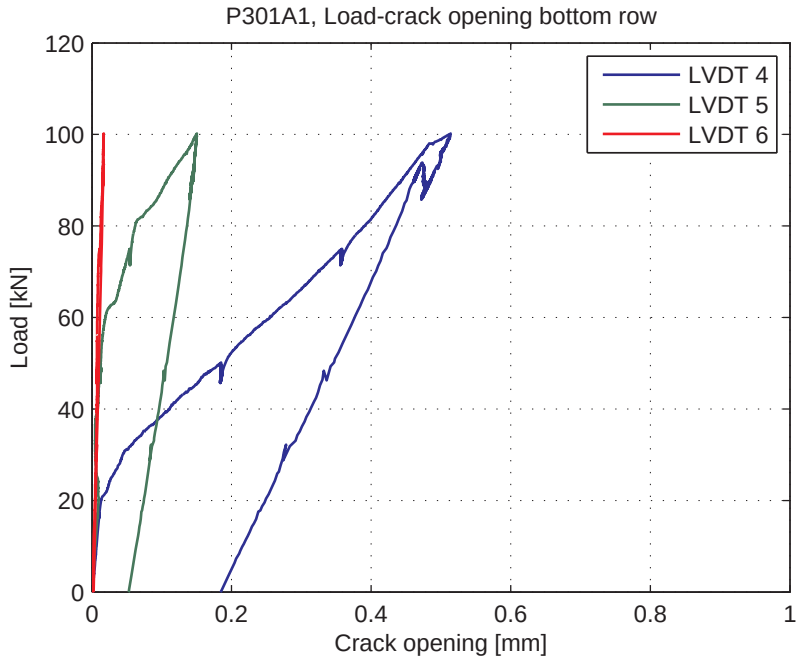


Fig. 5.71.7. Load-Crack opening for LVDT's 4-6 (bottom row)

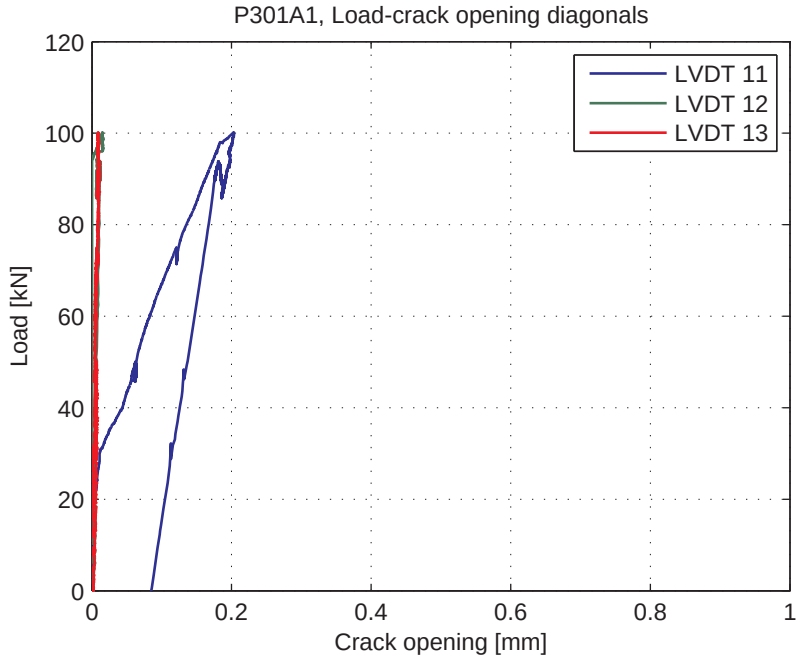


Fig. 5.71.8. Load-Crack opening for LVDT's 11-13 (diagonal)

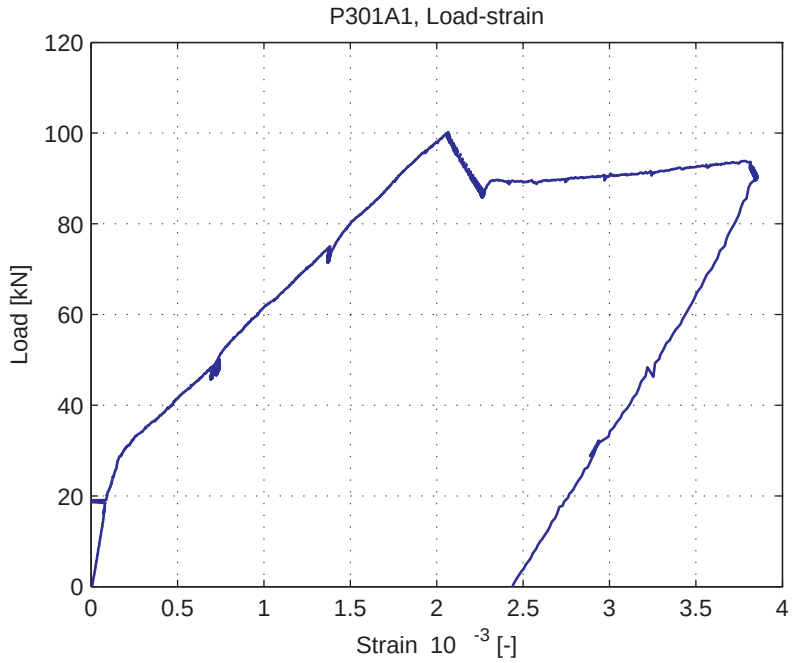


Fig. 5.71.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.72. P301A2

5.72.1. Test properties

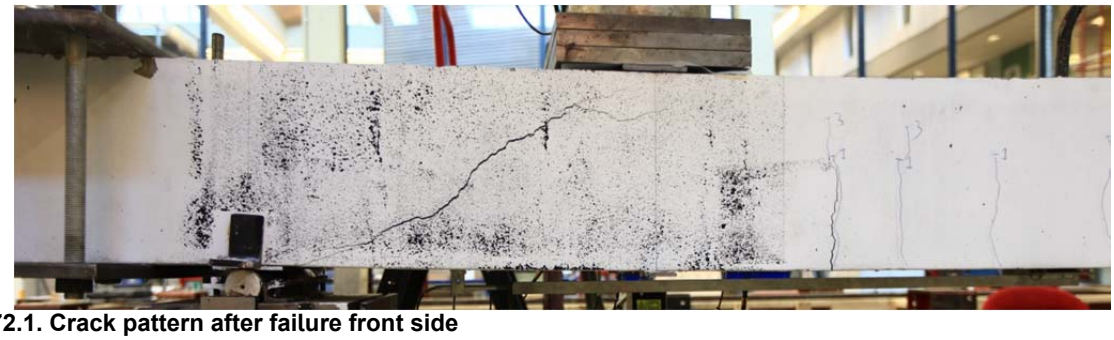


Fig. 5.72.1. Crack pattern after failure front side

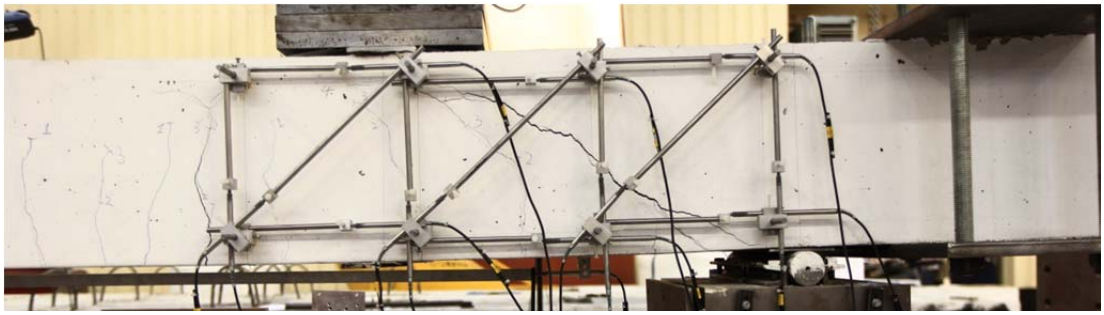


Fig. 5.72.2. Crack pattern after failure back side

Table 5.72.1. Beam properties

Date of test	22-01-2016
Reinforcement	3Ø20
Reinforcement ratio	1.19%
a	600
a / *d*	2.26
Concrete cube strength at testing	80.5 MPa
Peak load flexural / shear	124.1 kN / 122.6 kN
Failure mode	Flexural and shear

Table 5.72.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	100	
3	124.1	Shear failure

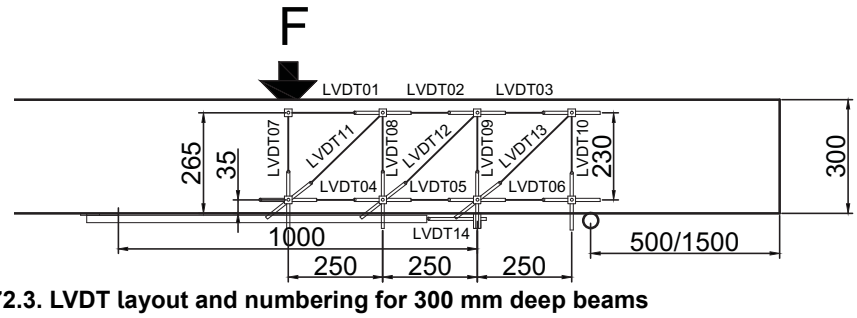


Fig. 5.72.3. LVDT layout and numbering for 300 mm deep beams

5.72.2. Measurement results

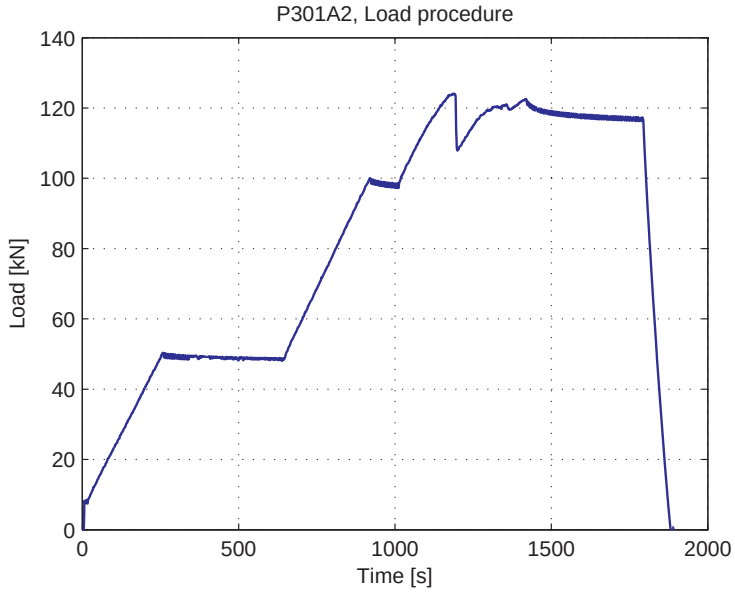


Fig. 5.72.4. Load-Time curve

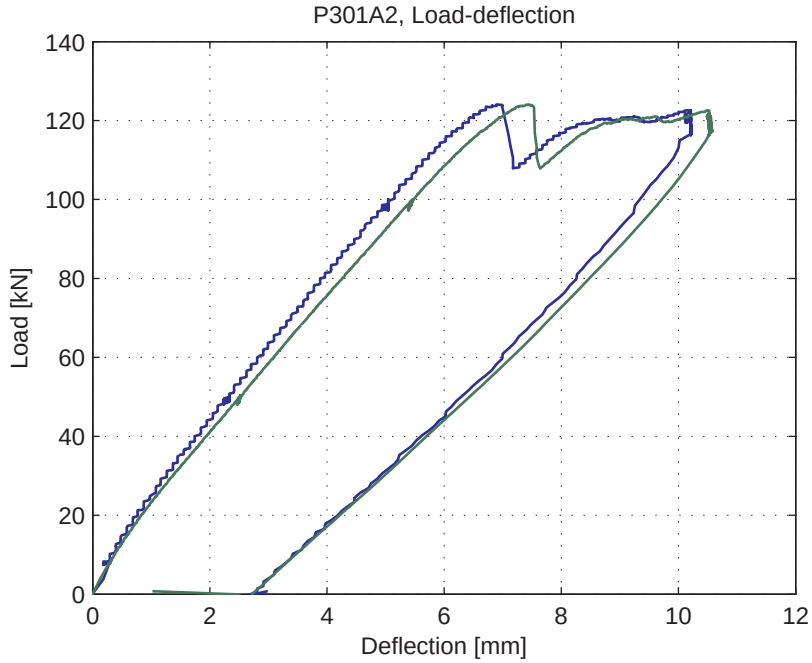


Fig. 5.72.5. Load-deflection curve

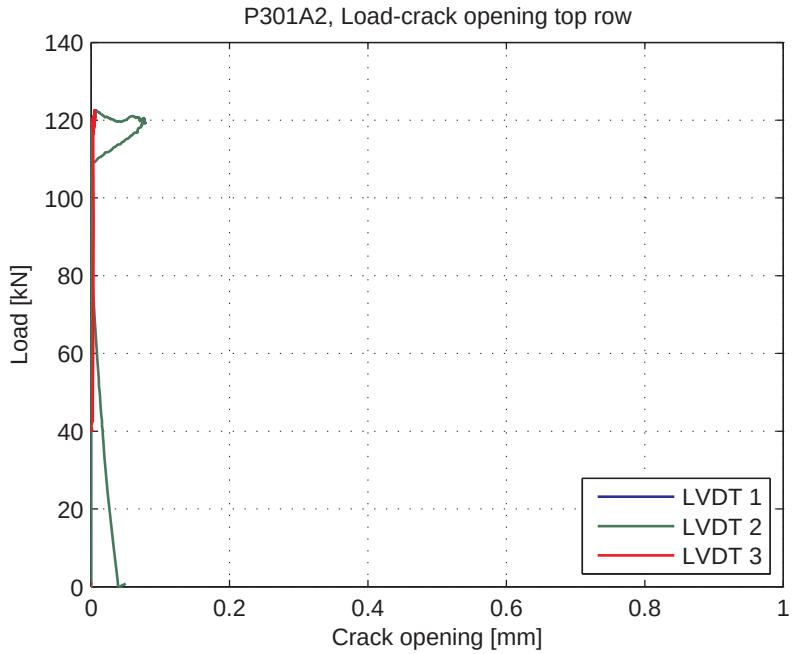


Fig. 5.72.6. Load-Crack opening for LVDT's 1-3 (top row)

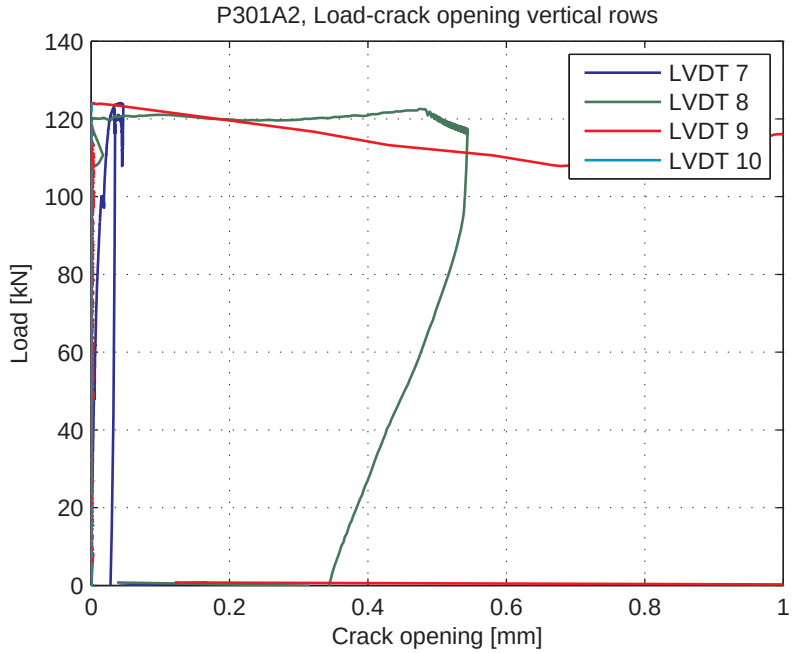


Fig. 5.72.7. Load-Crack opening for LVDT's 7-10 (vertical LVDT's)

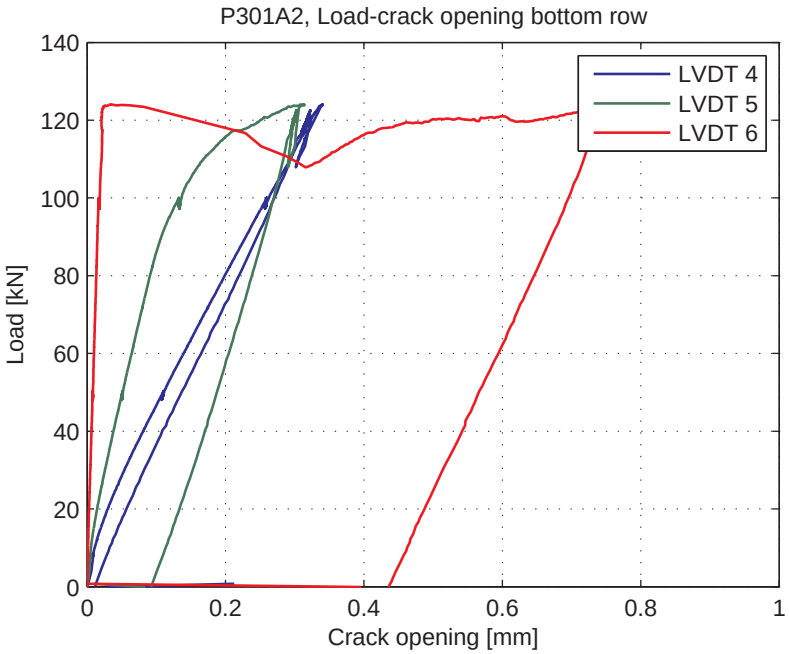


Fig. 5.72.8. Load-Crack opening for LVDT's 4-6 (bottom row)

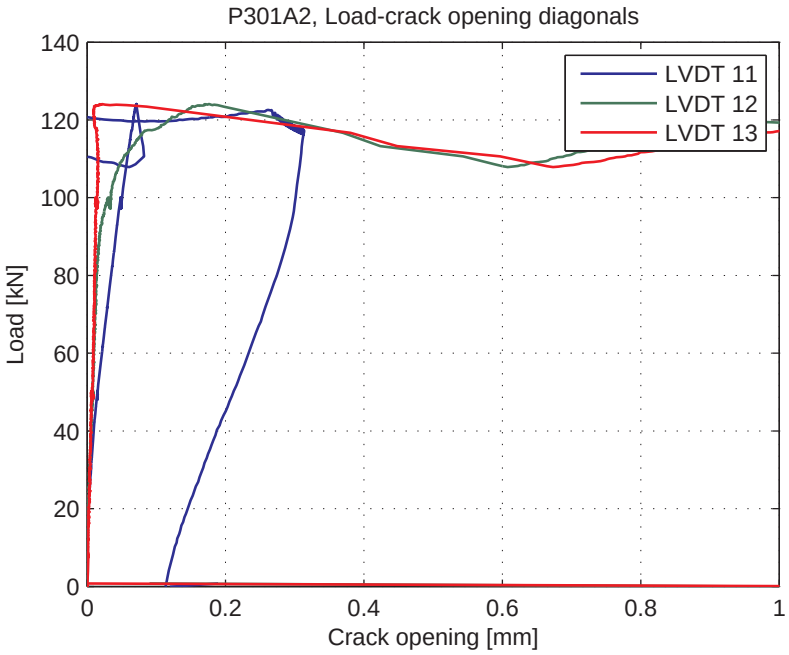


Fig. 5.72.9. Load-Crack opening for LVDT's 11-13 (diagonal)

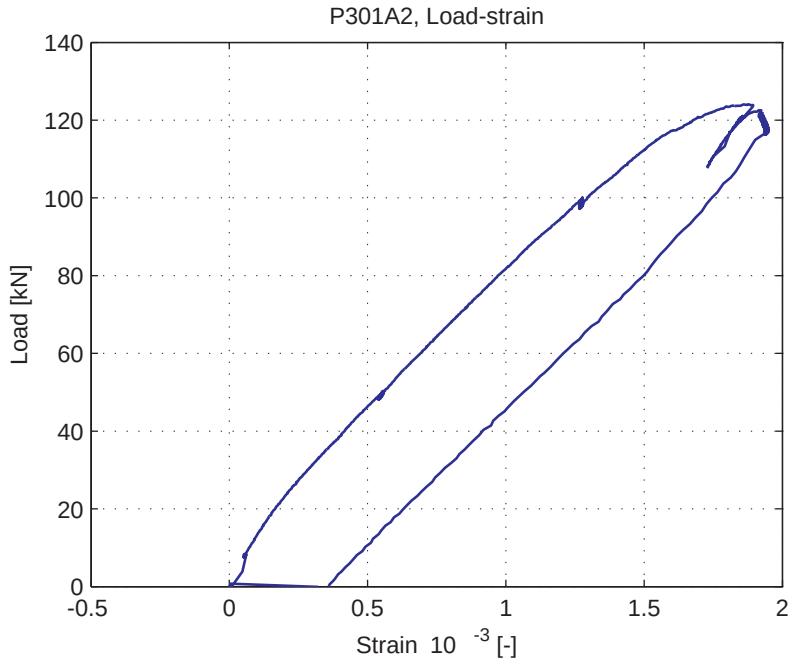


Fig. 5.72.10. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.73. P301A3

5.73.1. Test properties

Fig. 5.73.1. Crack pattern after failure front side

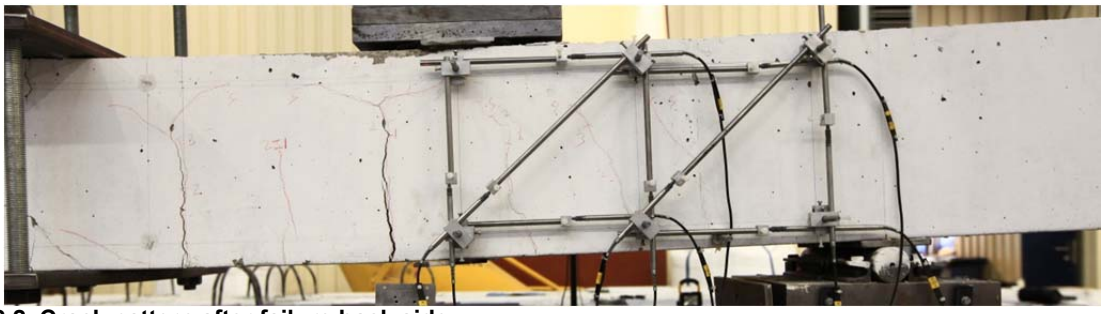


Fig. 5.73.2. Crack pattern after failure back side

Table 5.73.1. Beam properties

Date of test	25-01-2016
Reinforcement	3Ø20
Reinforcement ratio	1.19%
a	600 mm
a / *d*	2.26
Concrete cube strength at testing	80.5 MPa
Peak load	123.8 kN
Failure mode	Flexural

Table 5.73.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Clamped shear crack from previous test, No LVDT 14.
1	50	
2	75	
3	100	
4	126.4	Yielding, Stopped after jack displacement of 20.8 mm

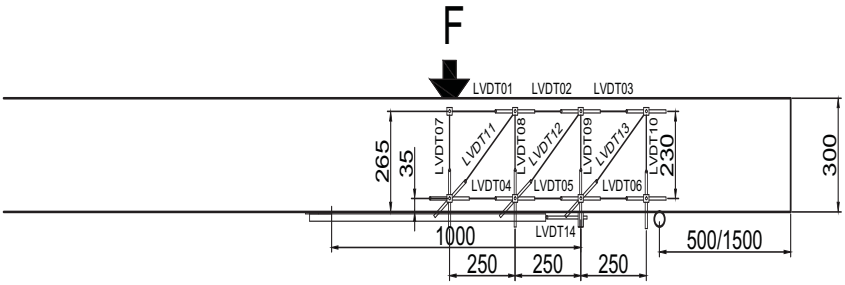


Fig. 5.73.3. LVDT layout and numbering for 300 mm deep beams

5.73.2. Measurement results

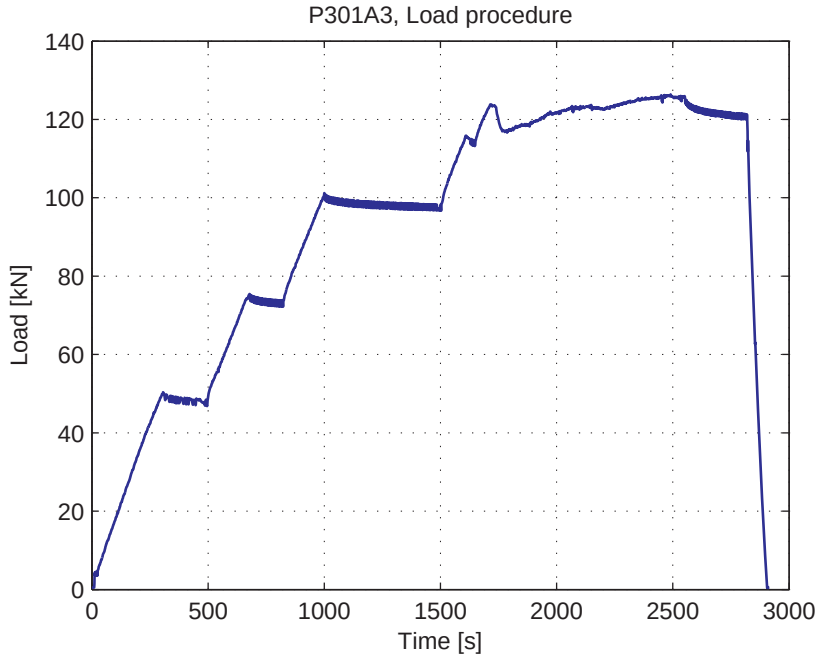


Fig. 5.73.4. Load-Time curve

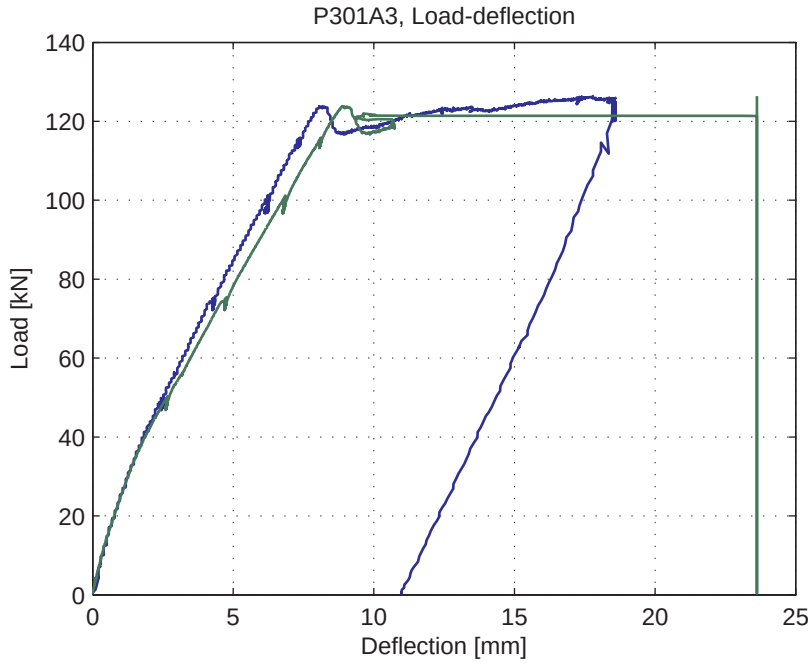


Fig. 5.73.5. Load-deflection curve

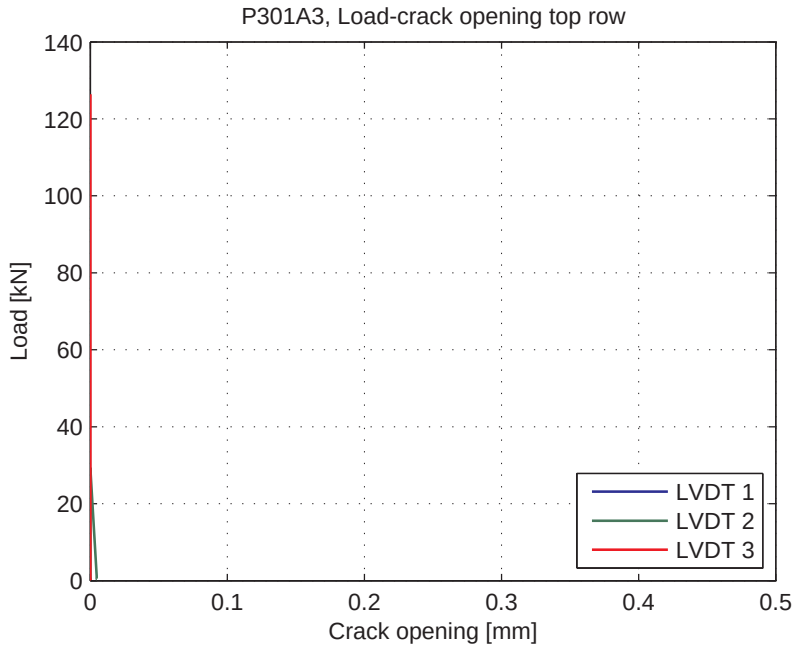


Fig. 5.73.6. Load-Crack opening for LVDT's 1-3 (top row)

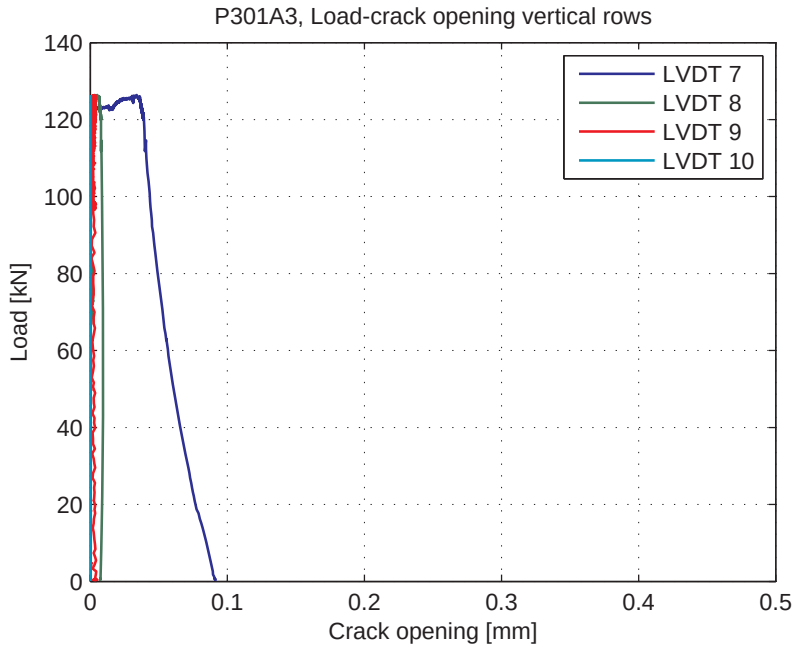


Fig. 5.73.7. Load-Crack opening for LVDT's 7-10 (vertical LVDT's)

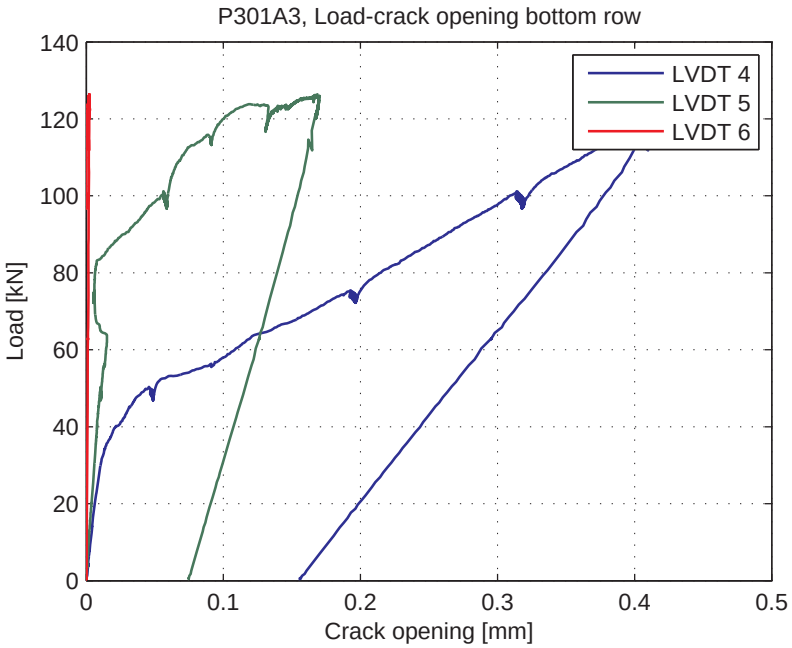


Fig. 5.73.8. Load-Crack opening for LVDT's 4-6 (bottom row)

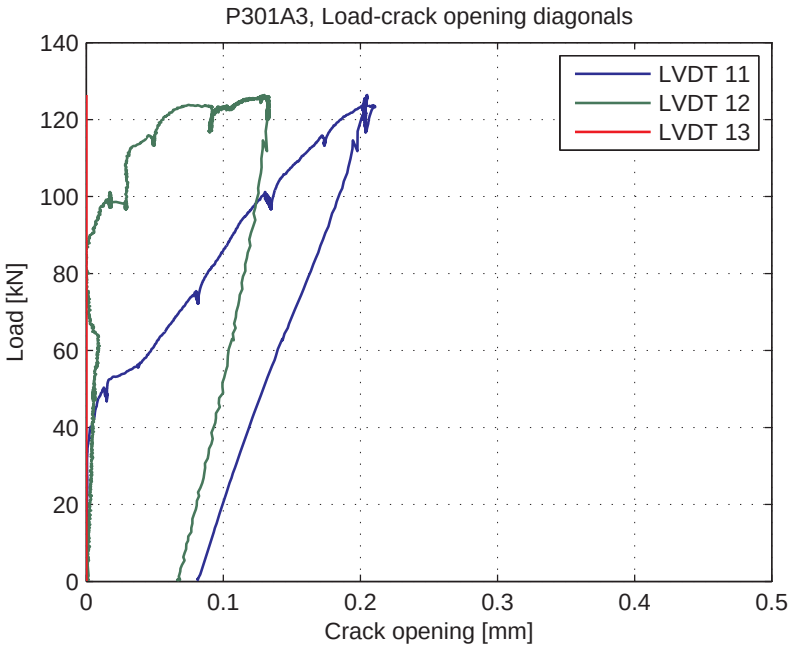


Fig. 5.73.9. Load-Crack opening for LVDT's 11-13 (diagonal)

5.74. P301A4

5.74.1. Test properties

Fig. 5.74.1. Crack pattern after failure front side

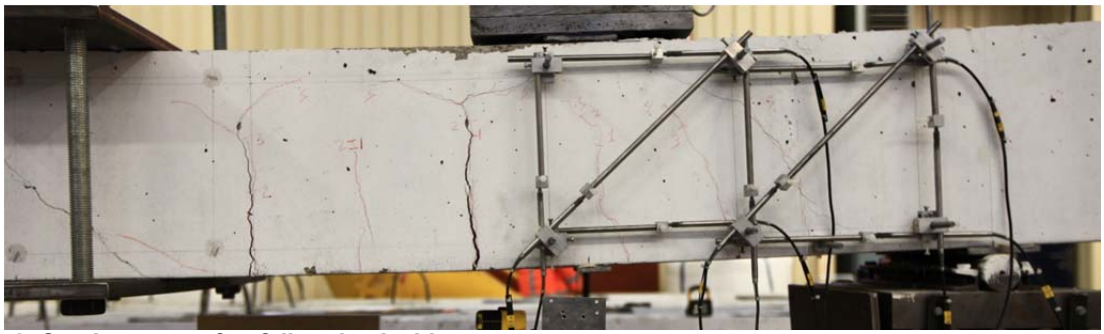


Fig. 5.74.2. Crack pattern after failure back side

Table 5.74.1. Beam properties

Date of test	25-01-2016
Reinforcement	3Ø20
Reinforcement ratio	1.19%
a	550 mm
a / *d*	2.08
Concrete cube strength at testing	80.5 MPa
Peak load	135.9 kN
Failure mode	Flexural

Table 5.74.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	75	
3	100	
4	125	
5	138.3	Stopped after jack displacement of 11.5 mm

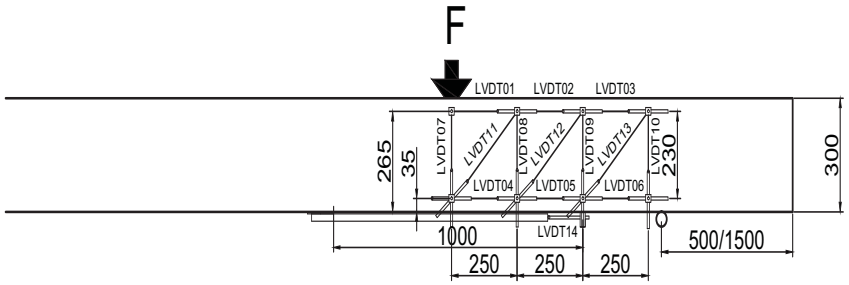


Fig. 5.74.3. LVDT layout and numbering for 300 mm deep beams

5.74.2. Measurement results

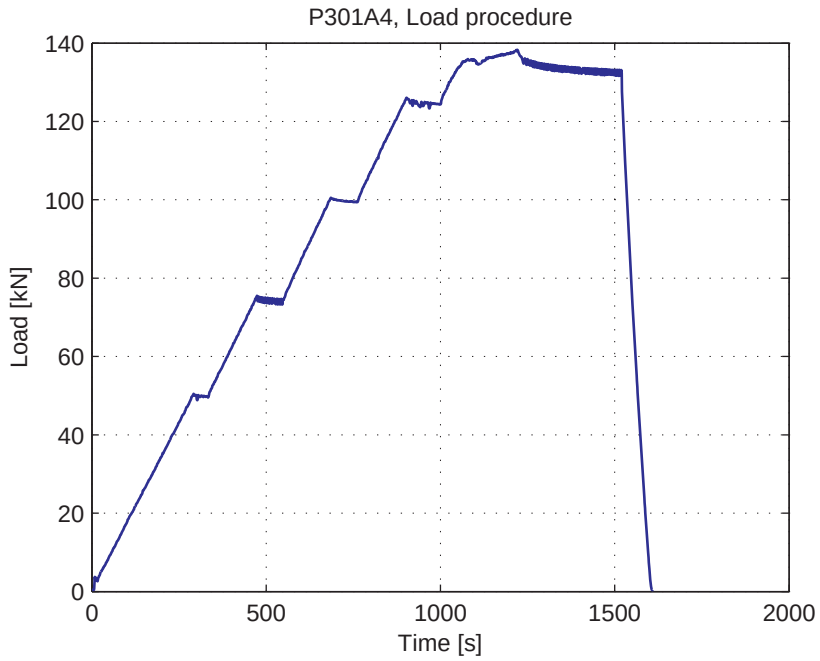


Fig. 5.74.4. Load-Time curve

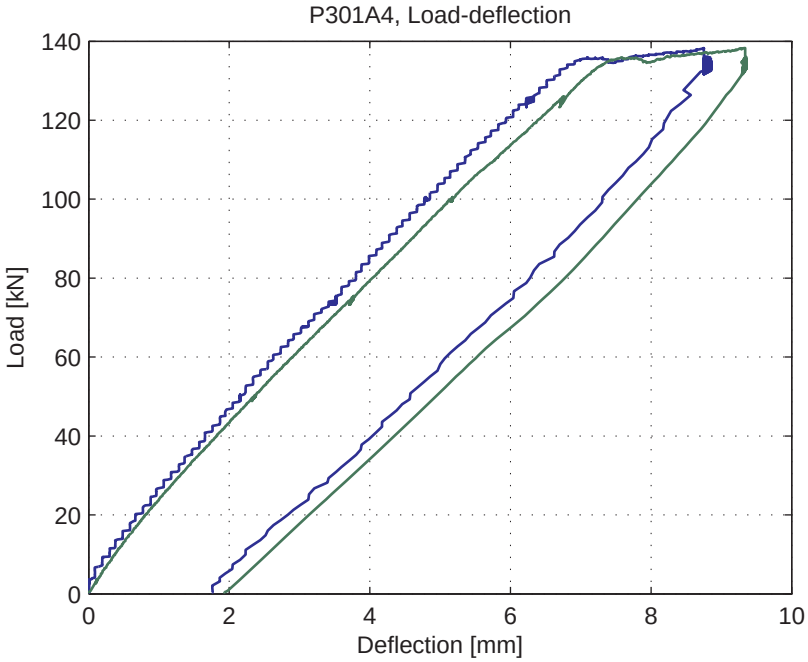


Fig. 5.74.5. Load-deflection curve

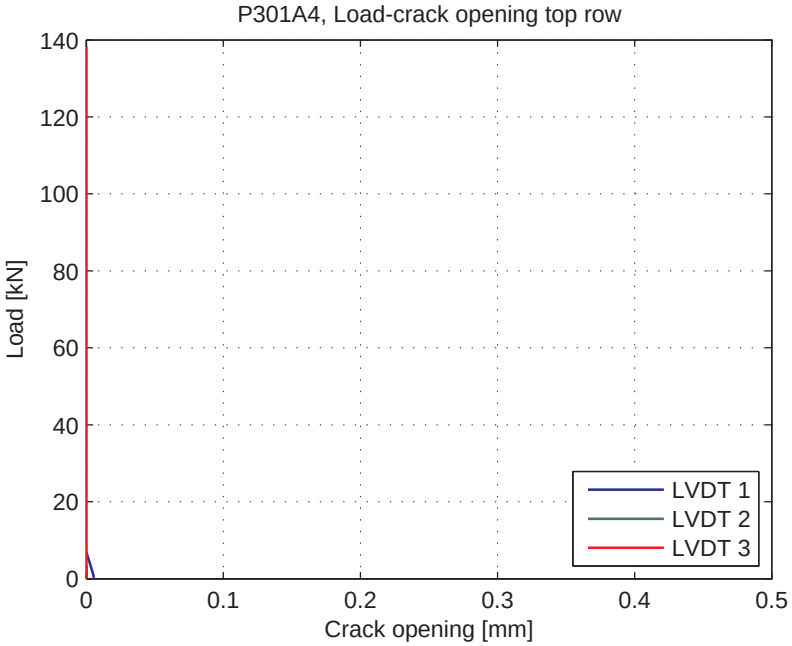


Fig. 5.74.6. Load-Crack opening for LVDT's 1-3 (top row)

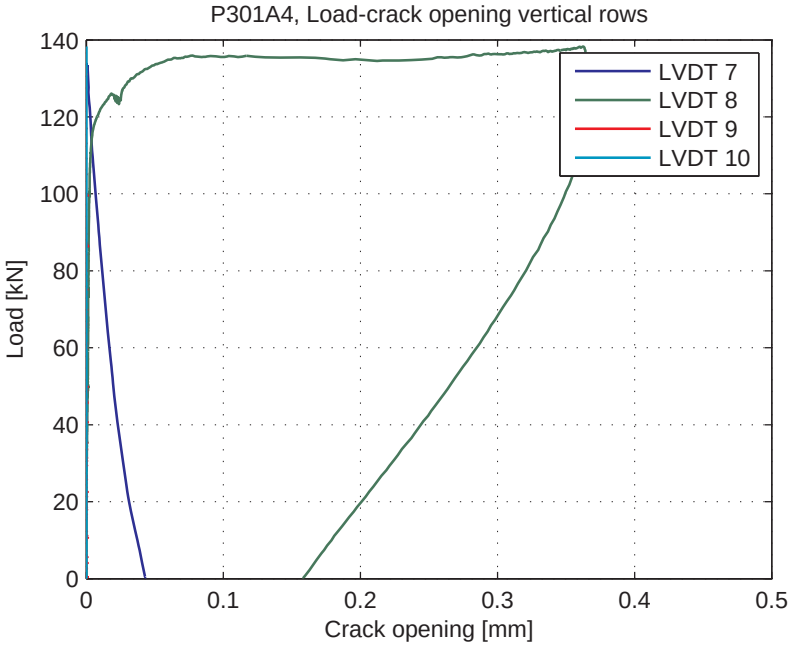


Fig. 5.74.7. Load-Crack opening for LVDT's 7-10 (vertical LVDT's)

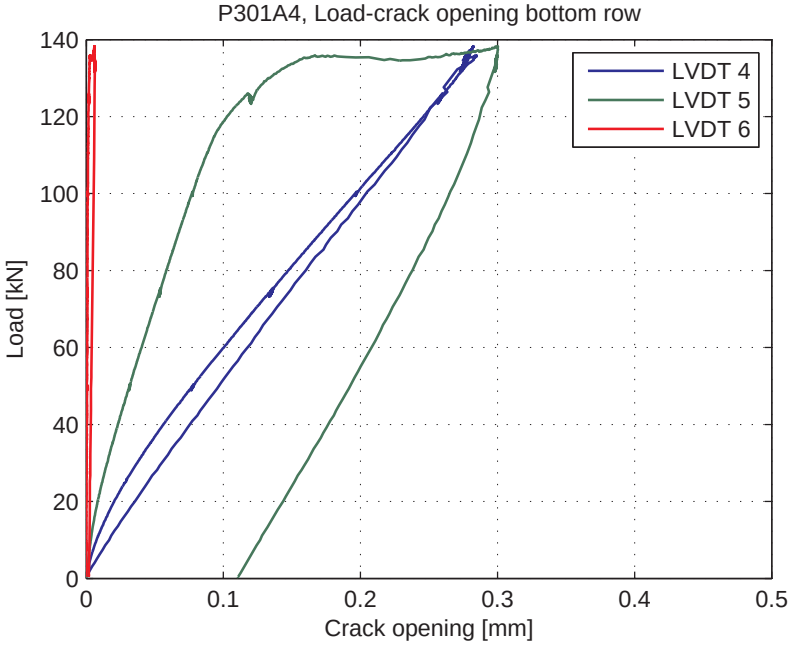


Fig. 5.74.8. Load-Crack opening for LVDT's 4-6 (bottom row)

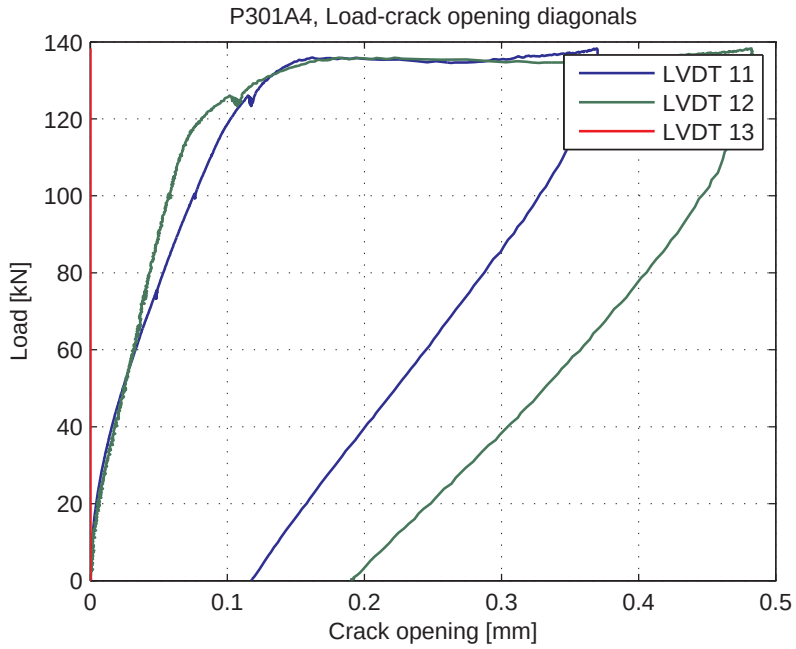


Fig. 5.74.9. Load-Crack opening for LVDT's 11-13 (diagonal)

5.75. P301B1

5.75.1. Test properties

Fig. 5.75.1. Crack pattern after failure front side

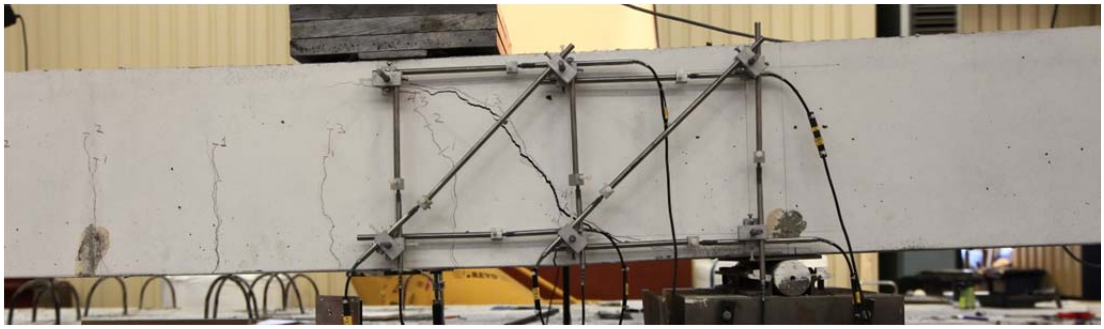


Fig. 5.75.2. Crack pattern after failure back side

Table 5.75.1. Beam properties

Date of test	26-01-2015
Reinforcement	3Ø20
Reinforcement ratio	1.19%
a	550 mm
a / *d*	2.08
Concrete cube strength at testing	80.5 MPa
Peak load flexural / shear	144.9 kN / 135.2 kN
Failure mode	Flexural and shear

Table 5.75.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	75	
3	100	
4	125	Yielding, stopped after jack displacement of 14.6 mm

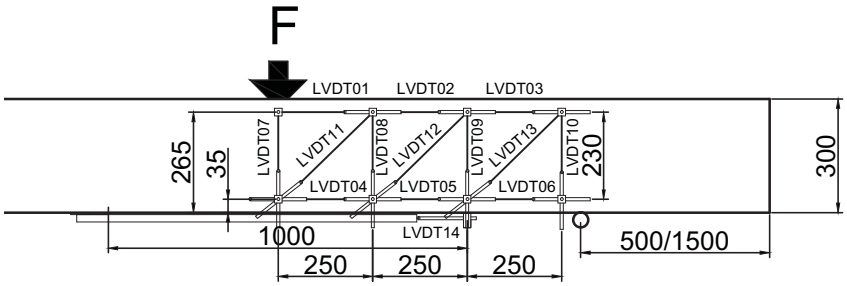


Fig. 5.75.3. LVDT layout and numbering for 300 mm deep beams

5.75.2. Measurement results

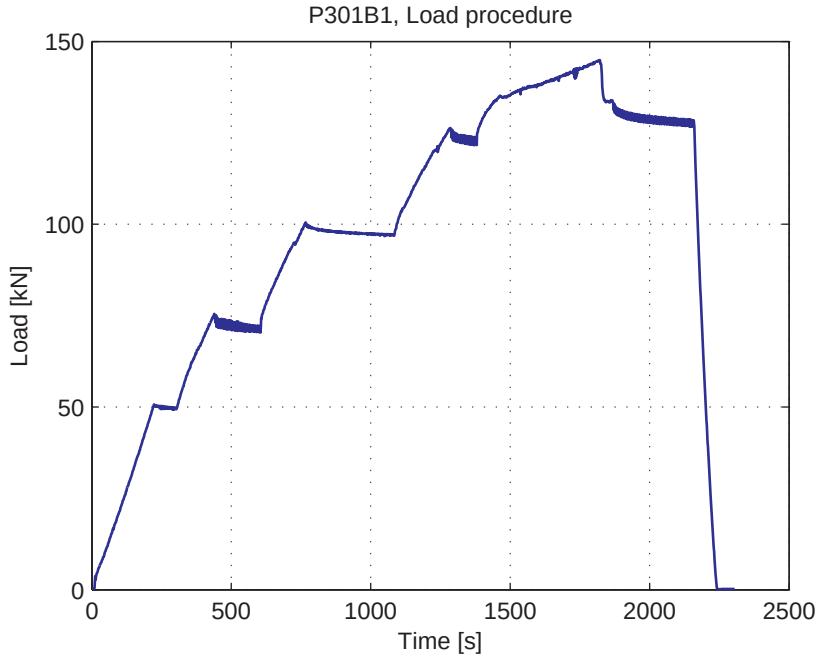


Fig. 5.75.4. Load-Time curve

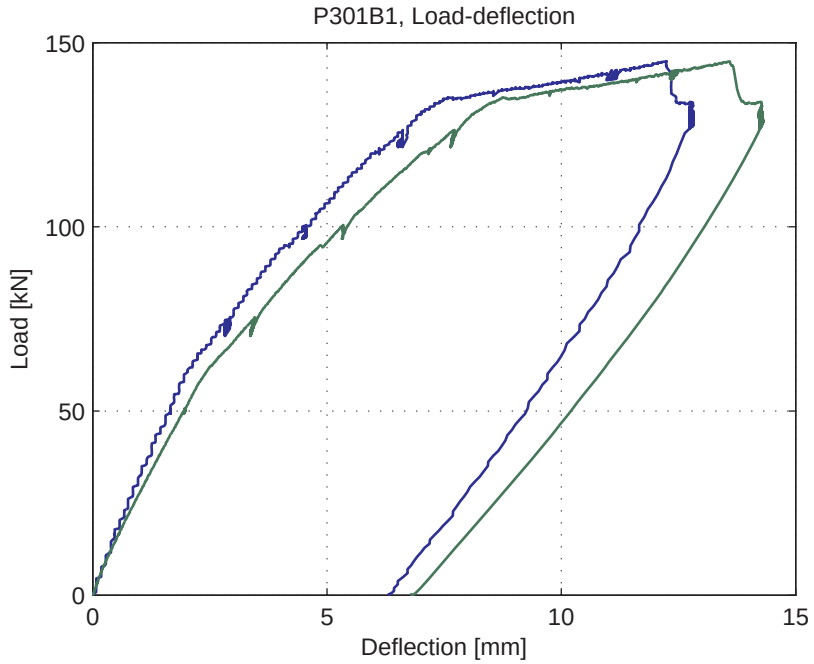


Fig. 5.75.5. Load-deflection curve

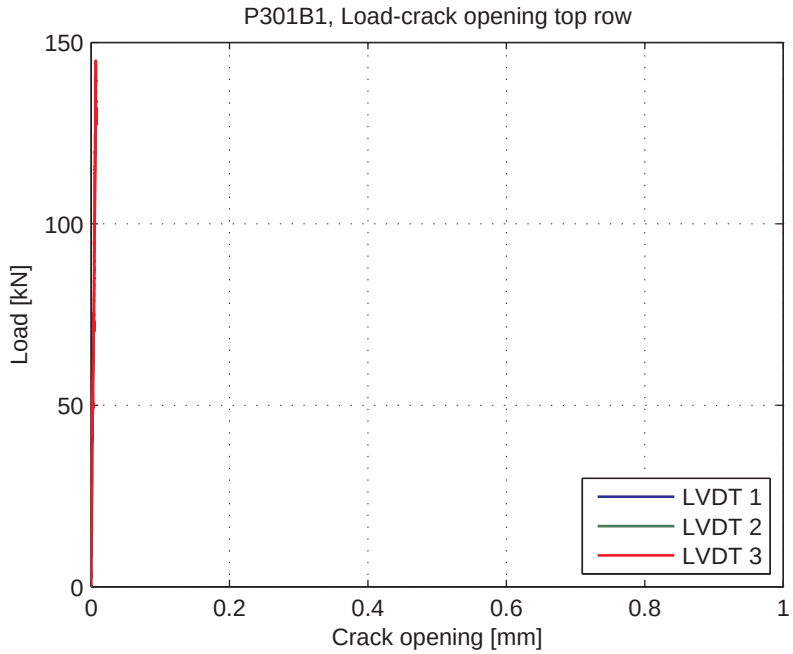


Fig. 5.75.6. Load-Crack opening for LVDT's 1-3 (top row)

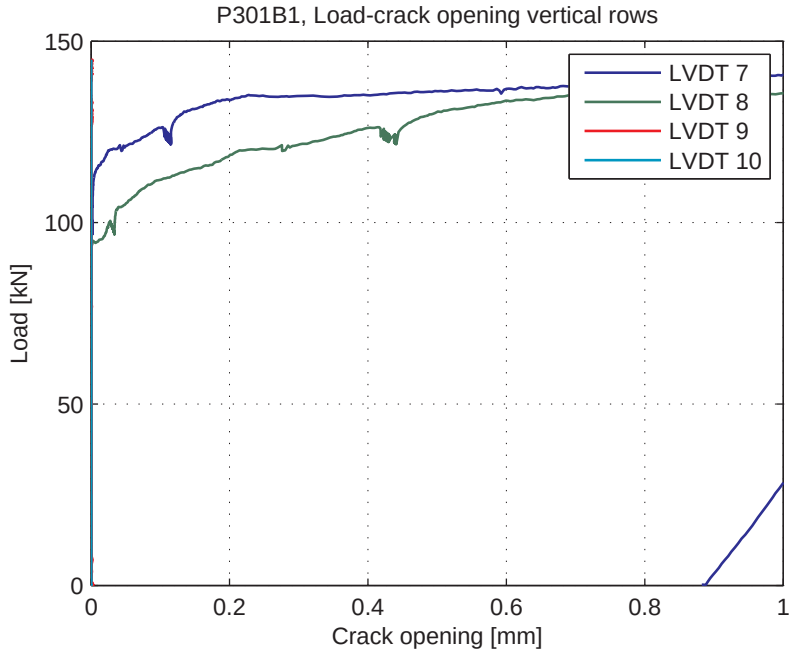


Fig. 5.75.7. Load-Crack opening for LVDT's 7-10 (vertical LVDT's)

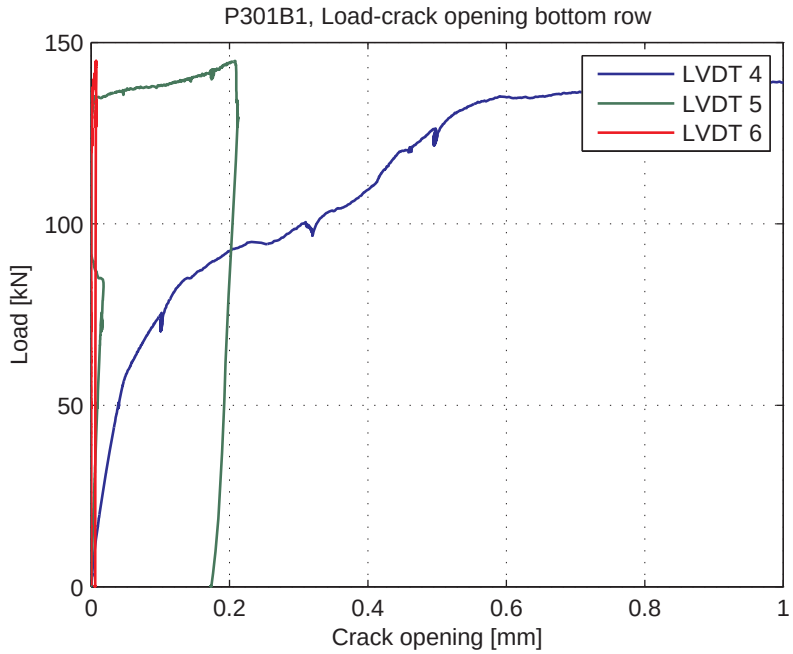


Fig. 5.75.8. Load-Crack opening for LVDT's 4-6 (bottom row)

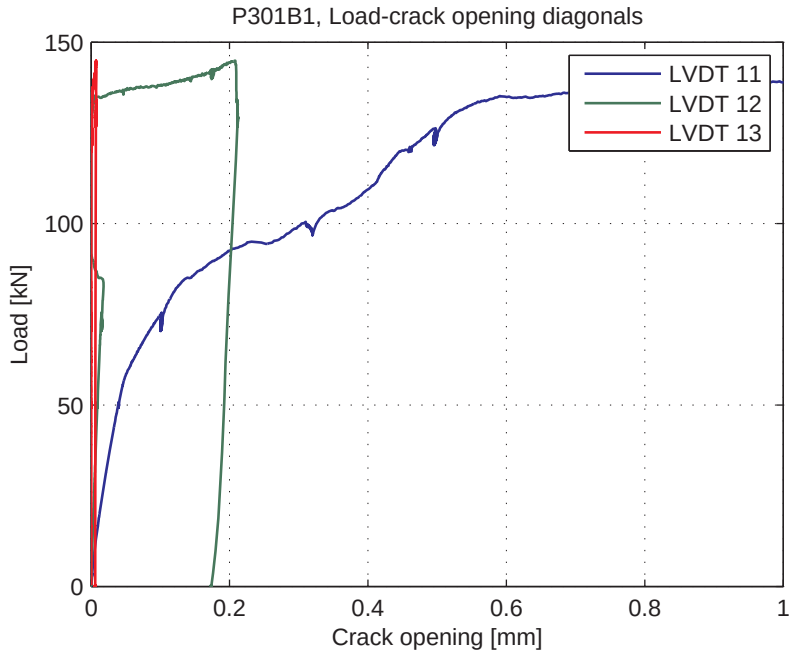


Fig. 5.75.9. Load-Crack opening for LVDT's 11-13 (diagonal)

5.76. P501A1

5.76.1. Test properties

Fig. 5.76.1. Crack pattern after failure front side

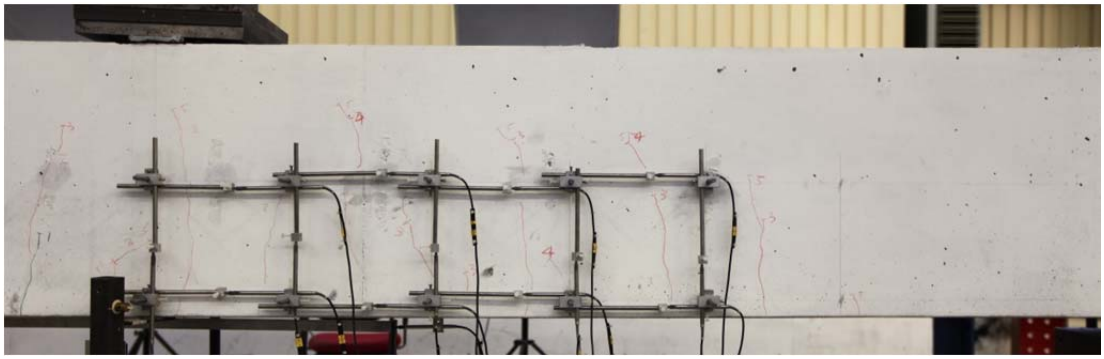


Fig. 5.76.2. Crack pattern after failure back side

Table 5.76.1. Beam properties

Date of test	25-02-2015
Reinforcement	5Ø20
Reinforcement ratio	1.15%
a	2000 mm
a / *d*	4.40
Concrete cube strength at testing	80.5 MPa
Peak load	147.2 kN
Failure mode	Flexural

Table 5.76.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	LVDT's 15 and 16 not used
1	50	
2	75	
3	100	
4	125	
5	147.2	Crack at lifting hook, drop back to 125 kN

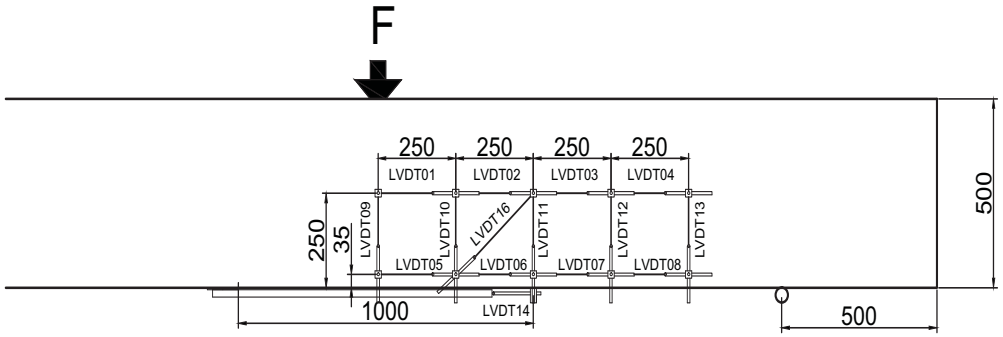


Fig. 5.76.3. LVDT layout and numbering for 500 mm deep beams

5.76.2. Measurement results

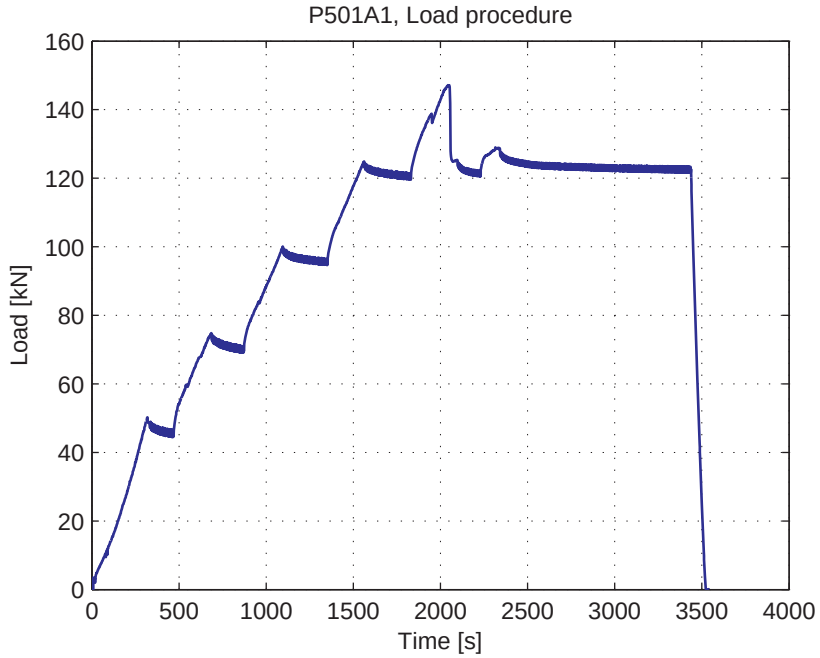


Fig. 5.76.4. Load-Time curve

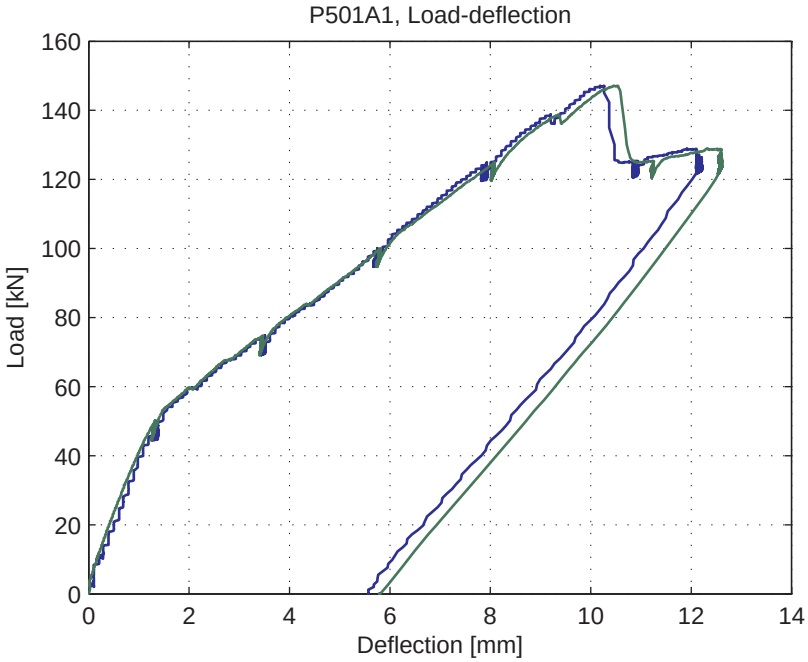


Fig. 5.76.5. Load-deflection curve

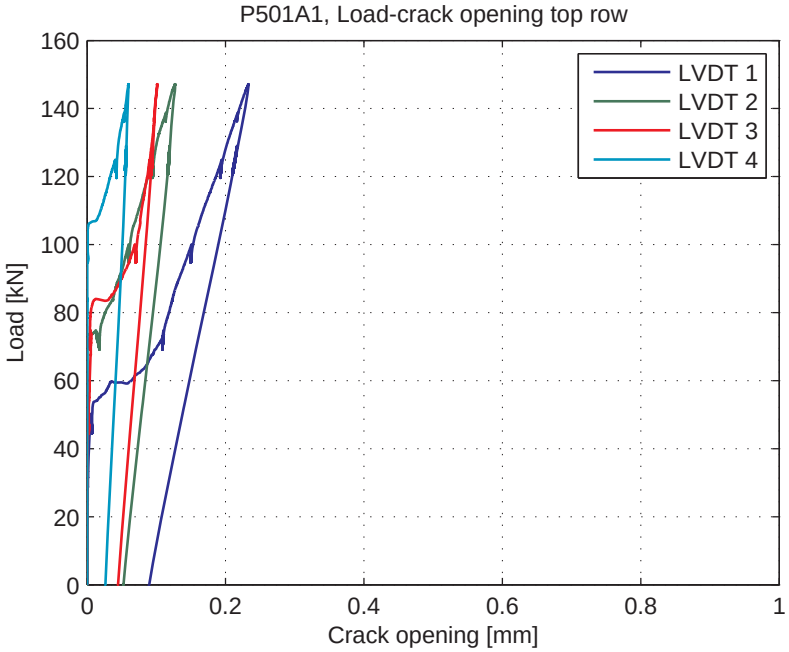


Fig. 5.76.6. Load-Crack opening for LVDT's 1-4 (top row)

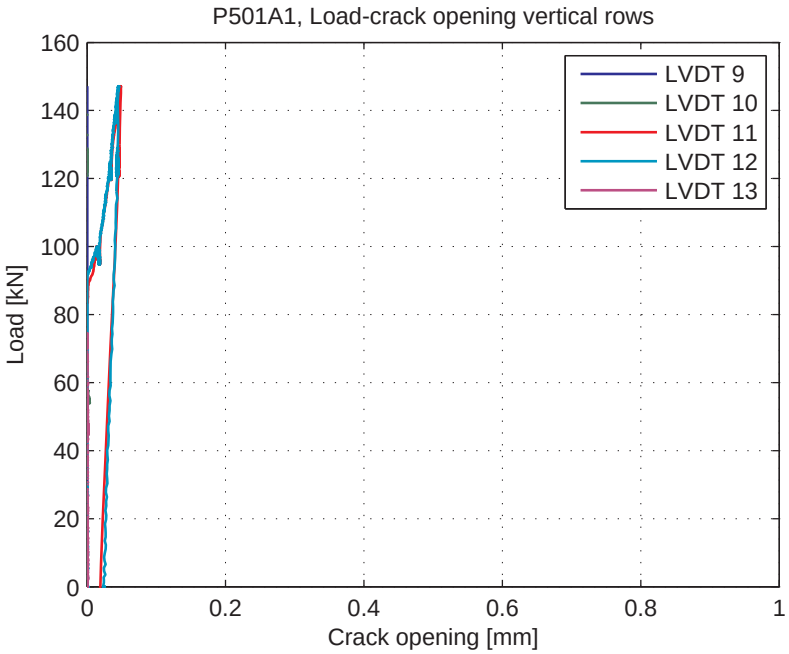


Fig. 5.76.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

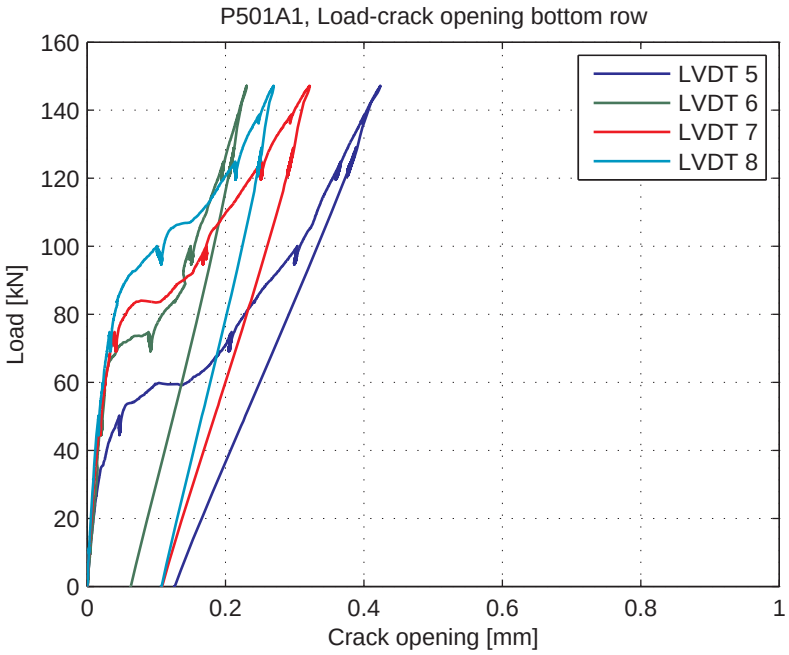


Fig. 5.76.8. Load-Crack opening for LVDT's 5-8 (bottom row)

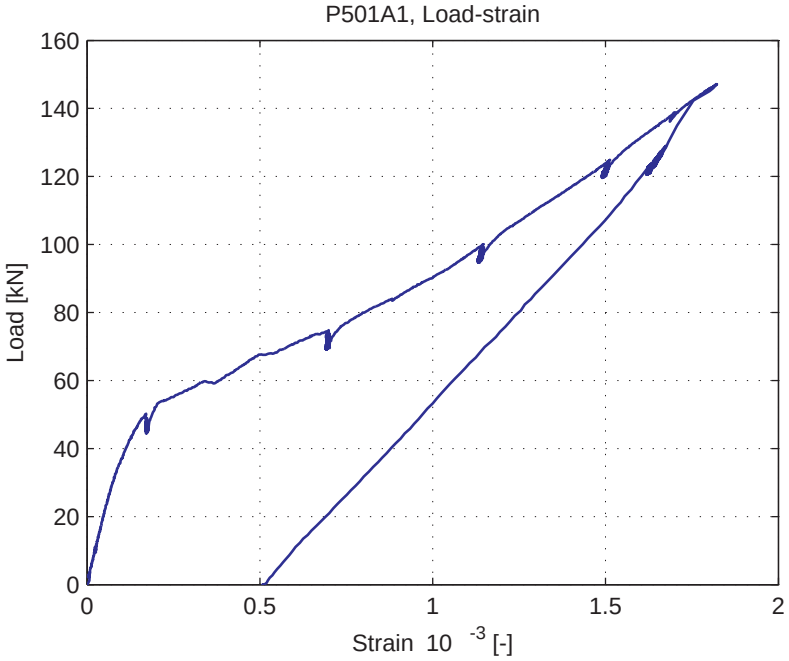


Fig. 5.76.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.77. P501A2

5.77.1. Test properties

Fig. 5.77.1. Crack pattern after failure front side

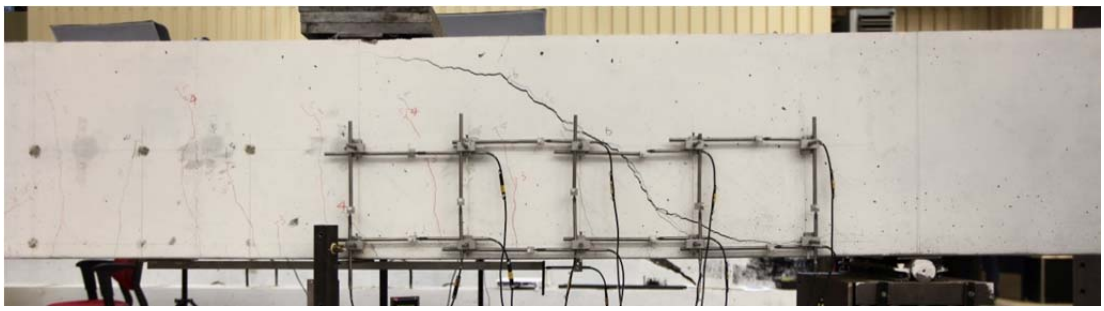


Fig. 5.77.2. Crack pattern after failure back side

Table 5.77.1. Beam properties

Date of test	26-02-2015
Reinforcement	5Ø20
Reinforcement ratio	1.15%
a	1250 mm
a / *d*	2.75
Concrete cube strength at testing	80.5 MPa
Peak load	175.5 kN
Failure mode	Shear

Table 5.77.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Cracked spot reinforced with metal strip 1500 x 80 x 10, glued with plexi-mon, prestressed on two places with 8 x M24
1	50	
2	75	
3	100	
4	125	
5	150	
6	175.5	Shear failure

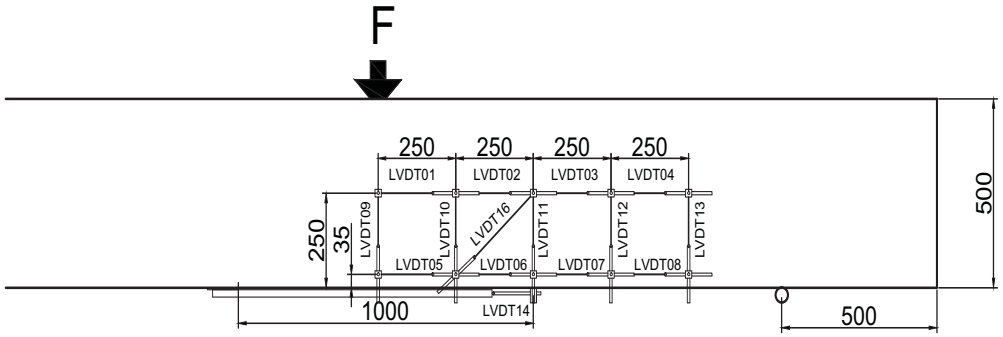


Fig. 5.77.3. LVDT layout and numbering for 500 mm deep beams

5.77.2. Measurement results

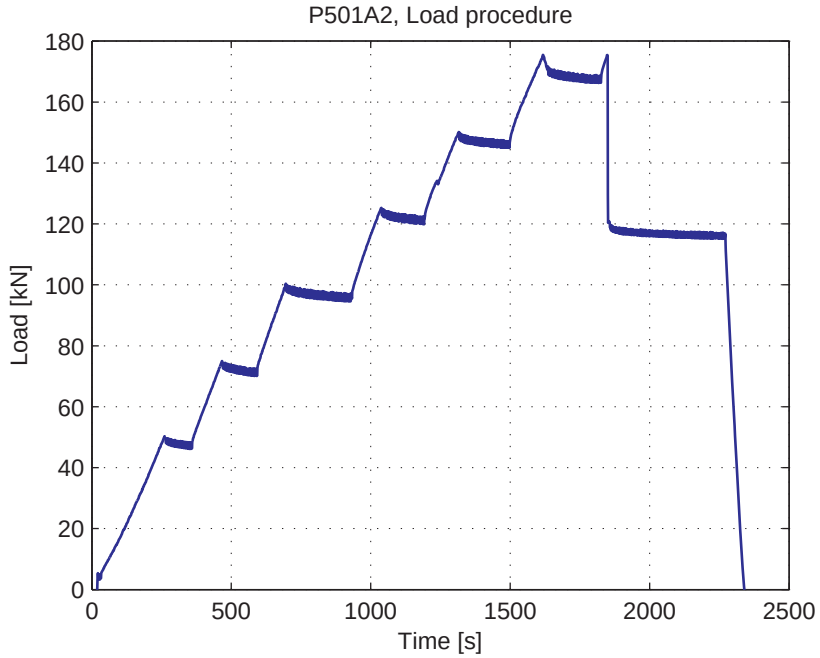


Fig. 5.77.4. Load-Time curve

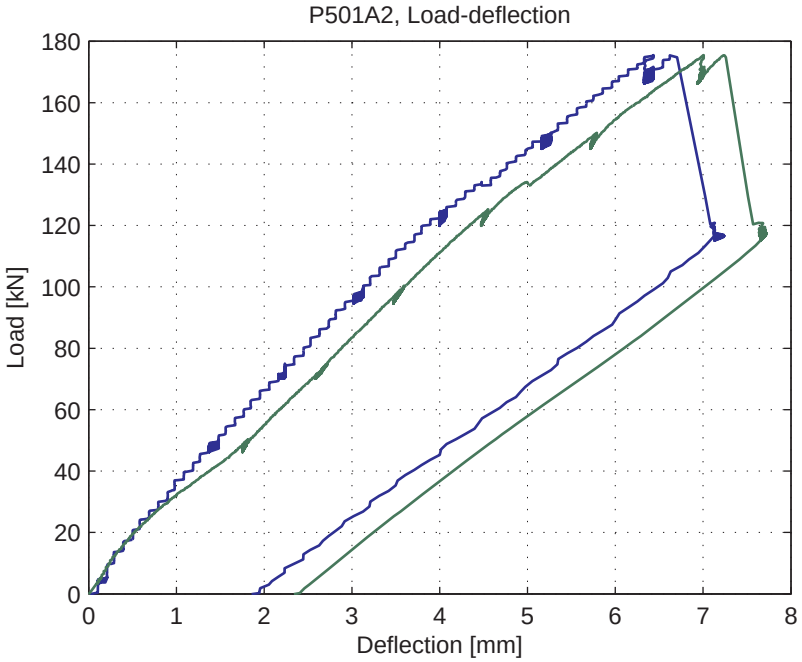


Fig. 5.77.5. Load-deflection curve

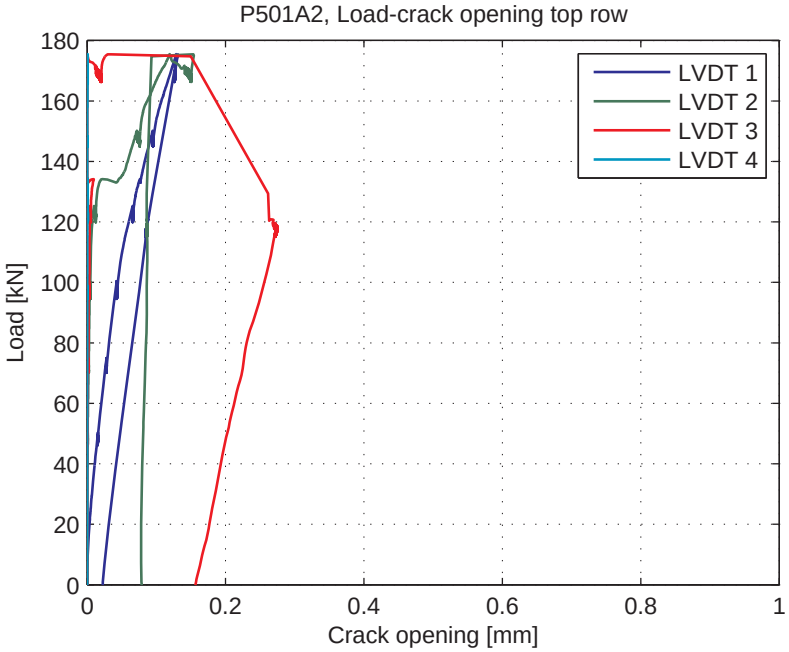


Fig. 5.77.6. Load-Crack opening for LVDT's 1-4 (top row)

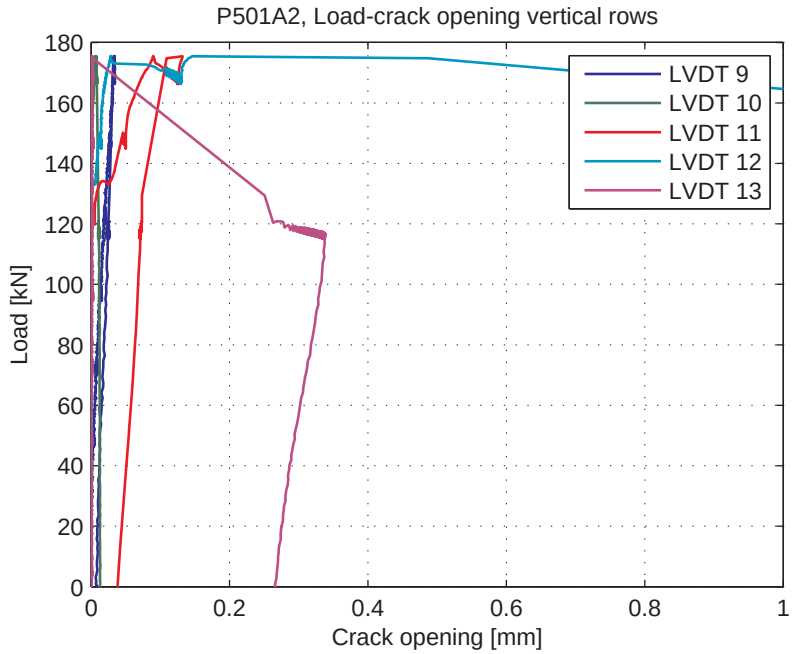


Fig. 5.77.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

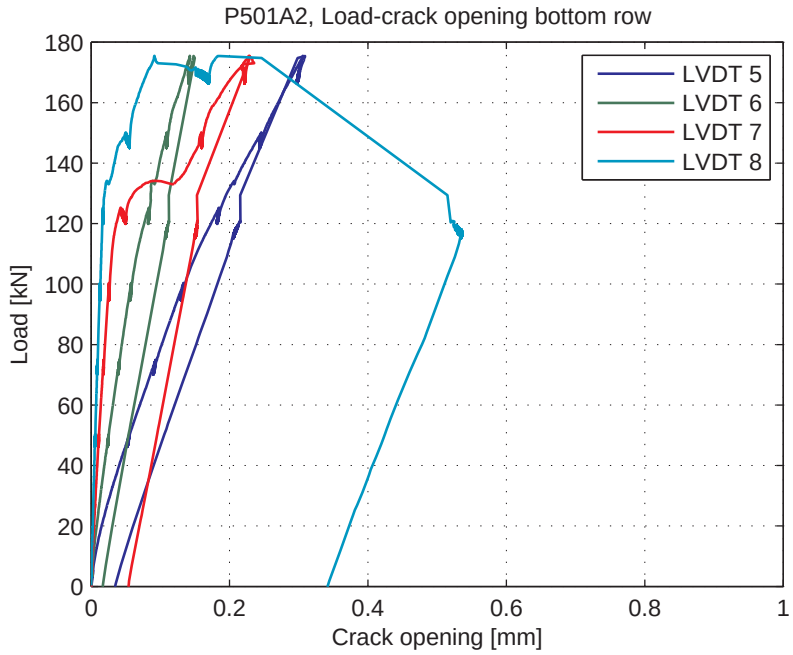


Fig. 5.77.8. Load-Crack opening for LVDT's 5-8 (bottom row)

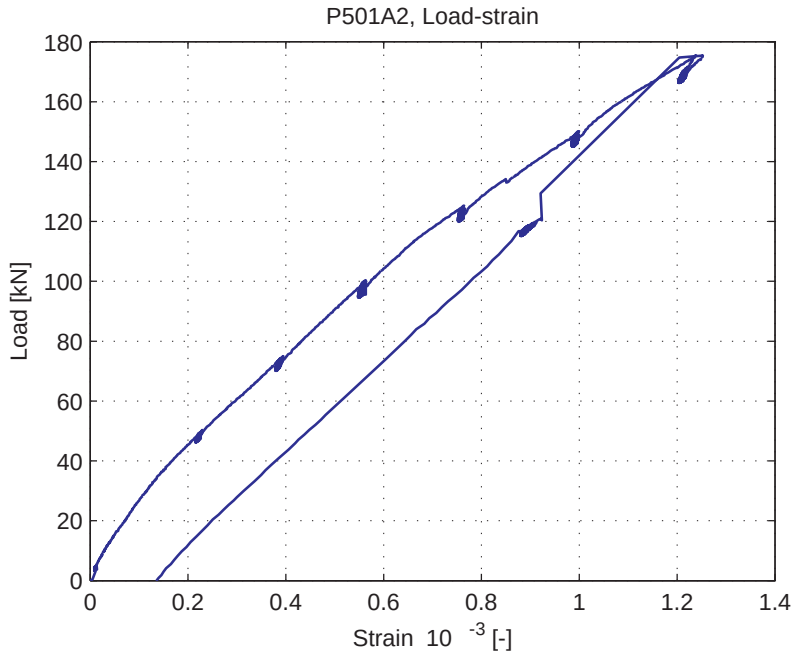


Fig. 5.77.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.78. P501B1

5.78.1. Test properties

Fig. 5.78.1. Crack pattern after failure front side

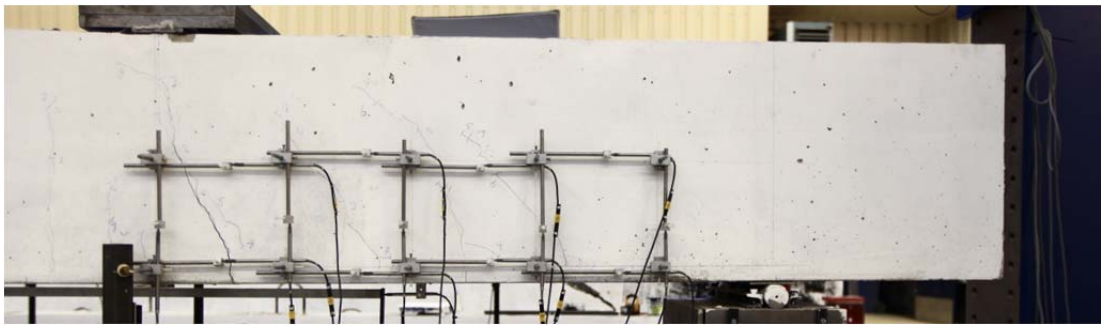


Fig. 5.78.2. Crack pattern after failure back side

Table 5.78.1. Beam properties

Date of test	29-01-2016
Reinforcement	5Ø20
Reinforcement ratio	1.15%
a	1250 mm
a / *d*	2.75
Concrete cube strength at testing	80.5 MPa
Peak load	207.8 kN
Failure mode	Flexural

Table 5.78.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	LVDT's 15 and 16 not used
1	50	
2	75	
3	100	
4	125	
5	150	
6	175	
7	200	
8	207.8	Yielding, stopped at jack displacement of 15.42 mm

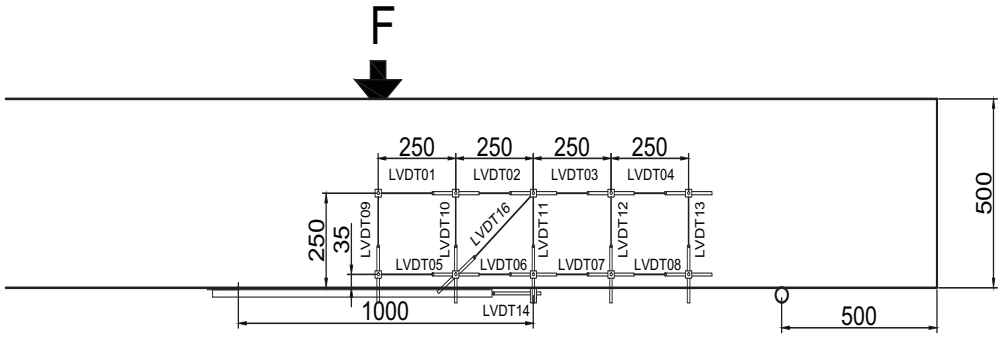


Fig. 5.78.3. LVDT layout and numbering for 500 mm deep beams

5.78.2. Measurement results

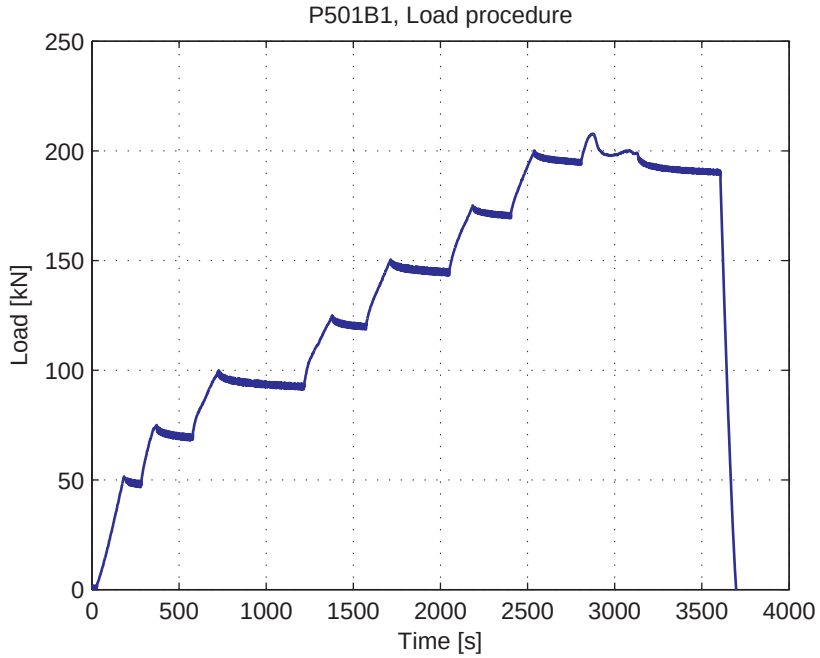


Fig. 5.78.4. Load-Time curve

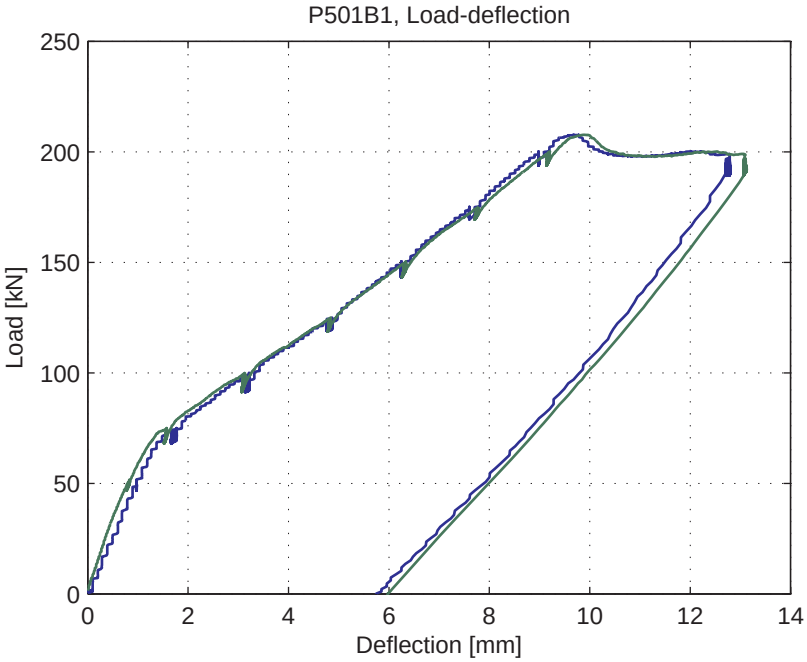


Fig. 5.78.5. Load-deflection curve

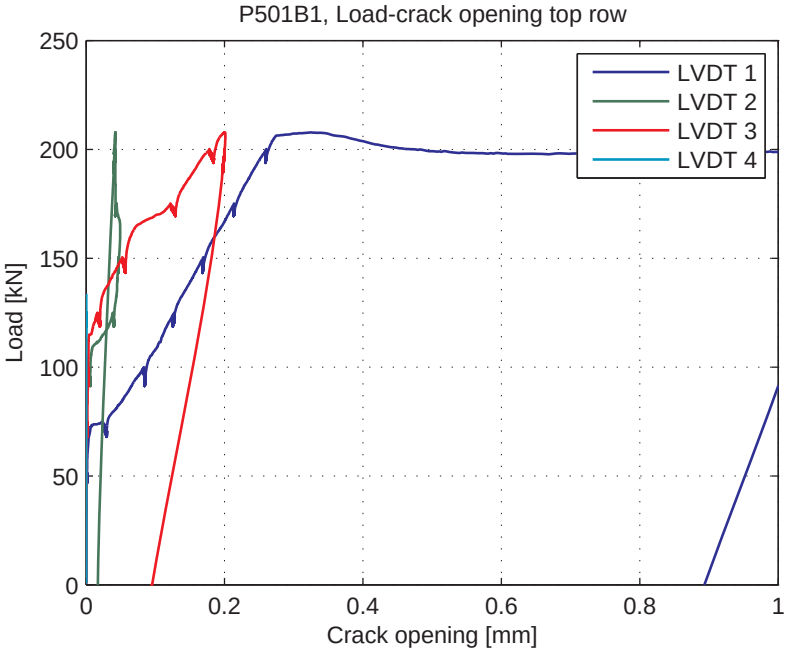


Fig. 5.78.6. Load-Crack opening for LVDT's 1-4 (top row)

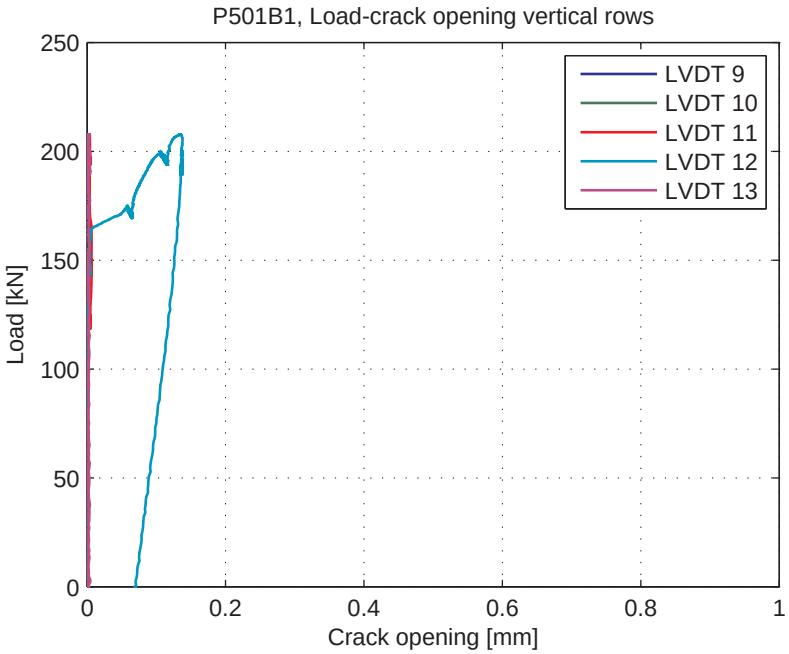


Fig. 5.78.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

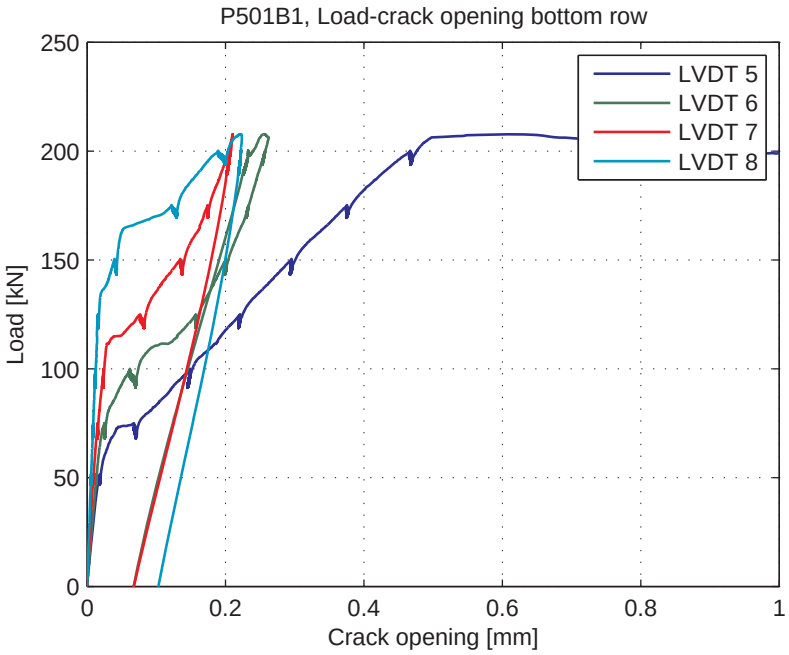


Fig. 5.78.8. Load-Crack opening for LVDT's 5-8 (bottom row)

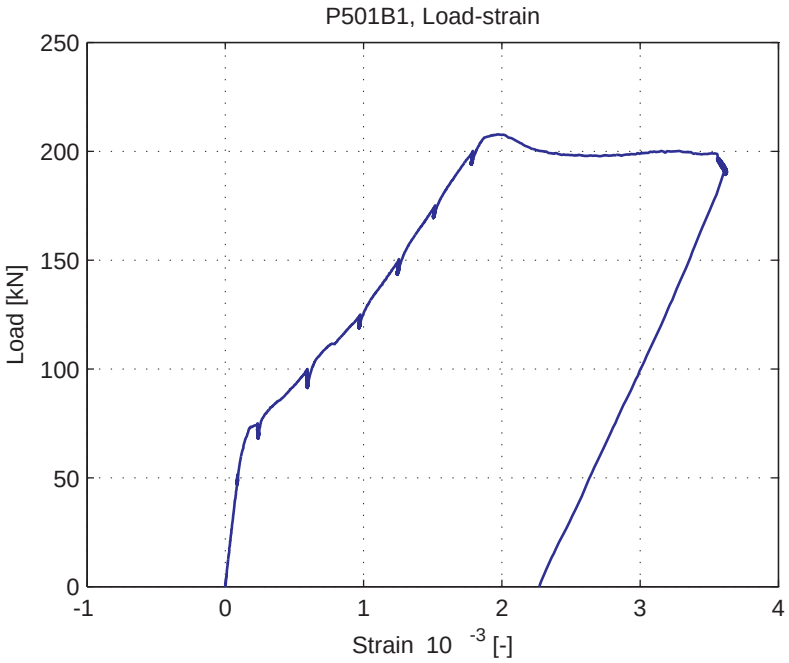


Fig. 5.78.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.79. P501B2

5.79.1. Test properties

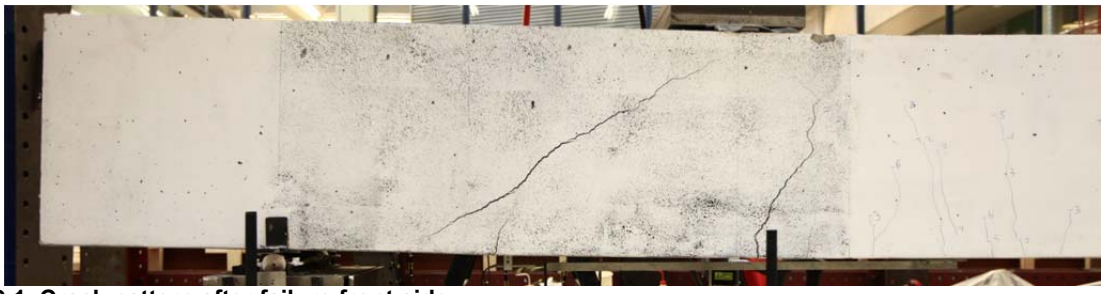


Fig. 5.79.1. Crack pattern after failure front side

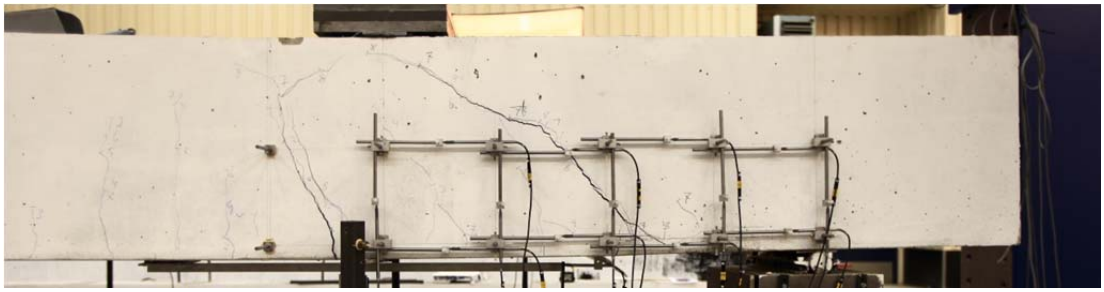


Fig. 5.79.2. Crack pattern after failure back side

Table 5.79.1. Beam properties

Date of test	01-03-2016
Reinforcement	5Ø20
Reinforcement ratio	1.15%
a	1000 mm
a / *d*	2.20
Concrete cube strength at testing	80.5 MPa
Peak load flexural / shear	244.3 kN/202.0 kN (flexural shear crack)
Failure mode	Flexural failure

Table 5.79.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	75	
3	100	
4	125	
5	150	
6	175	
7	200	
8	225	
9	244.3	First yielding at 202 kN, stopped after jack displacement of 18.33 mm

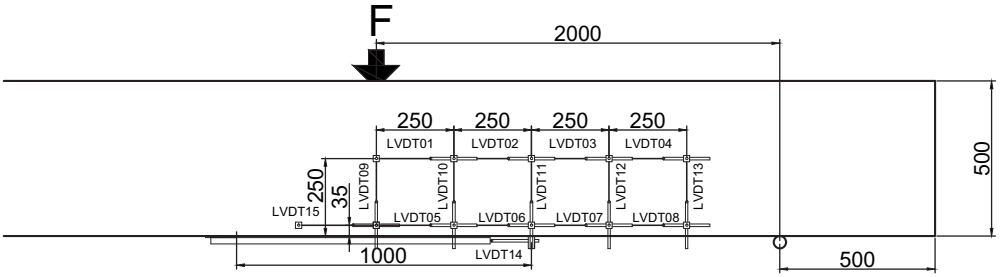


Fig. 5.79.3. LVDT layout and numbering for 500 mm deep beams (

5.79.2. Measurement results

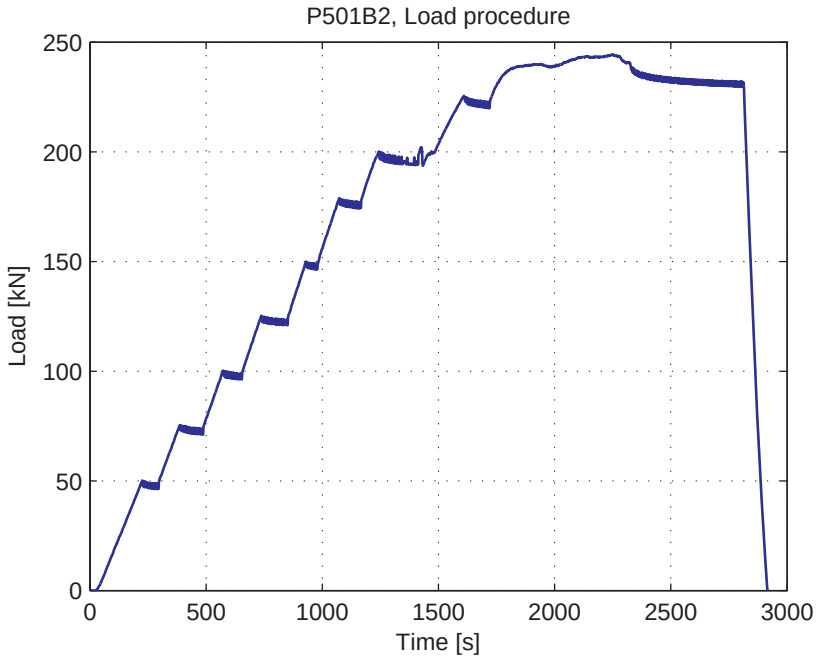


Fig. 5.79.4. Load-Time curve

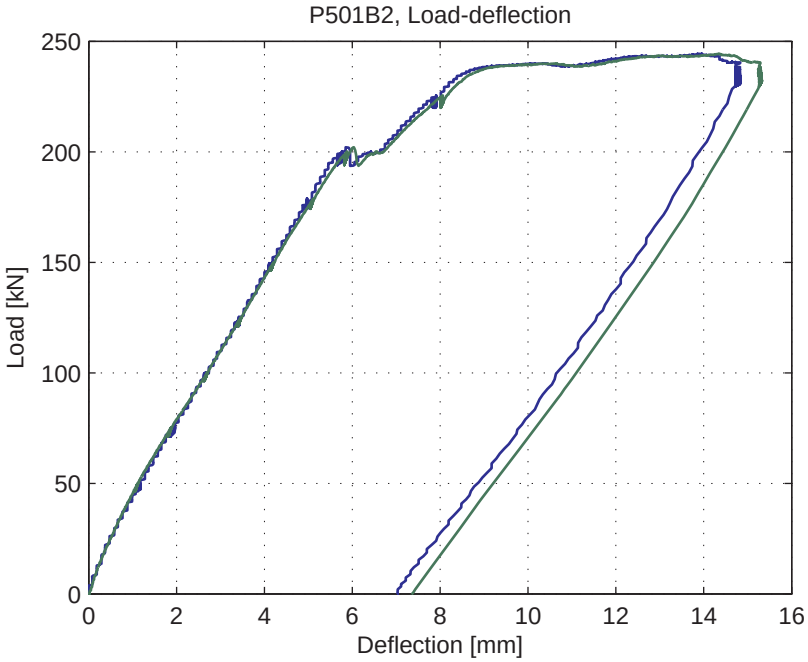


Fig. 5.79.5. Load-deflection curve

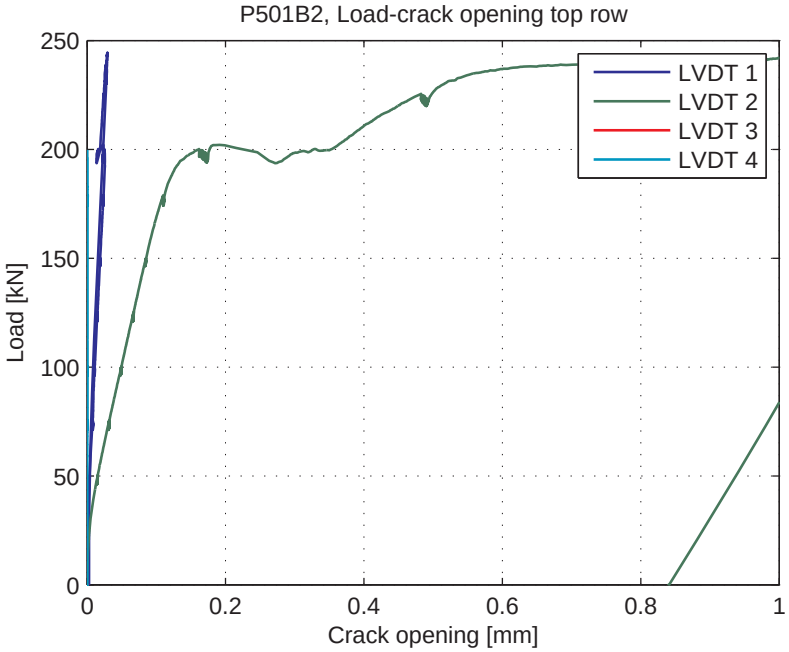


Fig. 5.79.6. Load-Crack opening for LVDT's 1-4 (top row)

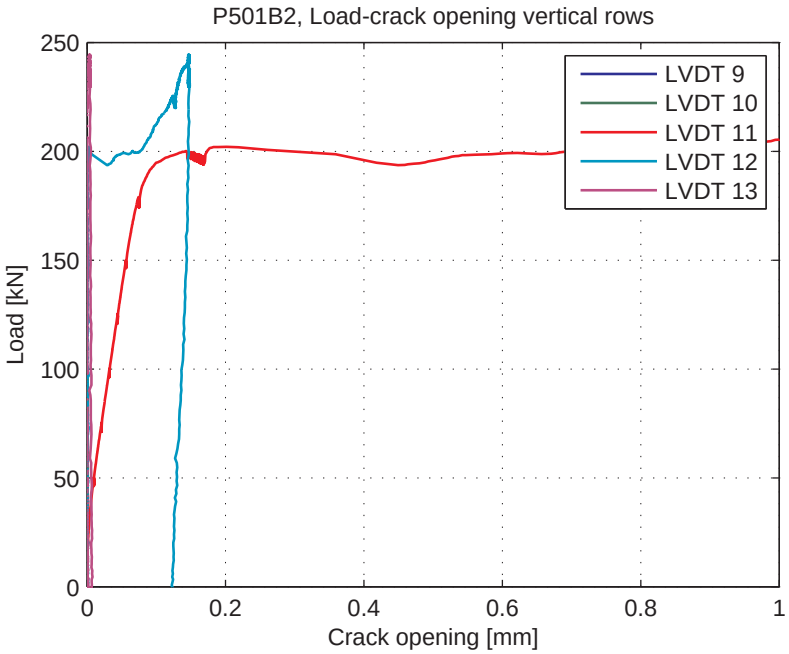


Fig. 5.79.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

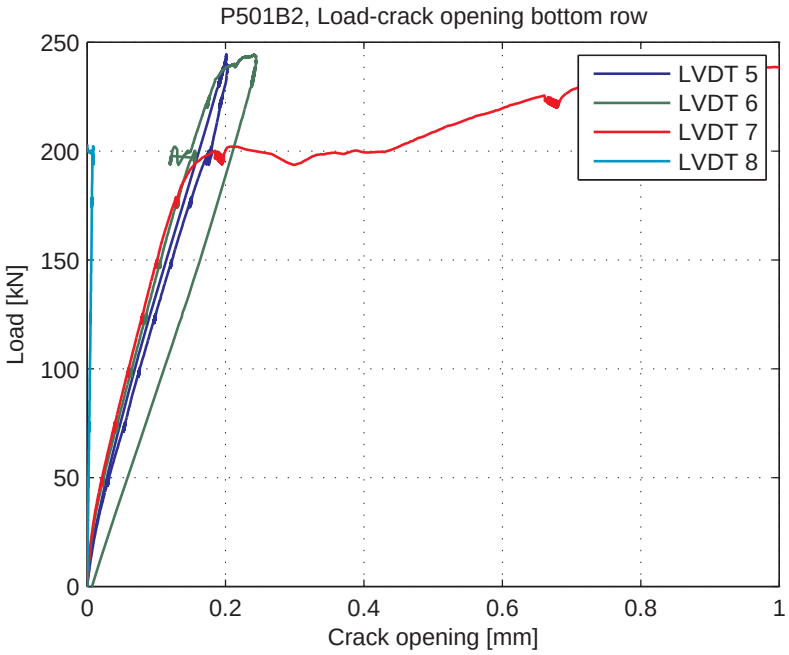


Fig. 5.79.8. Load-Crack opening for LVDT's 5-8 (bottom row)

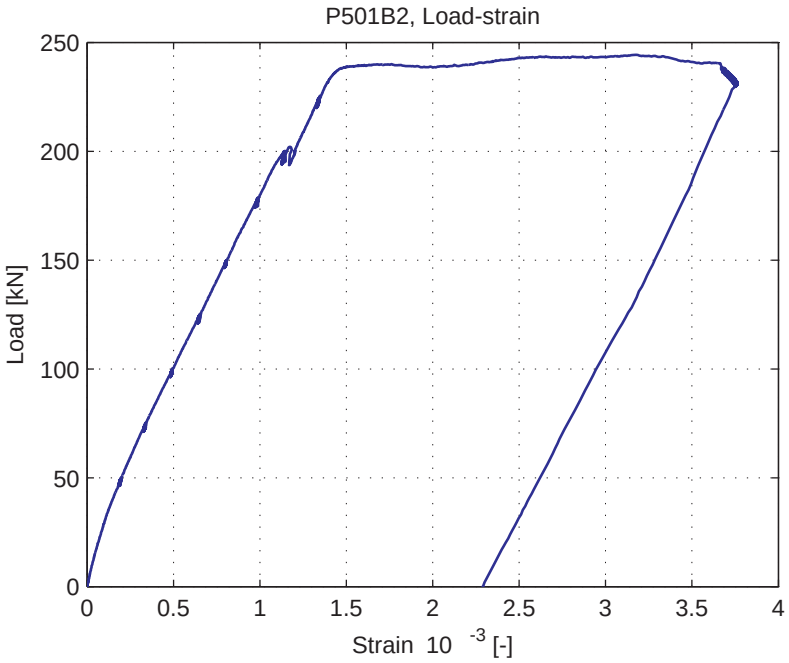


Fig. 5.79.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.80. P502A1

5.80.1. Test properties

Fig. 5.80.1. Crack pattern after failure front side

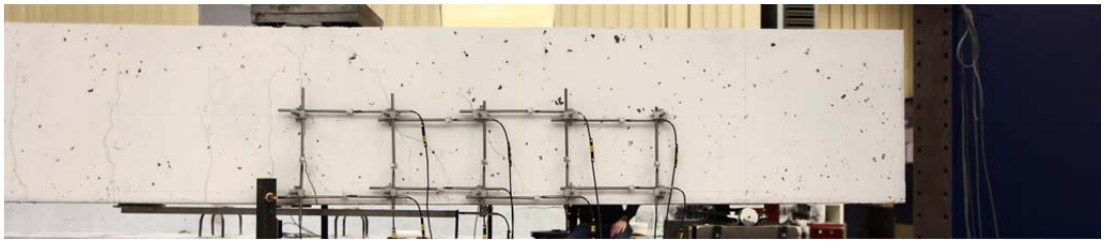


Fig. 5.80.2. Crack pattern after failure back side

Table 5.80.1. Beam properties

Date of test	04-03-2016
Reinforcement	3Ø20
Reinforcement ratio	0.68%
a	1250 mm
a / *d*	2.69
Concrete cube strength at testing	87.2 MPa
Peak load	130.6 kN
Failure mode	Flexural

Table 5.80.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	75	
3	100	
4	125	Back to 0 kN
5	0	
6	130.6	Yielding, stopped after jack displacement of 15.28 mm

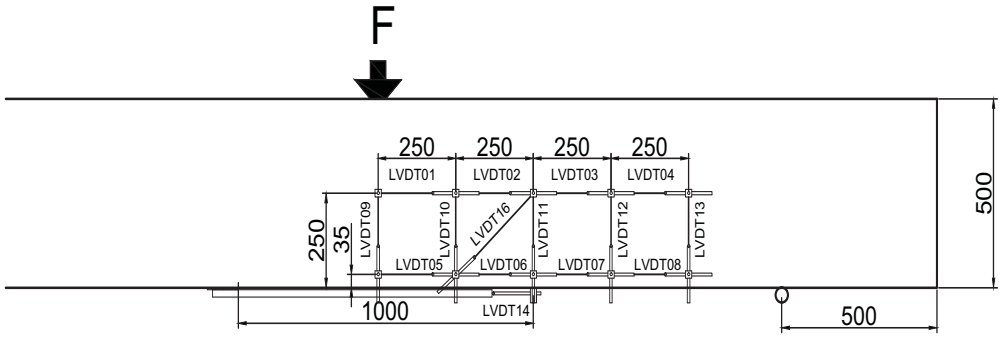


Fig. 5.80.3. LVDT layout and numbering for 500 mm deep beams

5.80.2. Measurement results

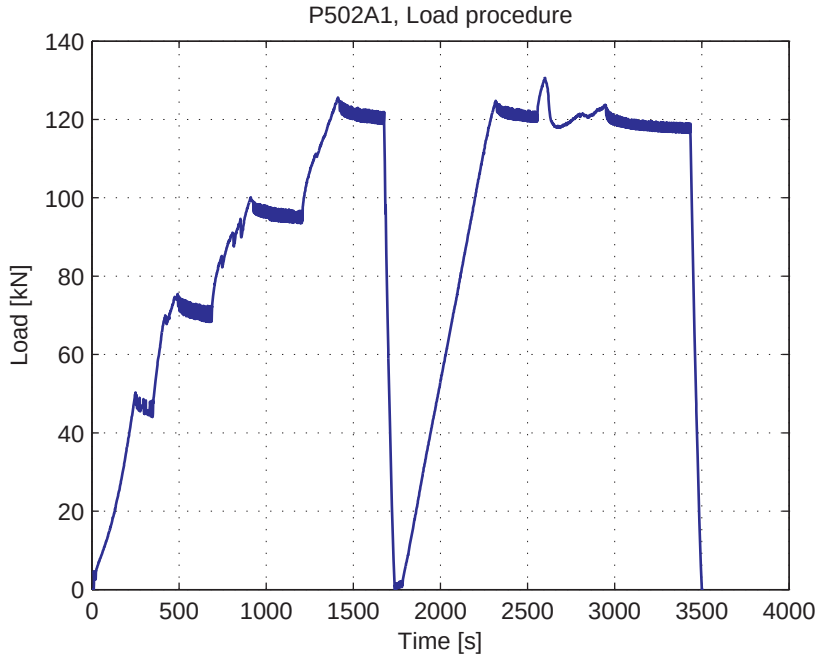


Fig. 5.80.4. Load-Time curve

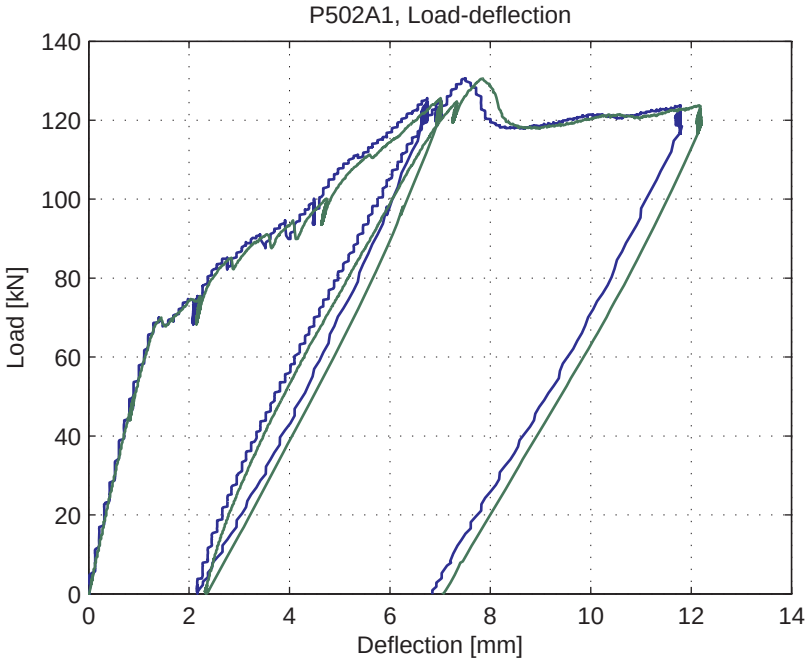


Fig. 5.80.5. Load-deflection curve

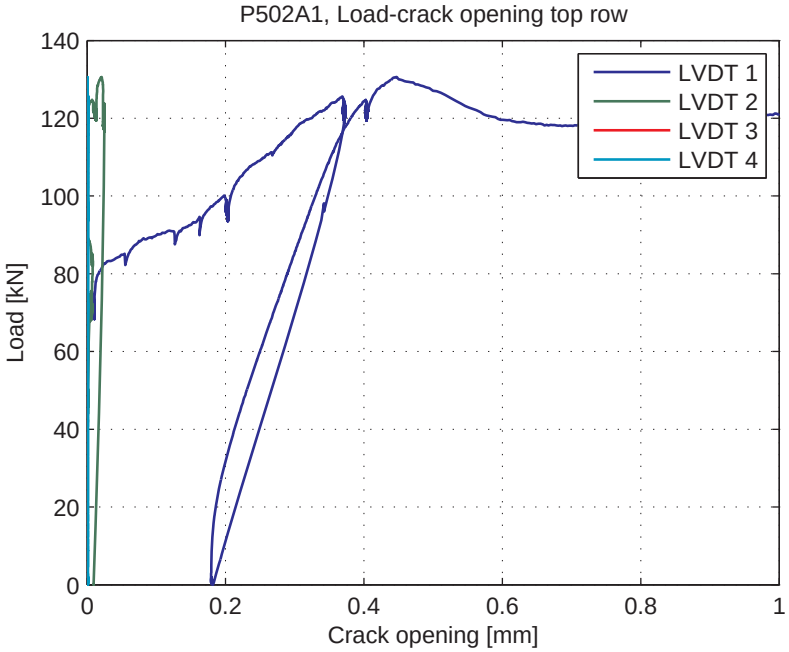


Fig. 5.80.6. Load-Crack opening for LVDT's 1-4 (top row)

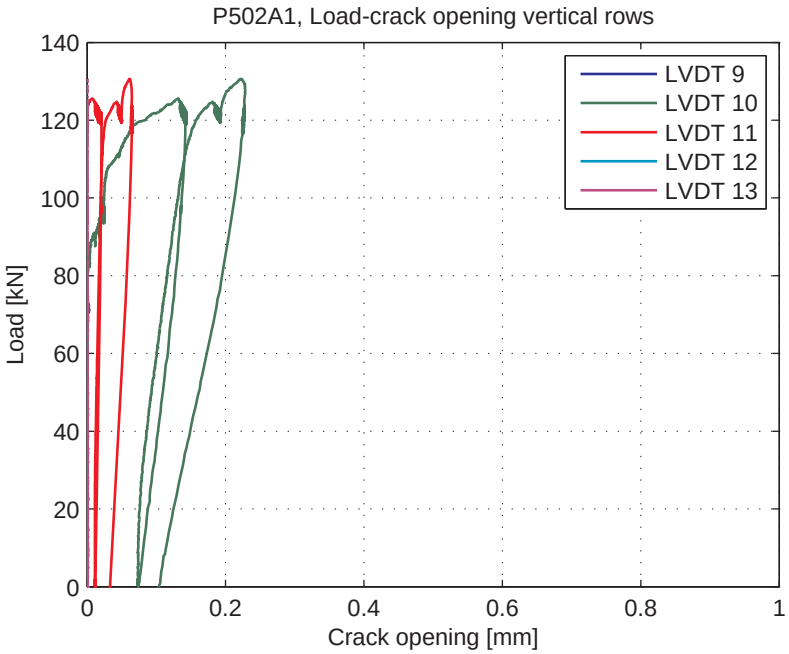


Fig. 5.80.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

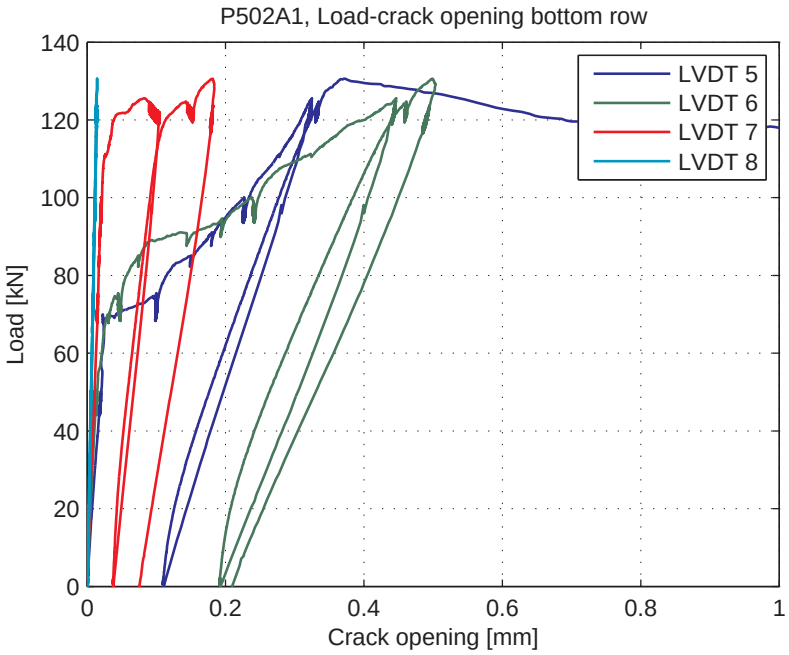


Fig. 5.80.8. Load-Crack opening for LVDT's 5-8 (bottom row)

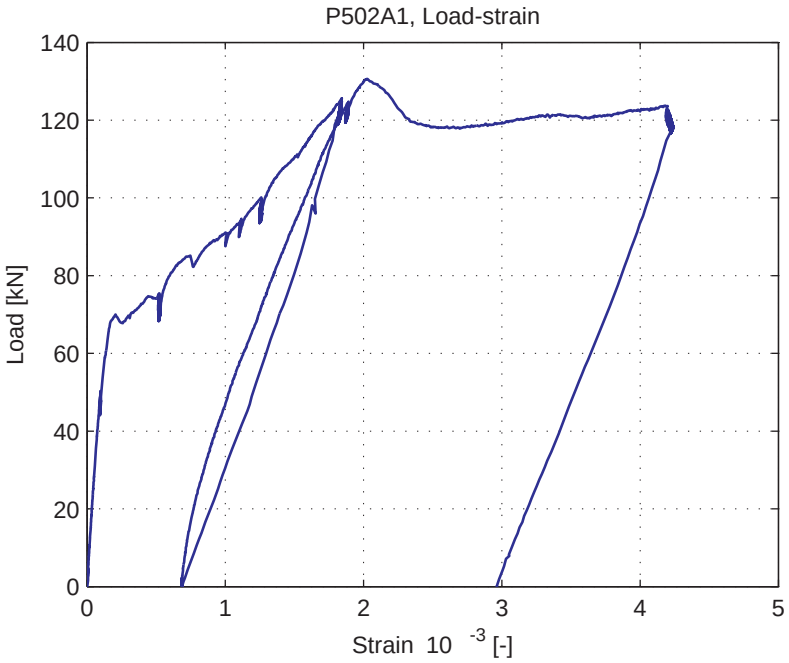


Fig. 5.80.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.81. P502A2

5.81.1. Test properties

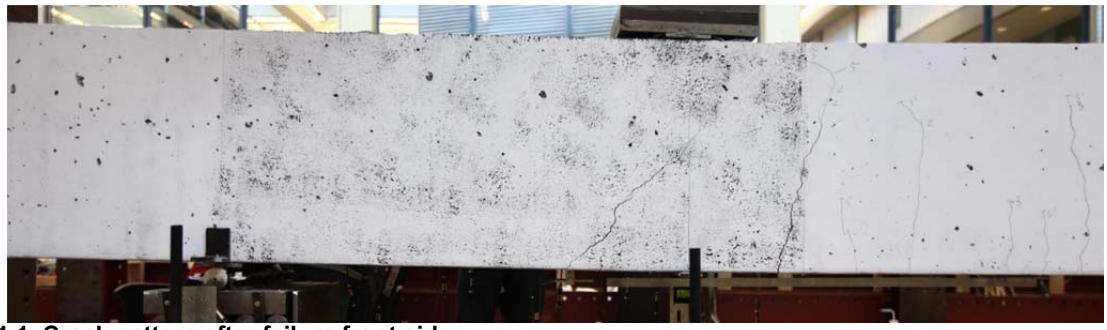


Fig. 5.81.1. Crack pattern after failure front side

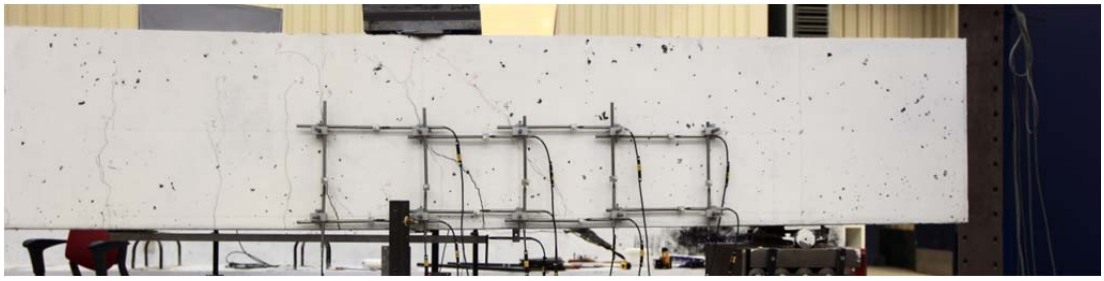


Fig. 5.81.2. Crack pattern after failure back side

Table 5.81.1. Beam properties

Date of test	07-03-2016
Reinforcement	3Ø20 plain
Reinforcement ratio	0.68%
a	1000 mm
a / *d*	2.15
Concrete cube strength at testing	87.2 MPa
Peak load	148.8 kN
Failure mode	Flexural

Table 5.81.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Separate report on this test is made (Stevin report 25.5-16-06)
1	50	
2	75	
3	0	Loading speed 0.1 mm/s
4	75	
5	100	
6	125	
7	0	Loading speed 0.1 mm/s
8	150	
9	0	Loading speed 0.1 mm/s
10	150.0	Yielding at 148.8 kN, stopped after jack displacement of 11.2 mm

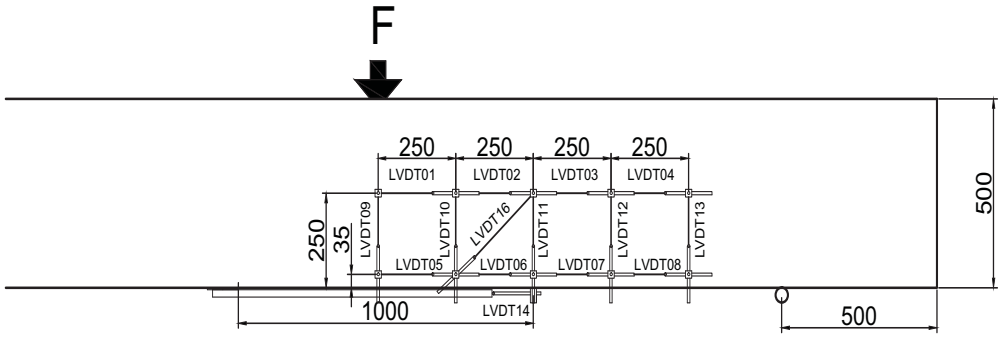


Fig. 5.81.3. LVDT layout and numbering for 500 mm deep beams

5.81.2. Measurement results

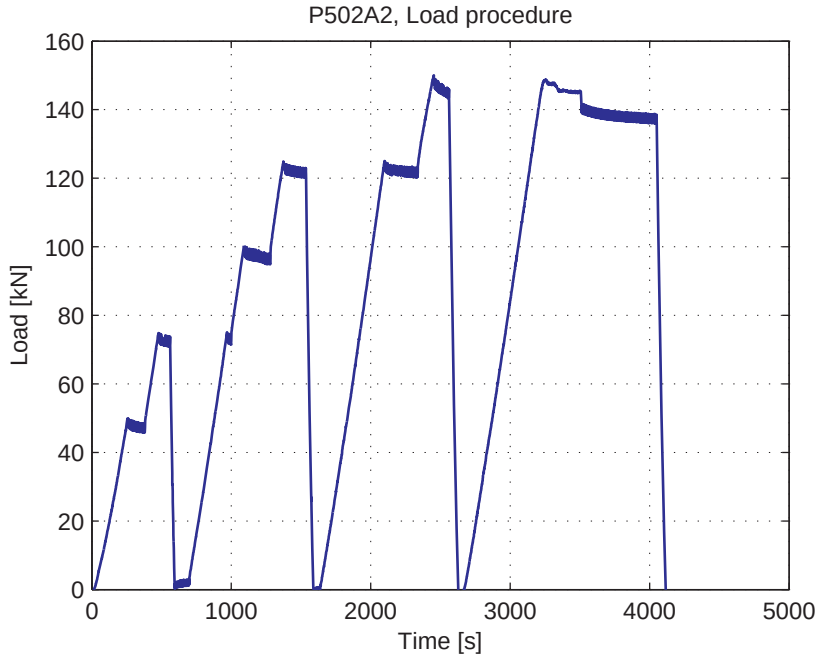


Fig. 5.81.4. Load-Time curve

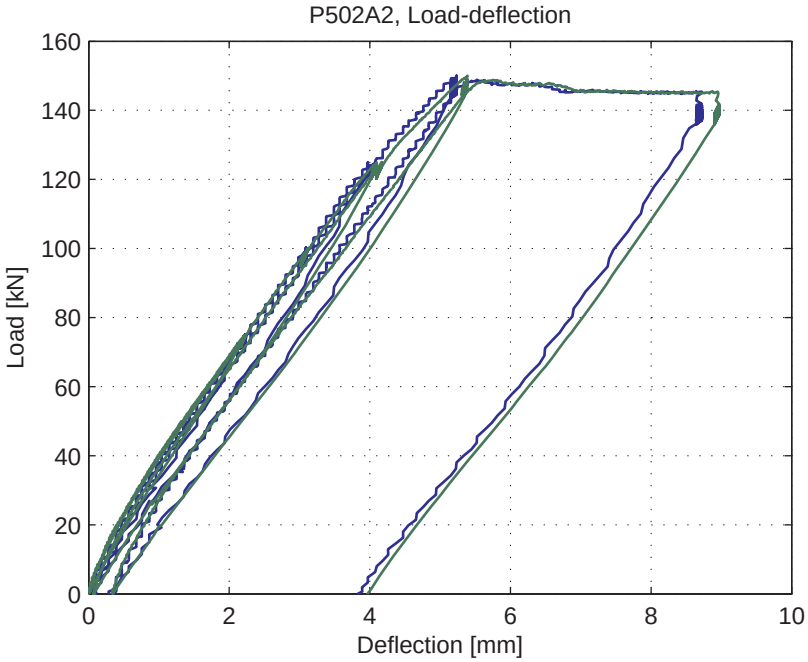


Fig. 5.81.5. Load-deflection curve

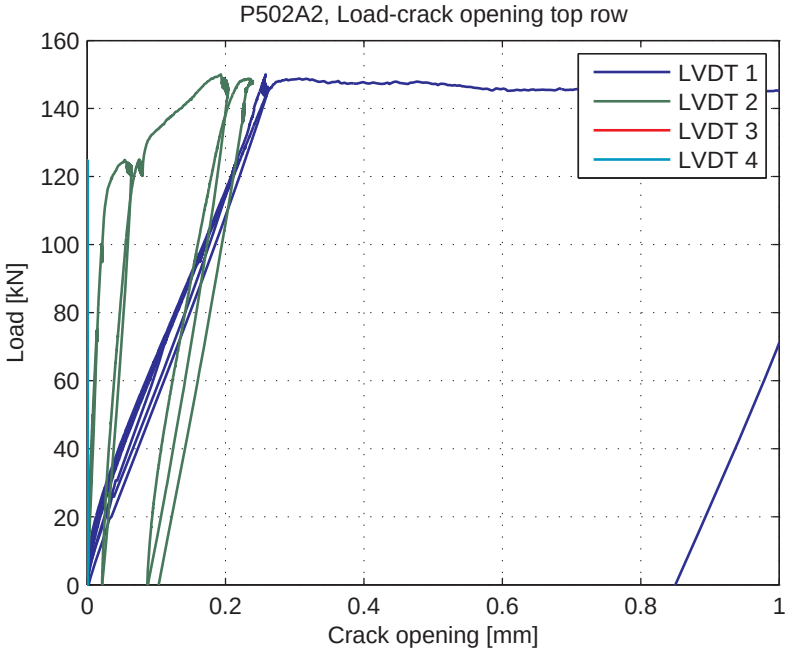


Fig. 5.81.6. Load-Crack opening for LVDT's 1-4 (top row)

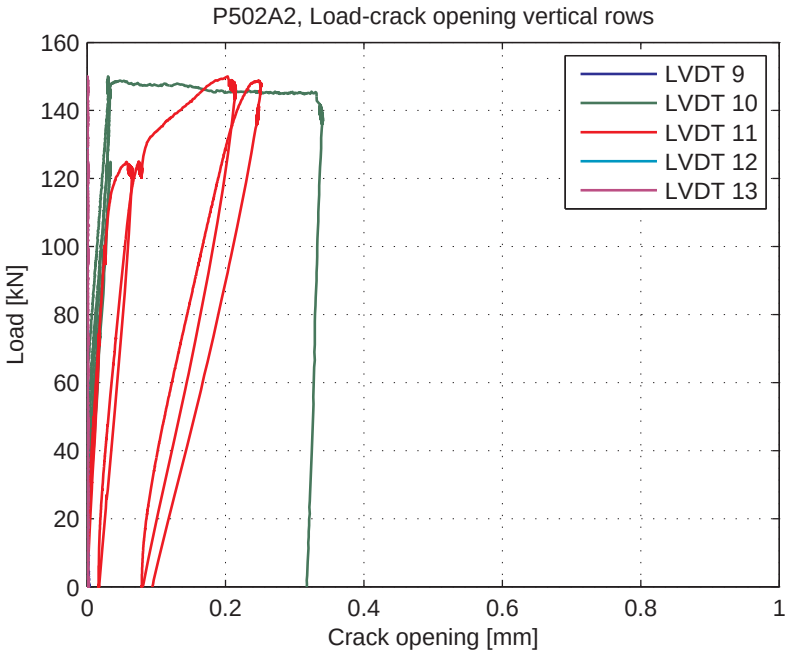


Fig. 5.81.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

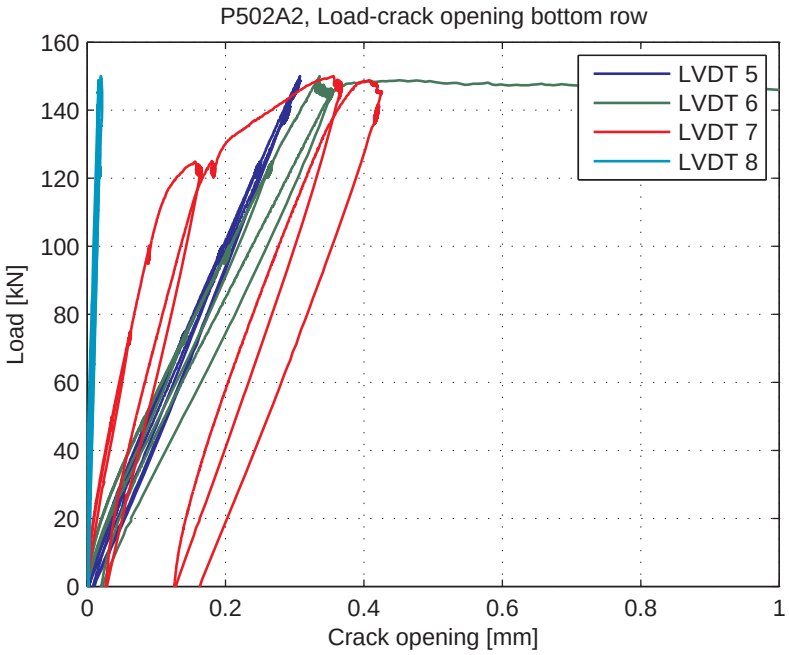


Fig. 5.81.8. Load-Crack opening for LVDT's 5-8 (bottom row)

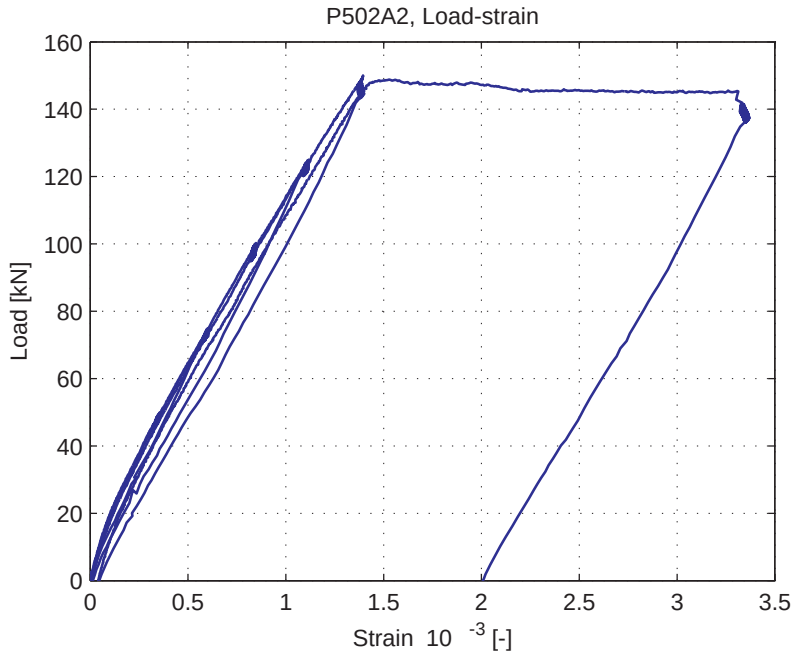


Fig. 5.81.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.82. P502B1

5.82.1. Test properties

Fig. 5.82.1. Crack pattern after failure north side

Fig. 5.82.2. Crack pattern after failure south side

Table 5.82.1. Beam properties

Date of test	11-03-2016 and 14-03-2016
Reinforcement	3Ø20 plain
Reinforcement ratio	0.68%
a	1500 mm
a / *d*	3.23
Concrete cube strength at testing	87.2 MPa
Peak load	112.2 kN
Failure mode	Flexural

Table 5.82.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Master thesis research of Werner Vos
1	50	
2	0	
3	50	
4	0	Started second file, P502B2
5	50	
6	0	
7	65	
8	0	
9	65	
10	0	
11	65	
12	0	
13	80	
14	0	
15	80	
16	0	
17	80	
18	0	Started third file, P502B3
19	95	
20	0	Laser 2 and 4 not measuring, zeroed at 0 kN
21	95	
22	0	
23	95	
24	0	
25	100	
26	120	
27	0	
28	120	
29	0	
30	120	Yielding at 112 kN

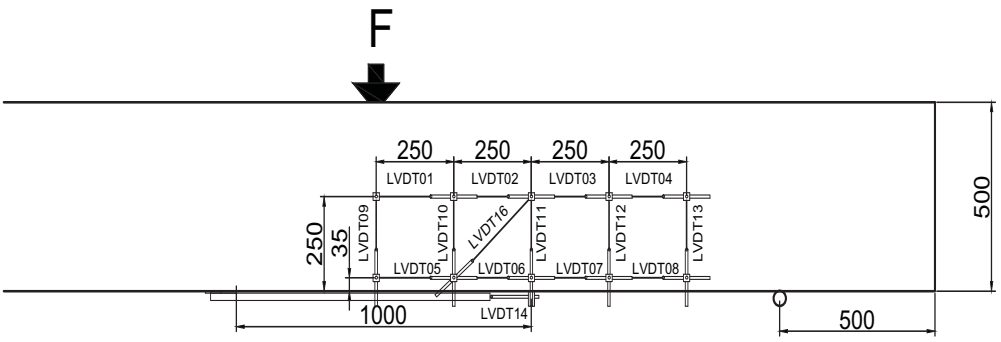


Fig. 5.82.3. LVDT layout and numbering for 500 mm deep beams

5.82.2. Measurement results

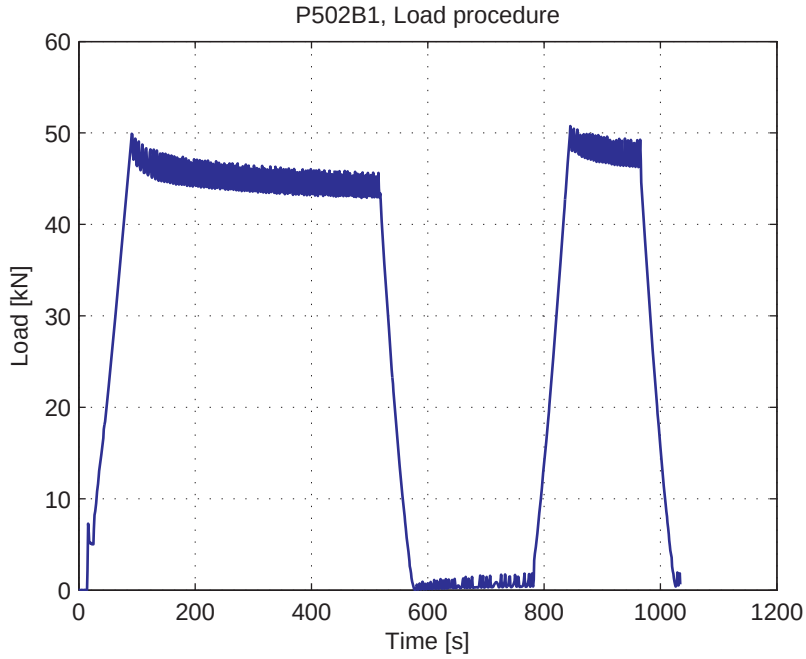


Fig. 5.82.4. Load-Time curve for first part of test

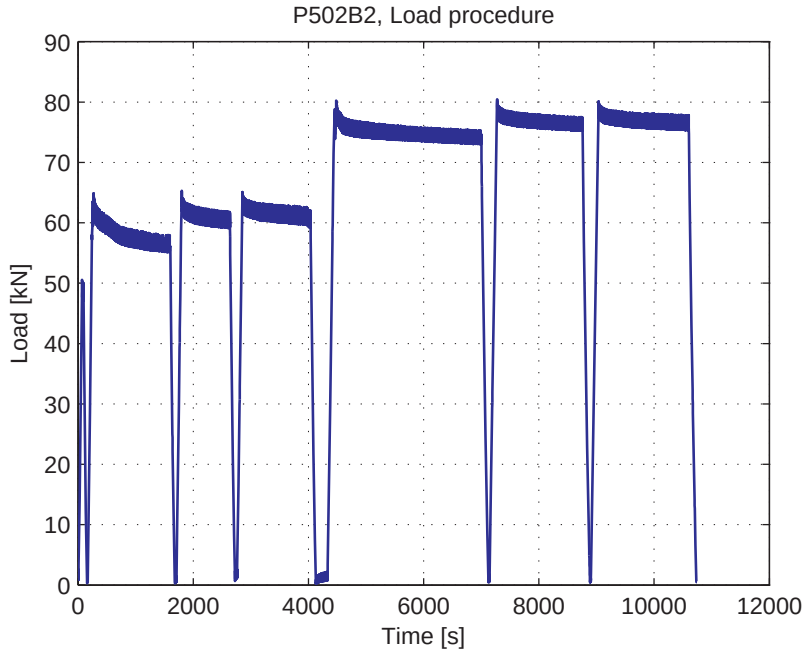


Fig. 5.82.5. Load-Time curve for second part of test

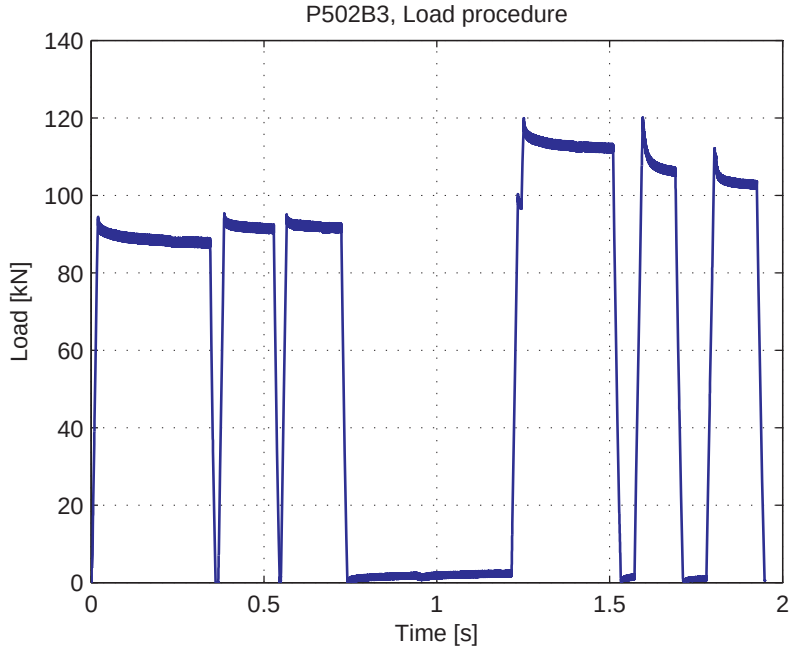


Fig. 5.82.6. Load-Time curve for third part of test

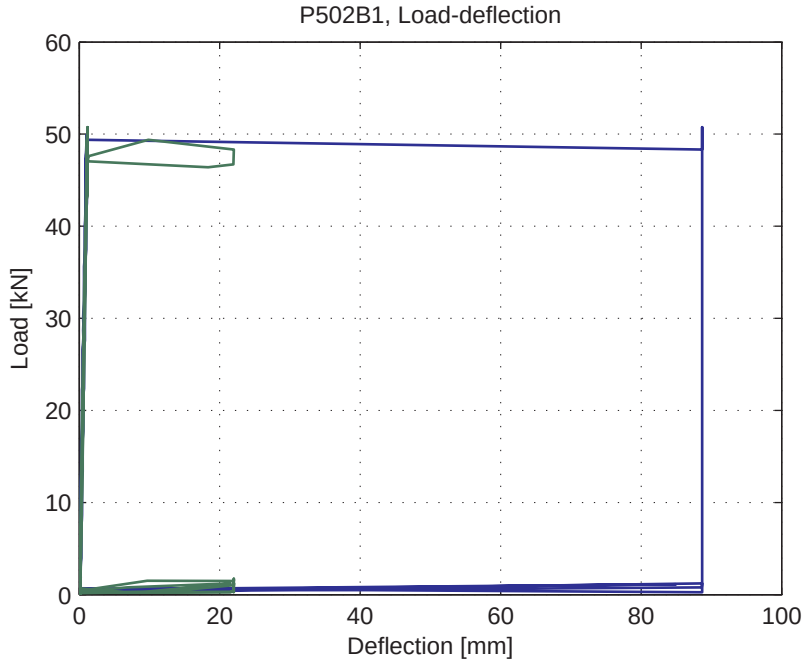


Fig. 5.82.7. Load-deflection curve for first part of test

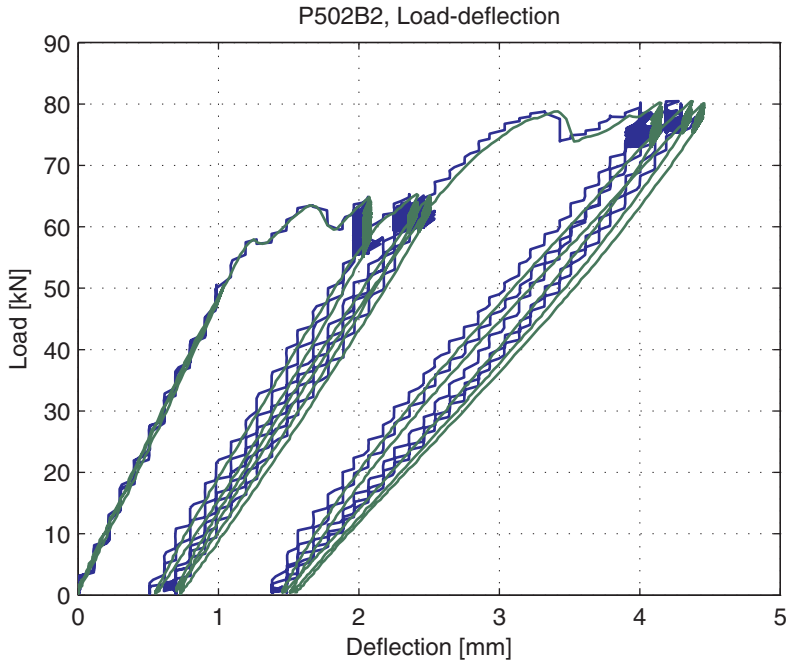


Fig. 5.82.8. Load-deflection curve for second part of test

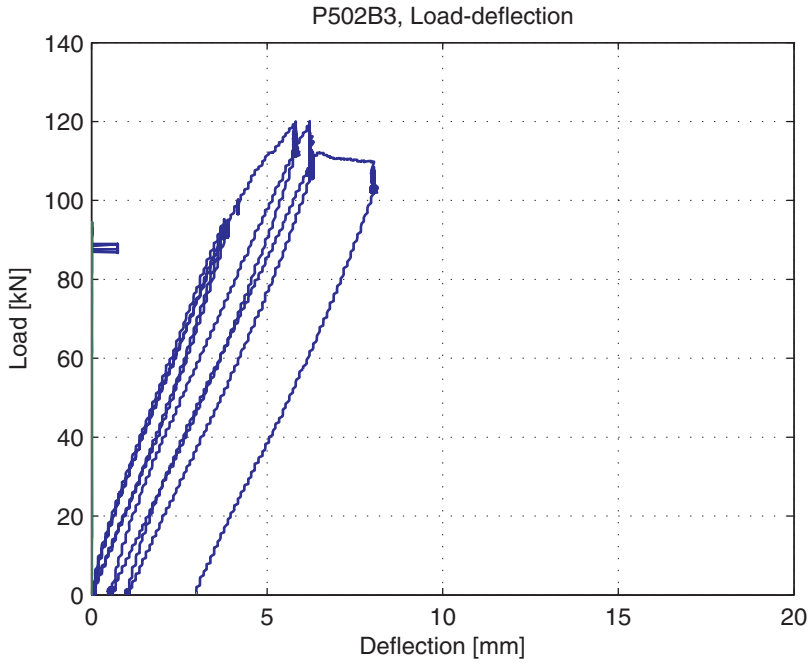


Fig. 5.82.9. Load-deflection curve for third part of test

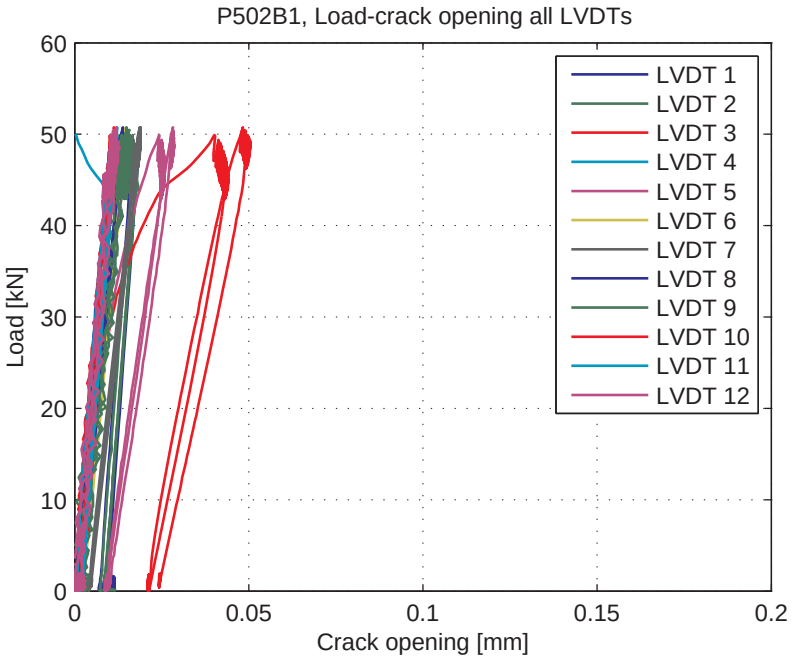


Fig. 5.82.10. Load-Crack opening first part of test for all LVDT's

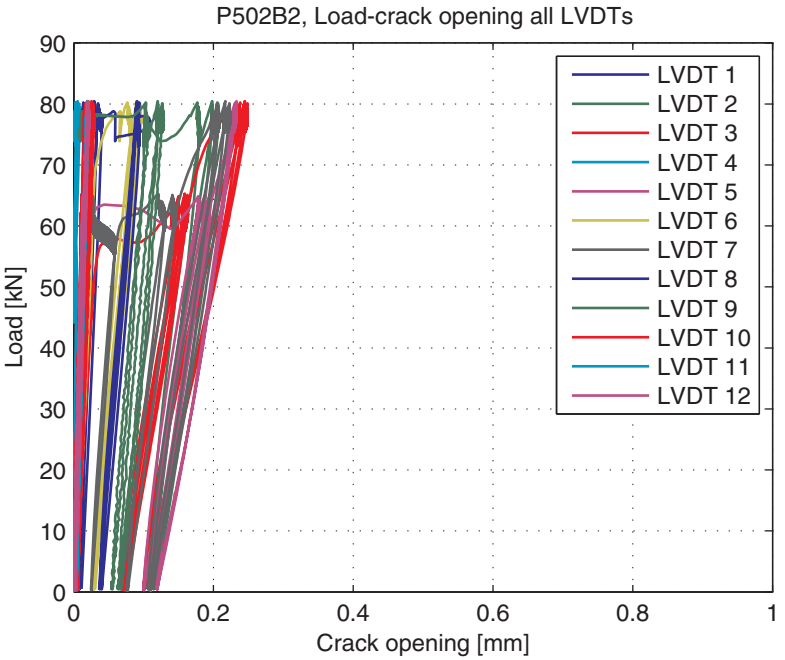


Fig. 5.82.11. Load-Crack opening second part of test for all LVDT's

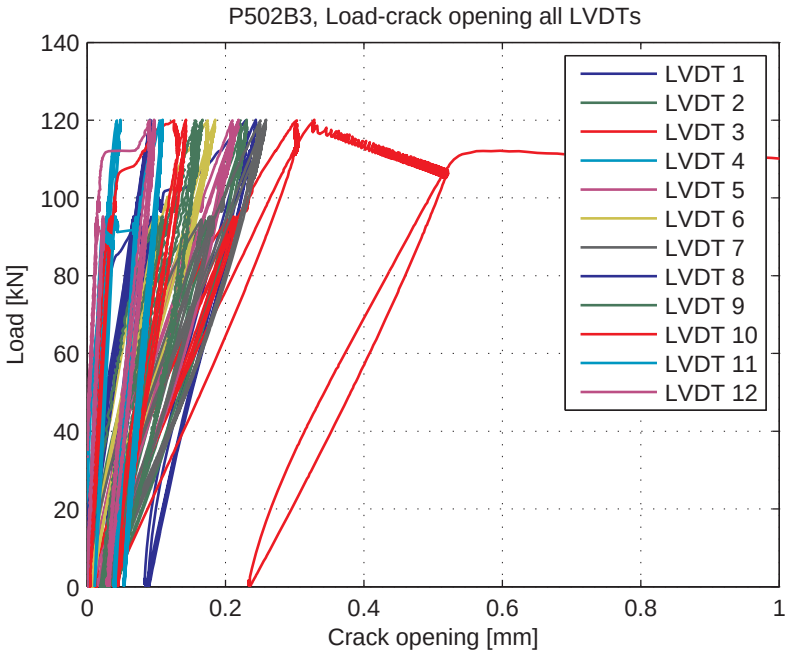


Fig. 5.82.12. Load-Crack opening third part of test for all LVDT's

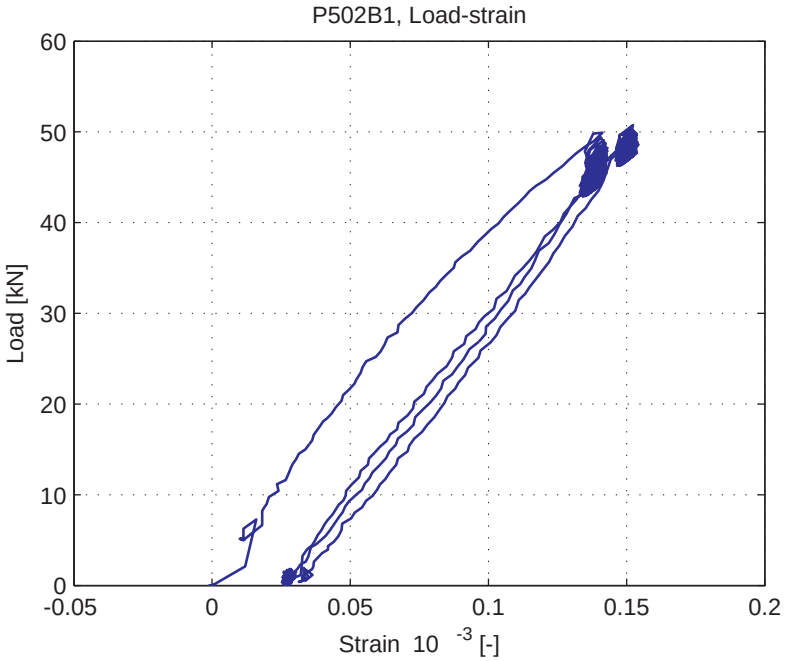


Fig. 5.82.13. Average strain over 1m length for first part of test, measured at bottom of specimen (LVDT 13)

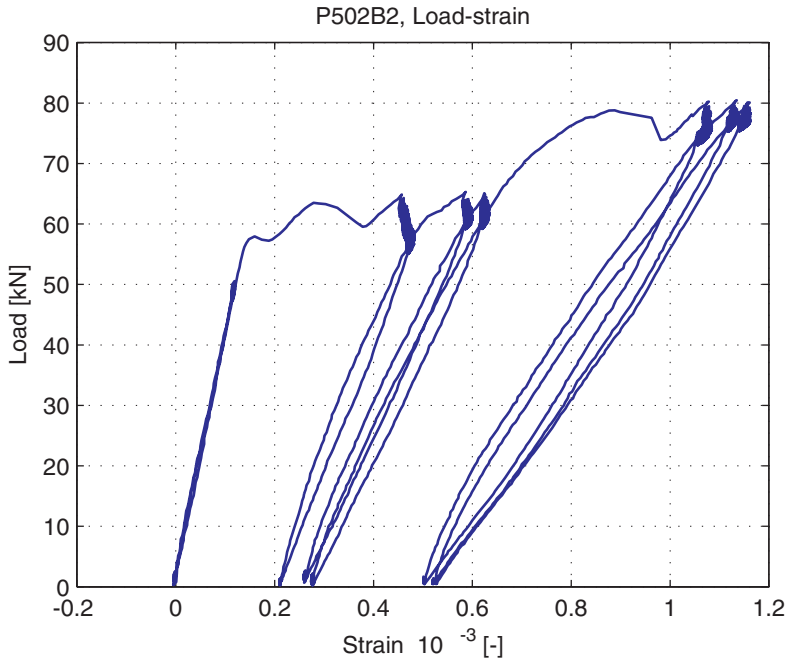


Fig. 5.82.14. Average strain over 1m length for second part of test, measured at bottom of specimen (LVDT 13)

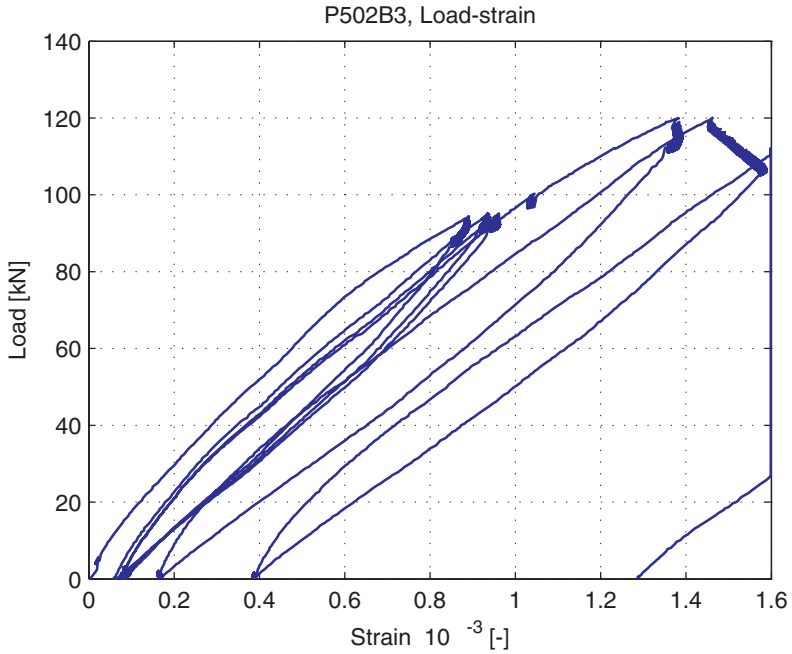


Fig. 5.82.15. Average strain over 1m length for third part of test, measured at bottom of specimen (LVDT 13)

5.83. P801A1

5.83.1. Test properties

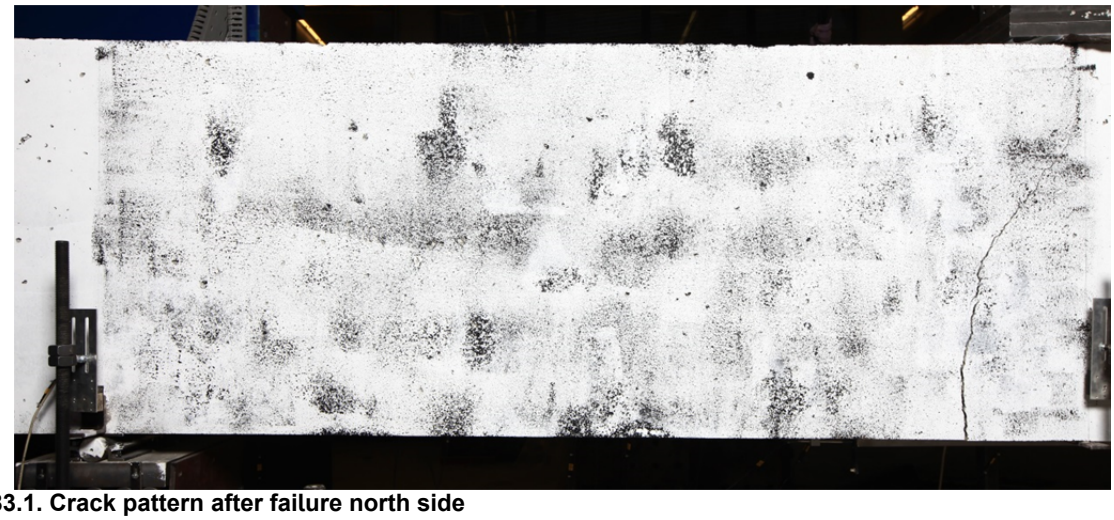


Fig. 5.83.1. Crack pattern after failure north side

Table 5.83.1. Beam properties

Date of test	06-01-2016
Reinforcement	3Ø25 plain
Reinforcement ratio	0.64%
a	2000 mm
a / *d*	2.62
Concrete cube strength at testing	86.9 MPa
Peak load	196.6 kN
Failure mode	Flexural

Table 5.83.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Used new calibration for LVDT's
1	50	
2	100	
3	150	
4	196.6	Yielding

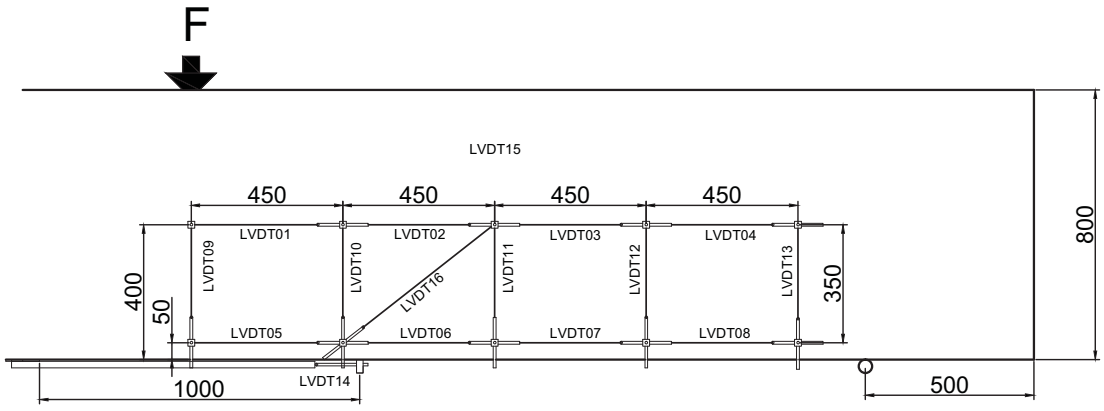


Fig. 5.83.2. LVDT layout and numbering for 800 mm deep beams

5.83.2. Measurement results

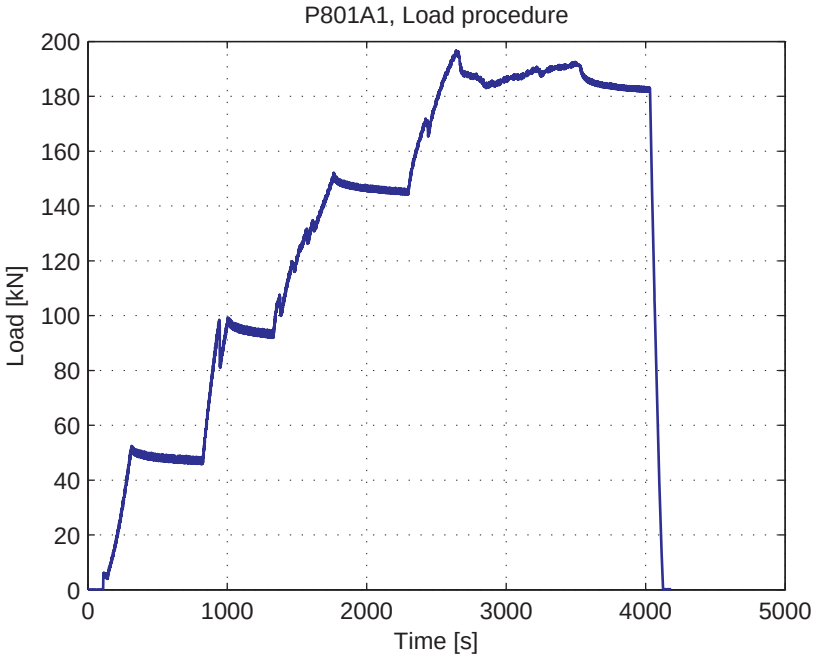


Fig. 5.83.3. Load-Time curve

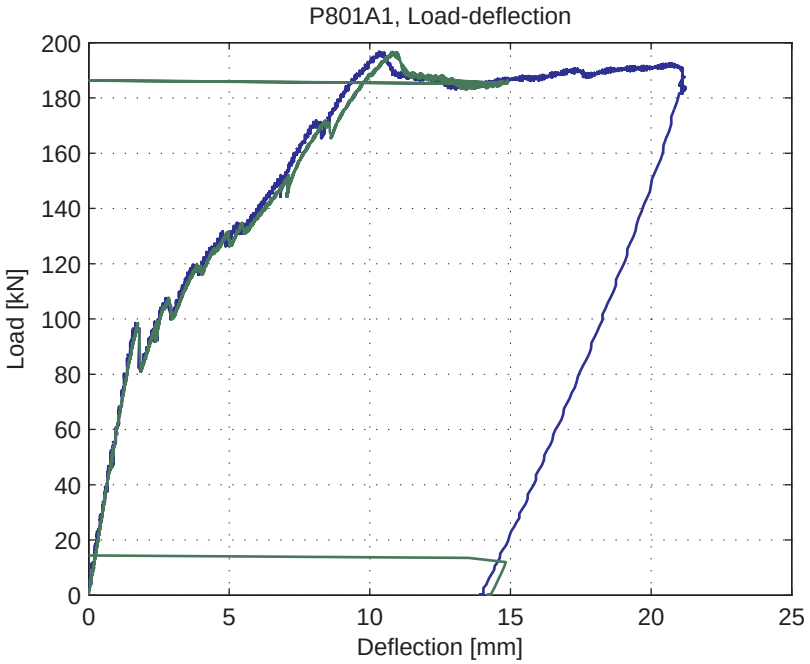


Fig. 5.83.4. Load-deflection curve

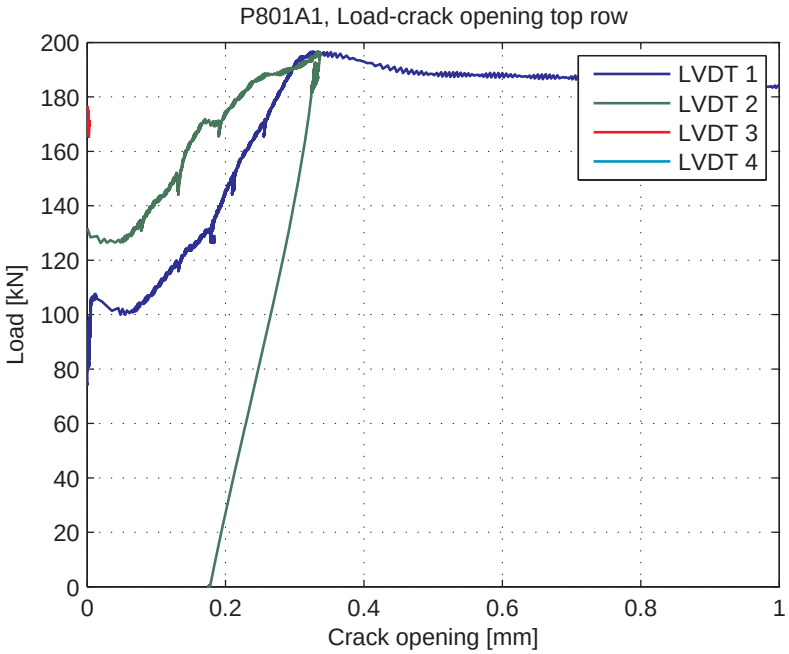


Fig. 5.83.5. Load-Crack opening for LVDT's 1-4 (top row)

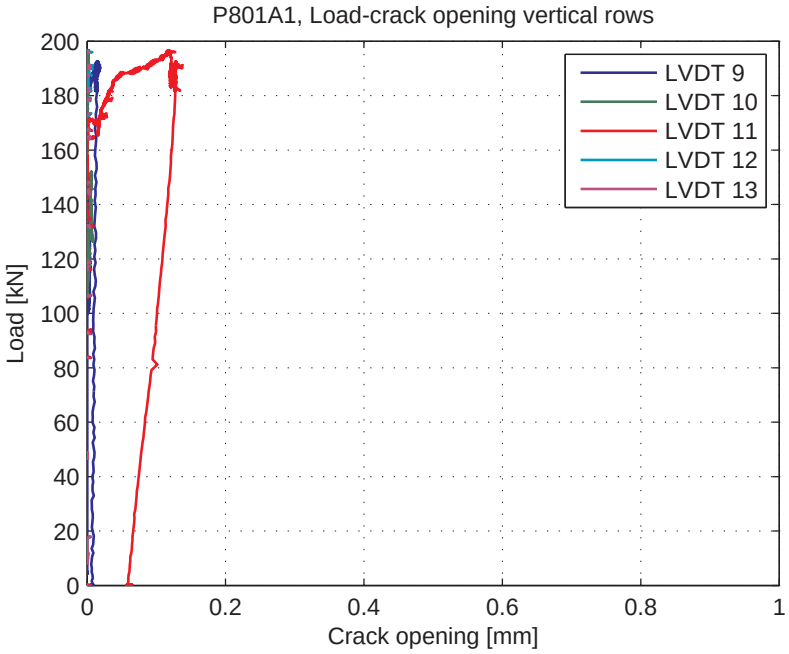


Fig. 5.83.6. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

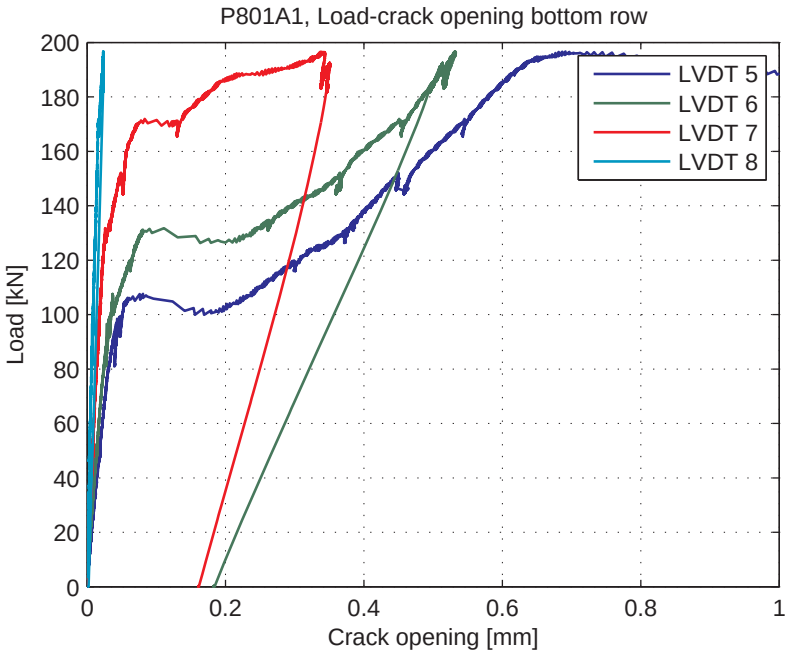


Fig. 5.83.7. Load-Crack opening for LVDT's 5-8 (bottom row)

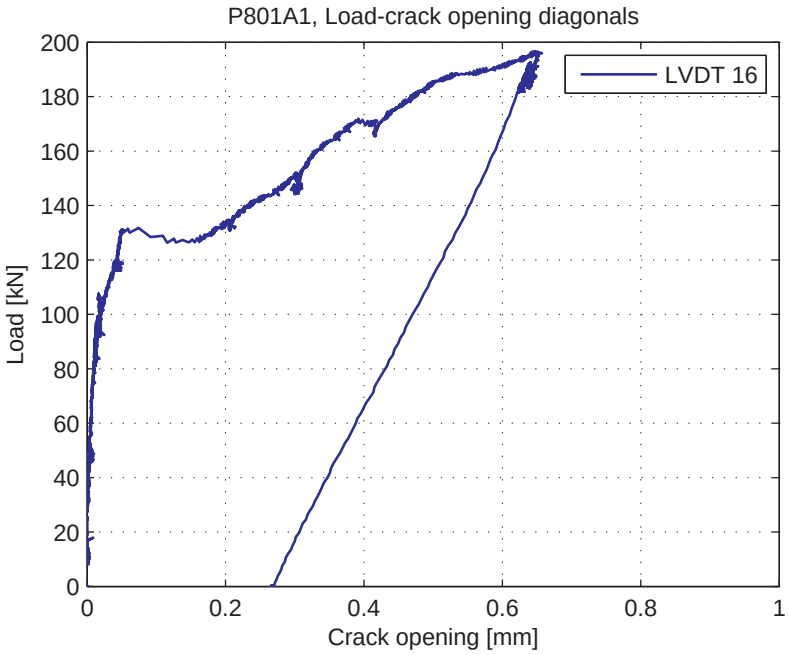


Fig. 5.83.8. Load-Crack opening for LVDT 16 (diagonal)

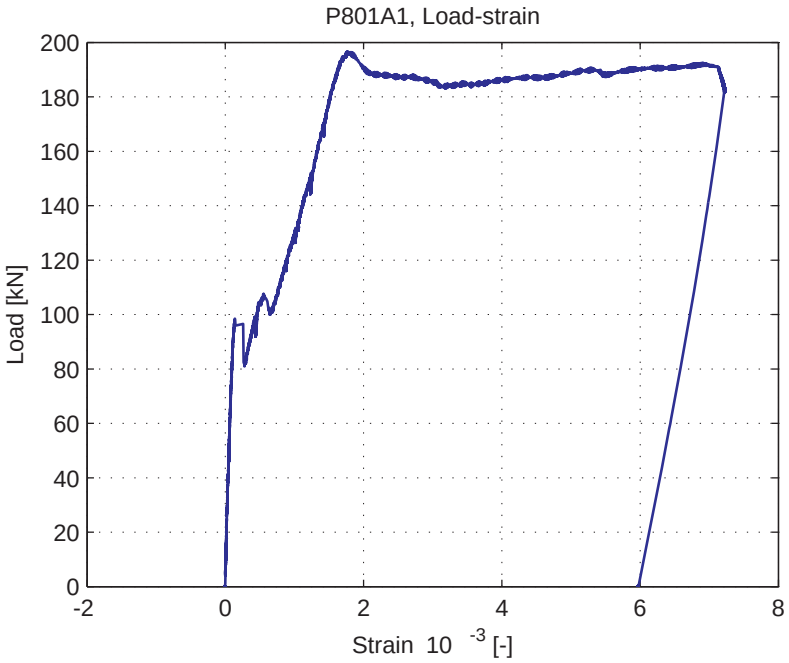


Fig. 5.83.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.84. P801A2

5.84.1. Test properties

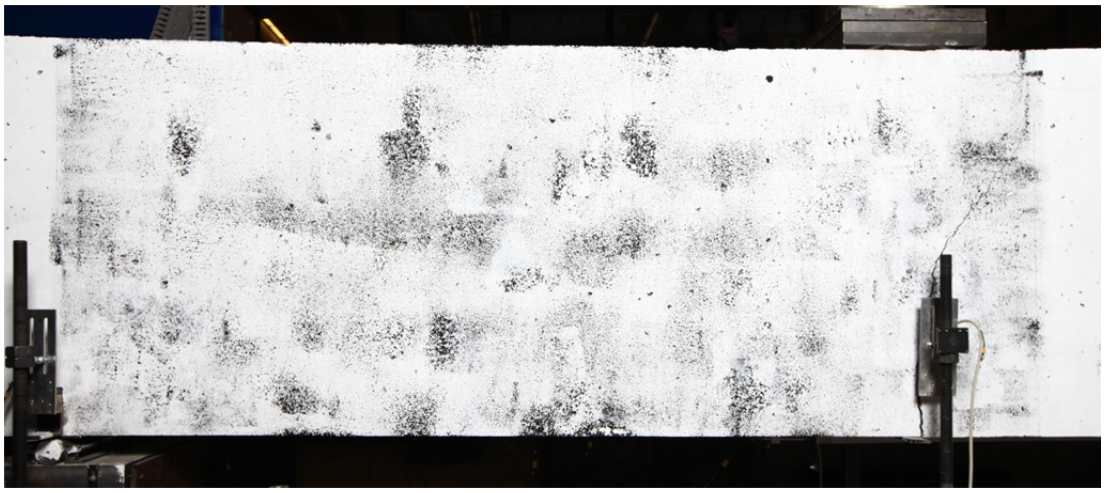


Fig. 5.84.1. Crack pattern after failure north side

Table 5.84.1. Beam properties

Date of test	07-01-2016
Reinforcement	3Ø25 plain
Reinforcement ratio	0.64%
a	1750 mm
a / *d*	2.30
Concrete cube strength at testing	87.0 MPa
Peak load	205.9 kN
Failure mode	Flexural

Table 5.84.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	100	
3	150	Placed LVDT 15, returned to 0 kN
4	0	Changed loading speed to 0.012 mm/s
5	150	
6	200	
7	212.2	Yielding, stopped after jack displacement of 14.36 mm

Table 5.84.3. Location LVDT's used for crack opening measurements

LVDT	Distance from support [mm]	Distance from bottom beam [mm]
15	1260	500

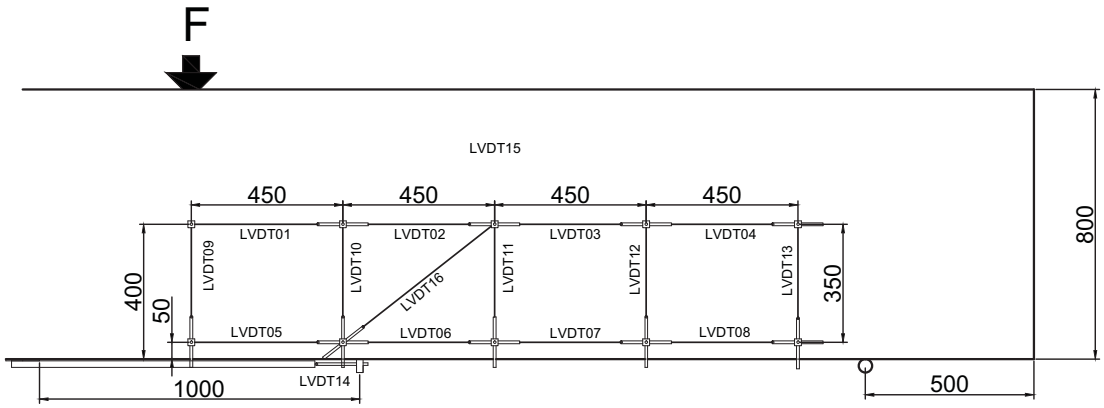


Fig. 5.84.2. LVDT layout and numbering for 800 mm deep beams

5.84.2. Measurement results

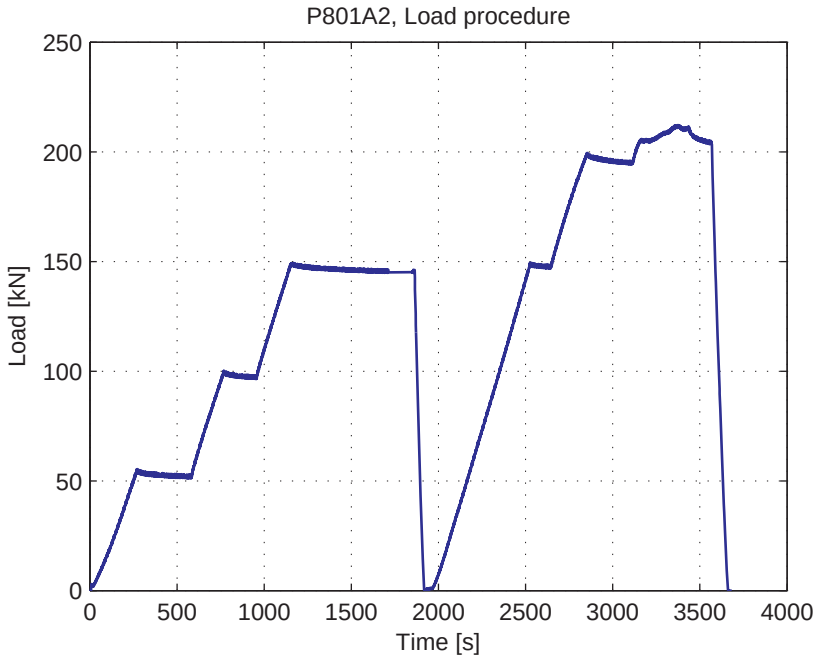


Fig. 5.84.3. Load-Time curve

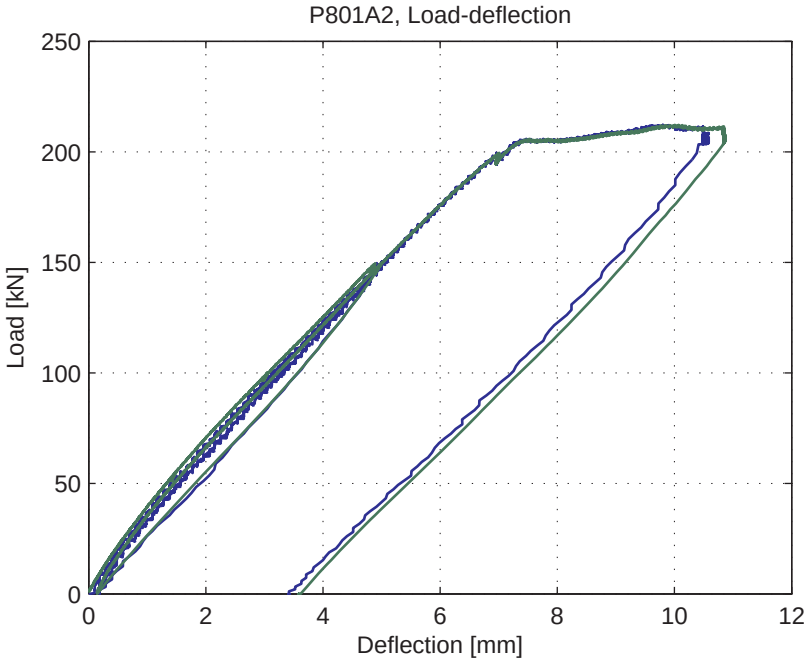


Fig. 5.84.4. Load-deflection curve

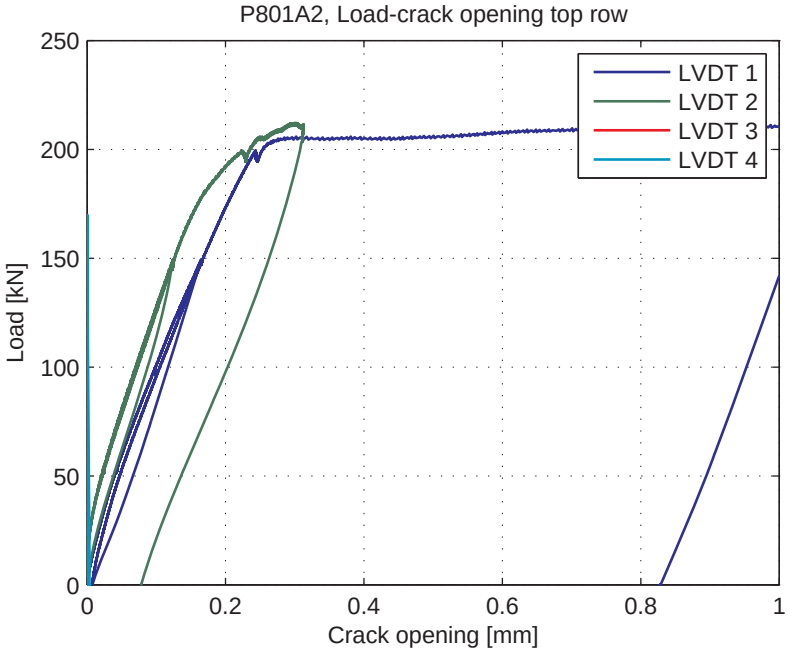


Fig. 5.84.5. Load-Crack opening for LVDT's 1-4 (top row)

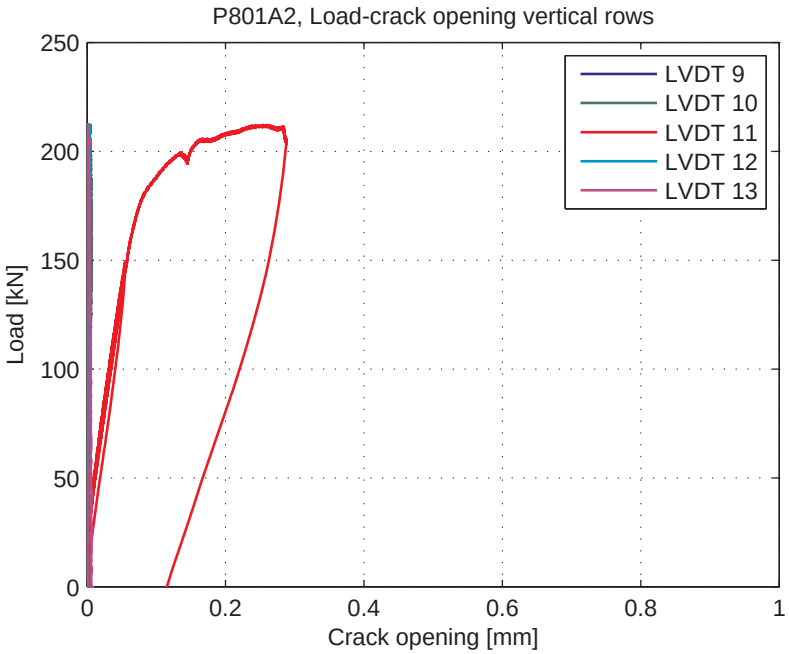


Fig. 5.84.6. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

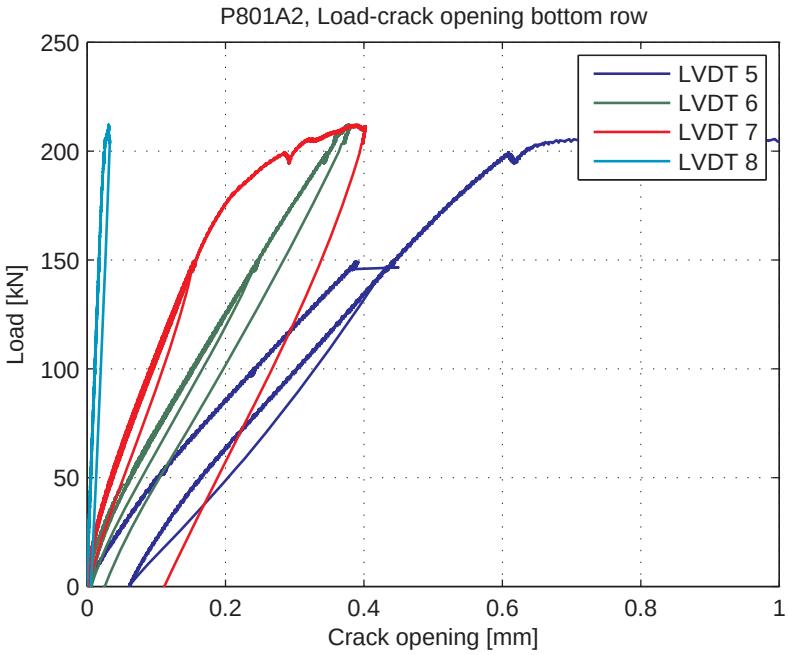


Fig. 5.84.7. Load-Crack opening for LVDT's 5-8 (bottom row)

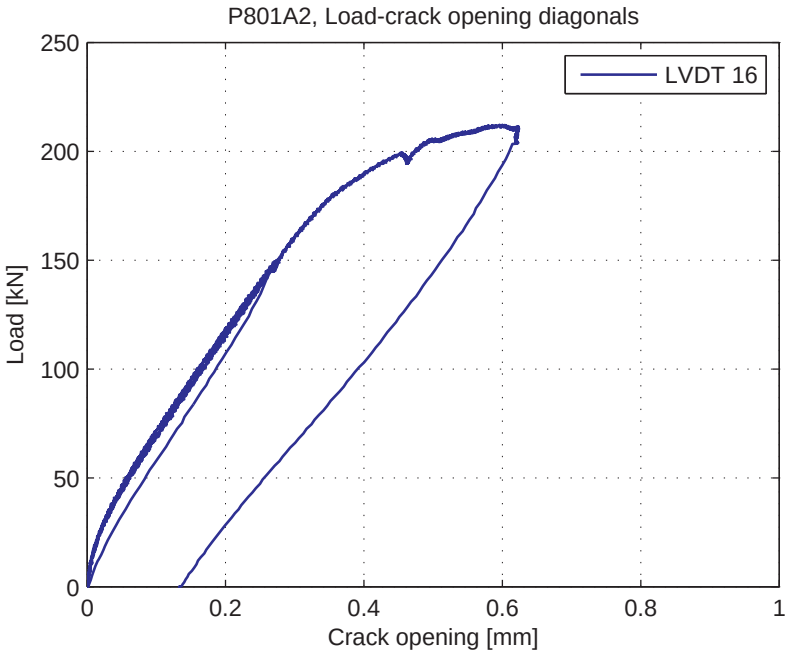


Fig. 5.84.8. Load-Crack opening for LVDT 16 (diagonal)

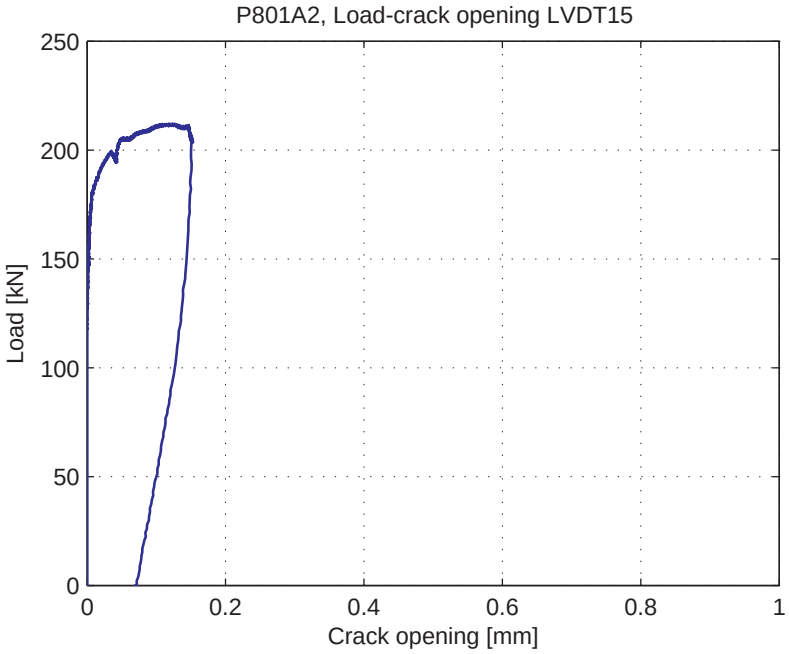


Fig. 5.84.9. Load-Crack opening for LVDT 15

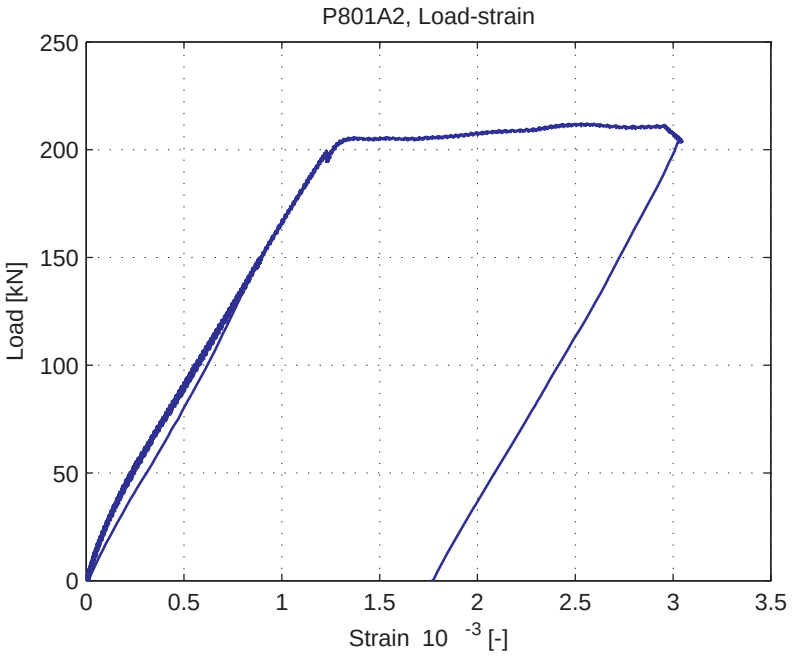


Fig. 5.84.10. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.85. P801A3

5.85.1. Test properties

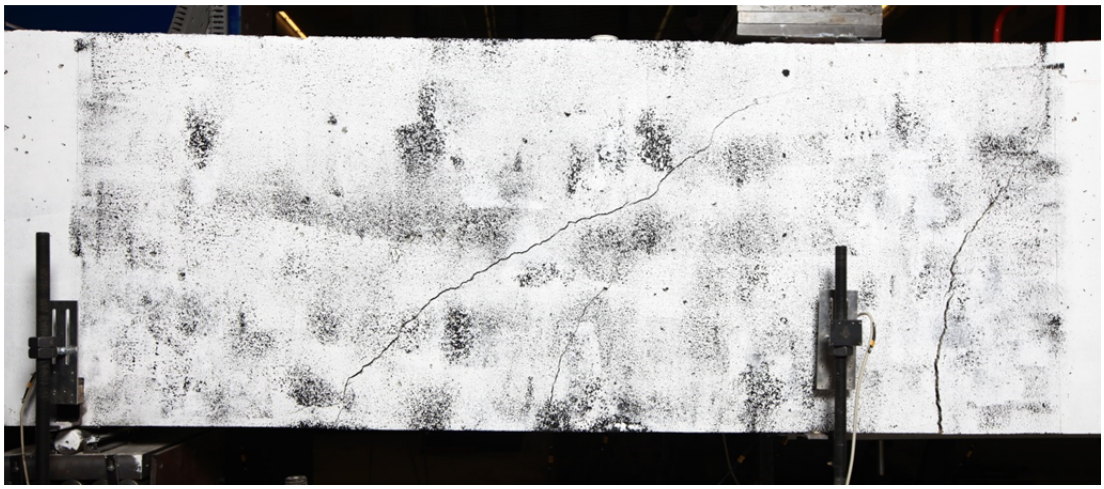


Fig. 5.85.1. Crack pattern after failure north side

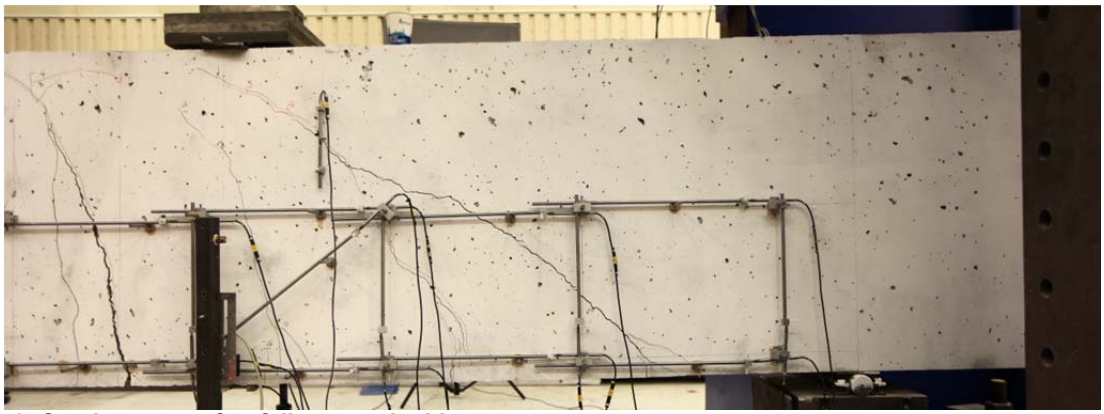


Fig. 5.85.2. Crack pattern after failure south side

Table 5.85.1. Beam properties

Date of test	07-01-2016
Reinforcement	3Ø25 plain
Reinforcement ratio	0.64%
a	1500 mm
a / *d*	1.97
Concrete cube strength at testing	87.0 MPa
Flexural crack load	227.6 kN
Failure mode	Flexural failure with fleuxrla shear crack

Table 5.85.2. Load steps

Load step	Load [kN]	Miscellaneous
0		
1	50	
2	100	
3	150	
4	200	
5	231.4	First shear crack at 227 kN, stopped at 230 kN after jack displacement of 16.3 mm

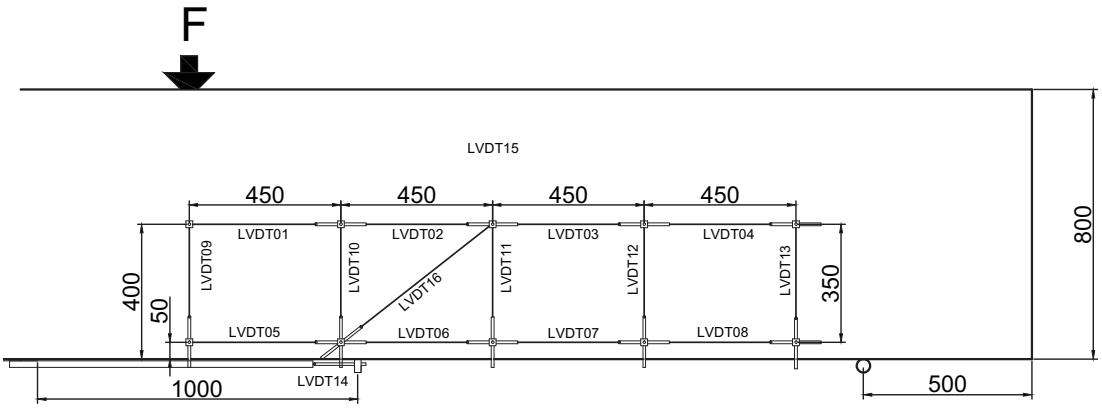


Fig. 5.85.3. LVDT layout and numbering for 800 mm deep beams

5.85.2. Measurement results

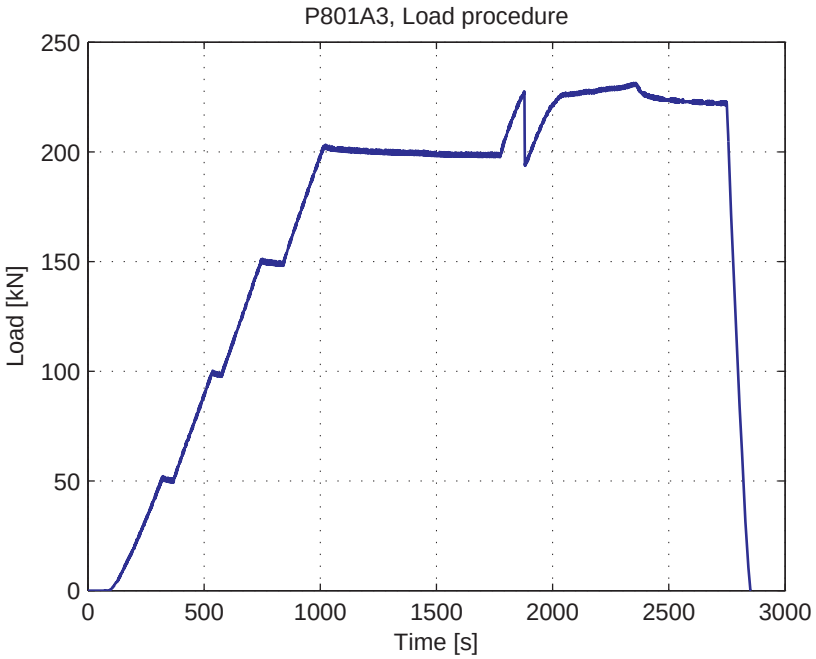


Fig. 5.85.4. Load-Time curve

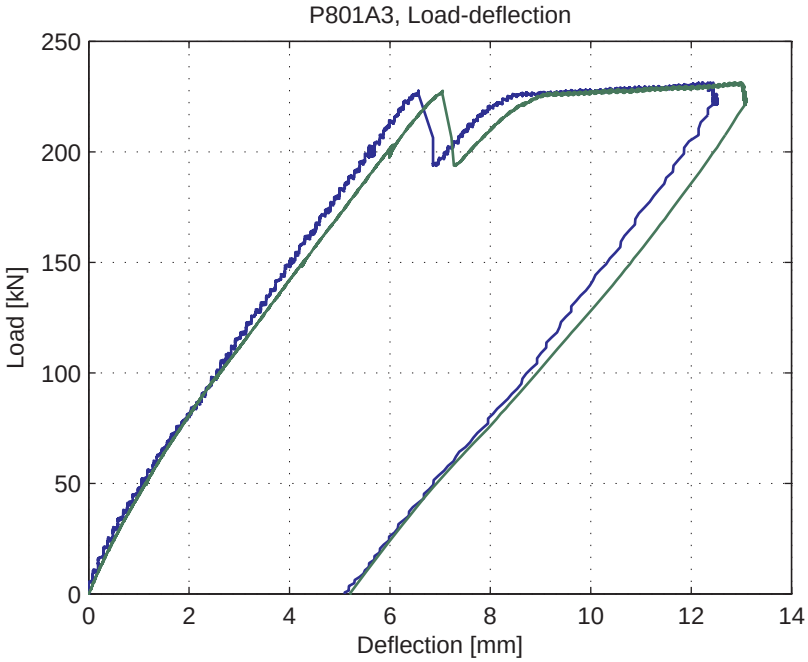


Fig. 5.85.5. Load-deflection curve

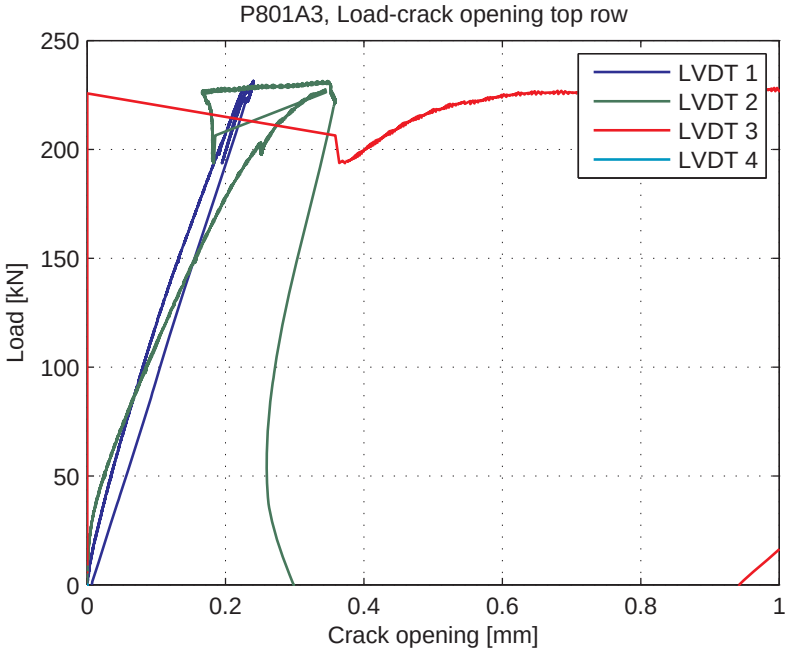


Fig. 5.85.6. Load-Crack opening for LVDT's 1-4 (top row)

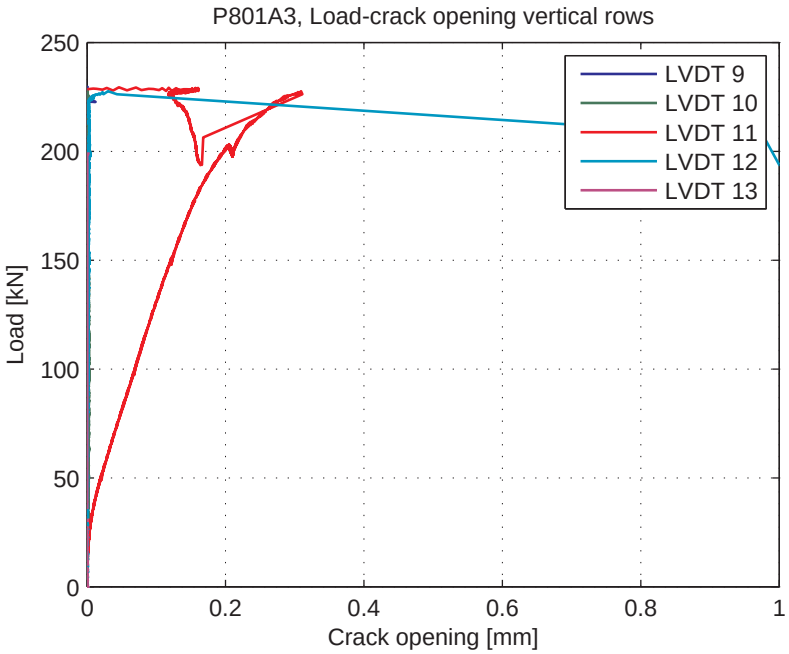


Fig. 5.85.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

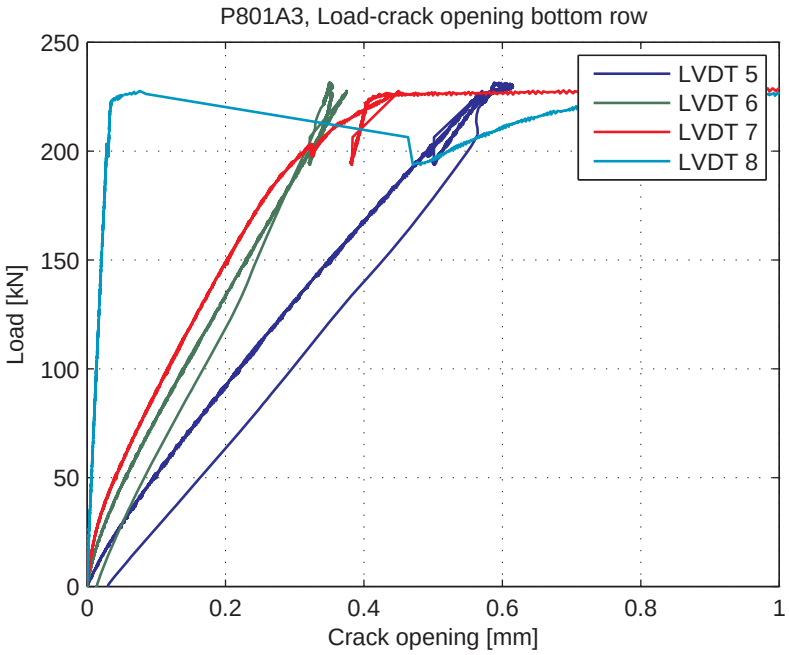


Fig. 5.85.8. Load-Crack opening for LVDT's 5-8 (bottom row)

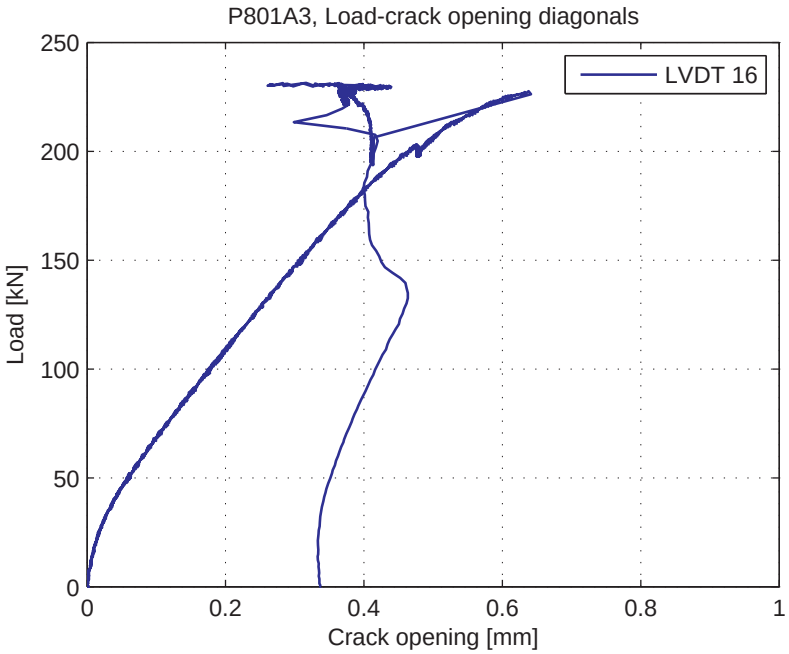


Fig. 5.85.9. Load-Crack opening for LVDT 16 (diagonal)

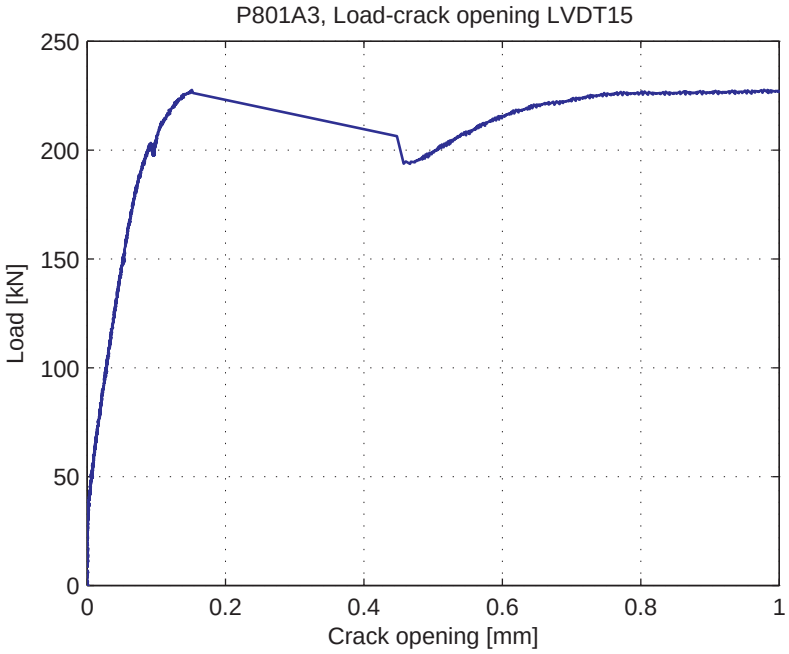


Fig. 5.85.10. Load-Crack opening for LVDT 15

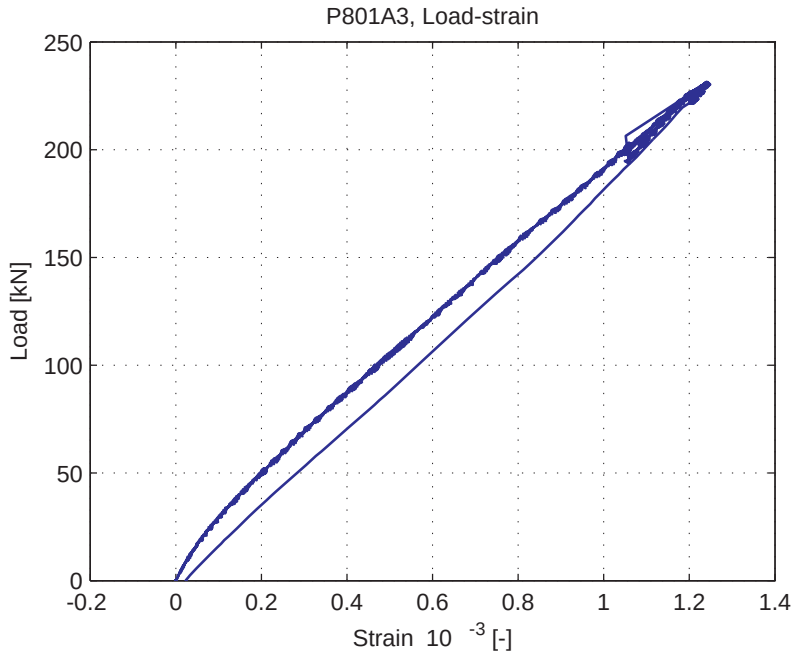


Fig. 5.85.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.86. P801B1

5.86.1. Test properties

Fig. 5.86.1. Crack pattern after failure north side

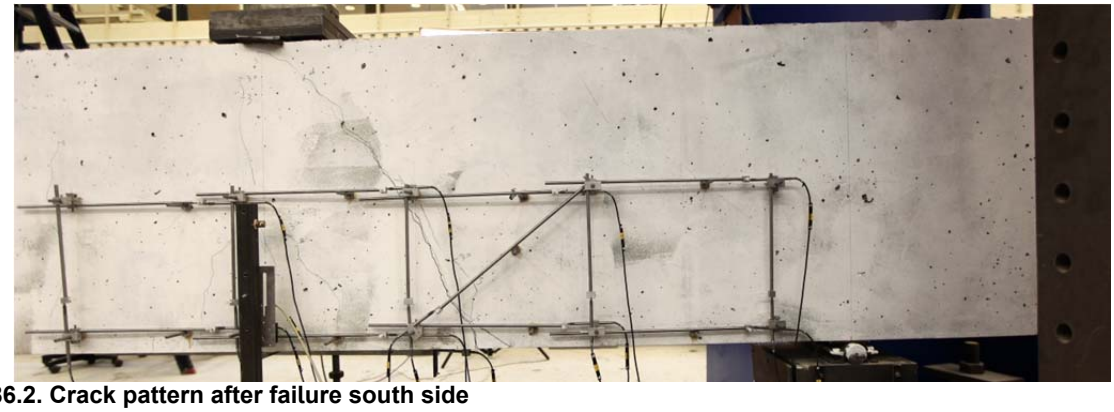


Fig. 5.86.2. Crack pattern after failure south side

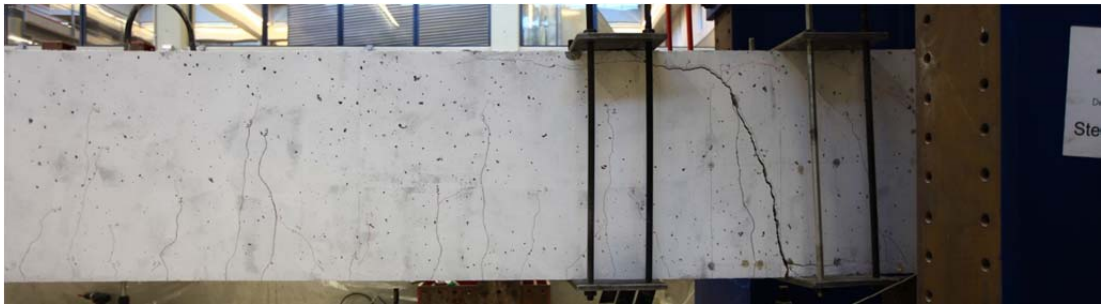


Fig. 5.86.3. Shear failure at A-side

Table 5.86.1. Beam properties

Date of test	08-01-2016
Reinforcement	3Ø25 plain
Reinforcement ratio	0.64%
a	1500 mm
a / *d*	1.97
Concrete cube strength at testing	87.2 MPa
Peak load	231.0 kN
Failure mode	Flexural failure

Table 5.86.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	100	
3	150	
4	180	Shear crack at A-side, stopped, zipping effect on A-side on top reinforcement. A-side clamped with 8 x M24
5	0	Restart
6	100	
7	150	
8	200	
9	231.4	Yielding, stopped after jack displacement of 15.7 mm

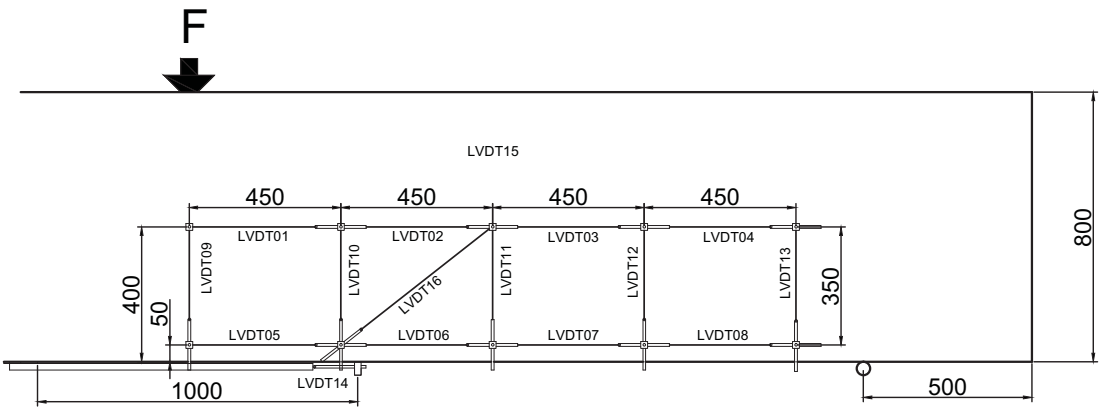


Fig. 5.86.4. LVDT layout and numbering for 800 mm deep beams

5.86.2. Measurement results

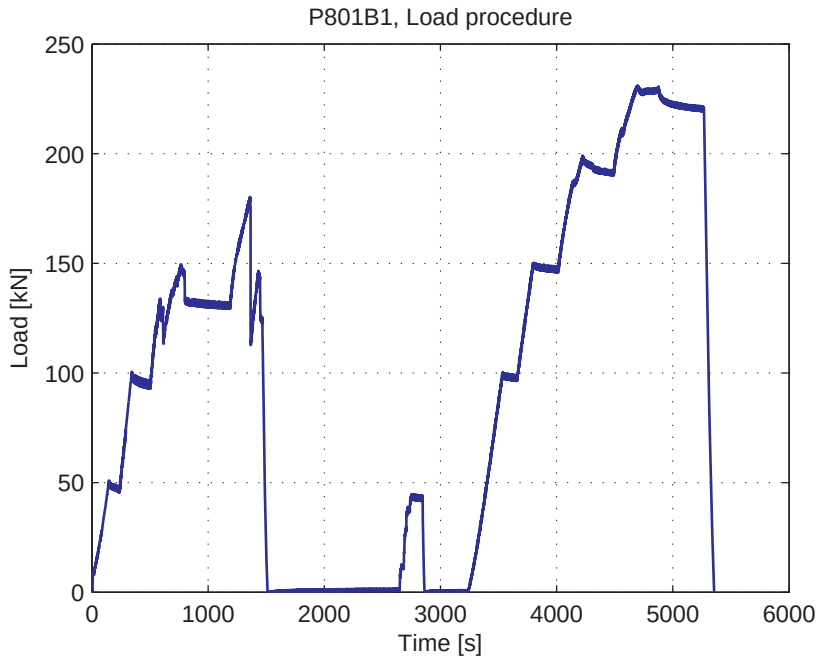


Fig. 5.86.5. Load-Time curve

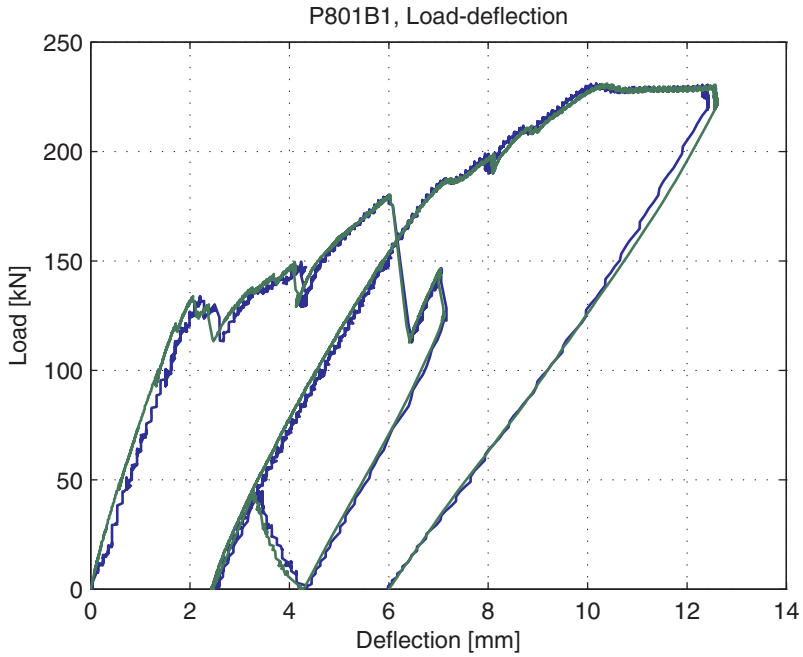


Fig. 5.86.6. Load-deflection curve

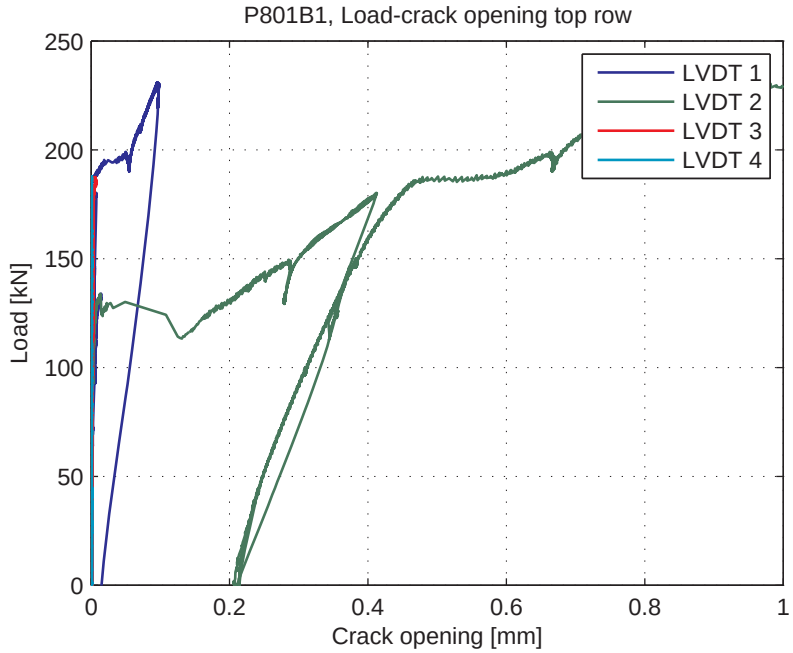


Fig. 5.86.7. Load-Crack opening for LVDT's 1-4 (top row)

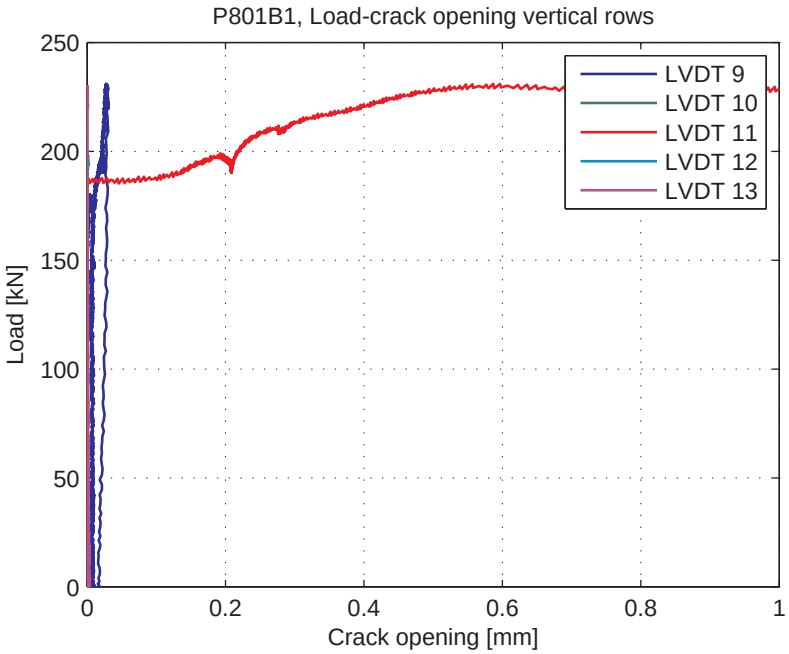


Fig. 5.86.8. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

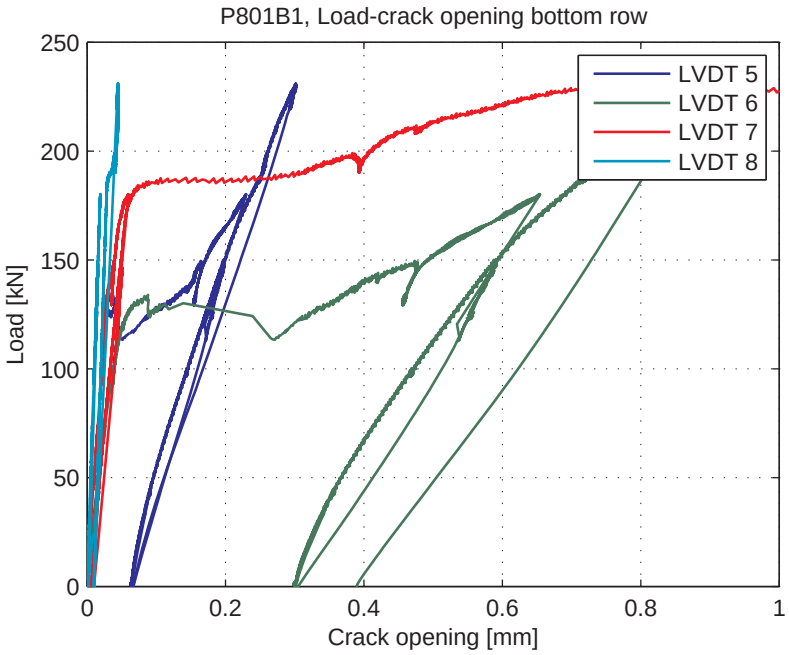


Fig. 5.86.9. Load-Crack opening for LVDT's 5-8 (bottom row)

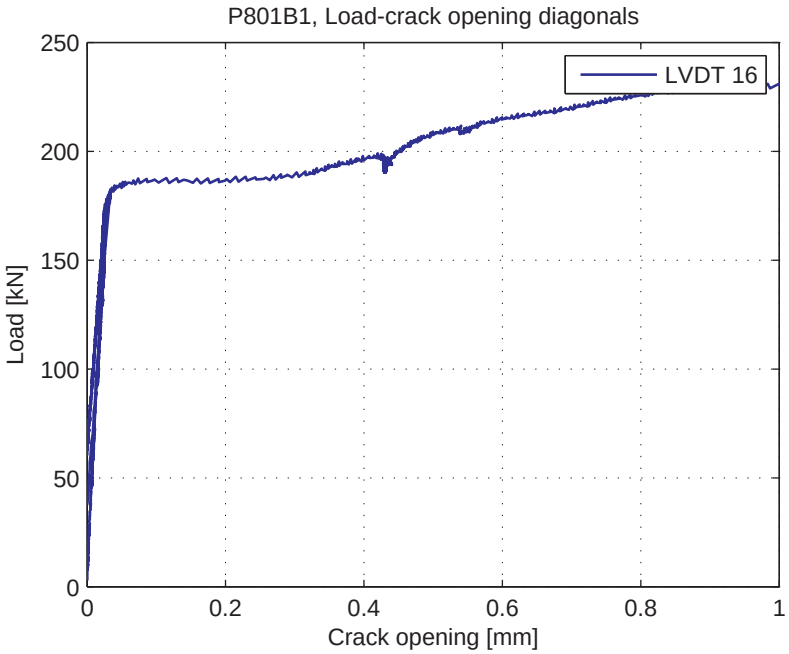


Fig. 5.86.10. Load-Crack opening for LVDT 16 (diagonal)

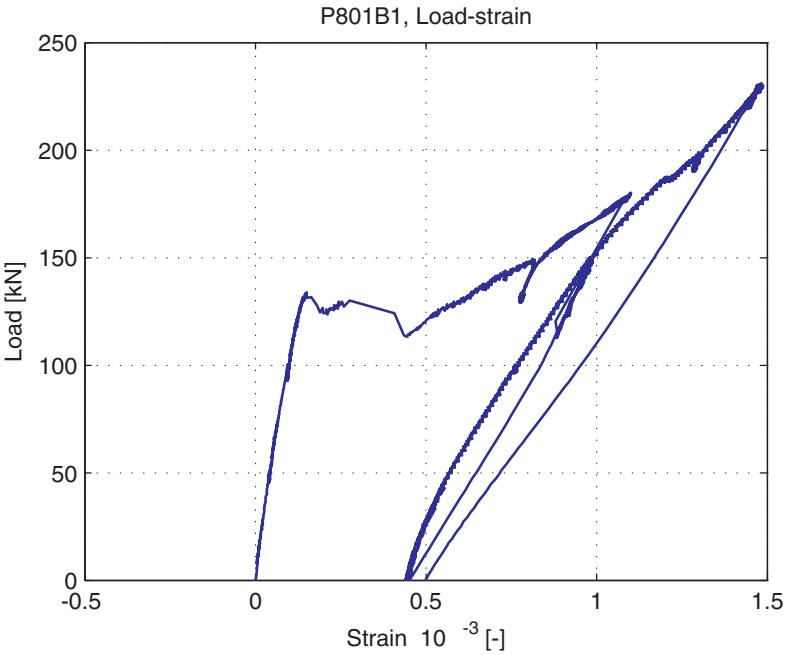


Fig. 5.86.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.87. P802A1

5.87.1. Test properties

Fig. 5.87.1. Crack pattern after failure at north side of beam

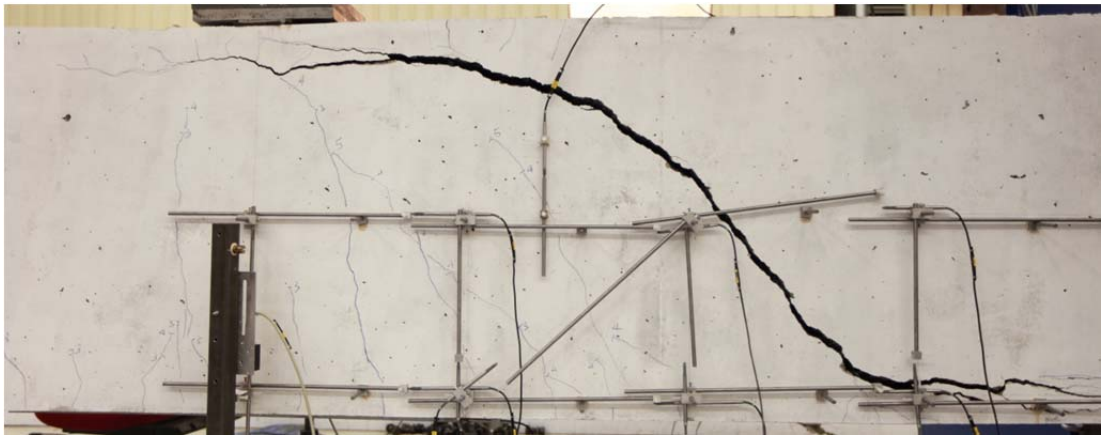


Fig. 5.87.2. Crack pattern after failure and LVDT layout at south side of beam

Table 5.87.1. Beam properties

Date of test	02-12-2015
Reinforcement	6Ø20 plain
Reinforcement ratio	0.83%
a	2000 mm
a / *d*	2.65
Concrete cube strength at testing	75.8 MPa
Peak load	249.0 kN
Failure mode	Shear

Table 5.87.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Test with photogrammetry, black paint added with spray paint.
1	50	
2	100	
3	150	
4	200	Added LVDT 15, LVDT 16 in 2nd grid. Return to 0 kN
5	0	
6	249.0	Shear failure

Table 5.87.3. Location LVDT's used for crack opening measurements

LVDT	Distance from support [mm]	Distance from bottom beam [mm]
15	1390	415

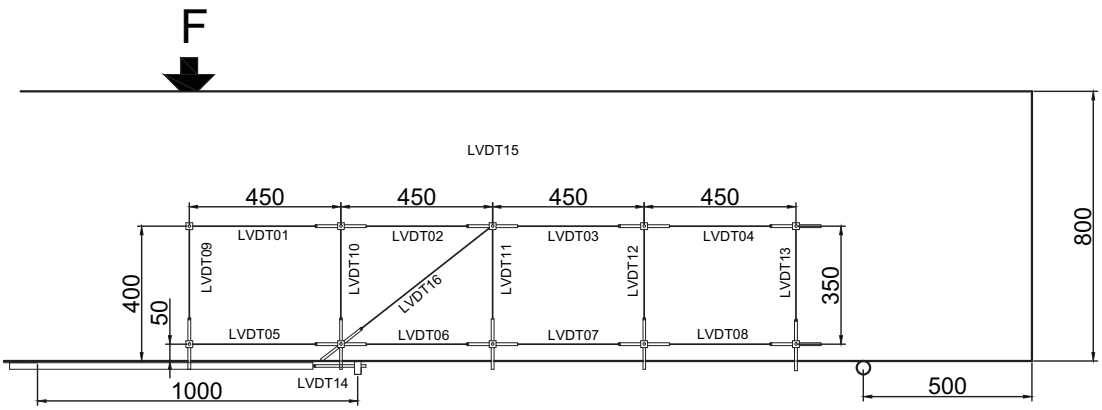


Fig. 5.87.3. LVDT layout and numbering for 800 mm deep beams

5.87.2. Measurement results

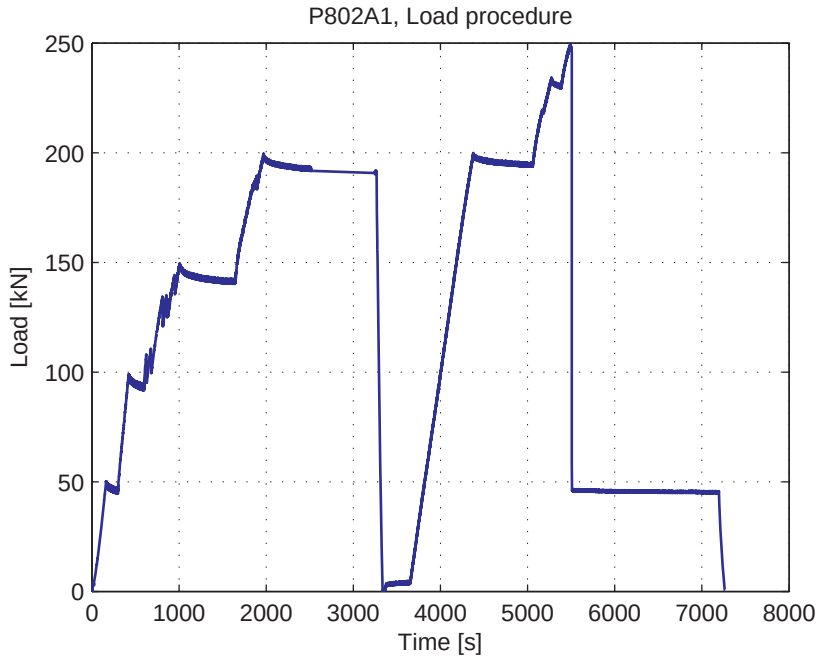


Fig. 5.87.4. Load-Time curve

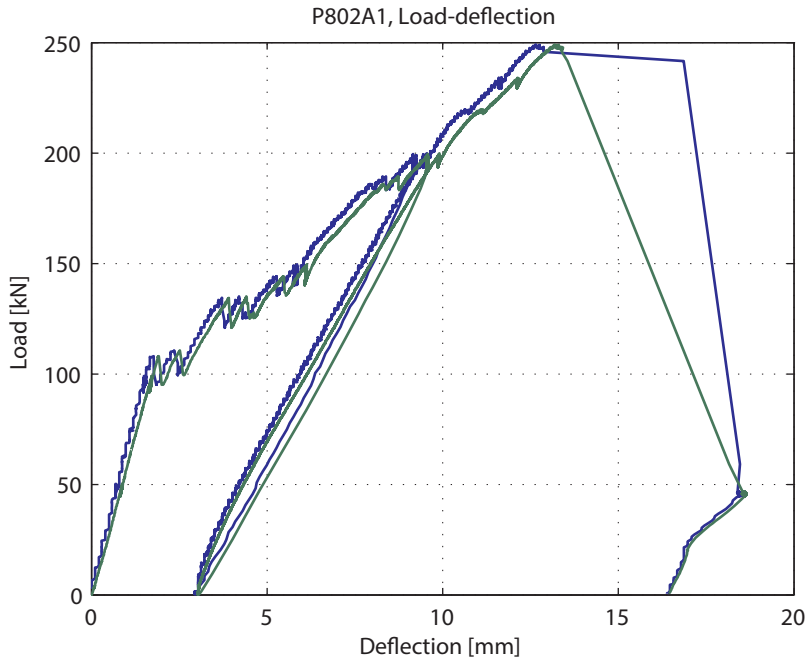


Fig. 5.87.5. Load-deflection curve

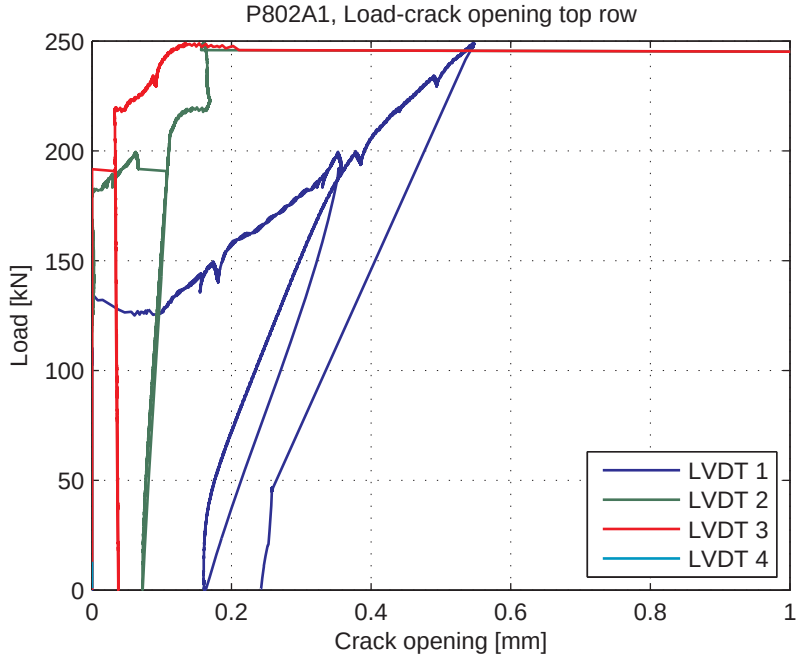


Fig. 5.87.6. Load-Crack opening for LVDT's 1-4 (top row)

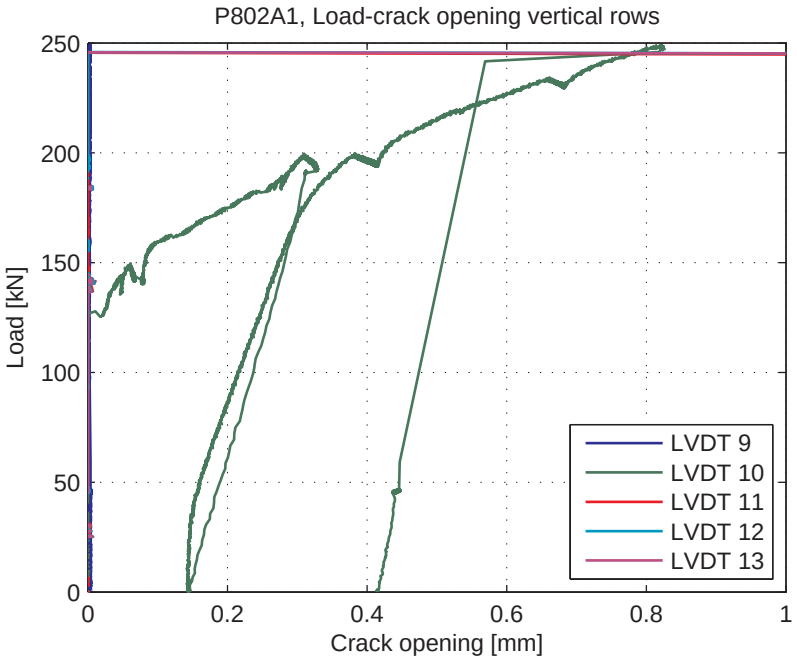


Fig. 5.87.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

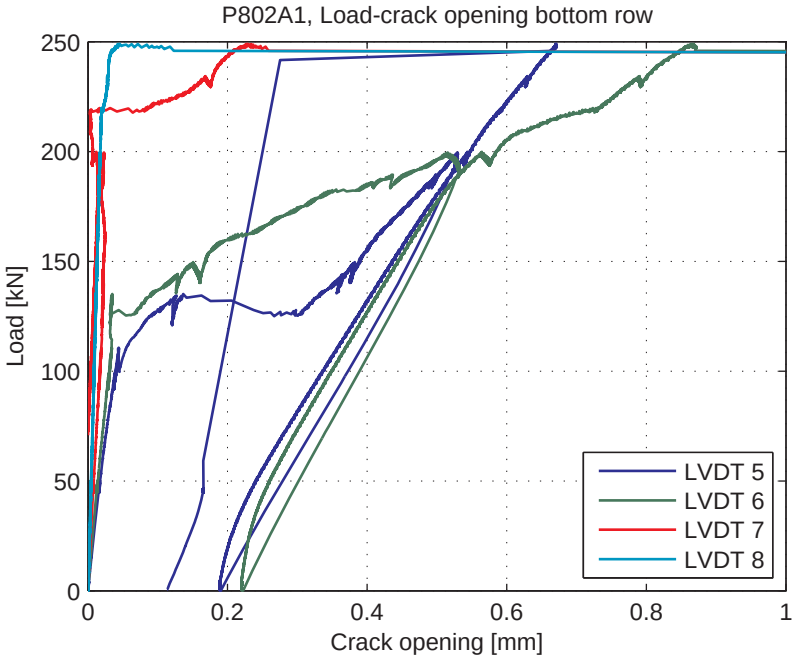


Fig. 5.87.8. Load-Crack opening for LVDT's 5-8 (bottom row)

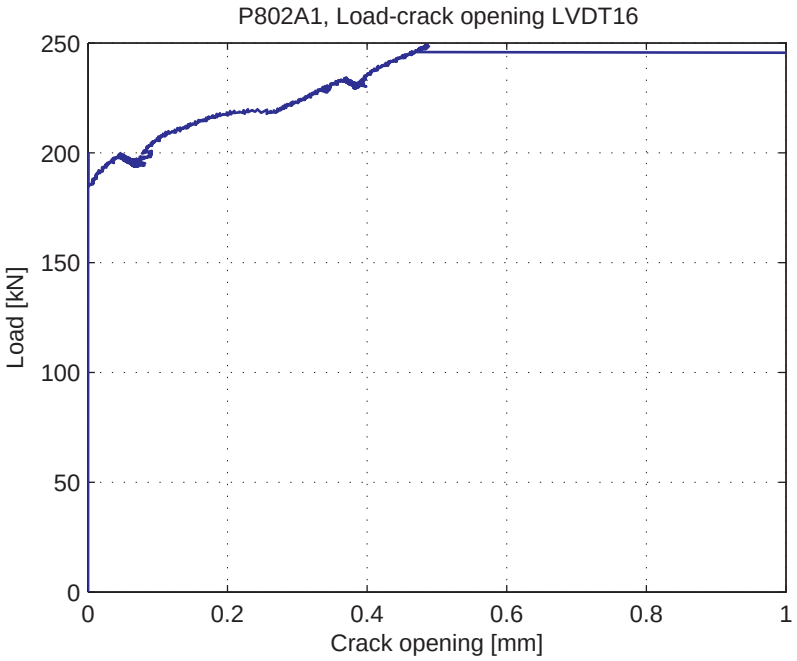


Fig. 5.87.9. Load-Crack opening for LVDT16 (diagonal)

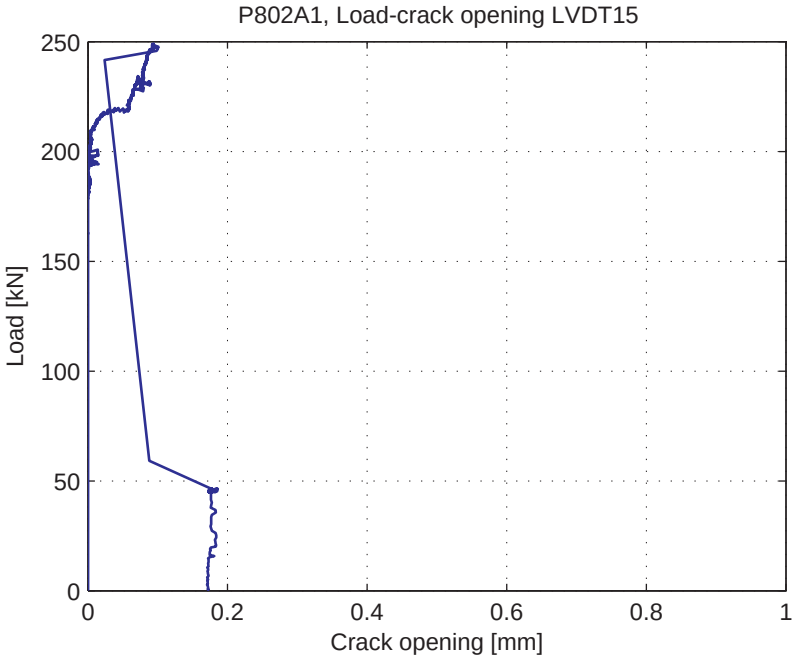


Fig. 5.87.10. Load-Crack opening for LVDT15

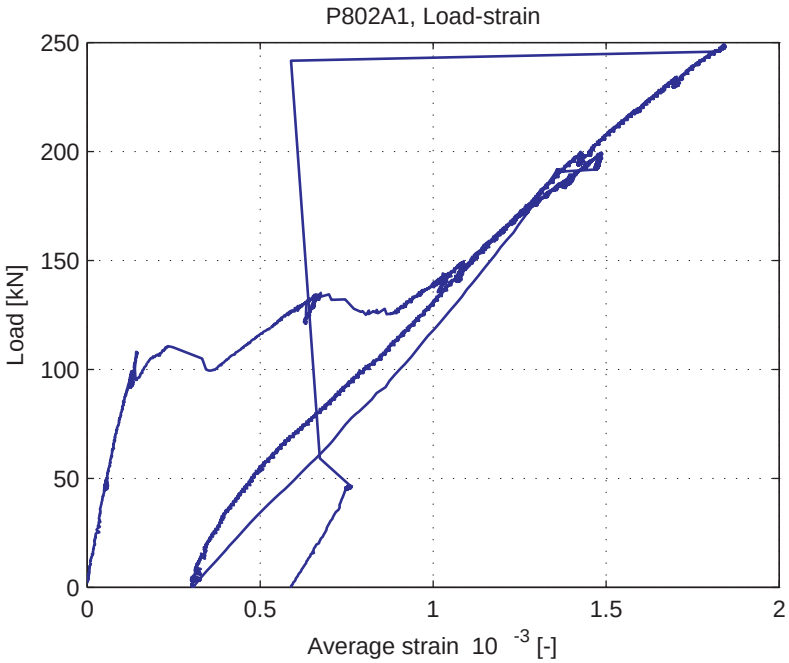


Fig. 5.87.11. Average strain over 1m length, measured at bottom of beam (LVDT 14)

5.88. P802B1

5.88.1. Test properties

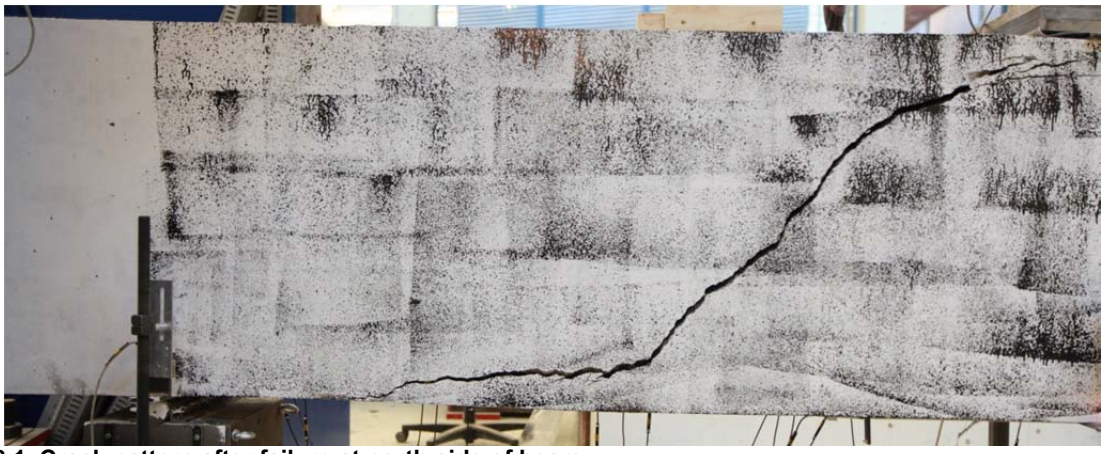


Fig. 5.88.1. Crack pattern after failure at north side of beam

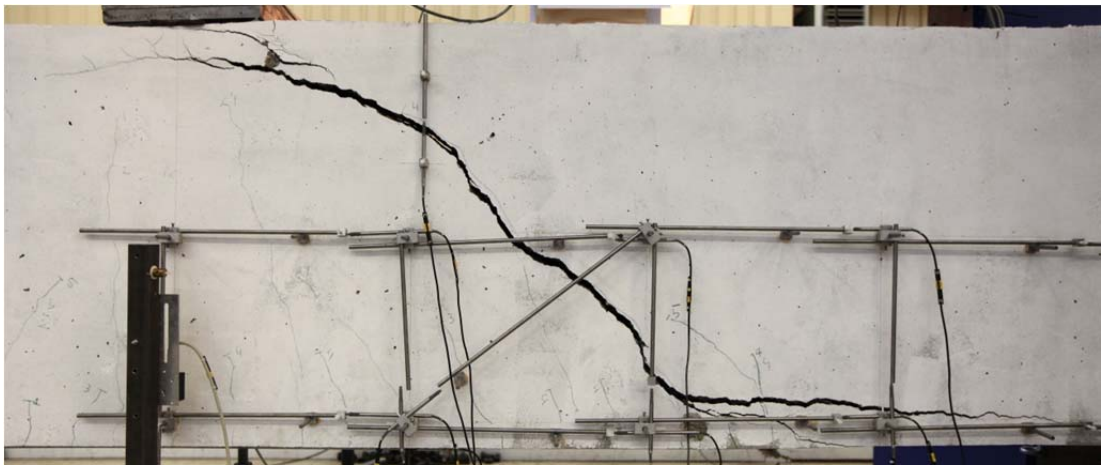


Fig. 5.88.2. Crack pattern after failure and LVDT layout at south side of beam

Table 5.88.1. Beam properties

Date of test	04-12-2015
Reinforcement	6Ø20 plain
Reinforcement ratio	0.83%
a	2000 mm
a / *d*	2.65
Concrete cube strength at testing	75.8 MPa
Peak load	208.1 kN
Failure mode	Shear

Table 5.88.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	LVDT 16 under 45º in second raster. Test with photogrammetry, black paint added with roller
1	50	
2	100	
3	150	
4	200	Added LVDT 15
5	208.1	Shear failure

Table 5.88.3. Location LVDT's used for crack opening measurements

LVDT	Distance from support [mm]	Distance from bottom beam [mm]
15	1530	550

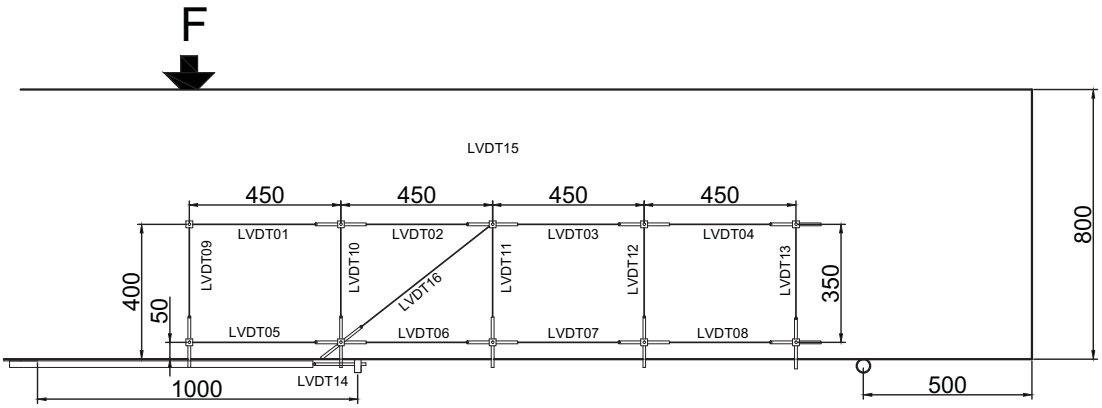


Fig. 5.88.3. LVDT layout and numbering for 800 mm deep beams

5.88.2. Measurement results

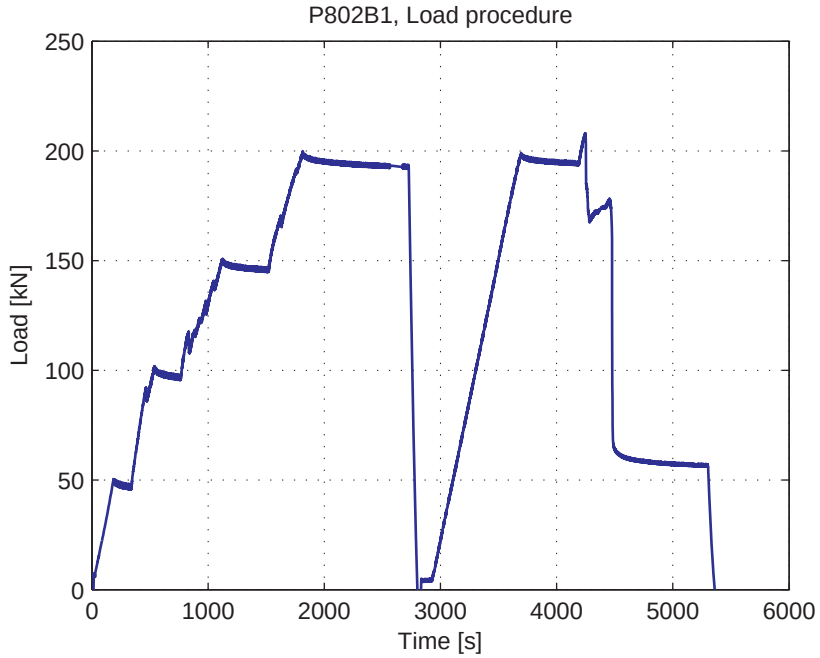


Fig. 5.88.4. Load-Time curve

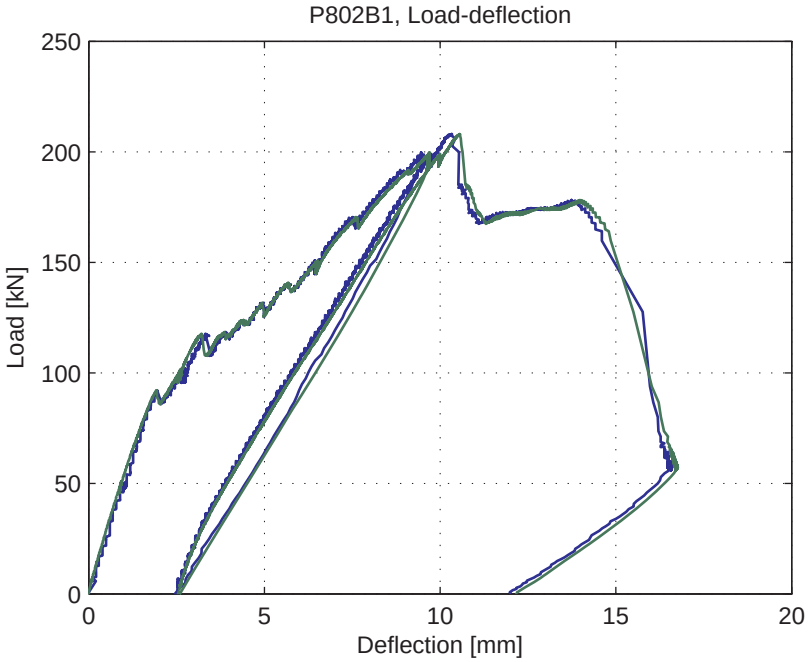


Fig. 5.88.5. Load-deflection curve

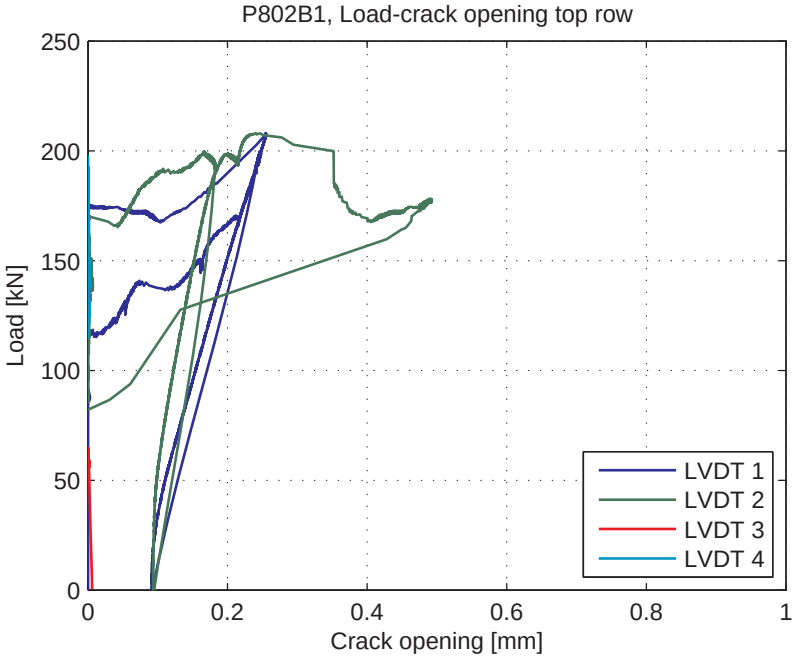


Fig. 5.88.6. Load-Crack opening for LVDT's 1-4 (top row)

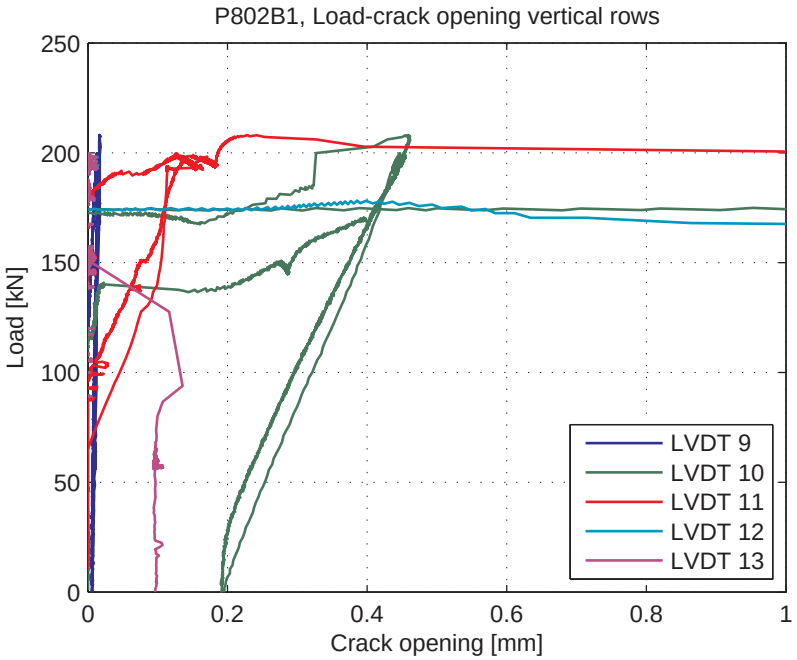


Fig. 5.88.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

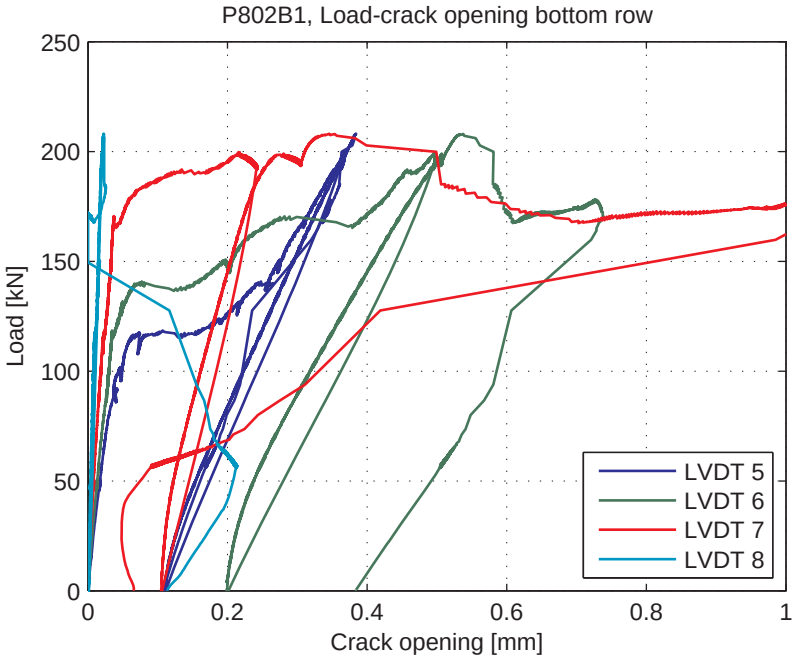


Fig. 5.88.8. Load-Crack opening for LVDT's 5-8 (bottom row)

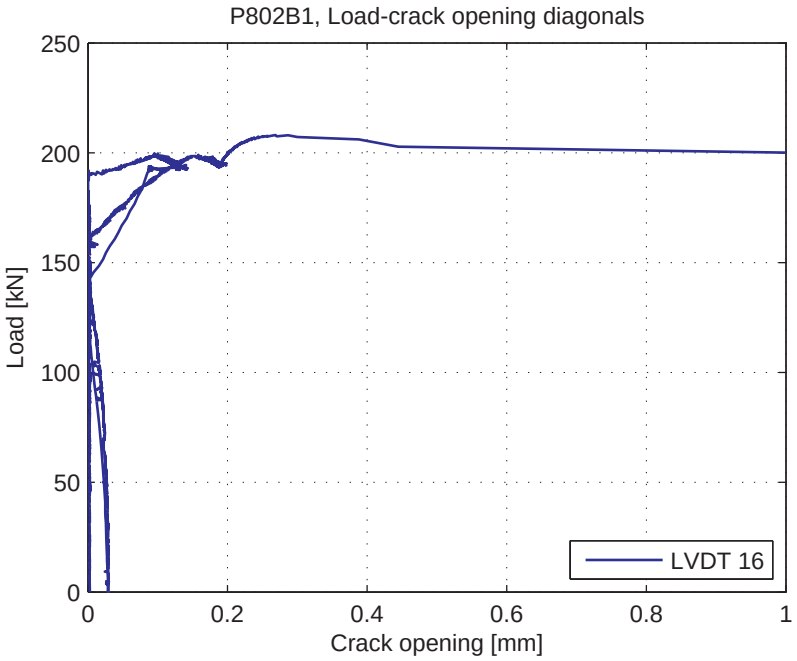


Fig. 5.88.9. Load-Crack opening for LVDT 16 (diagonal)

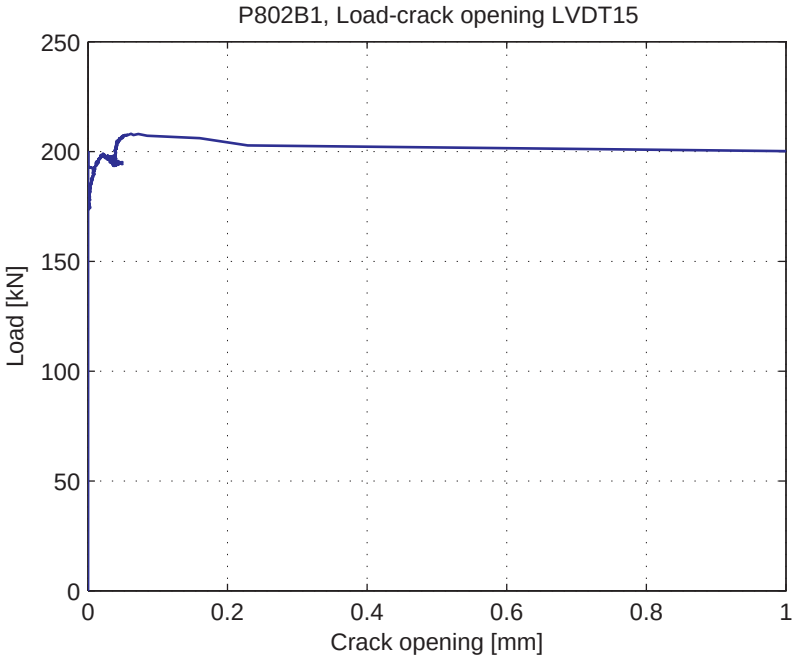


Fig. 5.88.10. Load-Crack opening for LVDT15

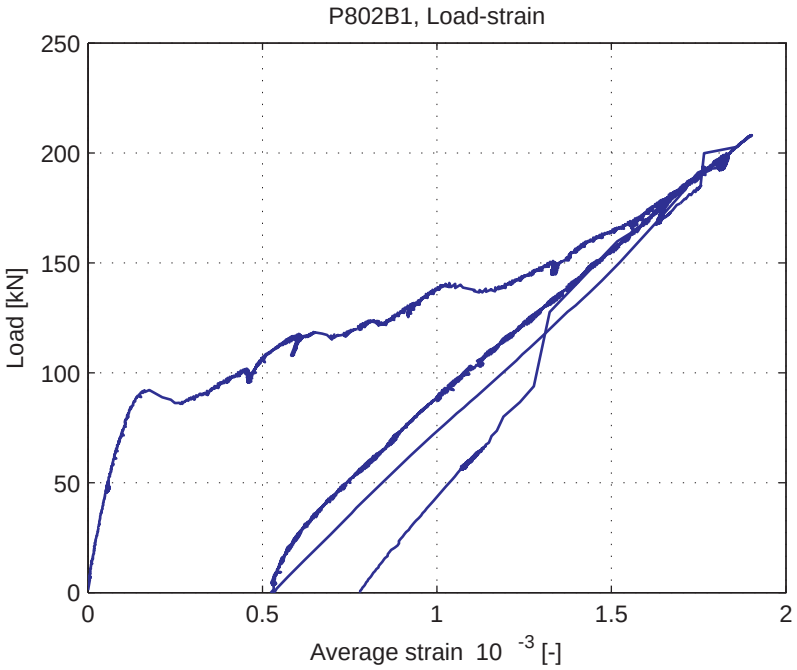


Fig. 5.88.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.89. P803A1

5.89.1. Test properties

Fig. 5.89.1. Crack pattern after failure north side

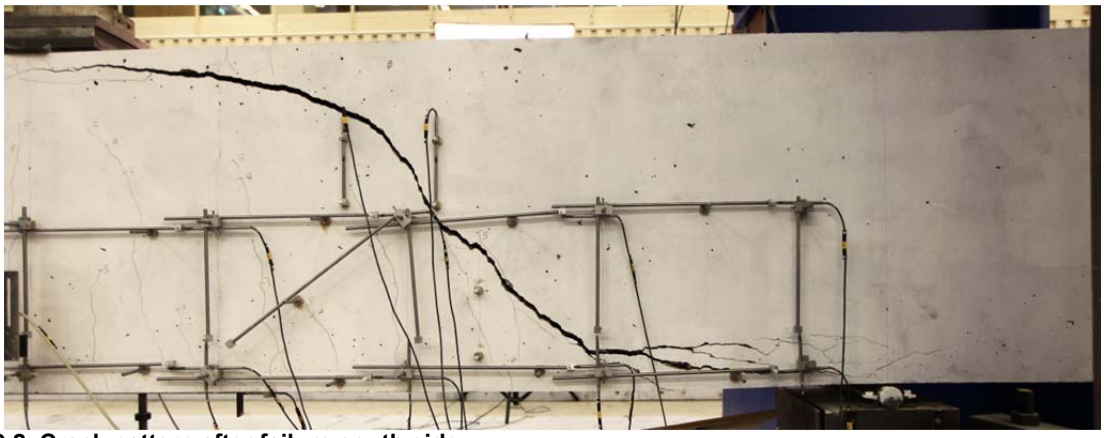


Fig. 5.89.2. Crack pattern after failure south side

Table 5.89.1. Beam properties

Date of test	12-01-2016
Reinforcement	4Ø25 + 2Ø20 plain
Reinforcement ratio	1.14%
a	2000 mm
a / *d*	2.65
Concrete cube strength at testing	75.8 MPa
Peak load	290.4 kN
Failure mode	Shear

Table 5.89.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	100	
3	150	
4	200	LVDT 16 removed from grid, to crack. Two LVDT's are installed: LVDT 15 and 16
5	250	Replaced LVDT 15
6	290.4	Shear failure

Table 5.89.3. Location LVDT's used for crack opening measurements

LVDT	Distance from support [mm]	Distance from bottom beam [mm]
15	1020	410
16	1240	80

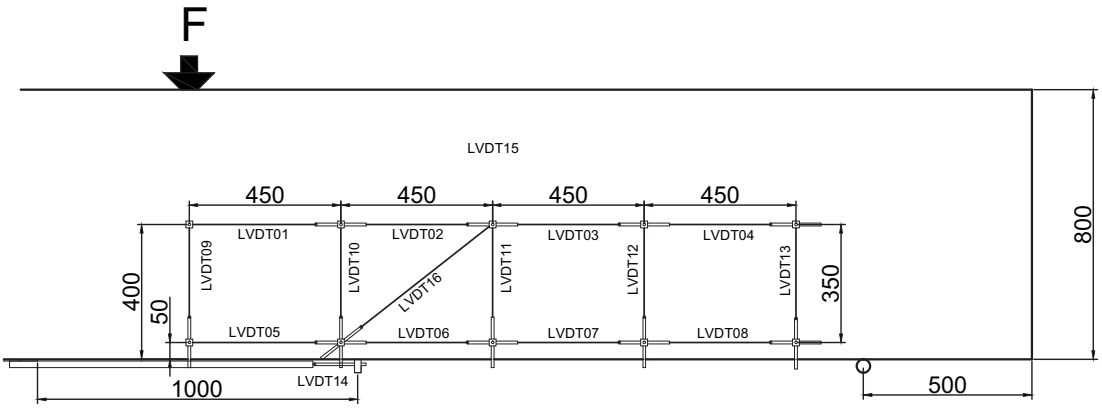


Fig. 5.89.3. LVDT layout and numbering for 800 mm deep beams

5.89.2. Measurement results

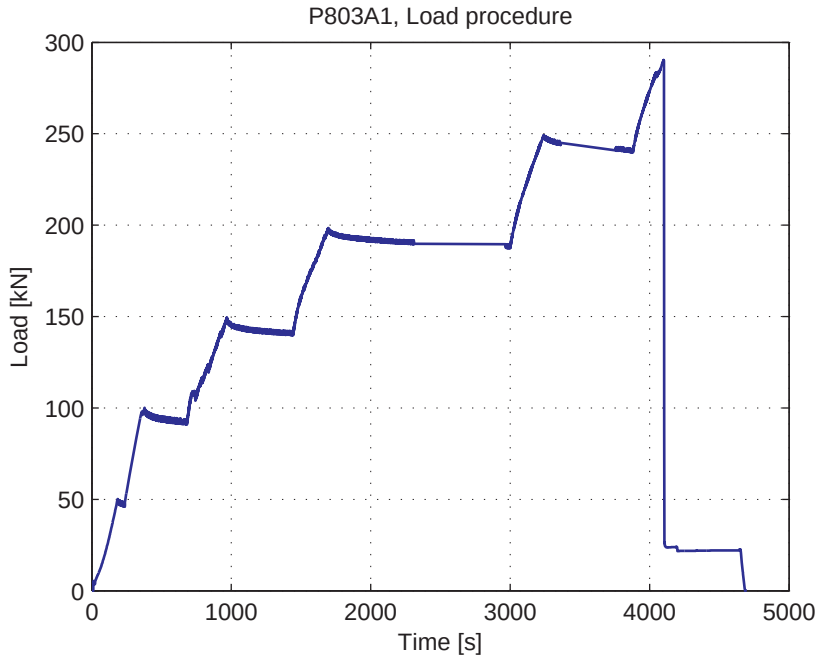


Fig. 5.89.4. Load-Time curve

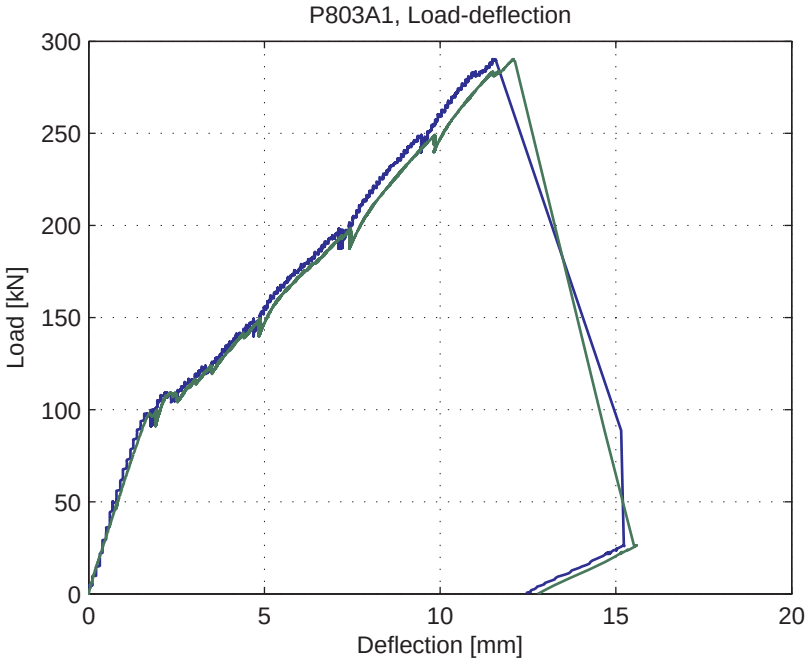


Fig. 5.89.5. Load-deflection curve

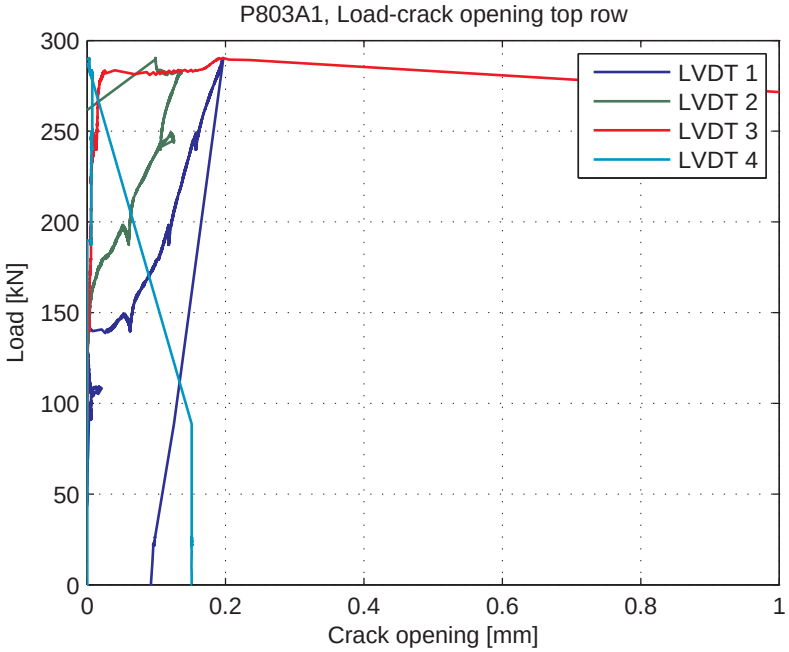


Fig. 5.89.6. Load-Crack opening for LVDT's 1-4 (top row)

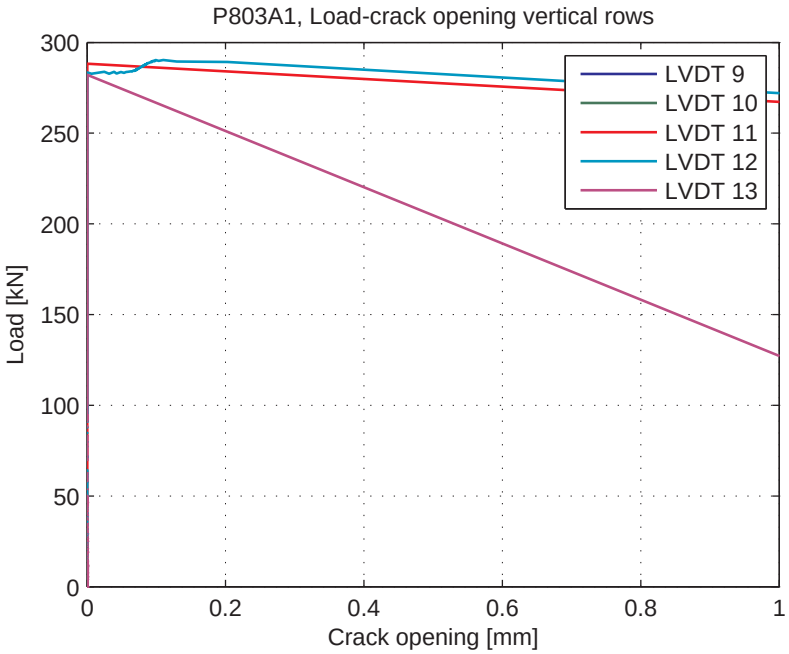


Fig. 5.89.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

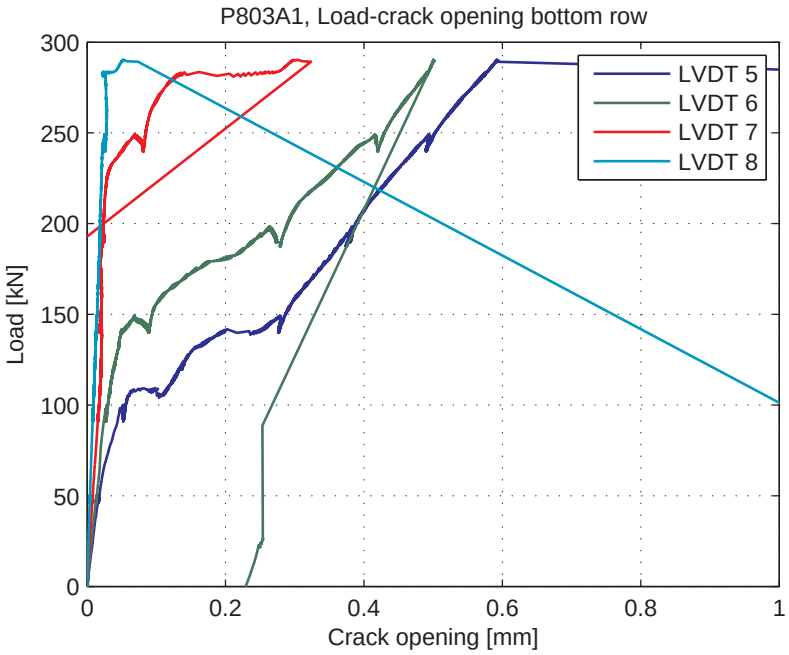


Fig. 5.89.8. Load-Crack opening for LVDT's 5-8 (bottom row)

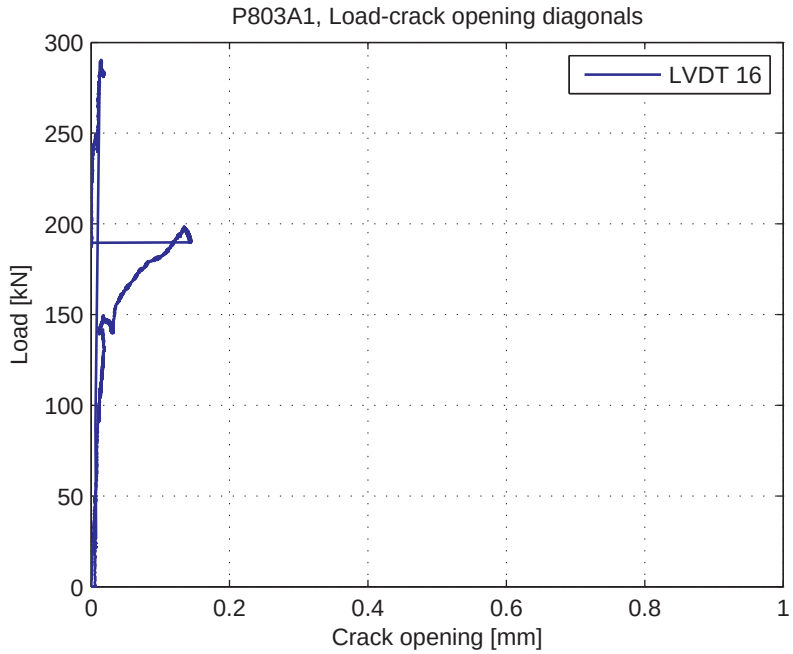


Fig. 5.89.9. Load-Crack opening for LVDT 16 (diagonal)

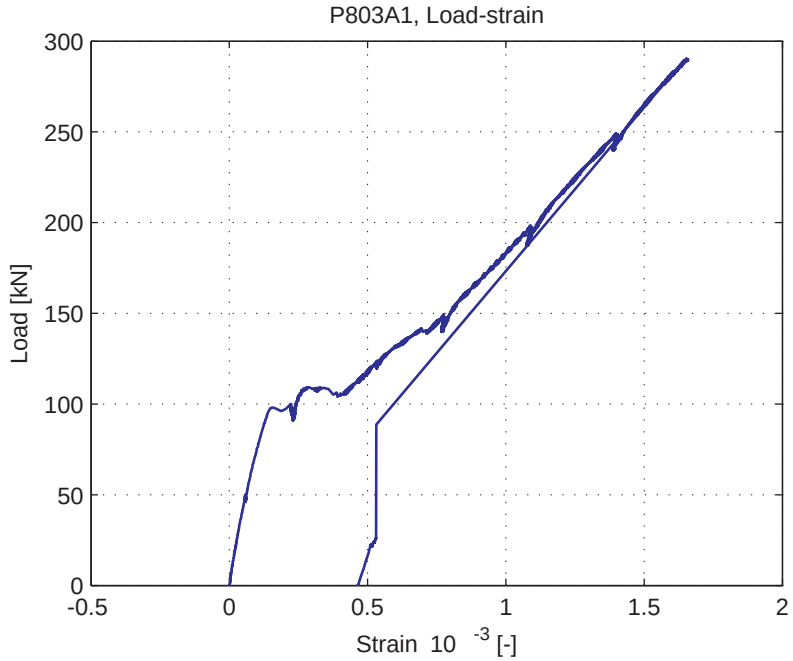


Fig. 5.89.10. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.90. P803B1

5.90.1. Test properties

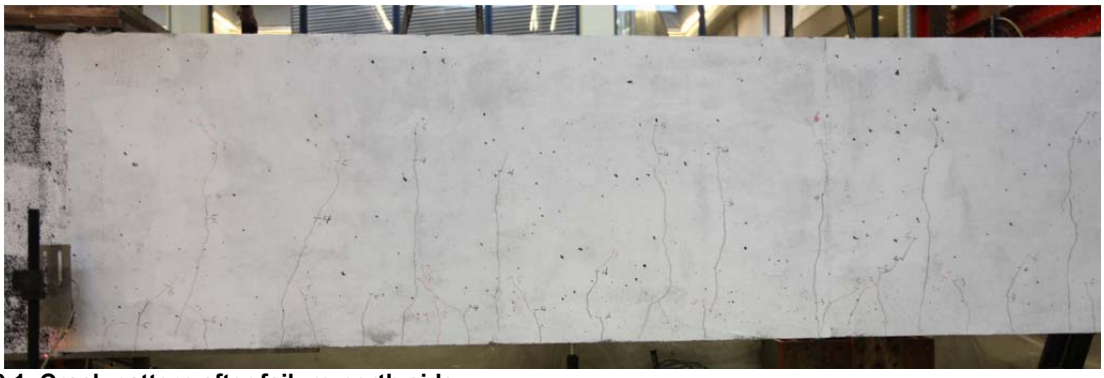


Fig. 5.90.1. Crack pattern after failure north side

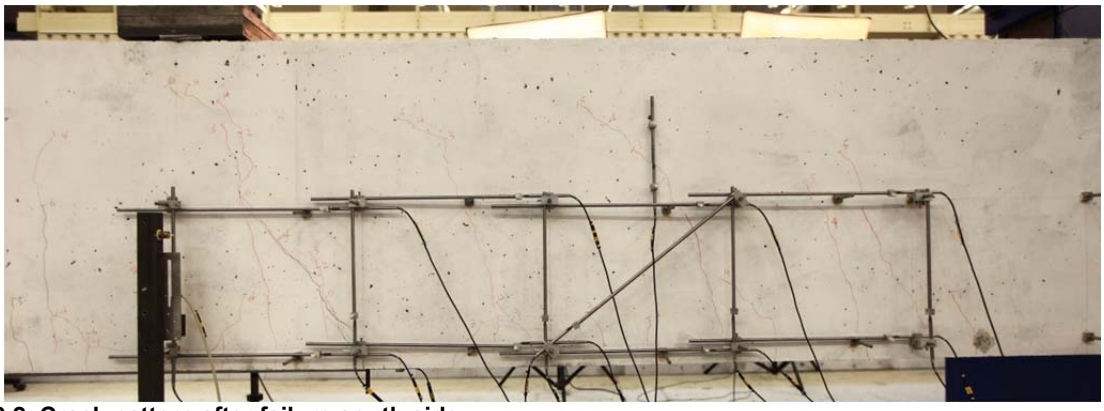


Fig. 5.90.2. Crack pattern after failure south side

Table 5.90.1. Beam properties

Date of test	15-01-2016
Reinforcement	4Ø25 + 2Ø20 plain
Reinforcement ratio	1.14%
a	3000 mm
a / *d*	3.97
Concrete cube strength at testing	75.8 MPa
Peak load	269.0
Failure mode	Flexural failure

Table 5.90.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	100	
3	150	
4	200	Placed LVDT 15, missed a short piece of measurement
5	250	
6	269.0	Yielding, stopped after jack displacement of 22.55 mm

Table 5.90.3. Location LVDT's used for crack opening measurements

LVDT	Distance from support [mm]	Distance from bottom beam [mm]
15	1845	440

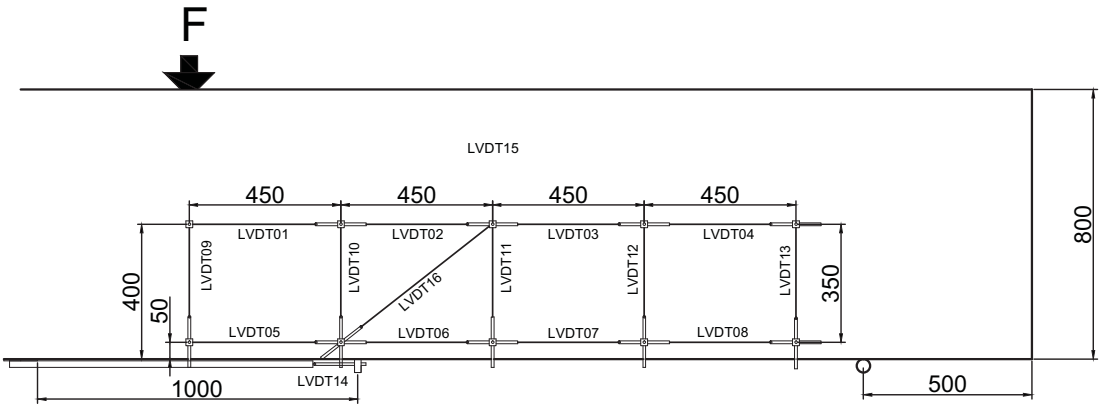


Fig. 5.90.3. LVDT layout and numbering for 800 mm deep beams

5.90.2. Measurement results

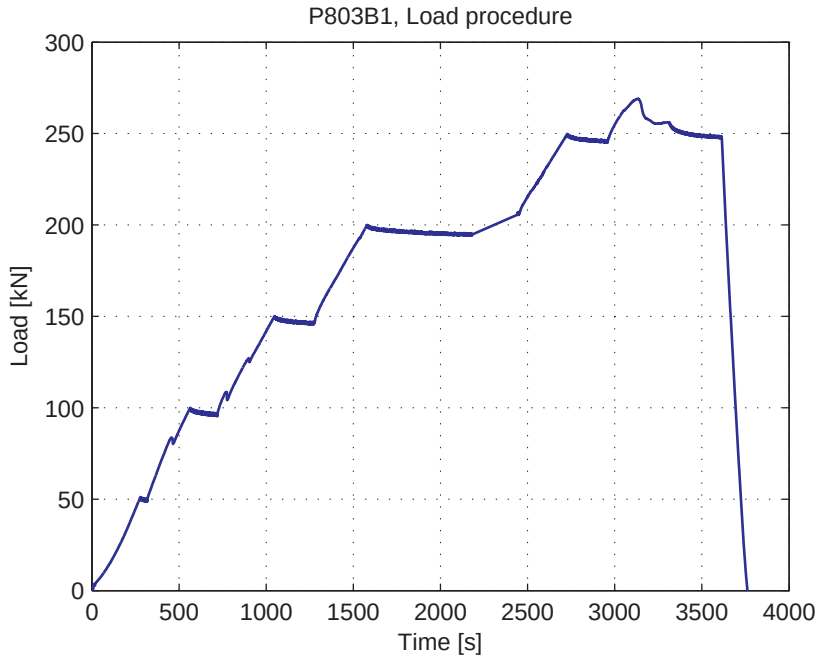


Fig. 5.90.4. Load-Time curve

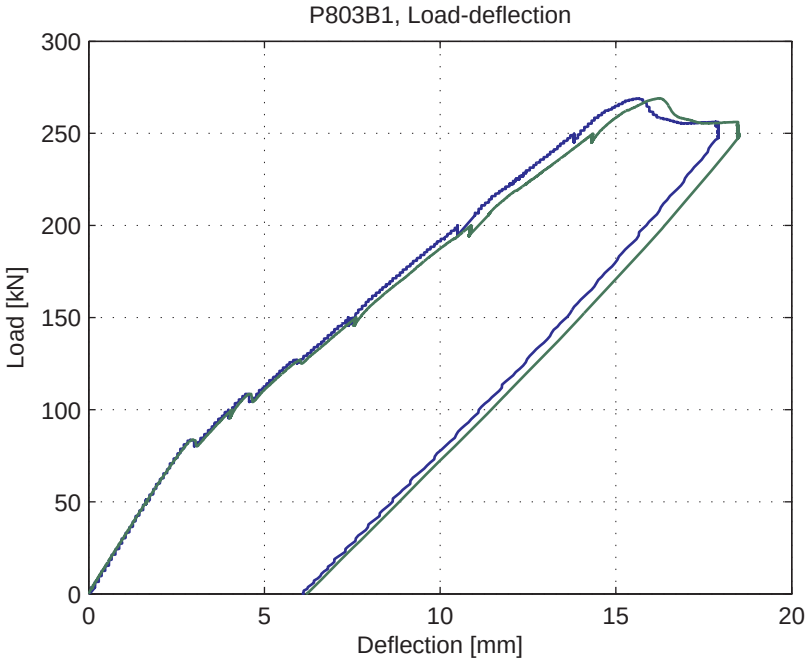


Fig. 5.90.5. Load-deflection curve

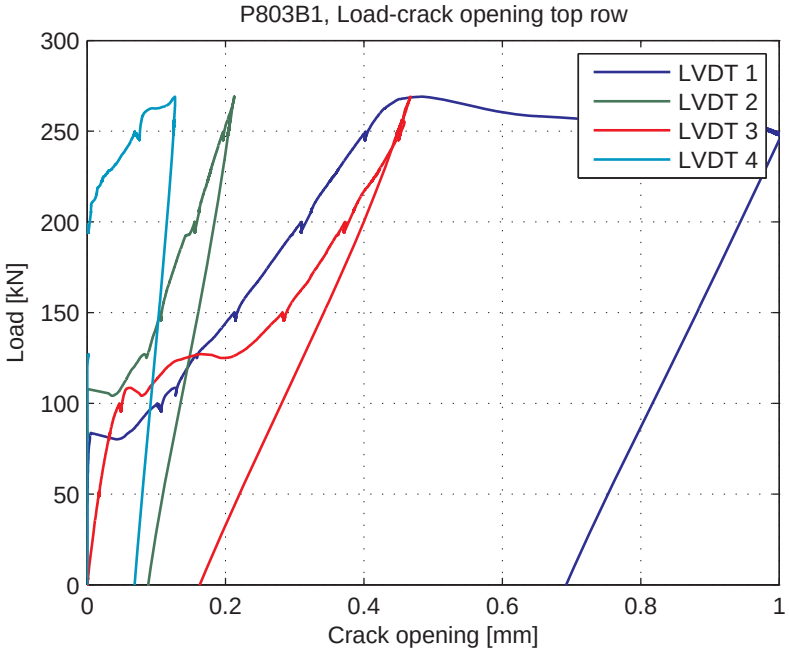


Fig. 5.90.6. Load-Crack opening for LVDT's 1-4 (top row)

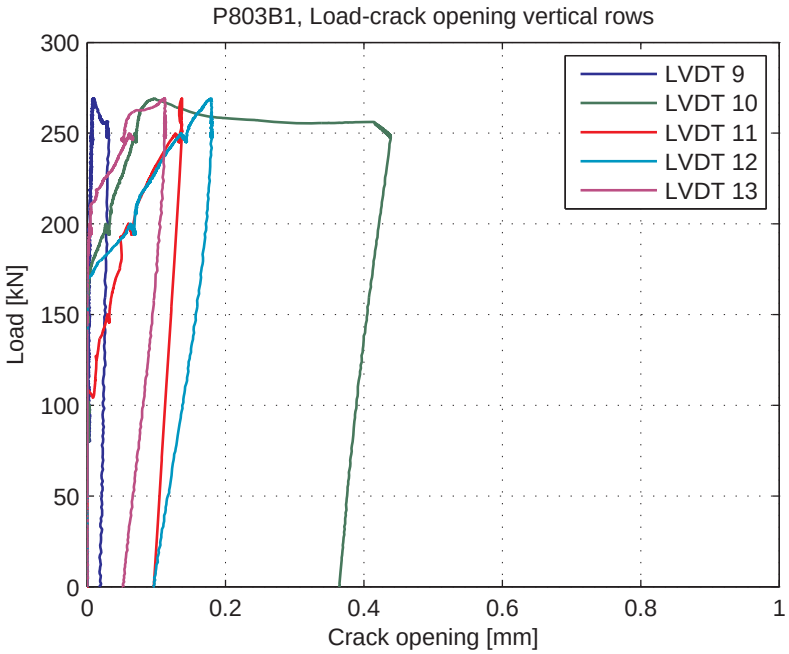


Fig. 5.90.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

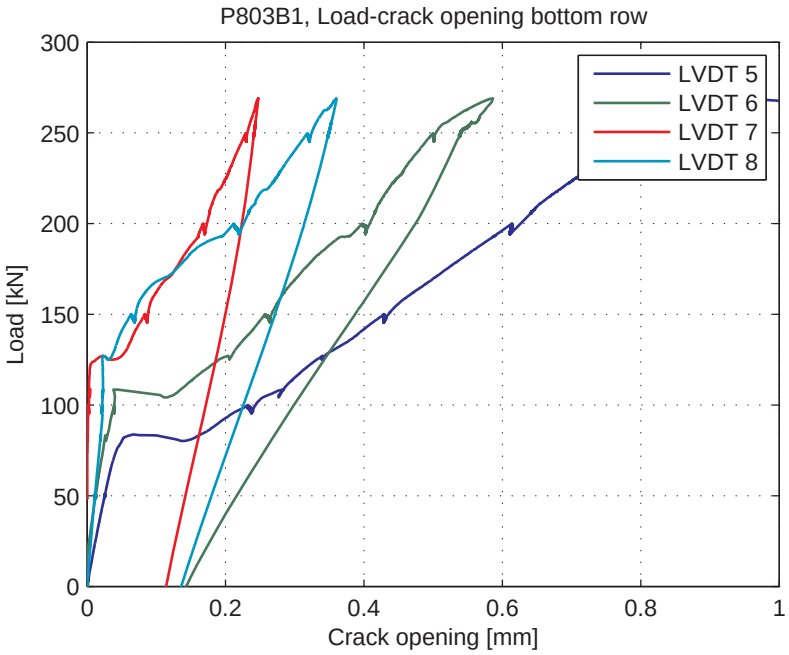


Fig. 5.90.8. Load-Crack opening for LVDT's 5-8 (bottom row)

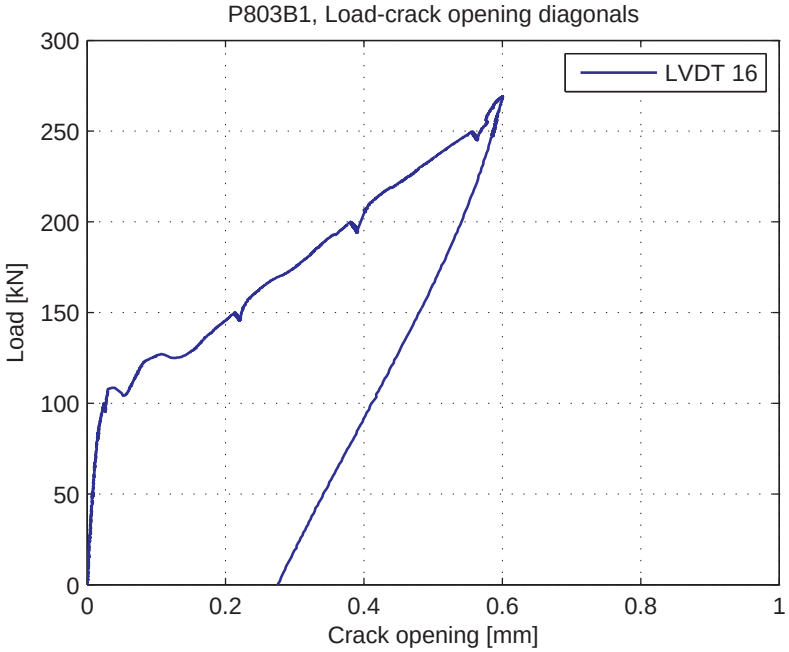


Fig. 5.90.9. Load-Crack opening for LVDT 16 (diagonal)

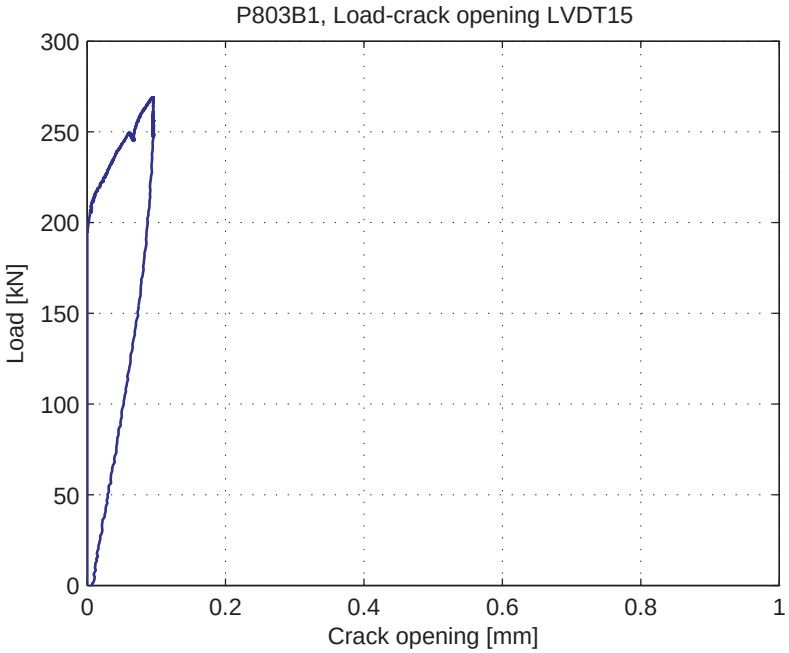


Fig. 5.90.10. Load-Crack opening for LVDT 15

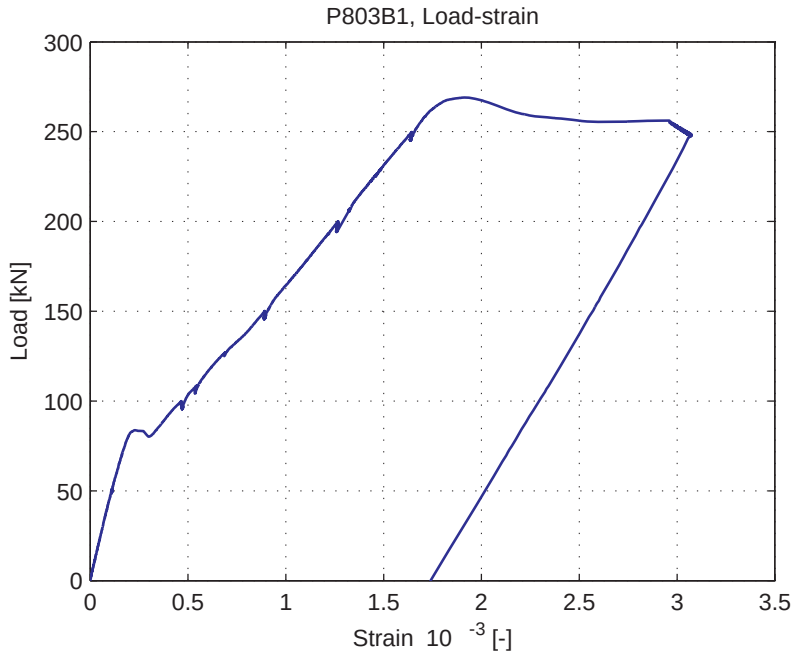


Fig. 5.90.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.91. P803B2

5.91.1. Test properties

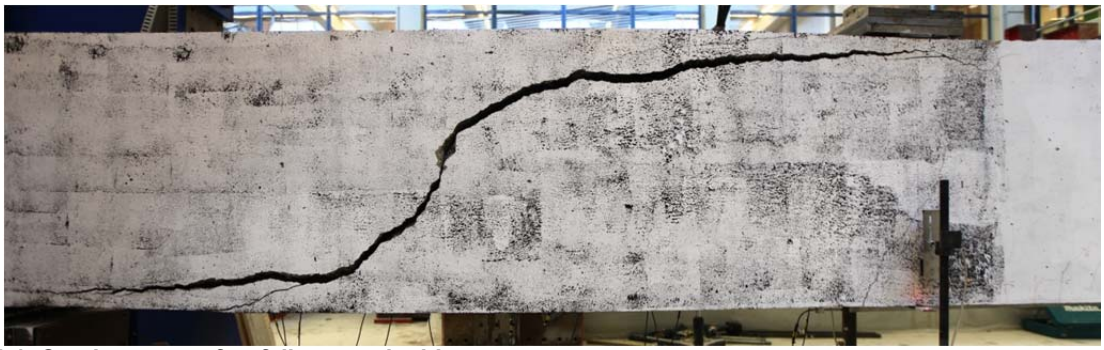


Fig. 5.91.1. Crack pattern after failure north side

Fig. 5.91.2. Crack pattern after failure south side

Table 5.91.1. Beam properties

Date of test	18-01-2016
Reinforcement	4Ø25 + 2Ø20 plain
Reinforcement ratio	1.14%
a	2750 mm
a / *d*	3.64
Concrete cube strength at testing	75.8 MPa
Peak load flexural / shear	277.9 kN / 274.6 kN
Failure mode	Flexural and shear

Table 5.91.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	LVDT's shifted 1 grid, LVDT 16 in second grid, LVDT 15 still in place
1	50	
2	100	
3	150	Added LVDT 16
4	200	
5	250	
6	277.9	Yielding at 277 kN, shear failure at 274 kN

Table 5.91.3. Location LVDT's used for crack opening measurements

LVDT	Distance from support [mm]	Distance from bottom beam [mm]
15	1845	440

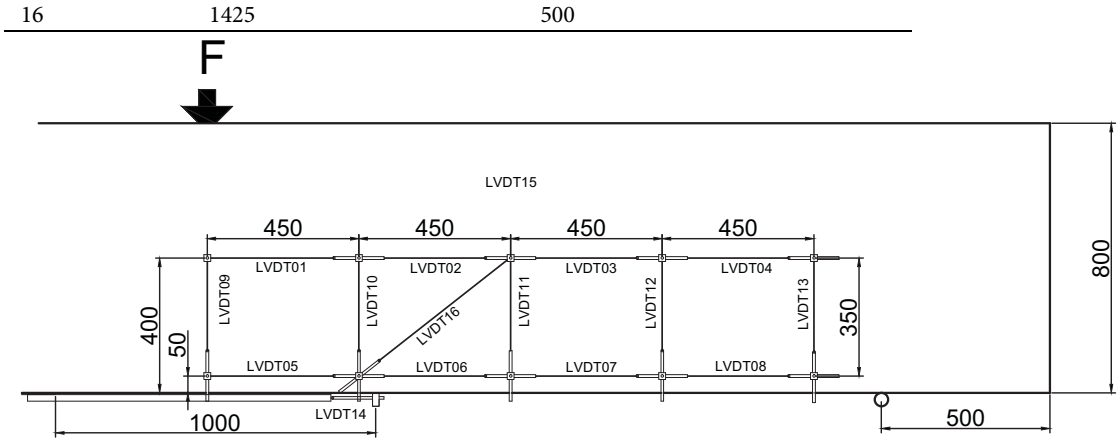


Fig. 5.91.3. LVDT layout and numbering for 800 mm deep beams

5.91.2. Measurement results

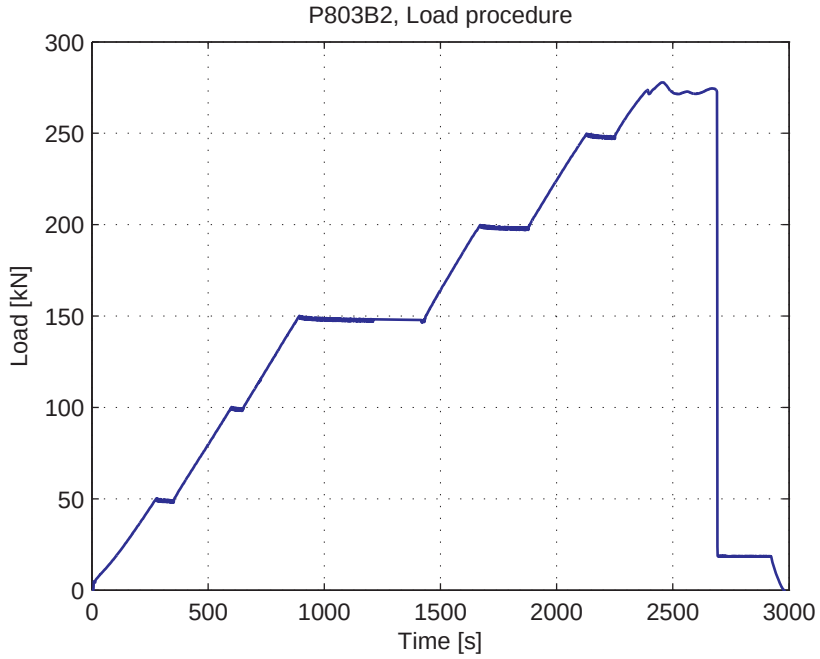


Fig. 5.91.4. Load-Time curve

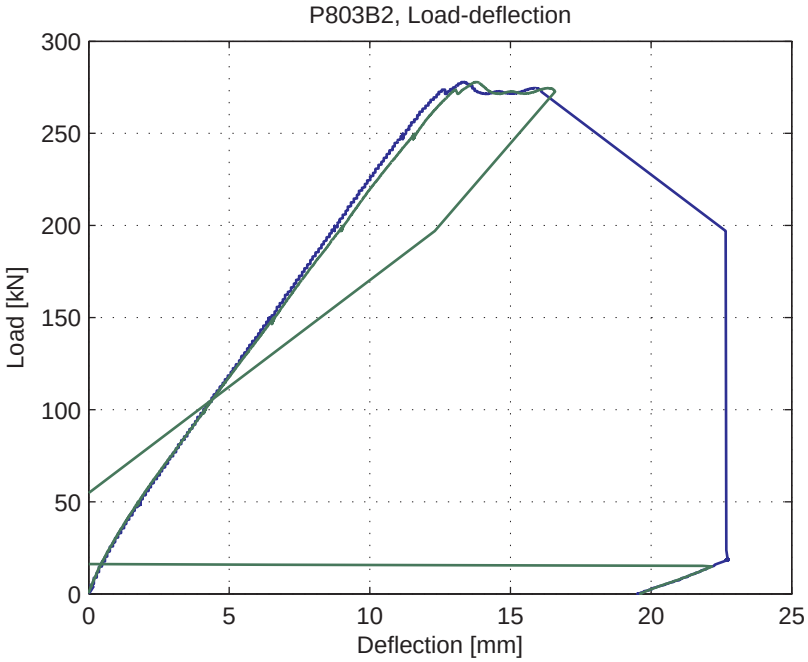


Fig. 5.91.5. Load-deflection curve

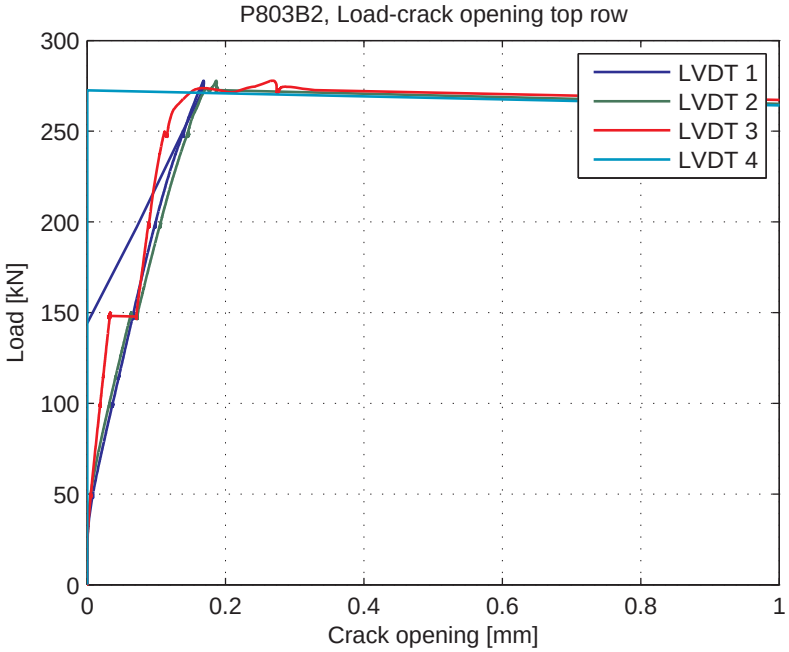


Fig. 5.91.6. Load-Crack opening for LVDT's 1-4 (top row)

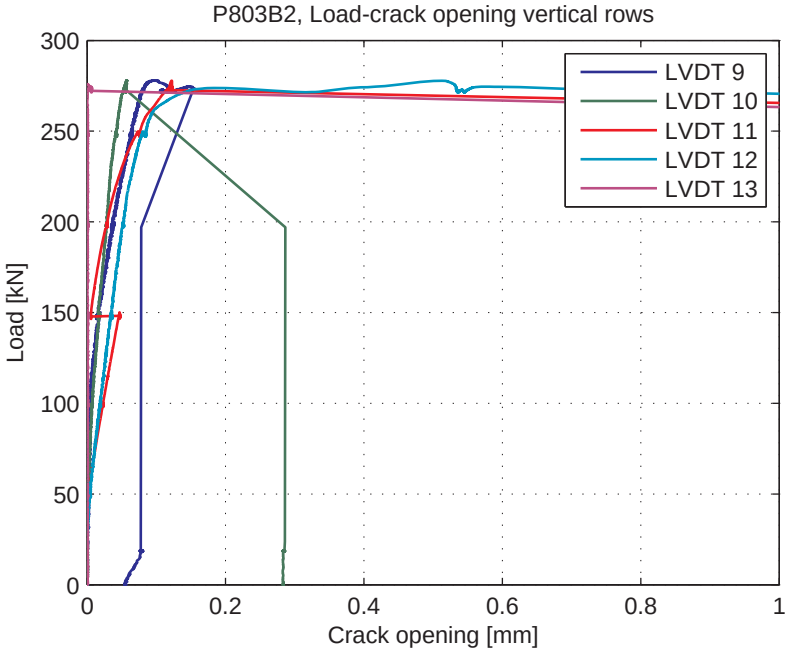


Fig. 5.91.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

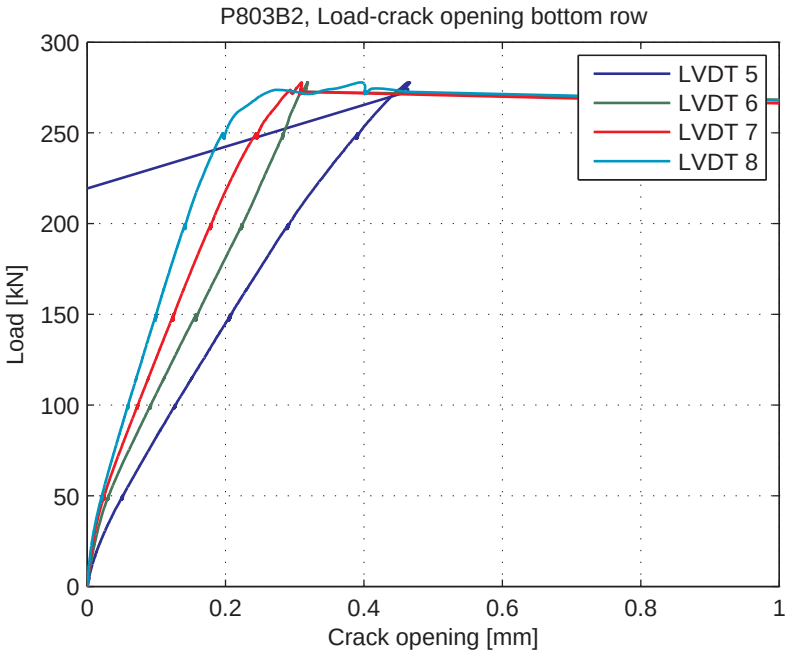


Fig. 5.91.8. Load-Crack opening for LVDT's 5-8 (bottom row)

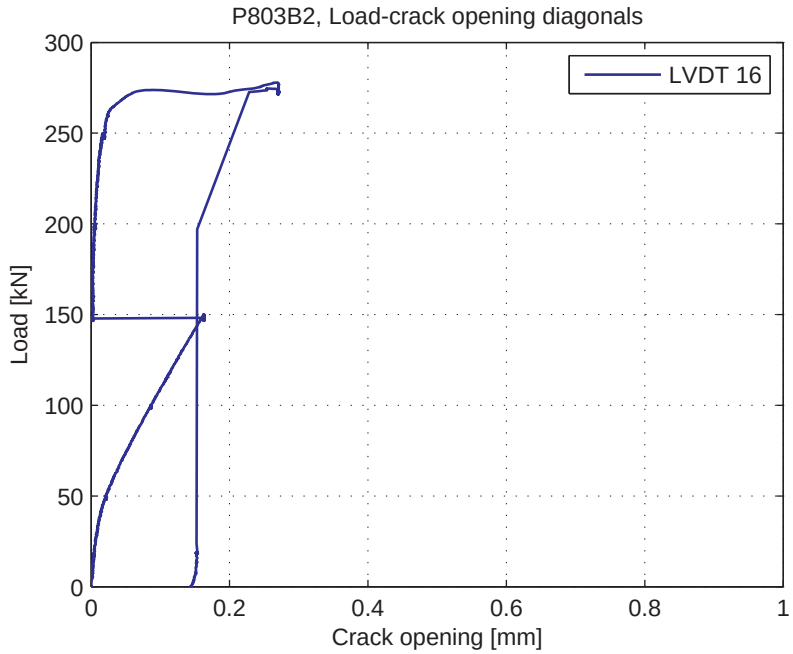


Fig. 5.91.9. Load-Crack opening for LVDT 16 (diagonal)

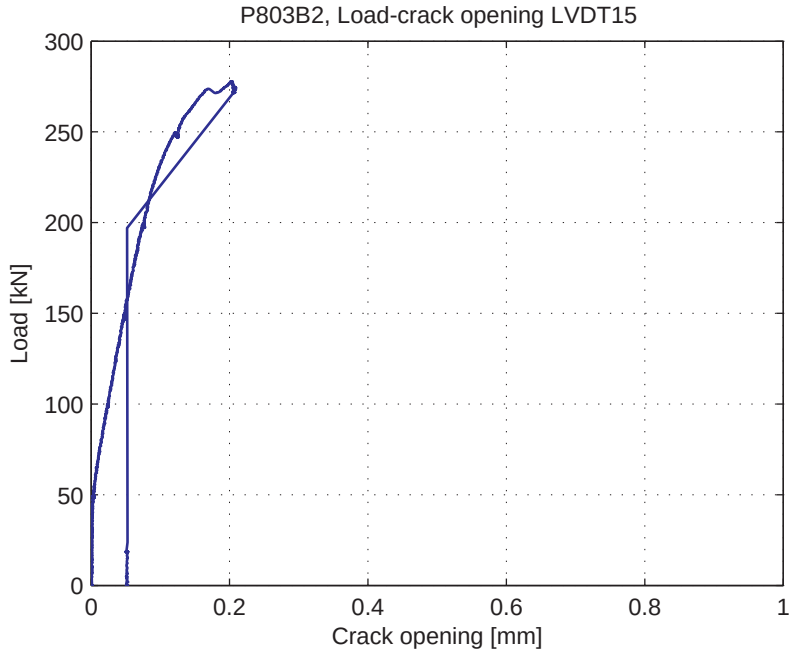


Fig. 5.91.10. Load-Crack opening for LVDT 15

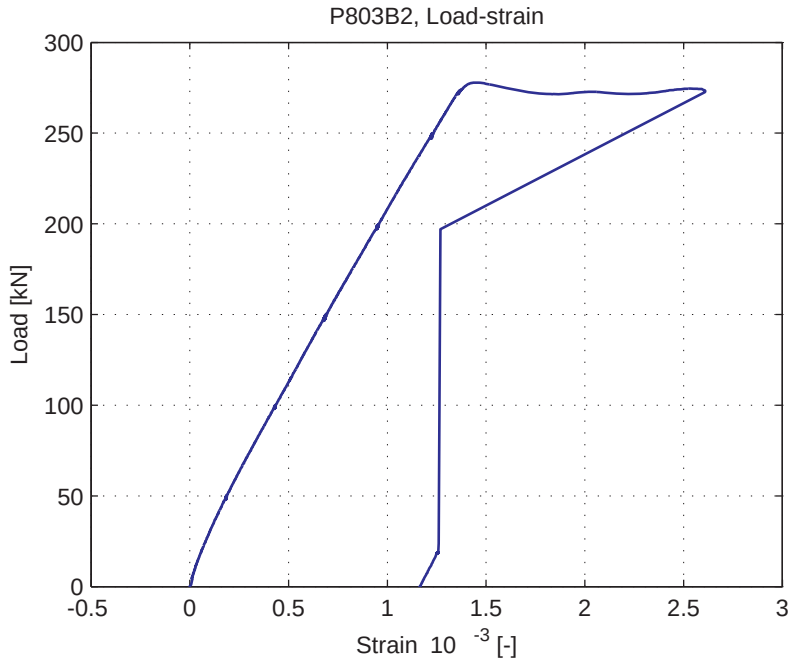


Fig. 5.91.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.92. P804A1

5.92.1. Test properties

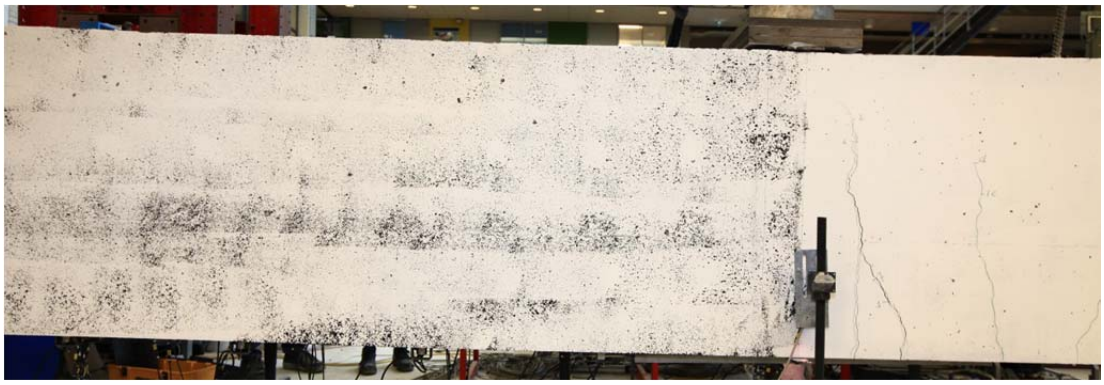


Fig. 5.92.1. Crack pattern after failure east side

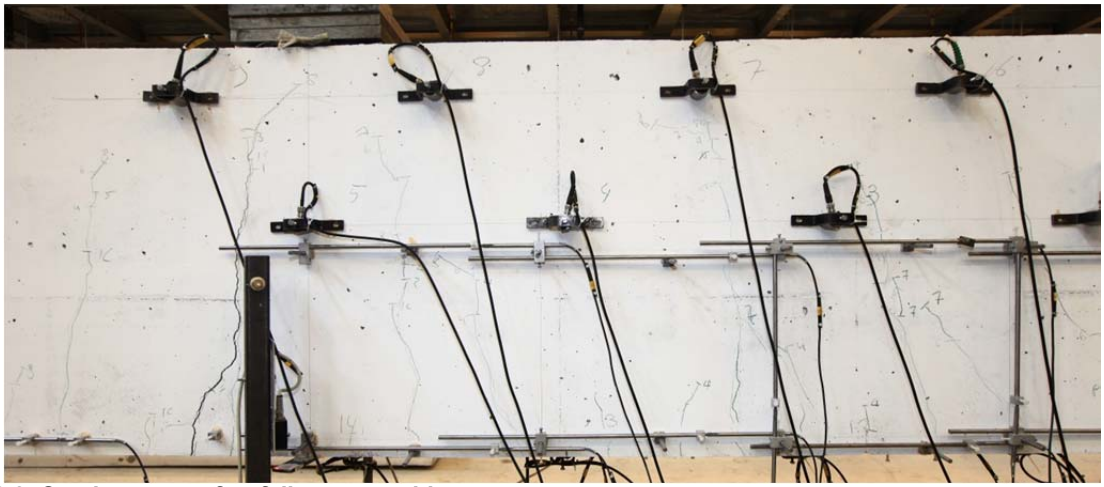


Fig. 5.92.2. Crack pattern after failure west side

Table 5.92.1. Beam properties

Date of test	08-06-2016
Reinforcement	6Ø20 (2 layers)
Reinforcement ratio	0.84%
a	3000 mm
a / *d*	3.97
Concrete cube strength at testing	85.1 MPa
Peak load	207.4 kN
Failure mode	Flexural failure

Table 5.92.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements. Separate report on this test is made (Stevin report 25.5-16-06)
1	75	Loading speed 0.004 mm/s
2	10	
3	75	Added LVDT 12, zeroed at 75 kN. Measurement stopped, zeroed LVDT12
4	10	LVDT9 and LVDT10 rezeroed, measurement stopped
5	75	
6	10	

7	75	Loading speed 0.04 mm/s
8	10	
9	75	
10	10	
11	75	
12	10	
13	75	Loading speed 0.2 mm/s
14	10	
15	75	
16	10	
17	75	
18	10	
19	75	
20	10	
21	75	
22	10	
23	75	
24	10	
25	75	
26	10	
27	75	
28	10	
29	75	Loading speed 0.4 mm/s
30	10	
31	75	
32	10	
33	75	
34	10	Discussion and break
35	75	Loading speed 0.2 mm/s
36	79	
37	85	
38	10	
39	85	
40	10	
41	85	
42	10	
43	85	
44	10	
45	85	
46	87	
47	90	
48	95	
49	10	
50	95	
51	10	
52	95	
53	10	
54	95	
55	10	Placed LVDT13 at bending crack and LVDT15 on bottom of beam
56	95	
57	97	
58	99	
59	101	
60	104	
61	107	Down to 99 kN because of cracking
62	106	

63	109	
64	111	After 1 minute crack formed
65	113	Load dropped to 108 kN during this load step
66	115	
67	117	
68	120	
69	10	
70	120	
71	10	
72	120	
73	10	
74	120	
75	10	
76	120	
77	122	
78	125	
79	129	
80	132	
81	135	
82	140	Kept load level for 30 minutes.
83	10	Kept load level for 15 minutes. LVDT13 reglued after it got knocked off using last known correct measurement. Moved LVDT12 to 670 mm from the load point in the shear span. Placed LVDT16 at 1150 mm from loading point in shear span.
84	140	
85	10	
86	140	
87	10	
88	140	
89	10	Kept load level until all activity stopped
90	140	
91	142	
92	145	
93	149	
94	152	
95	154	
96	158	
97	160	Kept load level for at least 15 minutes, until cracking activity stopped.
98	10	
99	160	
100	10	
101	160	
102	10	
103	160	
104	10	
105	160	
106	163	
107	167	
108	173	
109	176	
110	178	
111	180	Kept load level until cracking activity stopped
112	10	
113	180	
114	10	
115	180	

116	10	
117	180	
118	10	
119	207	Yielding

Table 5.92.3. Location LVDT's used for crack opening measurements

LVDT	Distance from load point [mm]	Distance from bottom beam [mm]
12 (1)	90	50
12 (2)	670	-
13	450	-
15	850	-

Notes on LVDT's:
LVDT12 was located on a major crack at the bottom of the beam
LVDT13 was located on a major bending crack, but not in the shear span
LVDT15 was located on a major crack
LVDT16 was located on a secondary crack

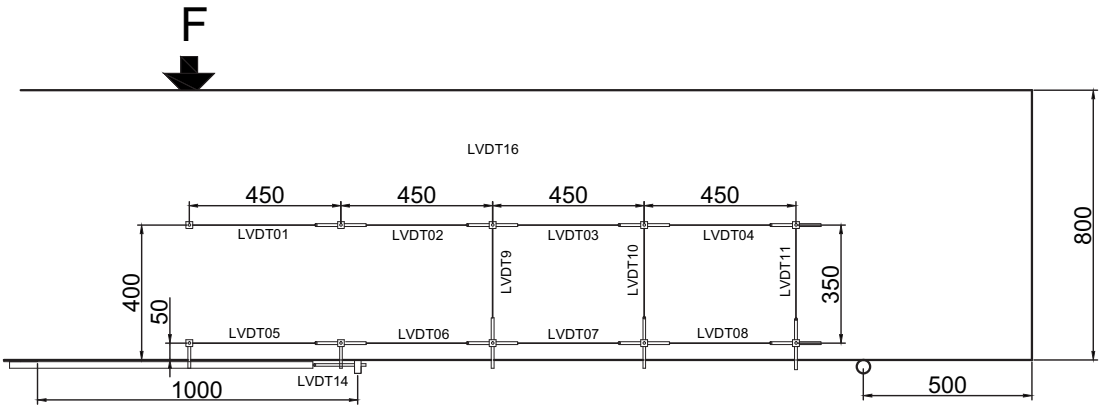


Fig. 5.92.3. LVDT layout and numbering for P804A1 beam

5.92.2. Measurement results

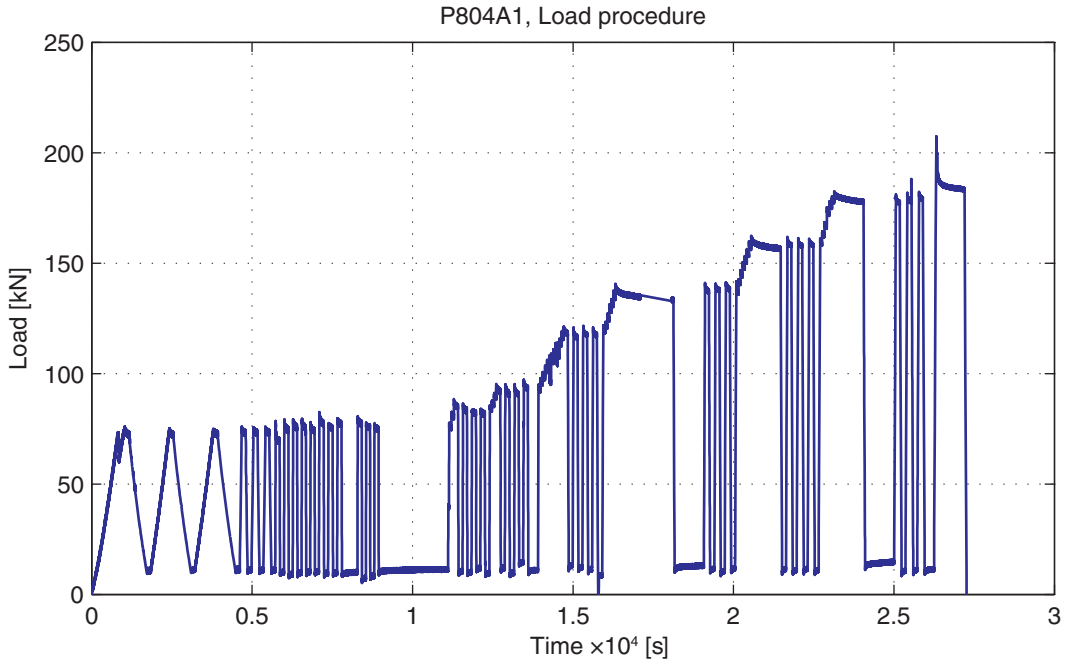


Fig. 5.92.4. Load-Time curve

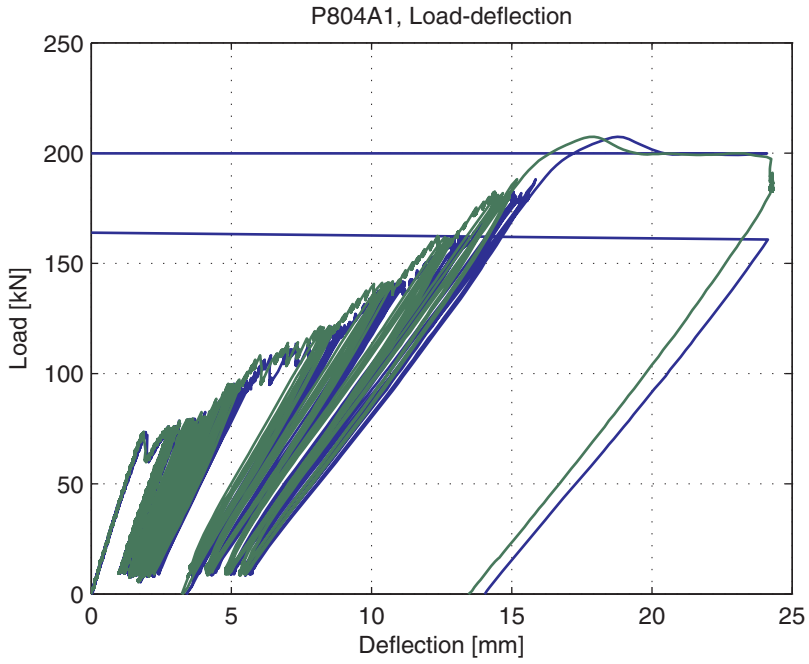


Fig. 5.92.5. Load-deflection curve

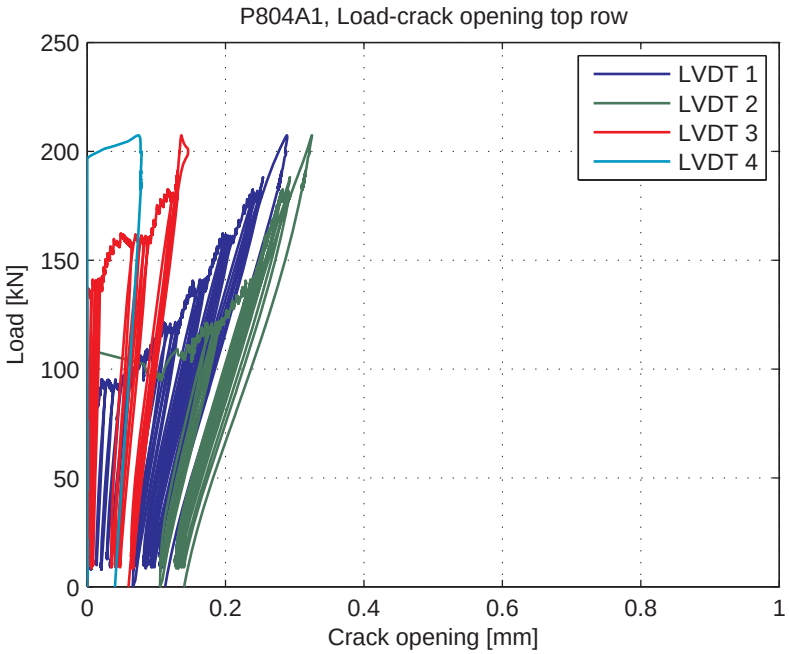


Fig. 5.92.6. Load-Crack opening for LVDT's 1-4 (top row)

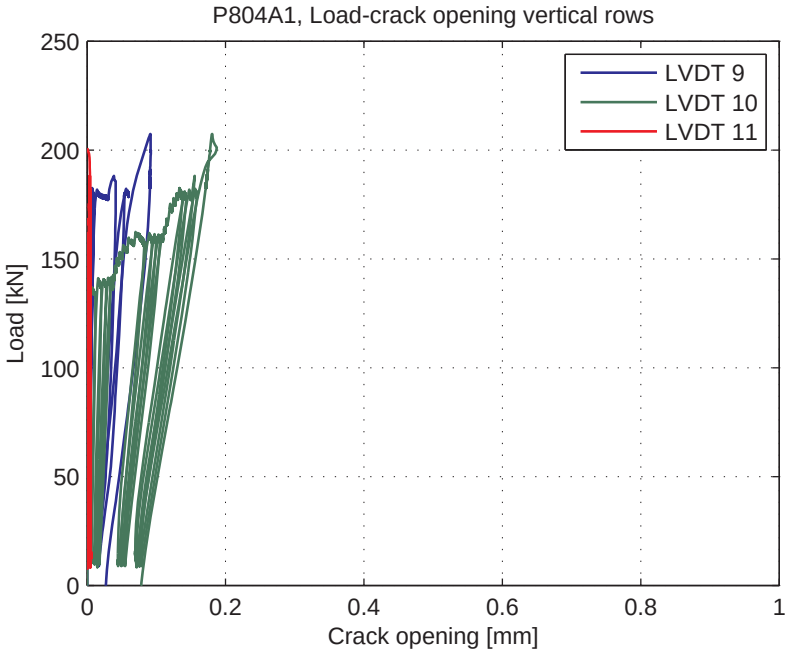


Fig. 5.92.7. Load-Crack opening for LVDT's 9-11 (vertical LVDT's)

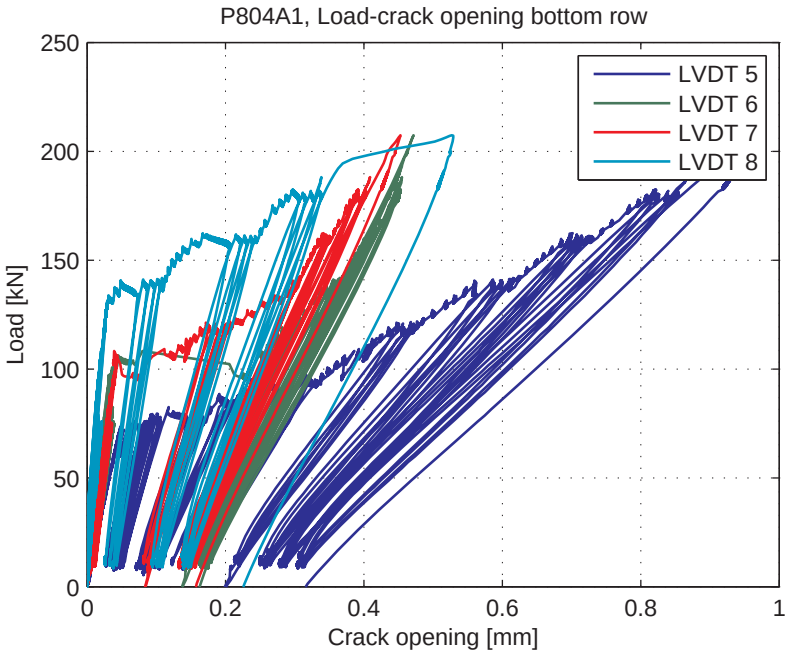


Fig. 5.92.8. Load-Crack opening for LVDT's 5-8 (bottom row)

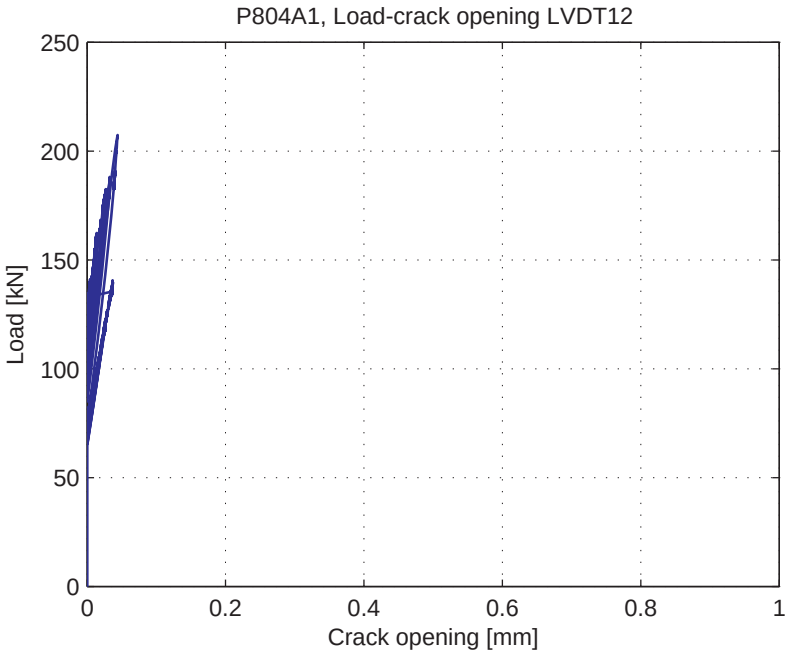


Fig. 5.92.9. Load-Crack opening for LVDT 12

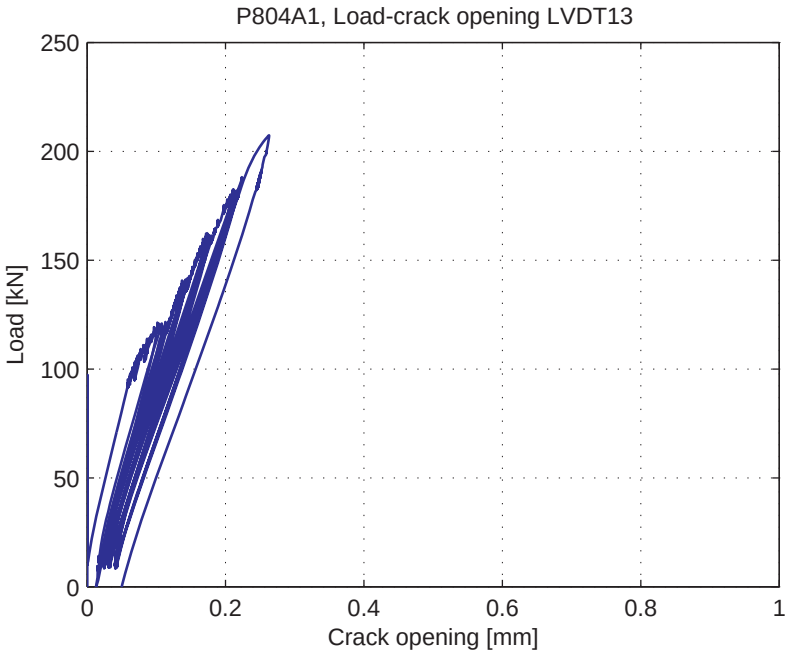


Fig. 5.92.10. Load-Crack opening for LVDT 13

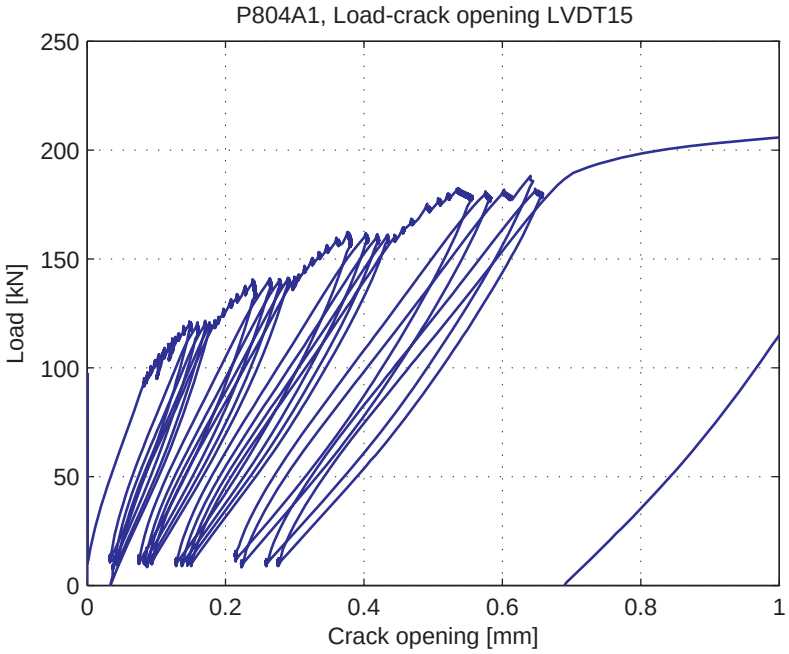


Fig. 5.92.11. Load-Crack opening for LVDT 15

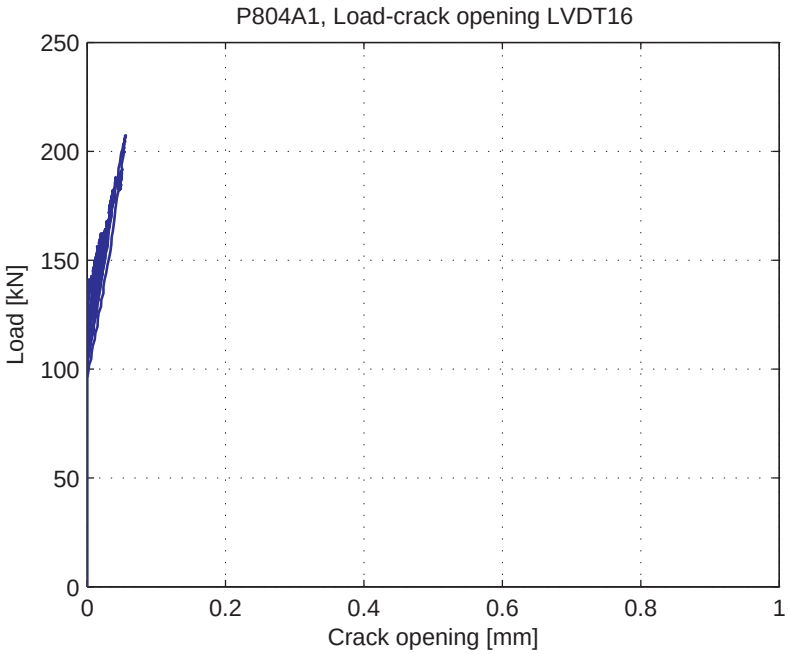


Fig. 5.92.12. Load-Crack opening for LVDT 16

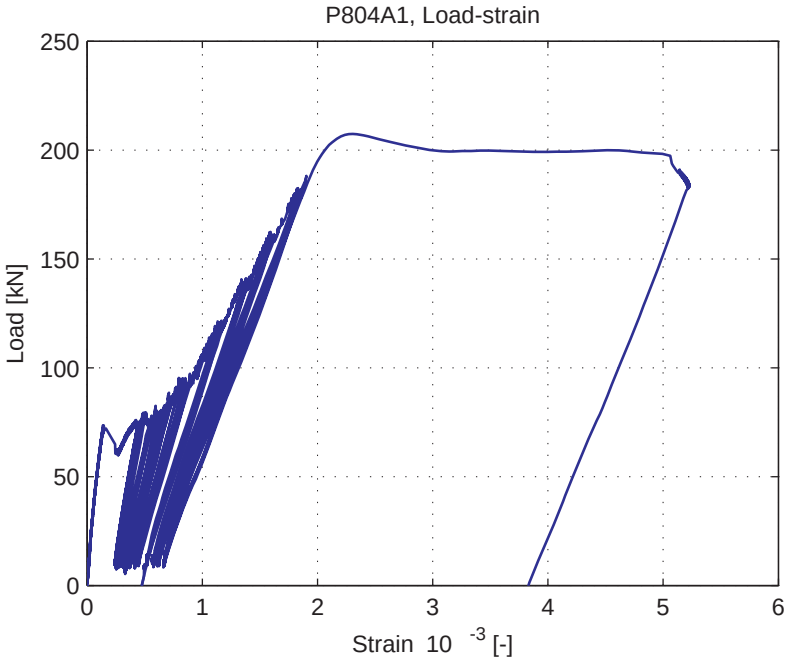


Fig. 5.92.13. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.93. P804A2

5.93.1. Test properties

Fig. 5.93.1. Crack pattern after failure east side

Table 5.93.1. Beam properties

Date of test	09-06-2016
Reinforcement	6Ø20 (2 layers)
Reinforcement ratio	0.84%
a	2500 mm
a / *d*	3.31
Concrete cube strength at testing	85.1 MPa
Peak load flexural / shear	231.7 kN
Failure mode	Shear

Table 5.93.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements. LVDT12 and LVDT16 are kesame pt in position as for test P804A1. Separate report on this test is made (Stevin report 25.5-16-06)
1	75	Kept load level for 15 minutes
2	10	Kept load level for 15 minutes
3	75	
4	10	
5	75	
6	10	
7	75	
8	80	
9	85	
10	90	
11	95	
12	100	
13	105	
14	110	
15	115	Kept load level for 15 minutes
16	10	
17	115	
18	10	
19	115	

20	10	
21	115	
22	10	
23	160	
24	170	
25	175	
26	180	
27	185	
28	190	
29	195	
30	200	Kept load level for 15 minutes
31	10	
32	200	
33	10	
34	200	
35	10	
36	200	
37	10	
38	210	Kept load level for 3 minutes
39	215	Kept load level for 3 minutes
40	220	Kept load level for 3 minutes
41	22	Kept load level for 3 minutes
42	230	Shear failure

Table 5.93.3. Location LVDT's used for crack opening measurements

LVDT	Distance from loading point [mm]	Distance from bottom beam [mm]
12	670	-
13	310	-
15	1350	-
16	790	-

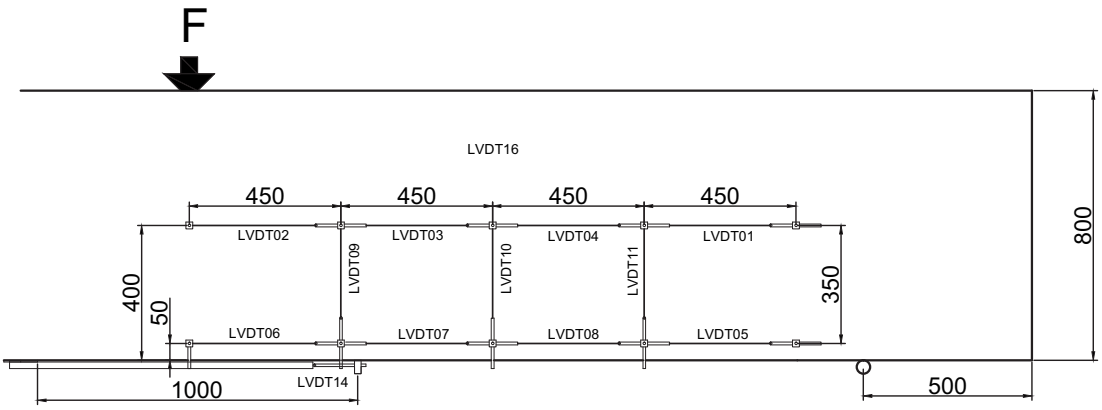


Fig. 5.93.2. LVDT layout and numbering for P804A2 beam

5.93.2. Measurement results

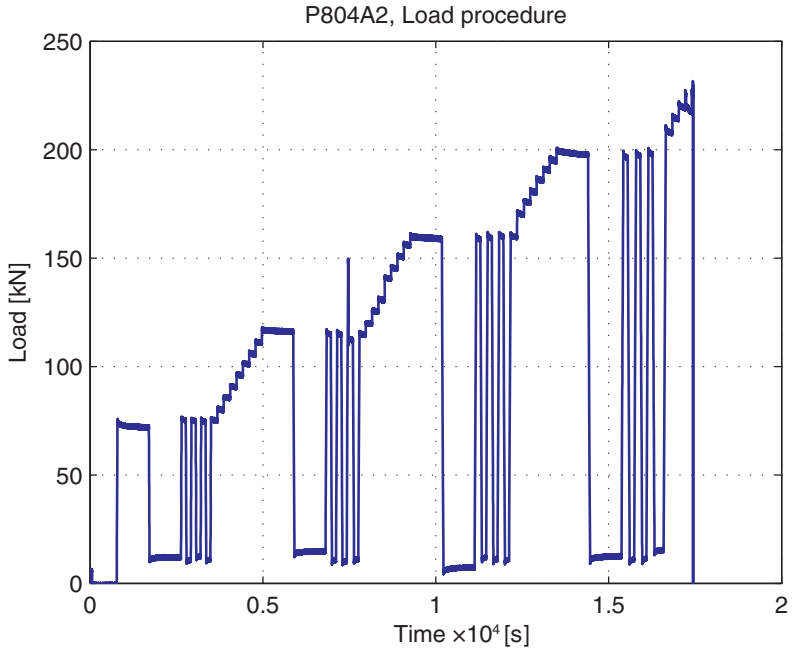


Fig. 5.93.3. Load-Time curve

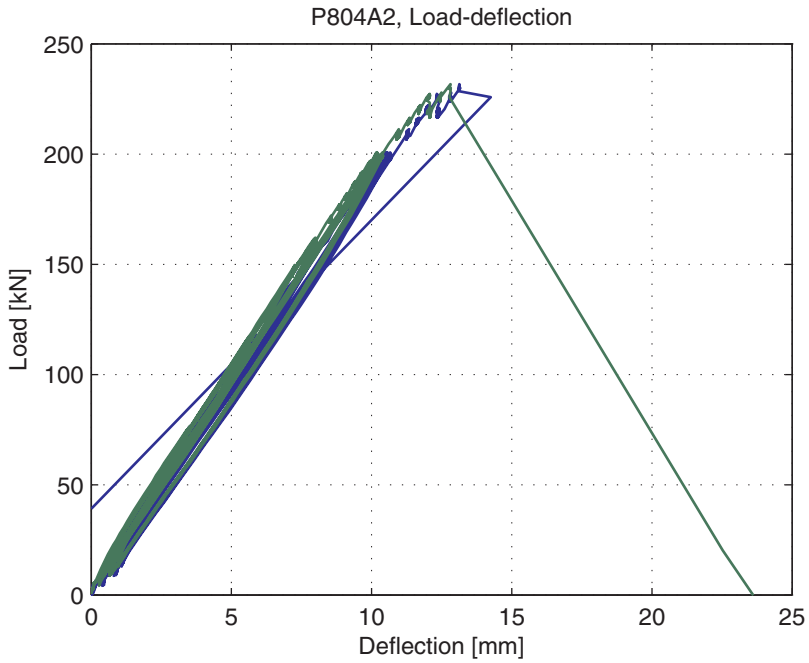


Fig. 5.93.4. Load-deflection curve

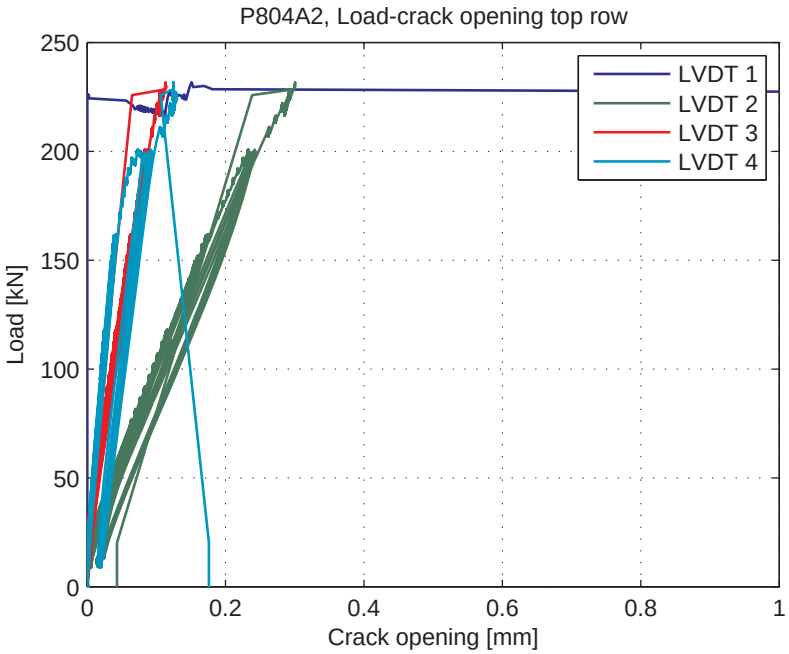


Fig. 5.93.5. Load-Crack opening for LVDT's 1-4 (top row)

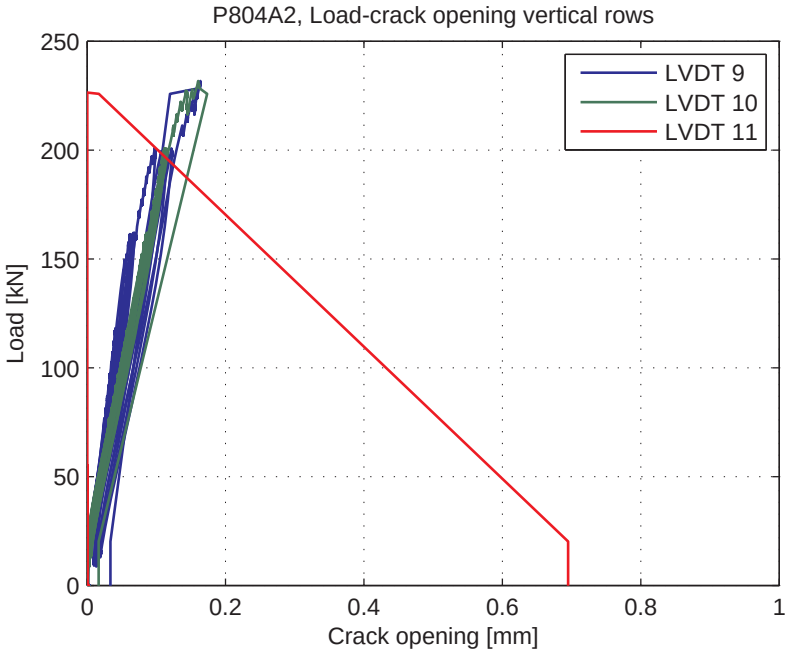


Fig. 5.93.6. Load-Crack opening for LVDT's 9-11 (vertical LVDT's)

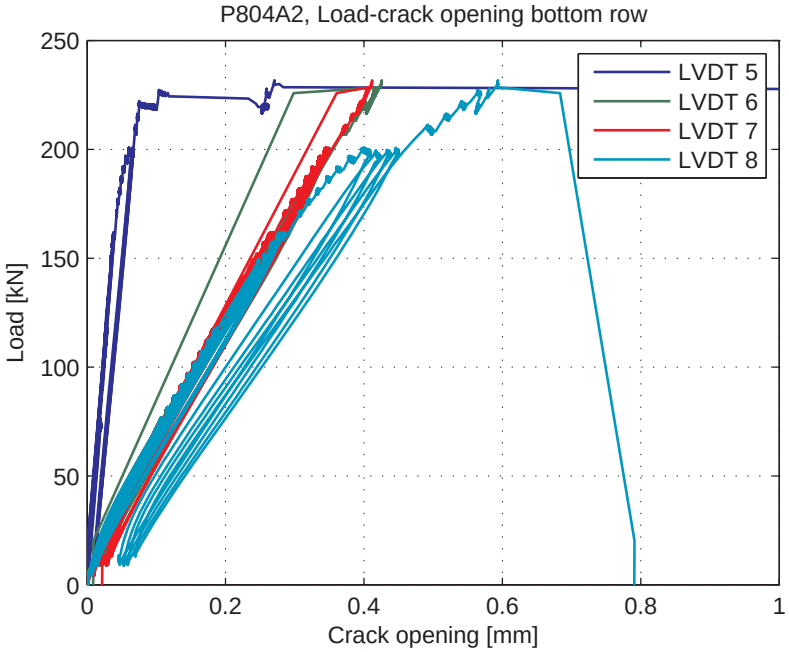


Fig. 5.93.7. Load-Crack opening for LVDT's 5-8 (bottom row)

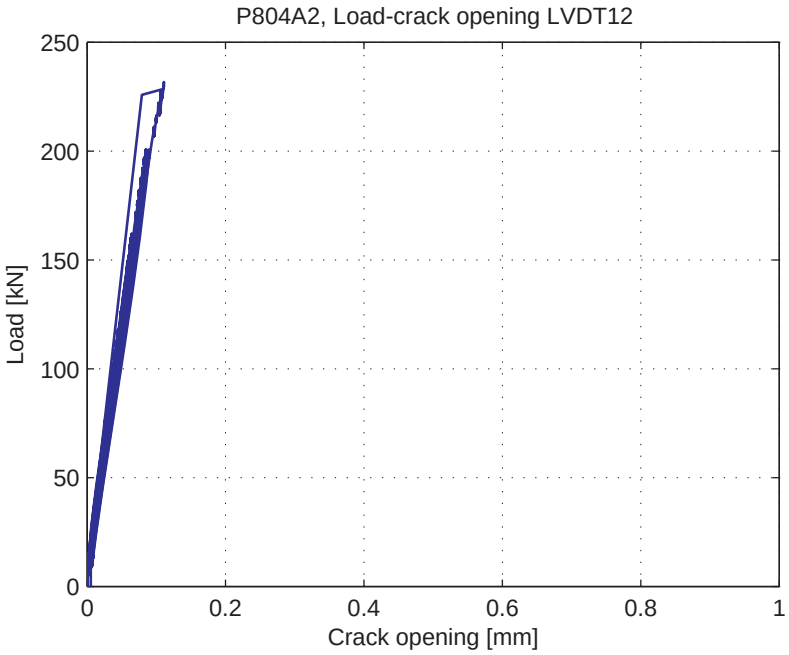


Fig. 5.93.8. Load-Crack opening for LVDT 12

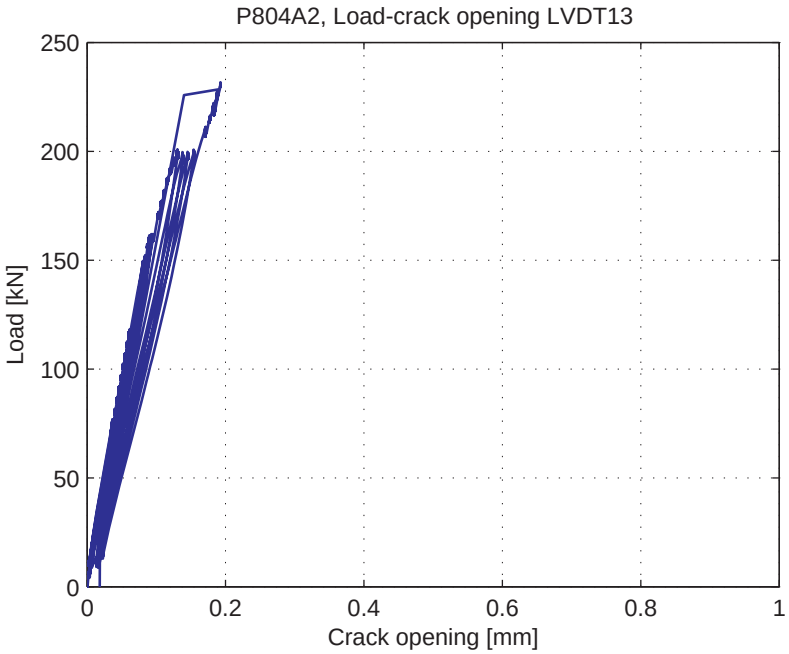


Fig. 5.93.9. Load-Crack opening for LVDT 13

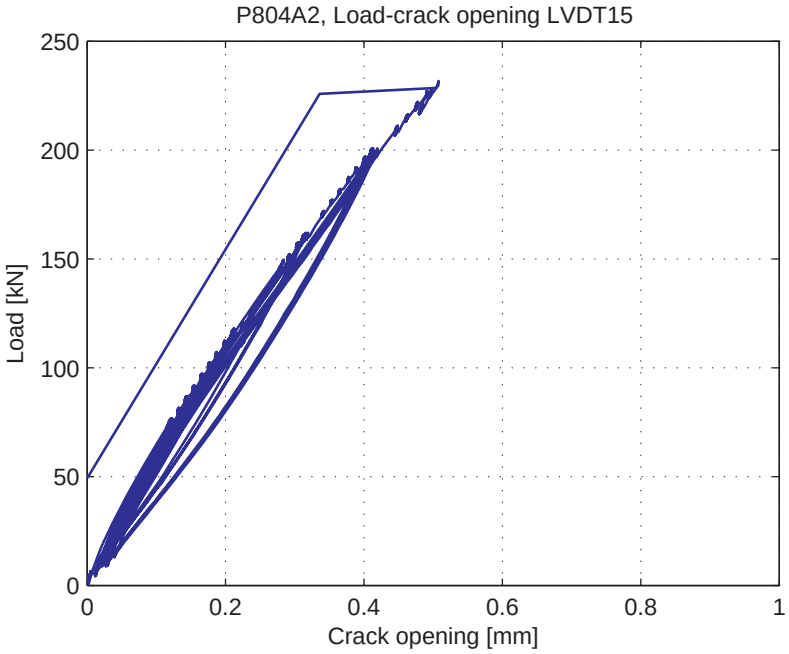


Fig. 5.93.10. Load-Crack opening for LVDT 15

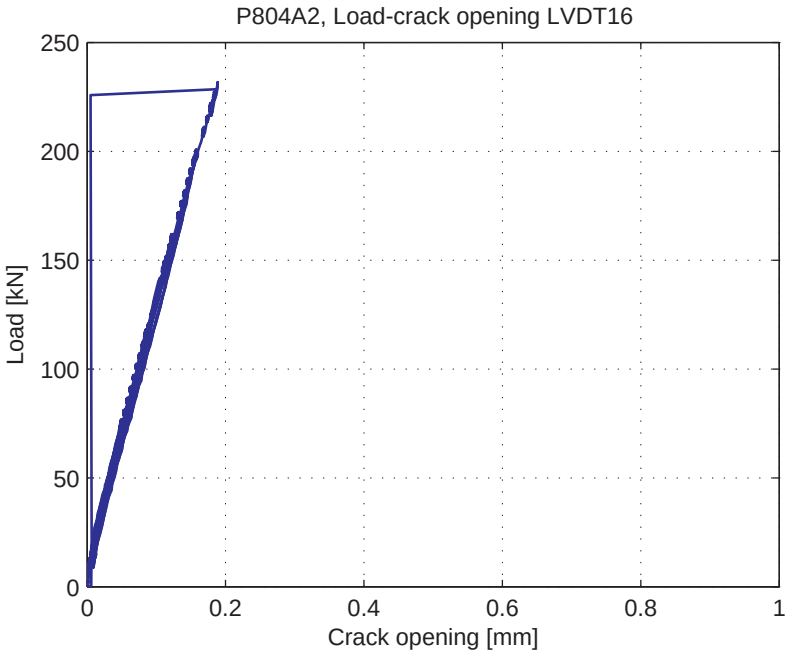


Fig. 5.93.11. Load-Crack opening for LVDT 16

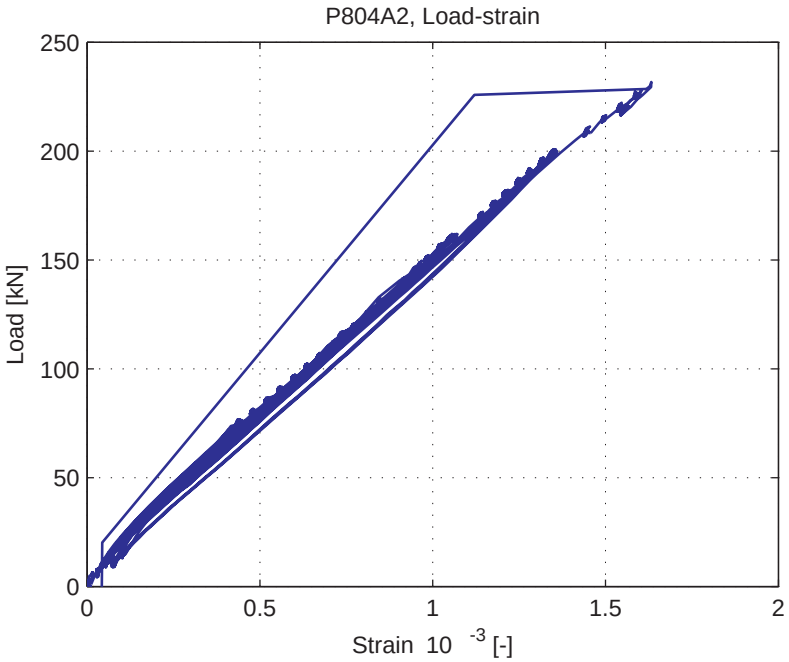


Fig. 5.93.12. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.94. P804B1

5.94.1. Test properties

Fig. 5.94.1. Crack pattern after failure east side

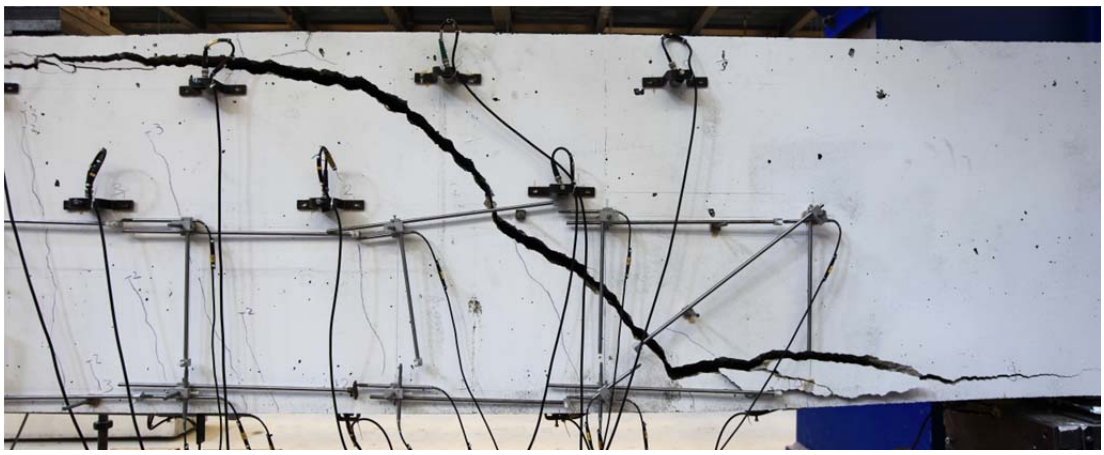


Fig. 5.94.2. Crack pattern after failure west side

Table 5.94.1. Beam properties

Date of test	13-06-2016
Reinforcement	6Ø20 (2 layers)
Reinforcement ratio	0.84%
a	2500
a / *d*	3.31
Concrete cube strength at testing	85.1 MPa
Peak load flexural / shear	195.6 kN
Failure mode	Shear

Table 5.94.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Test with AE measurements. Separate report on this test is made (Stevin report 25.5-16-06)
1	75	Kept load level for 5 minutes until AE activity stabilised
2	85	Kept load level for 2 minutes
3	95	Kept load level for 2 minutes
4	105	Kept load level for 2 minutes
5	115	Kept load level for 5 minutes until AE activity stabilised
6	120	Kept load level for 2 minutes

130	Kept load level for 2 minutes
140	Kept load level for 2 minutes
150	Kept load level for 2 minutes
160	Kept load level for 5 minutes until AE activity stabilised
165	Kept load level for 2 minutes
175	Kept load level for 2 minutes
195	Shear failure

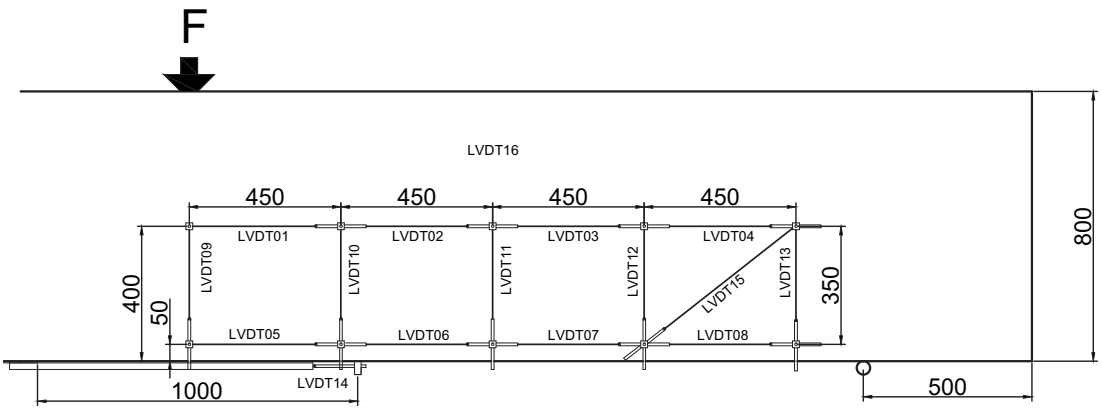


Fig. 5.94.3. LVDT layout and numbering for 800 mm deep beams

5.94.2. Measurement results

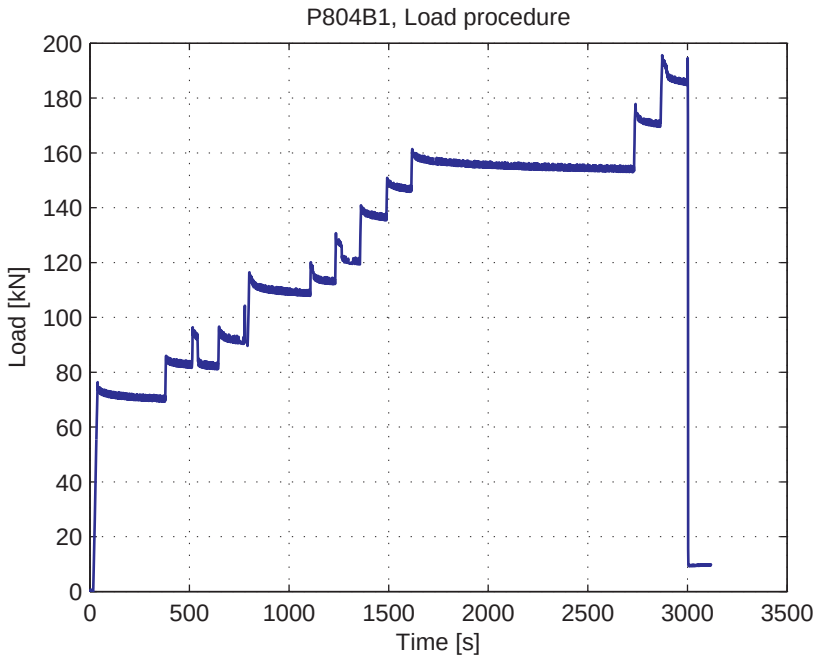


Fig. 5.94.4. Load-Time curve

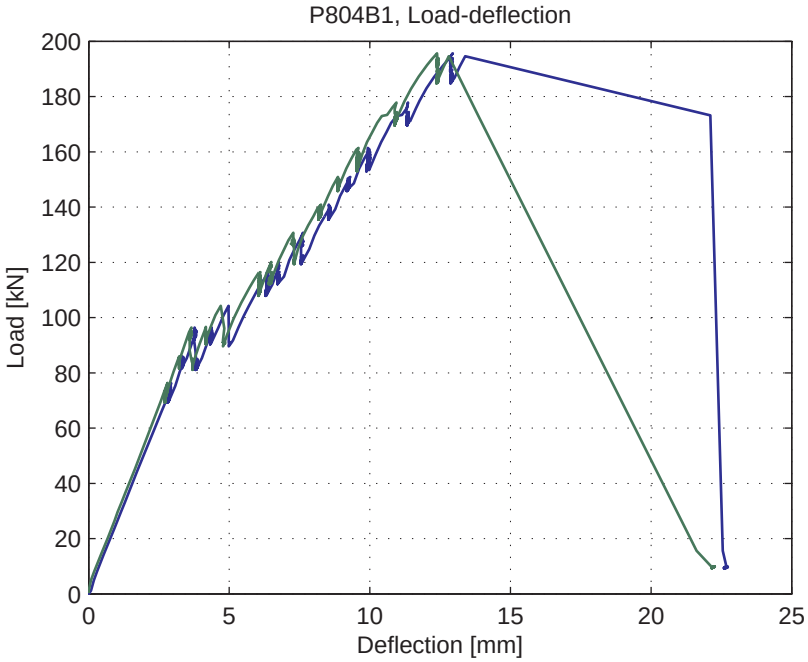


Fig. 5.94.5. Load-deflection curve

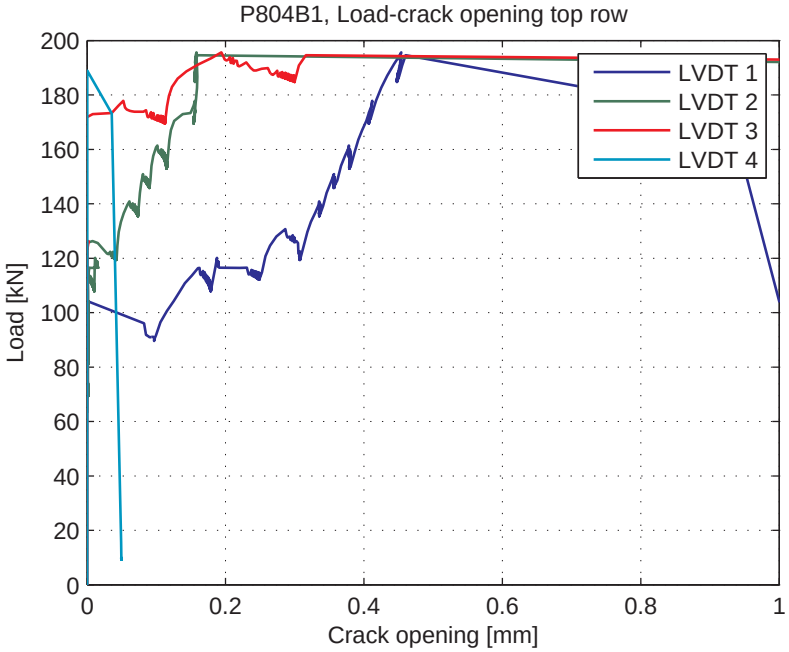


Fig. 5.94.6. Load-Crack opening for LVDT's 1-4 (top row)

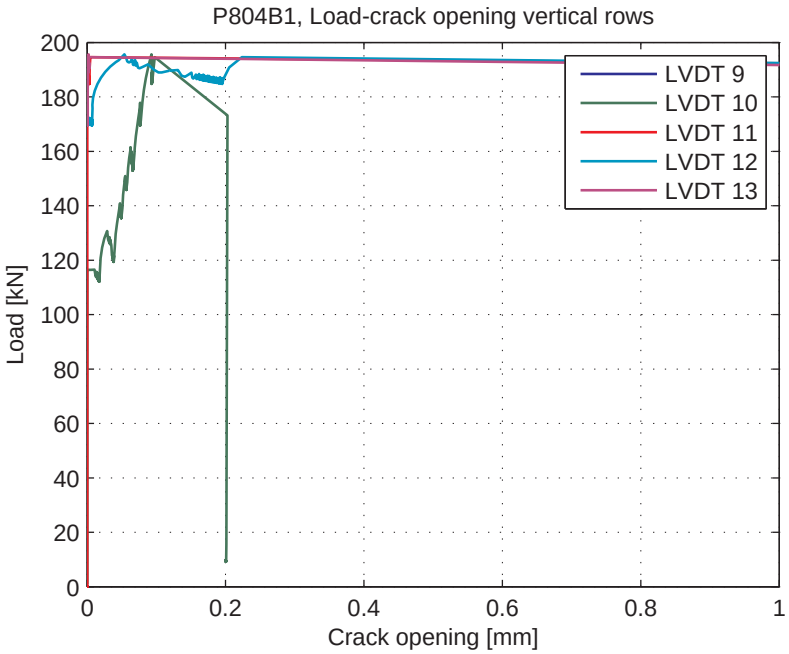


Fig. 5.94.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

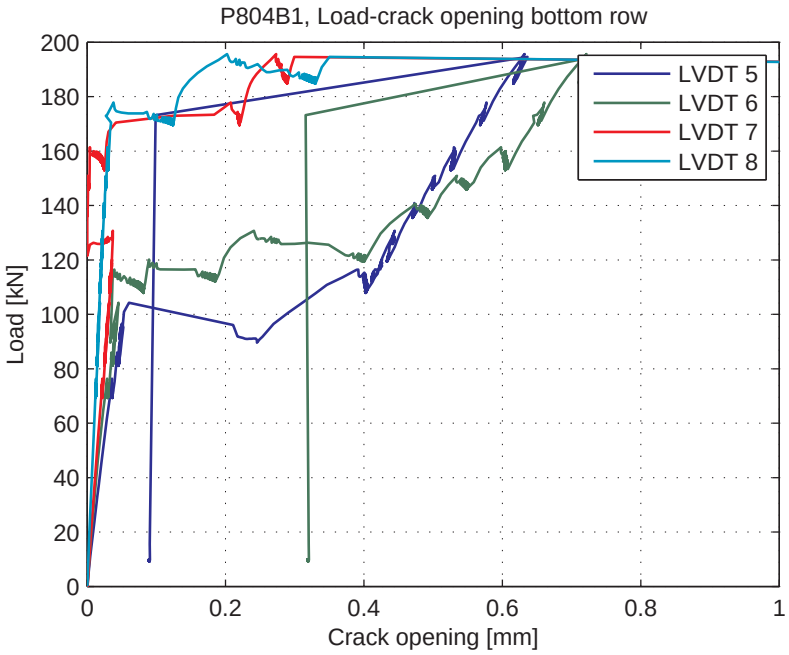


Fig. 5.94.8. Load-Crack opening for LVDT's 5-8 (bottom row)

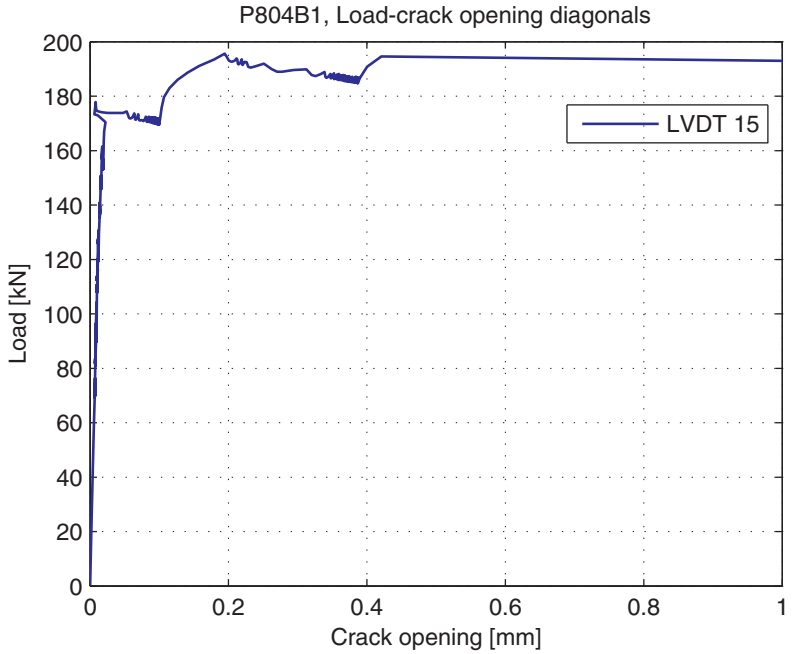


Fig. 5.94.9. Load-Crack opening for LVDT 15 (diagonal)

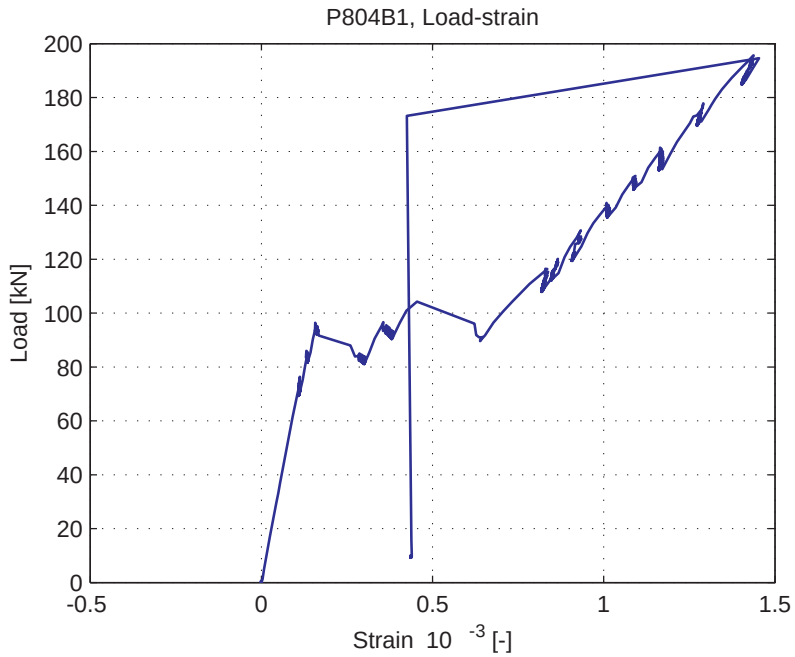


Fig. 5.94.10. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.95. R501A1

5.95.1. Test properties

Fig. 5.95.1. Crack pattern after failure north side

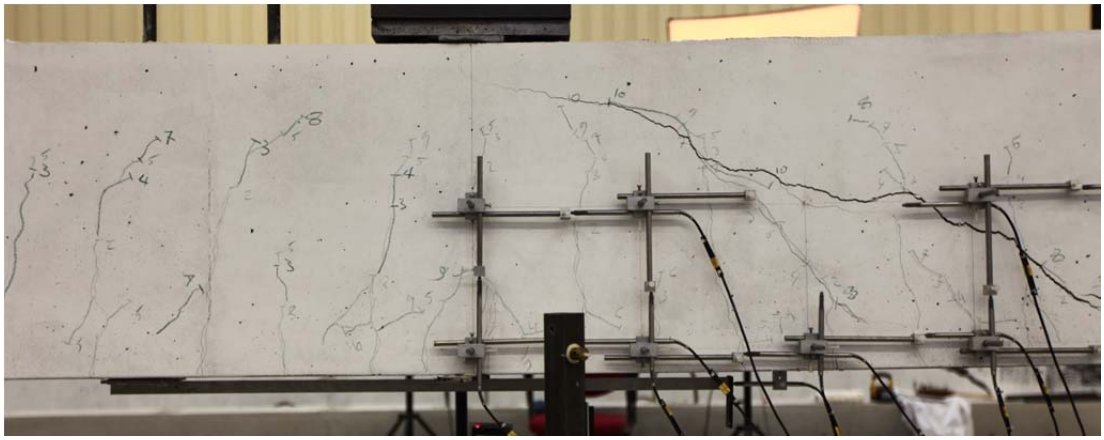


Fig. 5.95.2. Crack pattern after failure south side

Table 5.95.1. Beam properties

Date of test	23-02-2016
Reinforcement	5Ø20 ribbed
Reinforcement ratio	1.15%
a	2500 mm
a / *d*	5.49
Concrete cube strength at testing	80.5 MPa
Peak load	276.8 kN
Failure mode	Shear

Table 5.95.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	75	
3	100	
4	125	
5	150	
6	175	
7	200	
8	225	
9	250	
10	275	
11	267.8	Shear failure, drop back to 250 kN

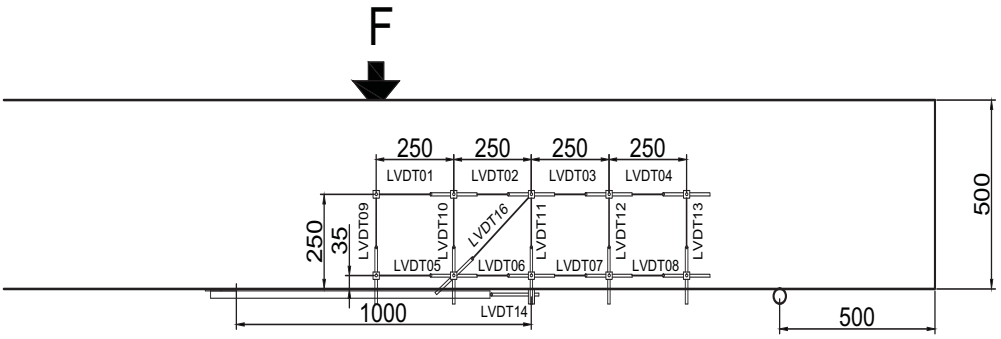


Fig. 5.95.3. LVDT layout and numbering for 500 mm deep beams

5.95.2. Measurement results

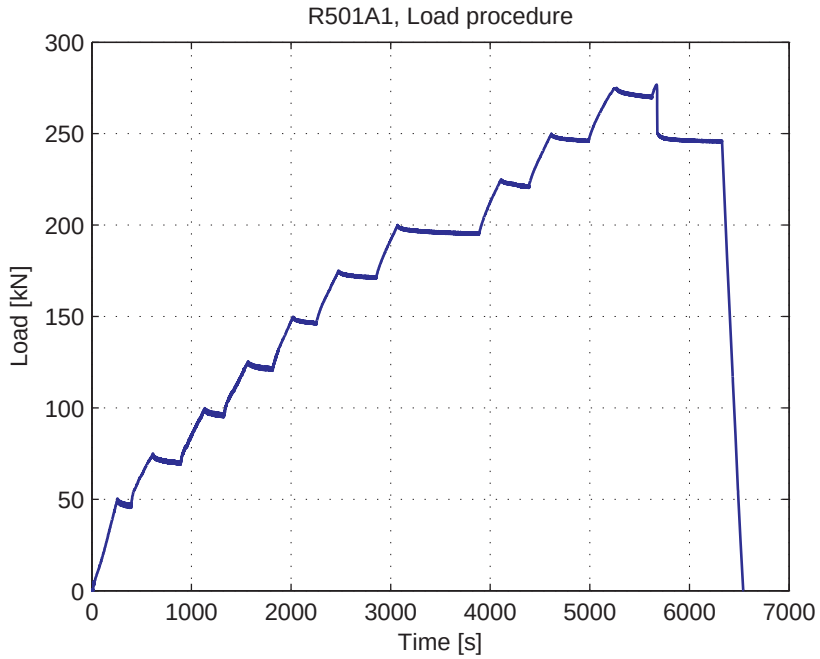


Fig. 5.95.4. Load-Time curve

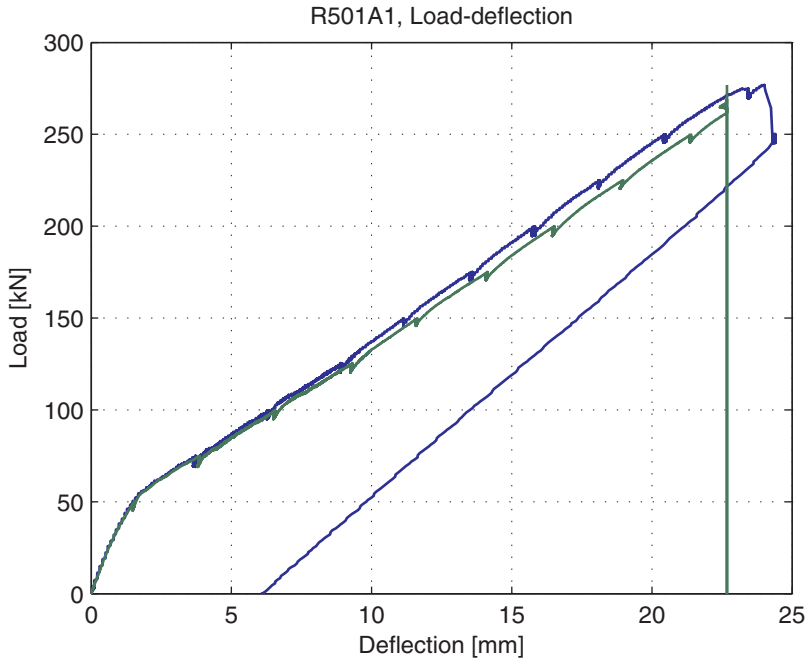


Fig. 5.95.5. Load-deflection curve

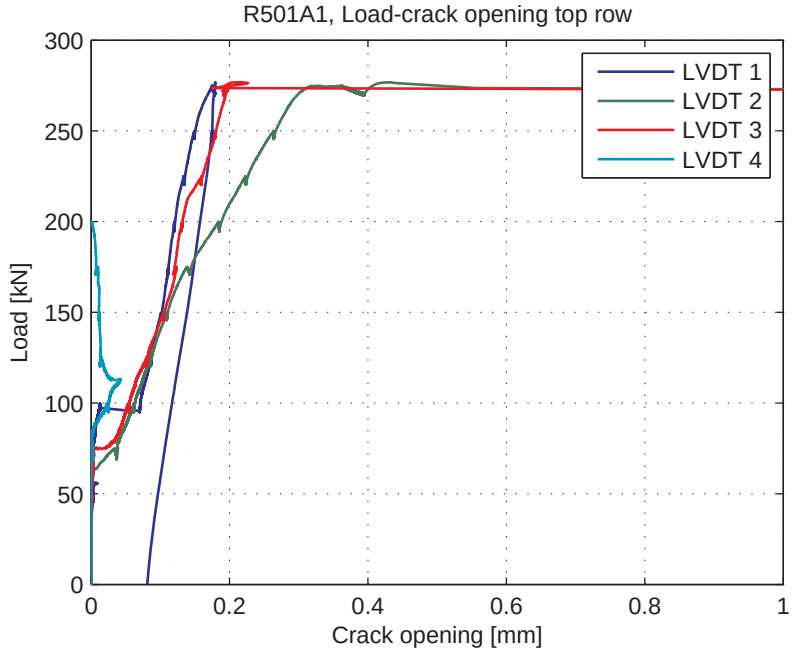


Fig. 5.95.6. Load-Crack opening for LVDT's 1-4 (top row)

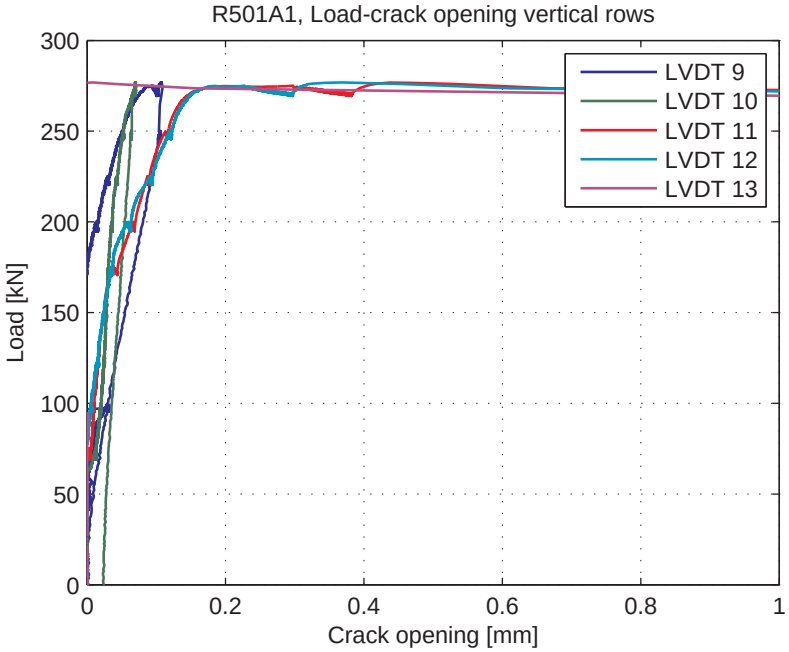


Fig. 5.95.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

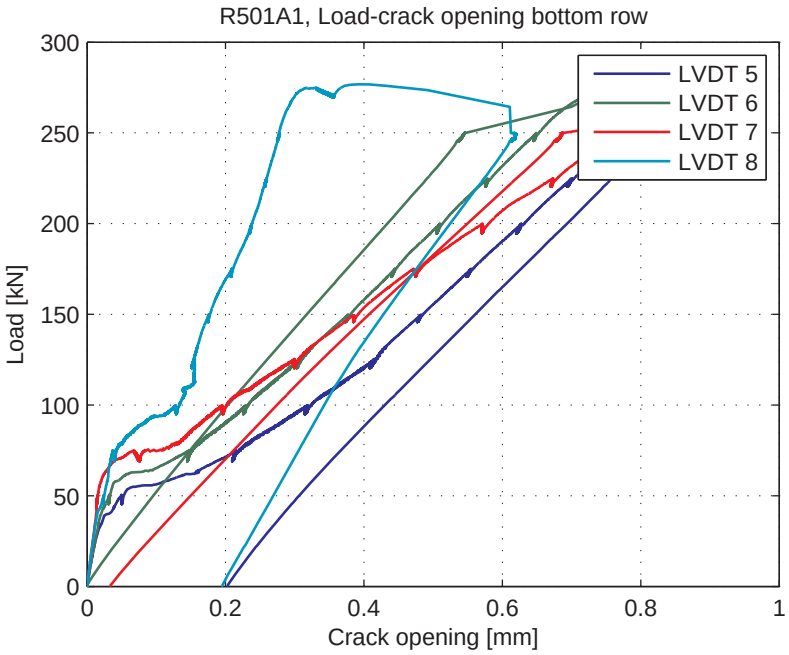


Fig. 5.95.8. Load-Crack opening for LVDT's 5-8 (bottom row)

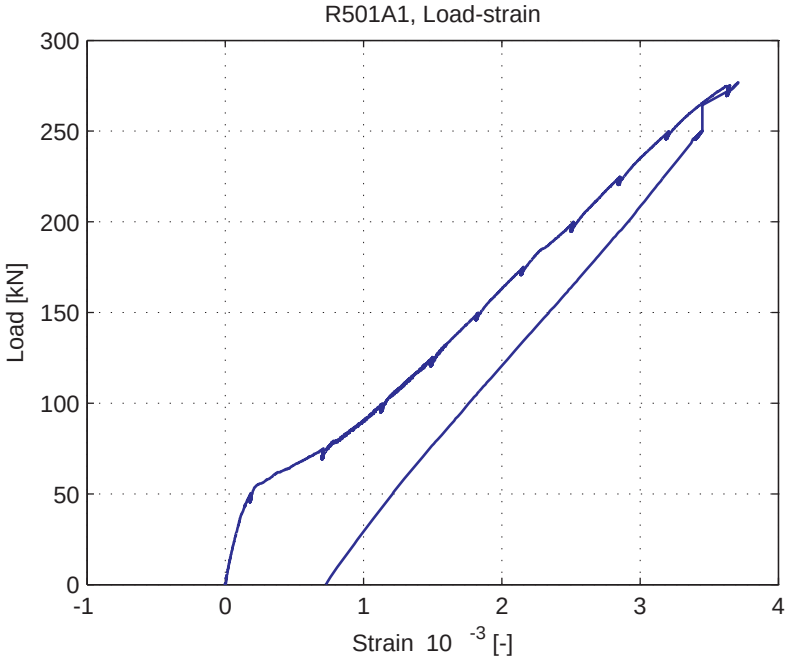


Fig. 5.95.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.96. R501B1

5.96.1. Test properties

Fig. 5.96.1. Crack pattern after failure north side

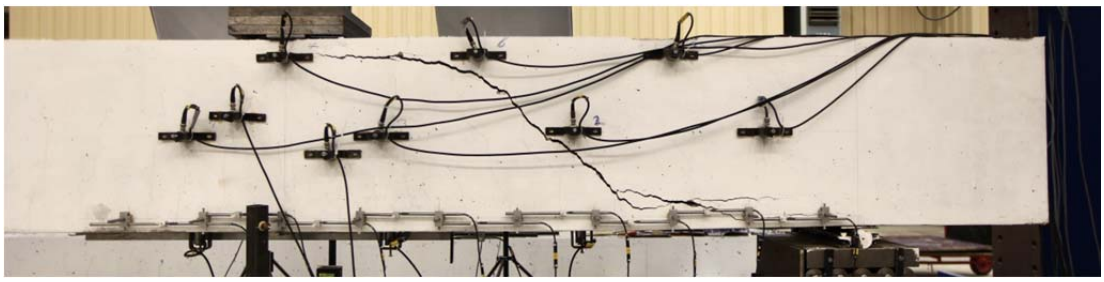


Fig. 5.96.2. Crack pattern after failure south side and sensors used for Acoustic Emissions measurements

Table 5.96.1. Beam properties

Date of test	23-03-2016
Reinforcement	5Ø20 ribbed
Reinforcement ratio	1.15%
a	1500 mm
a / *d*	3.30
Concrete cube strength at testing	75.8 MPa
Peak load	210.2 kN
Failure mode	Shear

Table 5.96.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements
1	50	
2	0	
3	50	
4	0	
5	60	
6	0	
7	75	
8	0	
9	75	
10	0	
11	75	Paused measurements, having pensile break test. Wave filter has been changed
12	0	
13	100	Mistake in loading, Additional load of 10 kN during unloading
14	0	
15	100	
16	0	
17	100	
18	0	
19	125	
20	0	
21	125	
22	0	
23	125	
24	0	
25	150	
26	0	
27	150	
28	0	
29	150	
30	0	
31	175	
32	0	
33	175	
34	0	
35	175	
36	0	
37	200	
38	0	
39	200	
40	0	
41	200	
42	0	Pencil break test
43	210.2	Shear failure after a few seconds

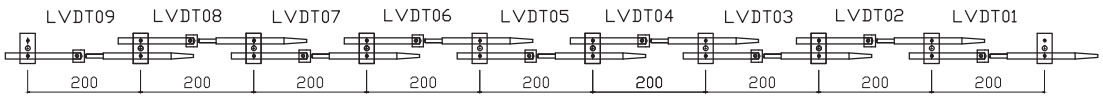


Fig. 5.96.3. LVDT layout and numbering for R501B1 beam

5.96.2. Measurement results

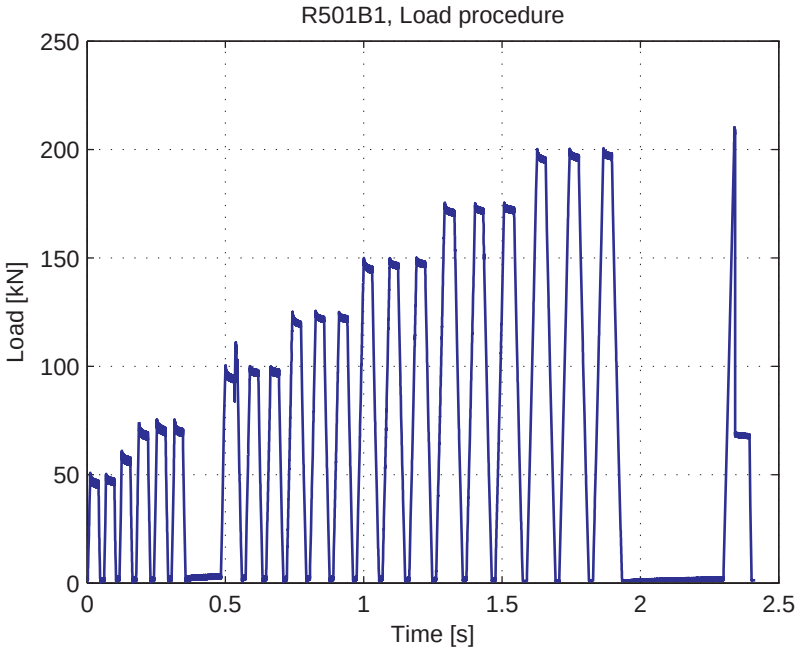


Fig. 5.96.4. Load-Time curve

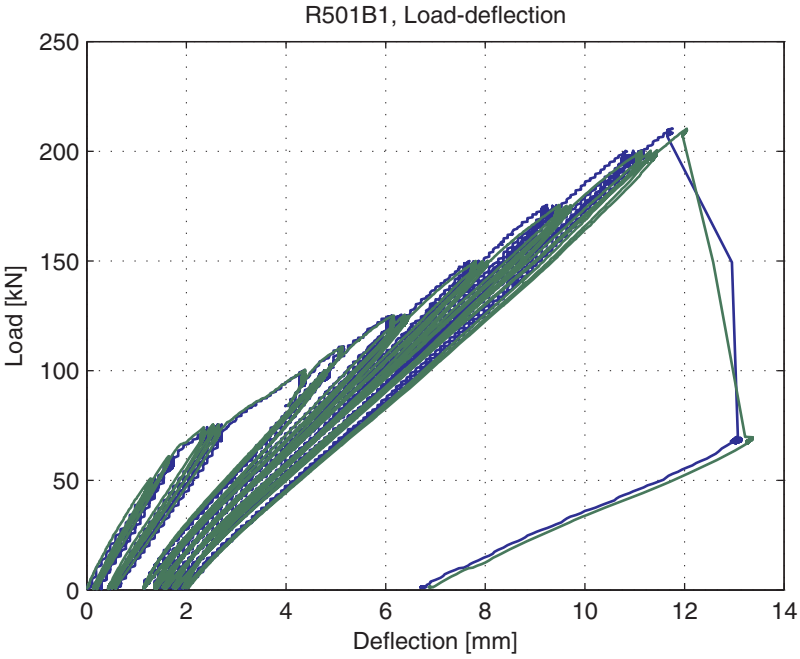


Fig. 5.96.5. Load-deflection curve

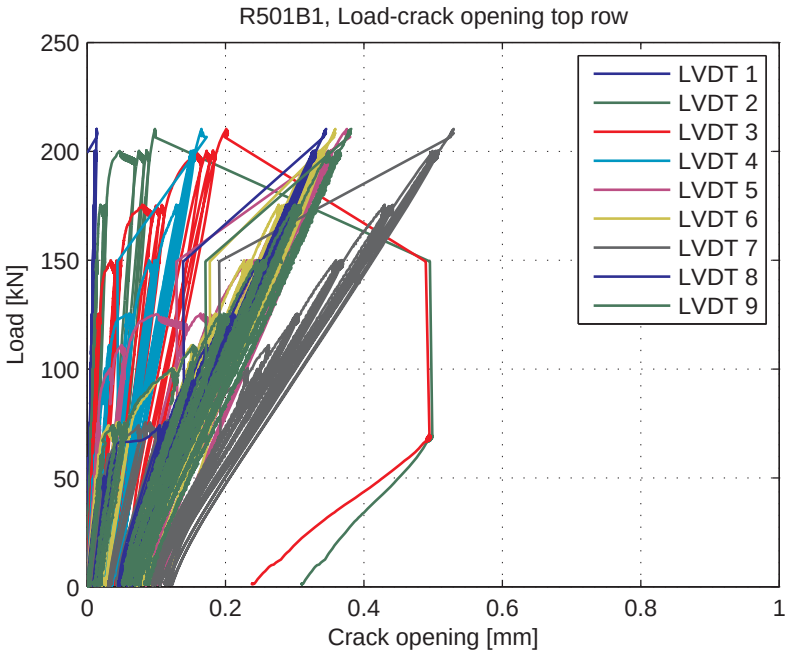


Fig. 5.96.6. Load-Crack opening for LVDT's 1-9

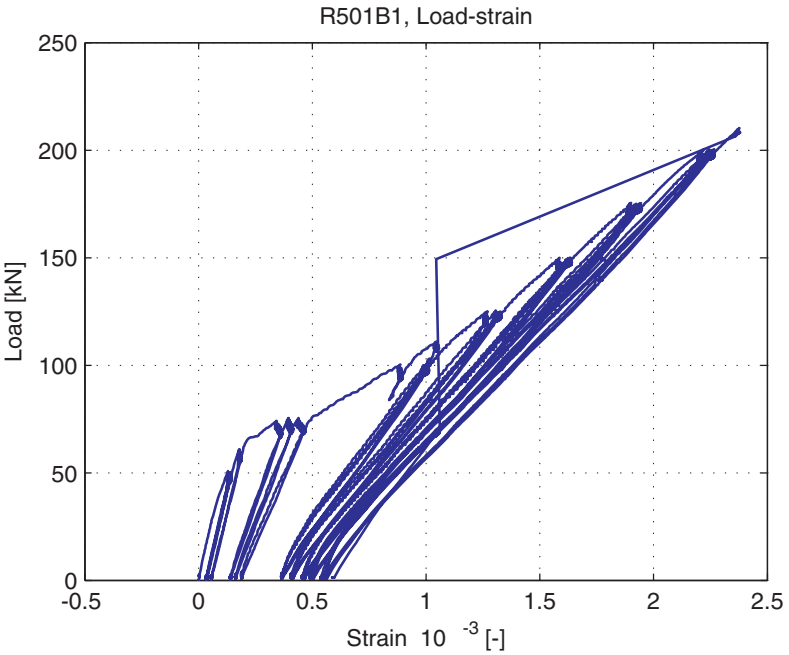


Fig. 5.96.7. Average strain over 1m length, measured at bottom of specimen (LVDT 10)

5.97. R502A1

5.97.1. Test properties

Fig. 5.97.1. Crack pattern after failure north side

Fig. 5.97.2. Crack pattern after failure south side

Table 5.97.1. Beam properties

Date of test	06-04-2016
Reinforcement	3Ø20 ribbed
Reinforcement ratio	0.68%
a	2000 mm
a / *d*	4.30
Concrete cube strength at testing	75.3 MPa
Peak load	173.1 kN
Failure mode	Flexural failure

Table 5.97.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Loaded at eastside of test specimen. Applied load cycles for Acoustic Emissions measurements
1	50	
2	0	
3	50	
4	0	
5	50	
6	0	Laser 2 and 4 are reversed, changing calibration. Zeroed for both channels
7	75	
8	0	
9	75	
10	0	
11	75	
12	0	
13	1000	
14	0	
15	100	
16	0	
17	100	
18	0	
19	125	
20	0	
21	125	
22	0	
23	125	
24	0	
25	150	
26	0	
27	150	
28	0	
29	150	
30	0	
31	178.3	Yielding at 173 kN, stopped after displacement of 25 mm for laser 4

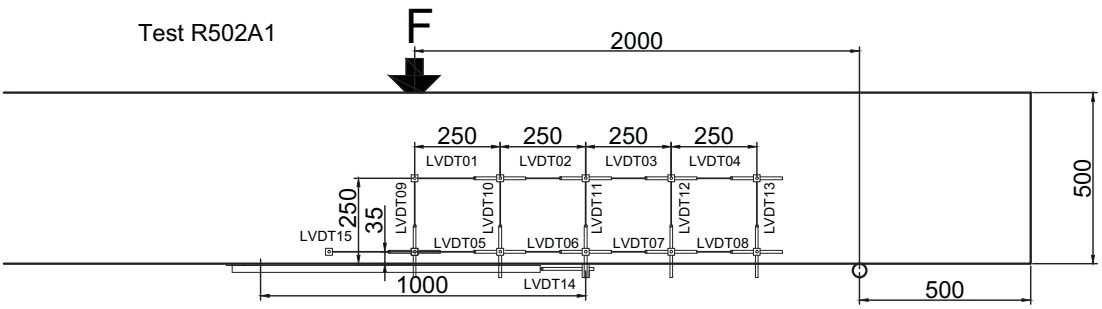


Fig. 5.97.3. LVDT layout and numbering for 500 mm deep beams for test R502A1

5.97.2. Measurement results

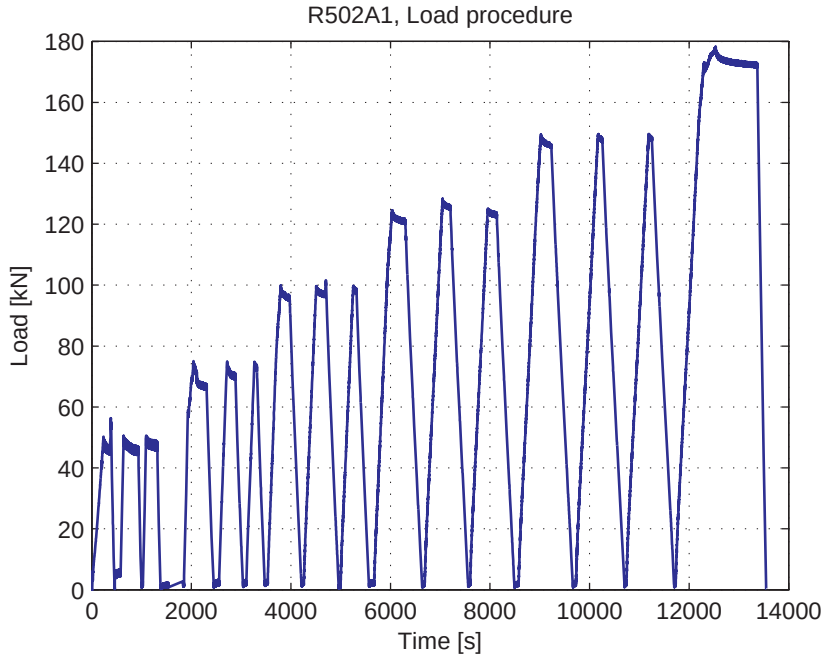


Fig. 5.97.4. Load-Time curve

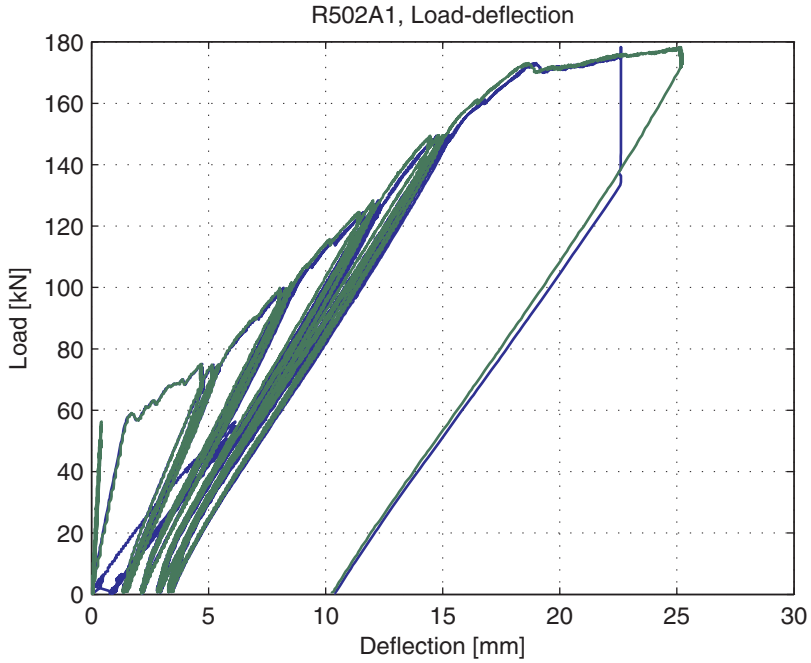


Fig. 5.97.5. Load-deflection curve

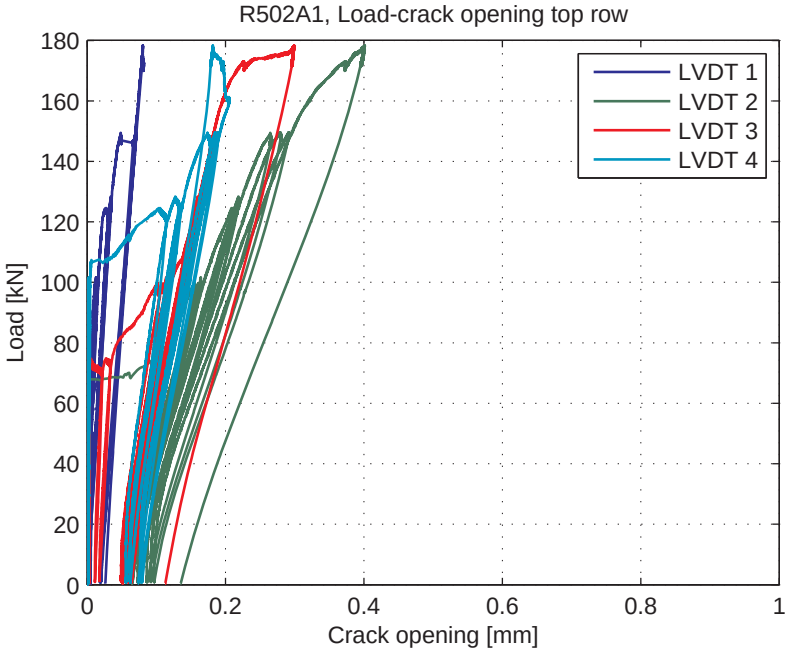


Fig. 5.97.6. Load-Crack opening for LVDT's 1-4 (top row)

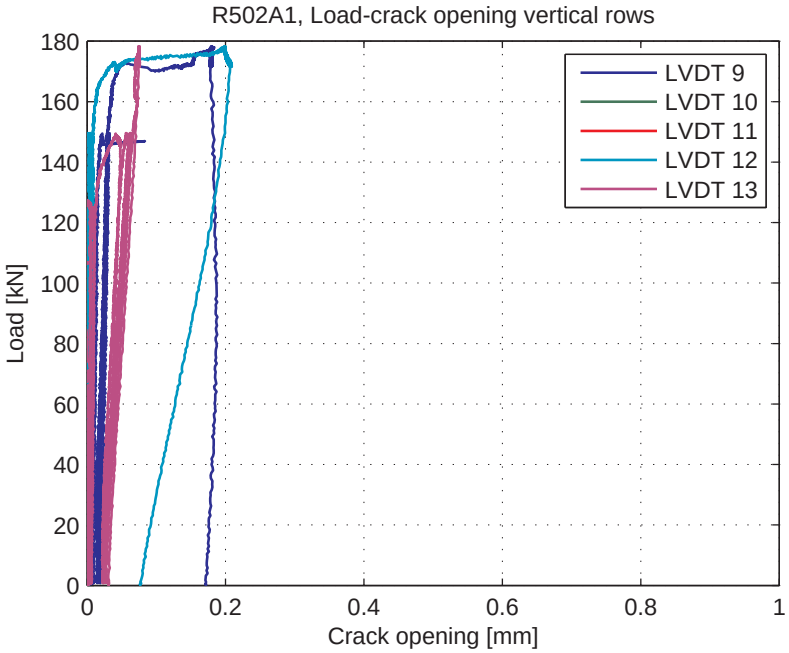


Fig. 5.97.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

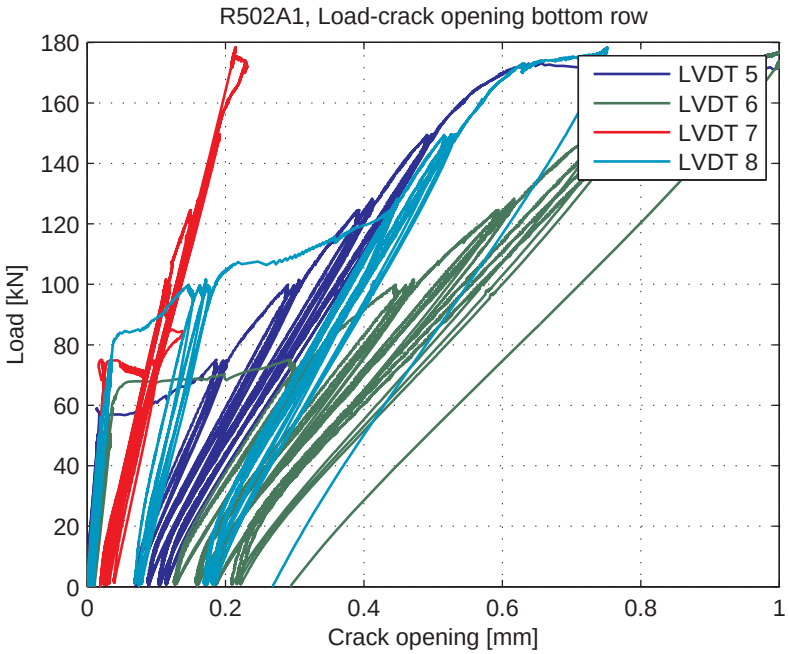


Fig. 5.97.8. Load-Crack opening for LVDT's 5-8 (bottom row)

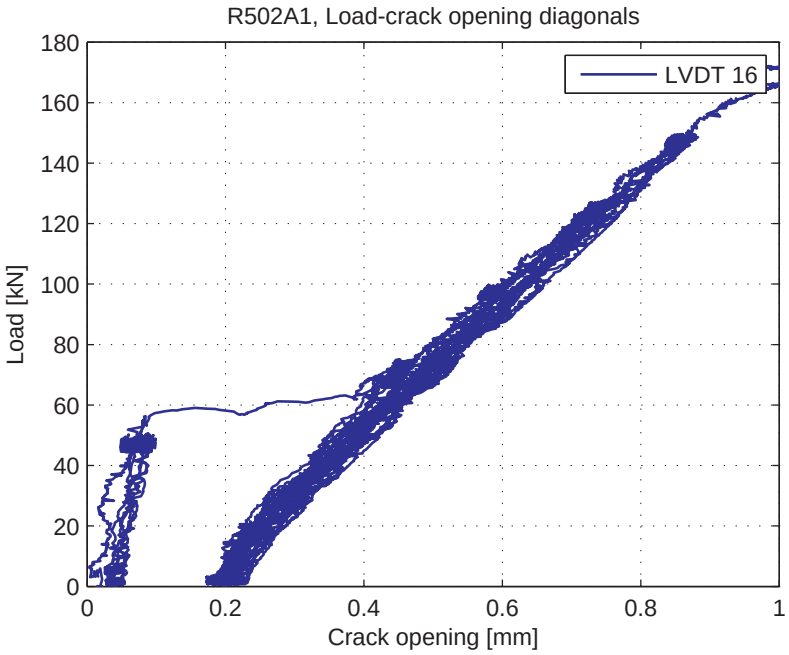


Fig. 5.97.9. Load-Crack opening for LVDT 16 (diagonal)

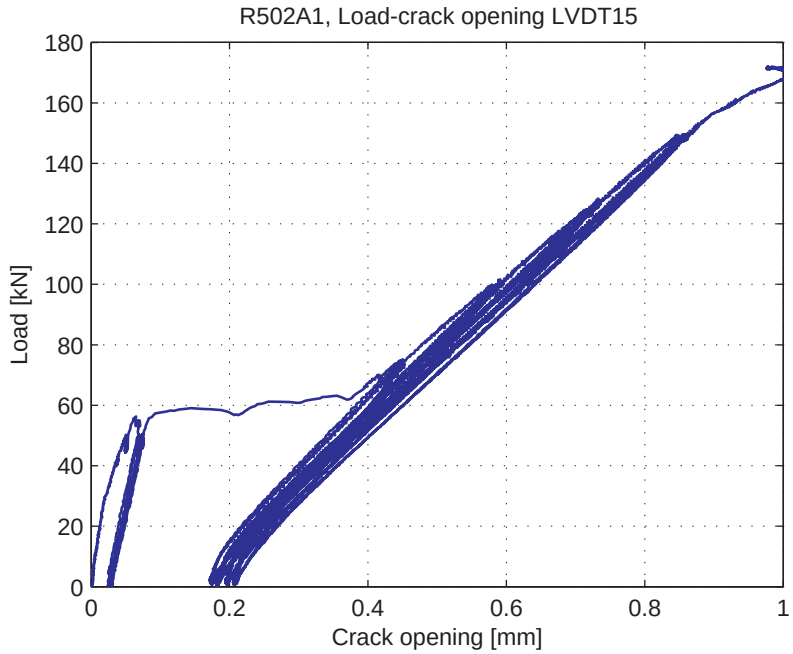


Fig. 5.97.10. Load-Crack opening for LVDT 15

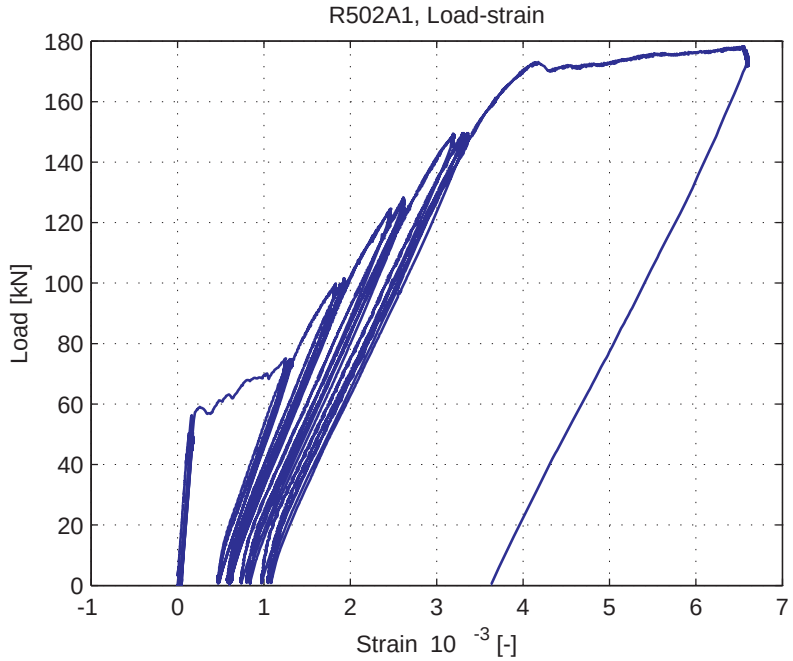


Fig. 5.97.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.98. R502A2

5.98.1. Test properties

Fig. 5.98.1. Crack pattern after failure north side

Table 5.98.1. Beam properties

Date of test	12-04-2016
Reinforcement	3Ø20 ribbed
Reinforcement ratio	0.68%
a	1600 mm
a / *d*	3.44
Concrete cube strength at testing	75.6 MPa
Peak load	163.9 kN
Failure mode	Shear

Table 5.98.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emissions measurements. Rearranged LVDT layout. No 1m lvdt.
1	50	
2	0	
3	50	
4	0	
5	50	
6	0	
7	75	
8	0	
9	75	
10	0	
11	75	
12	0	
13	100	
14	0	
15	100	
16	0	
17	100	
18	0	
19	125	
20	0	
21	125	
22	0	
23	125	
24	0	
25	150	
26	0	
27	150	
28	0	
29	150	
30	0	Stopped and restarted test
31	150	
32	163.9	Shear failure

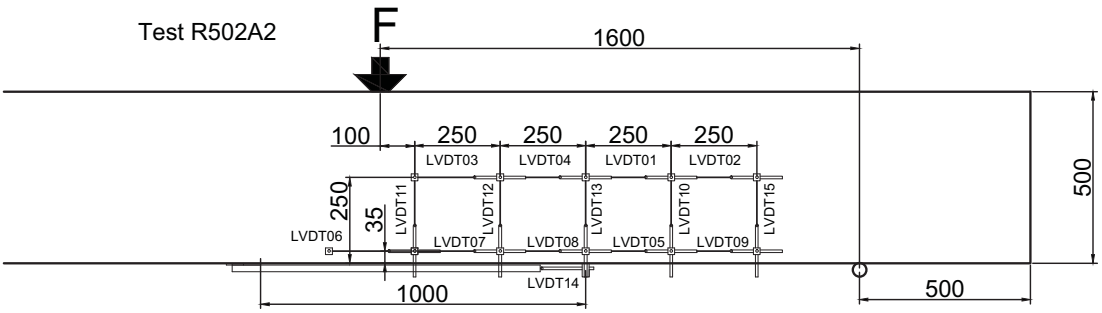


Fig. 5.98.2. LVDT layout and numbering for 500 mm deep beams for test R502A2

5.98.2. Measurement results

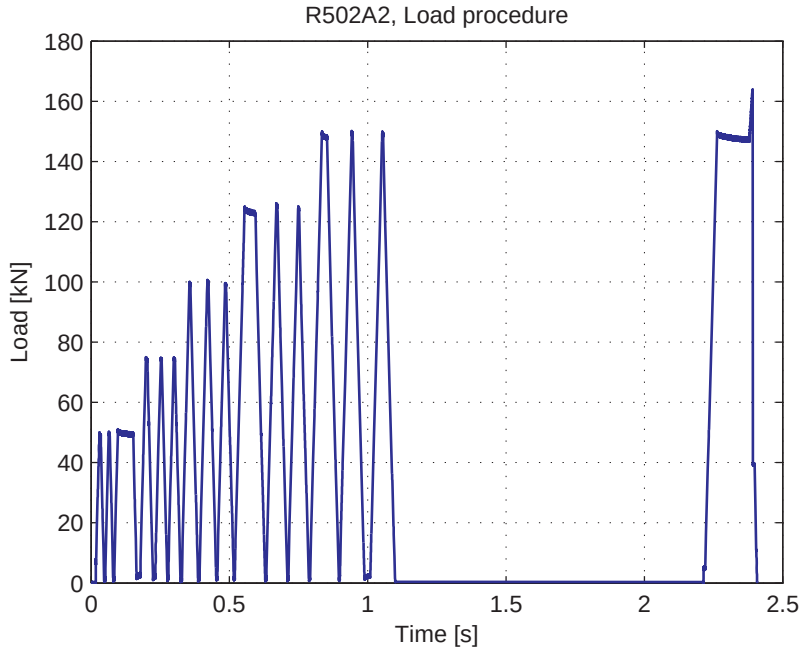


Fig. 5.98.3. Load-Time curve

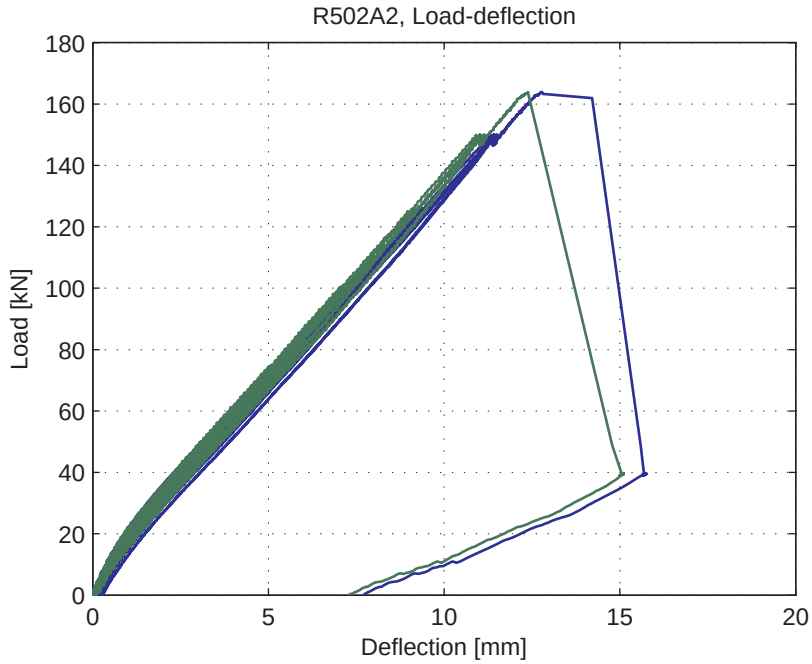


Fig. 5.98.4. Load-deflection curve

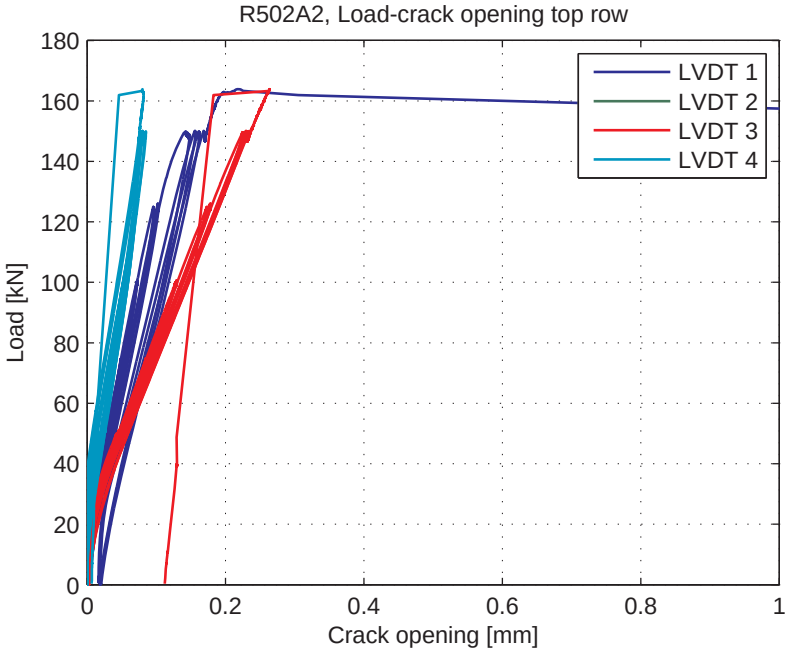


Fig. 5.98.5. Load-Crack opening for LVDT's 1-4 (top row)

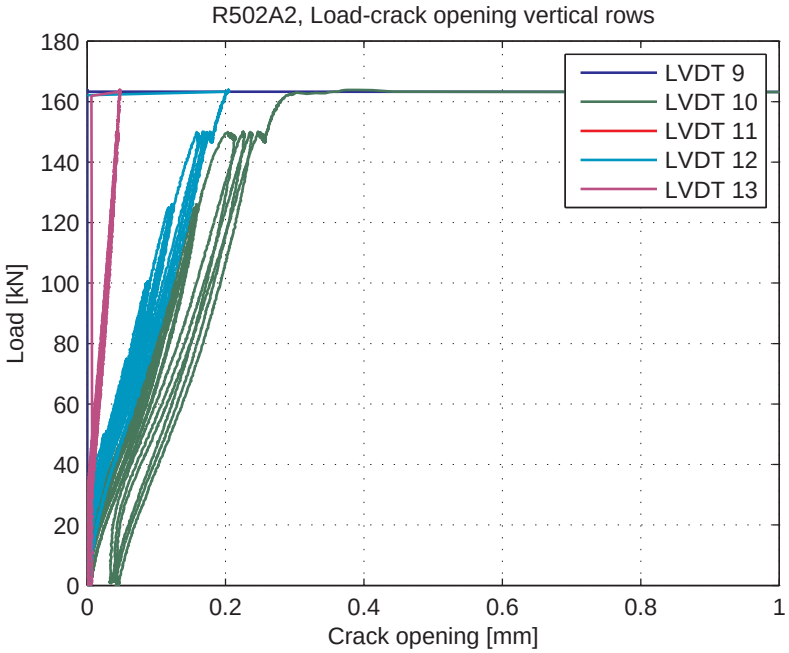


Fig. 5.98.6. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

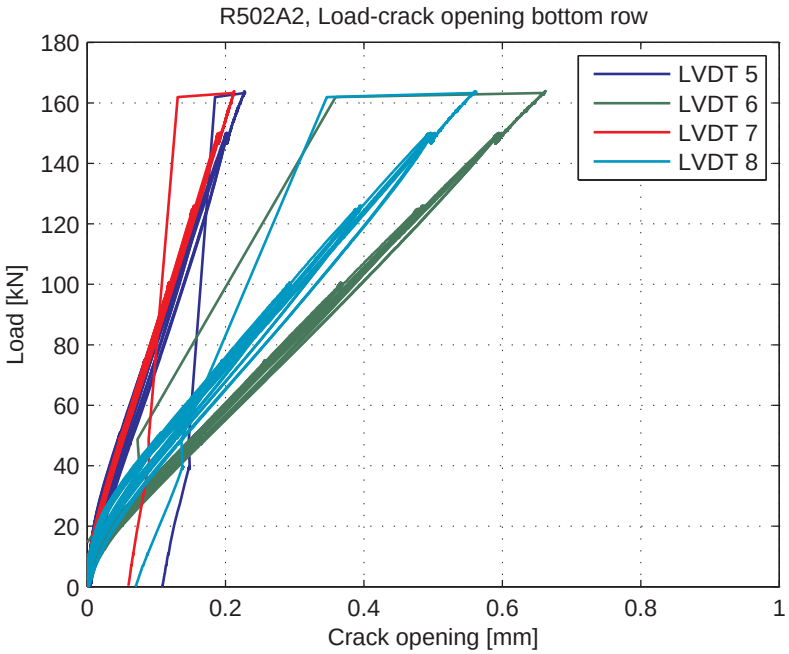


Fig. 5.98.7. Load-Crack opening for LVDT's 5-8 (bottom row)

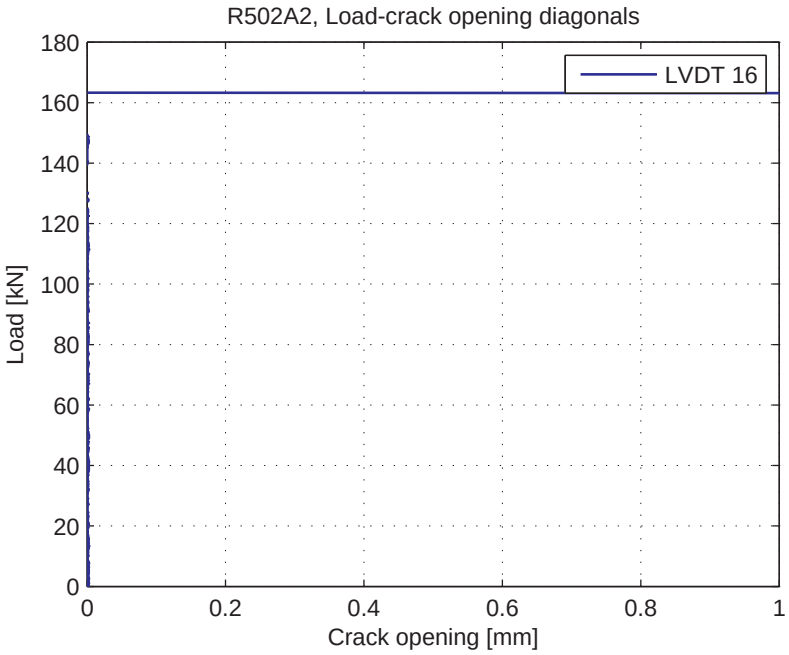


Fig. 5.98.8. Load-Crack opening for LVDT 16 (diagonal)

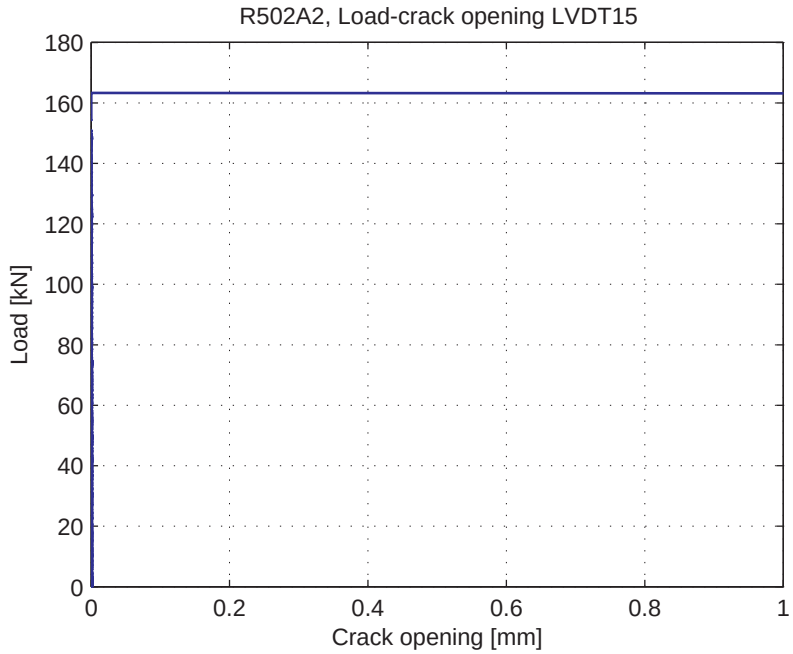


Fig. 5.98.9. Load-Crack opening for LVDT 15

5.99. R502B1

5.99.1. Test properties

Fig. 5.99.1. Crack pattern after failure east side

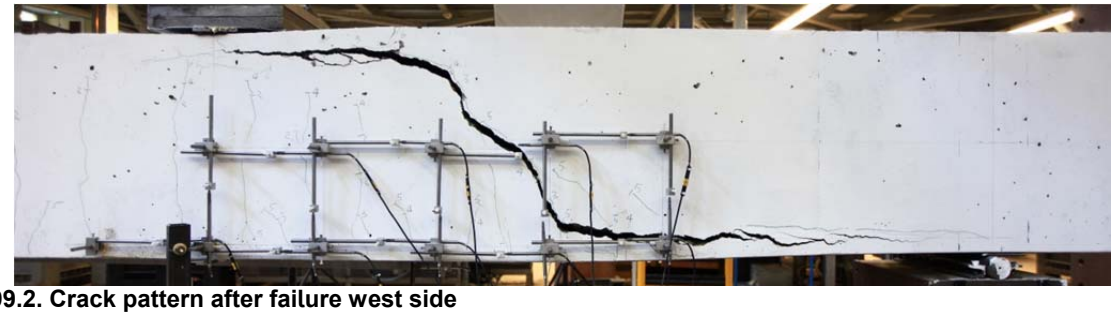


Fig. 5.99.2. Crack pattern after failure west side

Table 5.99.1. Beam properties

Date of test	19-04-2016
Reinforcement	3Ø20 ribbed
Reinforcement ratio	0.68%
a	1750 mm
a / *d*	3.76
Concrete cube strength at testing	77.1 MPa
Peak load	154.9 kN
Failure mode	Shear

Table 5.99.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Start of test
1	50	Turn on filter low pass 5Hz for LVDT 09, 10, 12, 13 and 15
2	75	
3	0	Stopped for fire alarm and restarted test after 45 min.
4	75	
5	100	
6	125	
7	150	
8	154.8	Shear failure

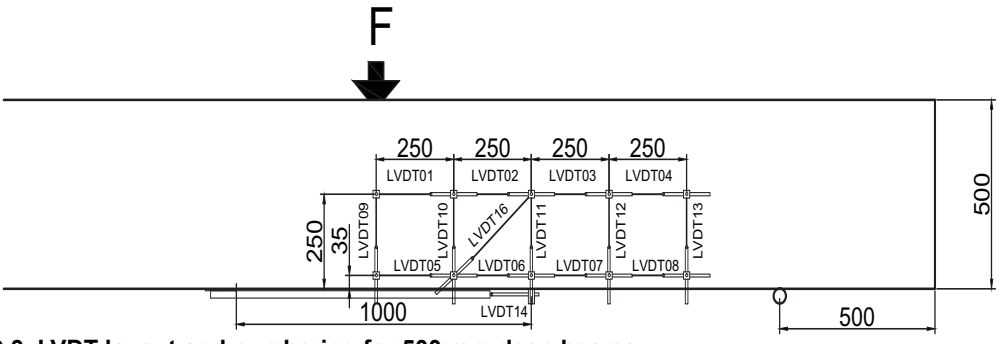


Fig. 5.99.3. LVDT layout and numbering for 500 mm deep beams

5.99.2. Measurement results

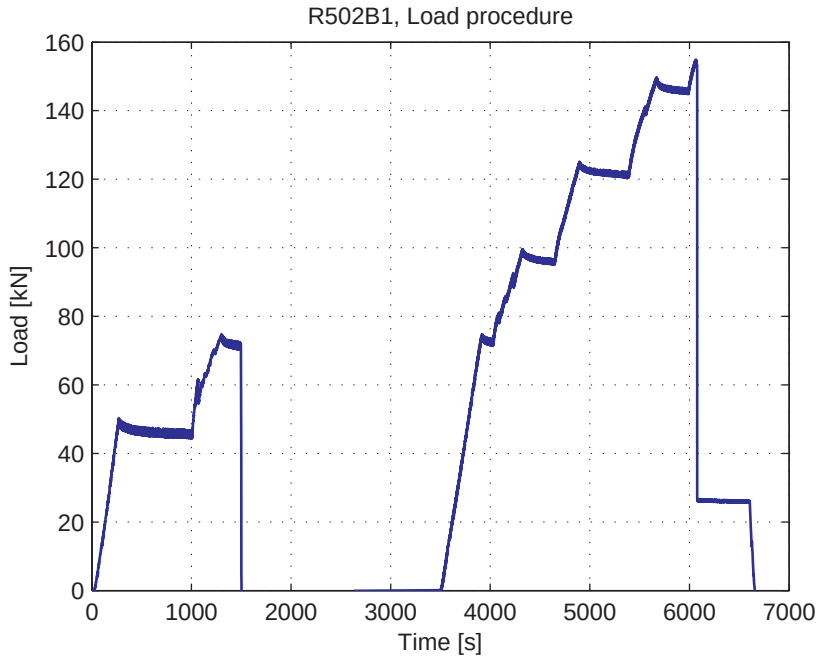


Fig. 5.99.4. Load-Time curve

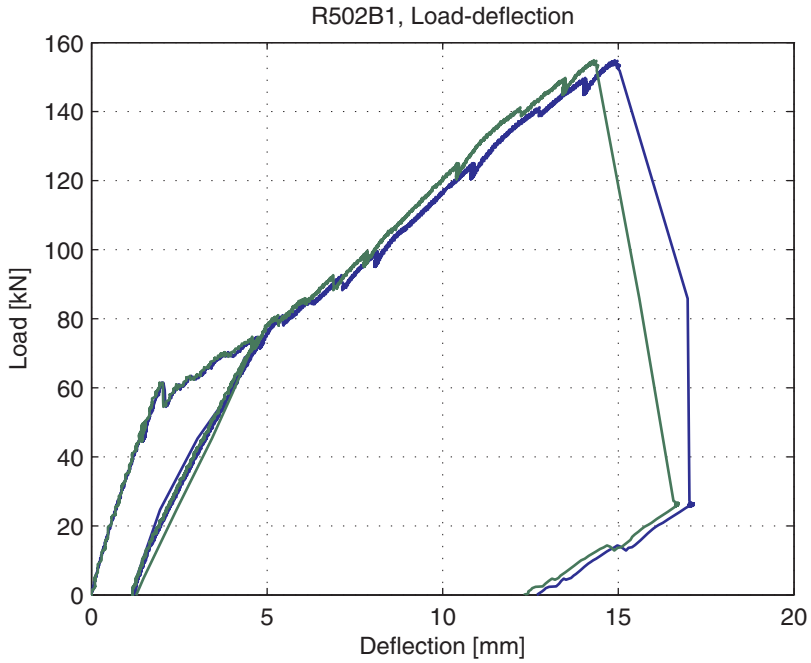


Fig. 5.99.5. Load-deflection curve

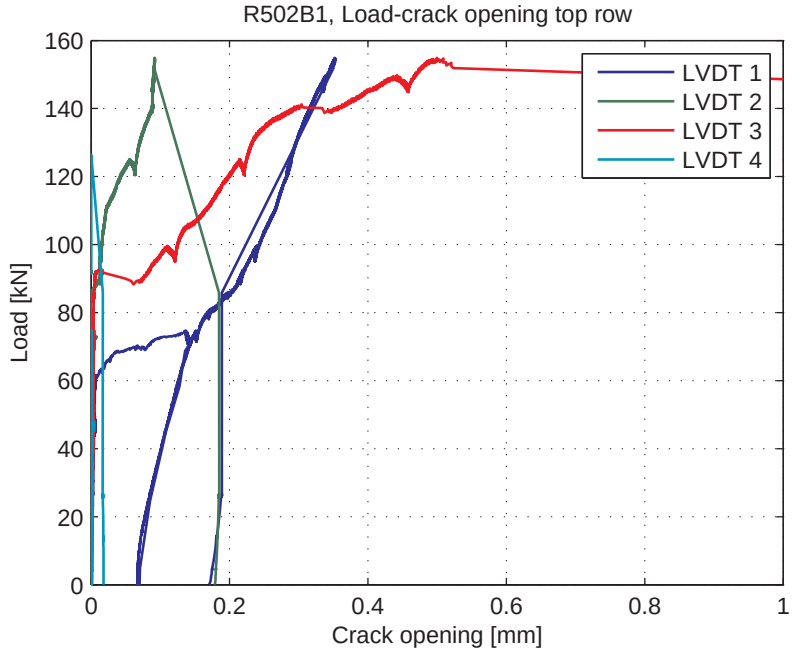


Fig. 5.99.6. Load-Crack opening for LVDT's 1-4 (top row)

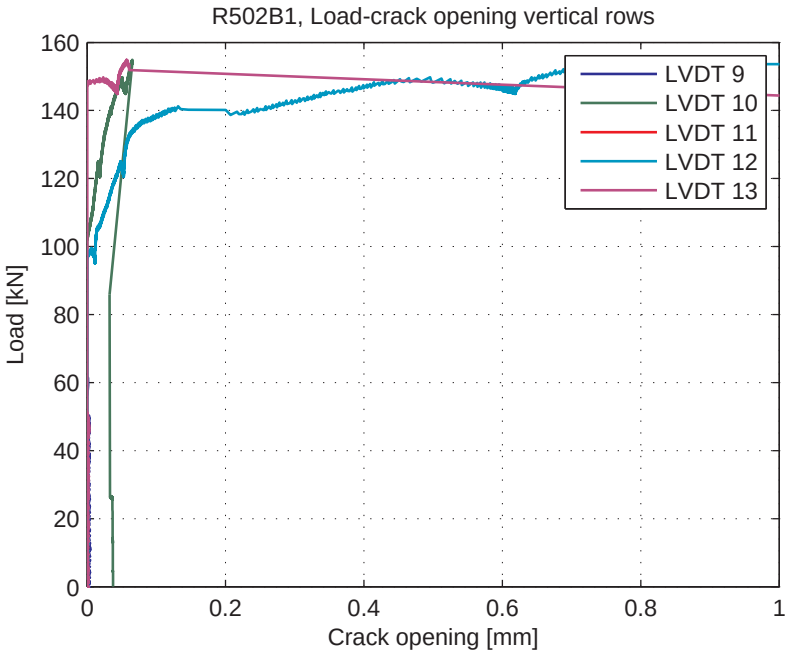


Fig. 5.99.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

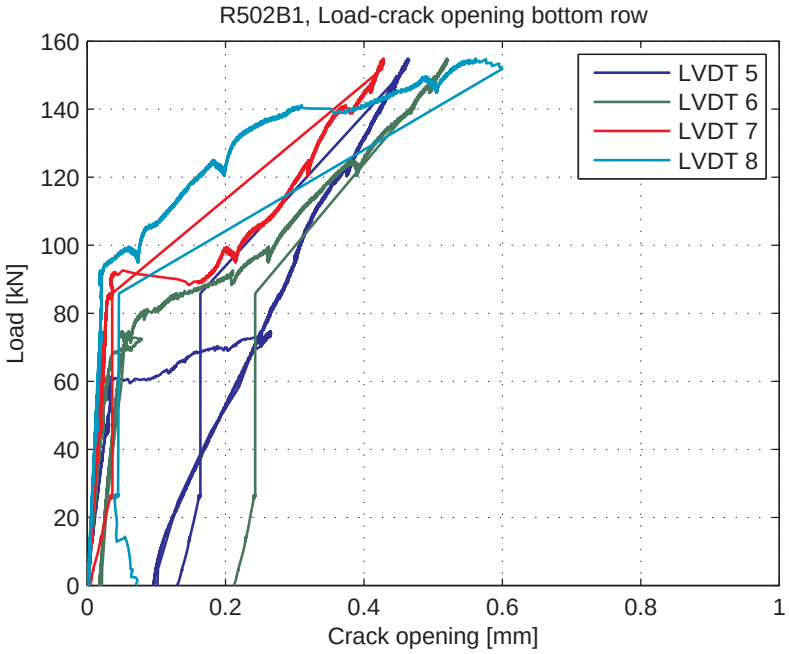


Fig. 5.99.8. Load-Crack opening for LVDT's 5-8 (bottom row)

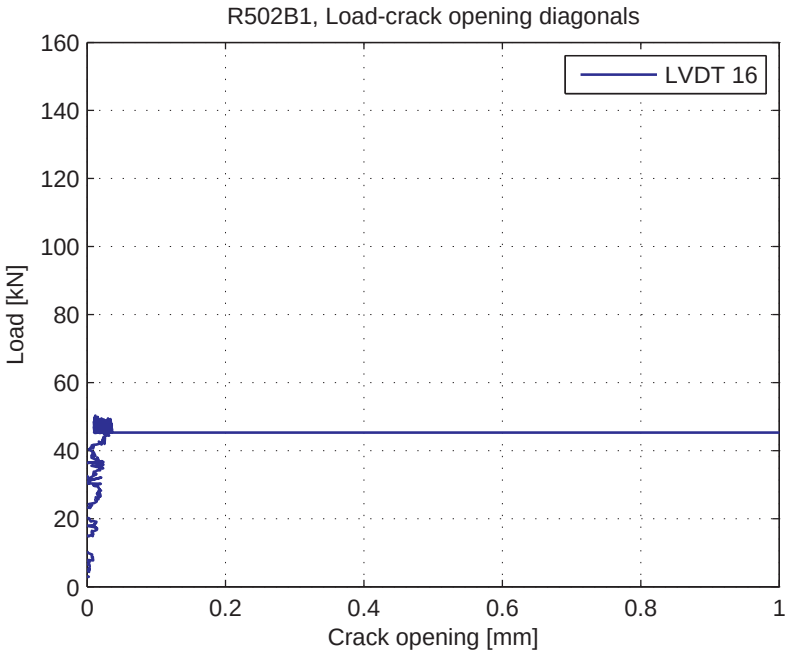


Fig. 5.99.9. Load-Crack opening for LVDT 16 (diagonal)

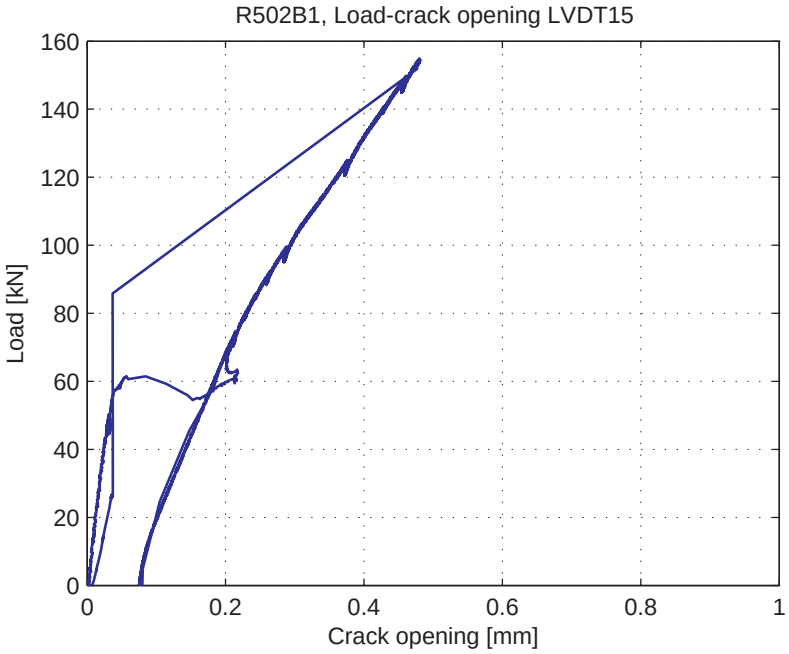


Fig. 5.99.10. Load-Crack opening for LVDT 15

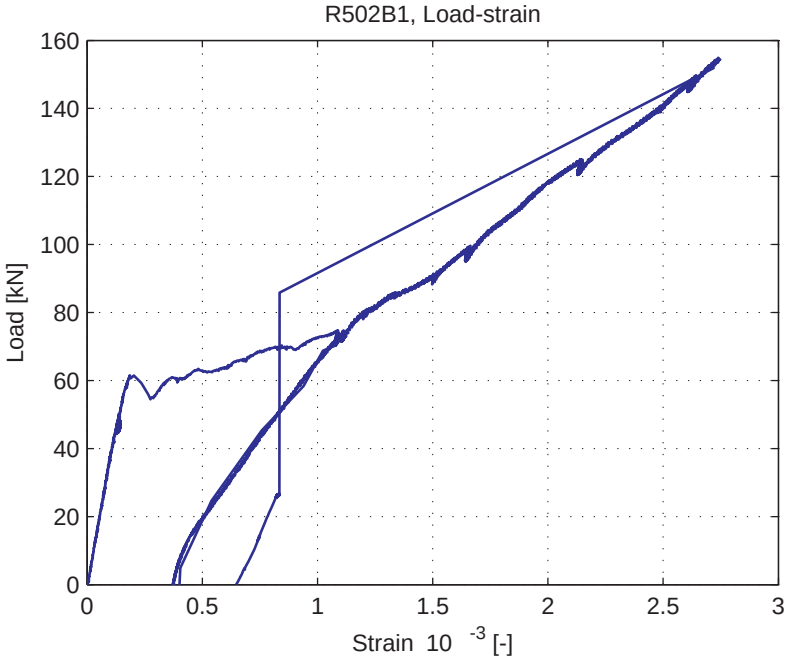


Fig. 5.99.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.100.R801A1

5.100.1. Test properties

Fig. 5.100.1. Crack pattern after failure north side

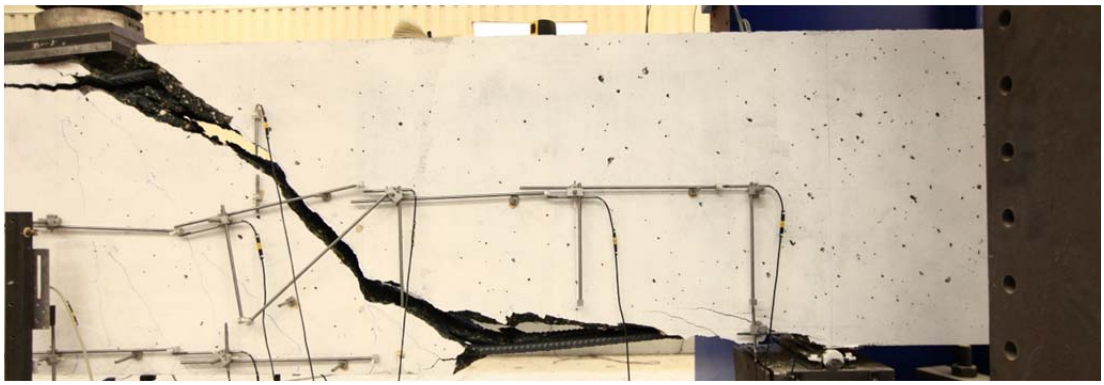


Fig. 5.100.2. Crack pattern after failure south side

Table 5.100.1. Beam properties

Date of test	16-12-2015
Reinforcement	3Ø25 ribbed
Reinforcement ratio	0.64%
a	2000 mm
a / *d*	2.62
Concrete cube strength at testing	84.0 MPa
Peak load	373.2 kN
Failure mode	Shear

Table 5.100.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	100	
3	150	
4	175	LVDT10 zeroed, placed LVDT 15
5	200	
6	250	First peak at 213 kN, developing pressure strut
7	275	
8	300	LVDT 16 moved to pressure zone, measuring length 100 mm. LVDT's 3 and 8 adjusted
9	0	LVDT16 zeroed
10	300	
11	350	
12	373,2	Shear failure

Table 5.100.3. Location LVDT's used for crack opening measurements

LVDT	Distance from support [mm]	Distance from bottom beam [mm]
15	1460	455

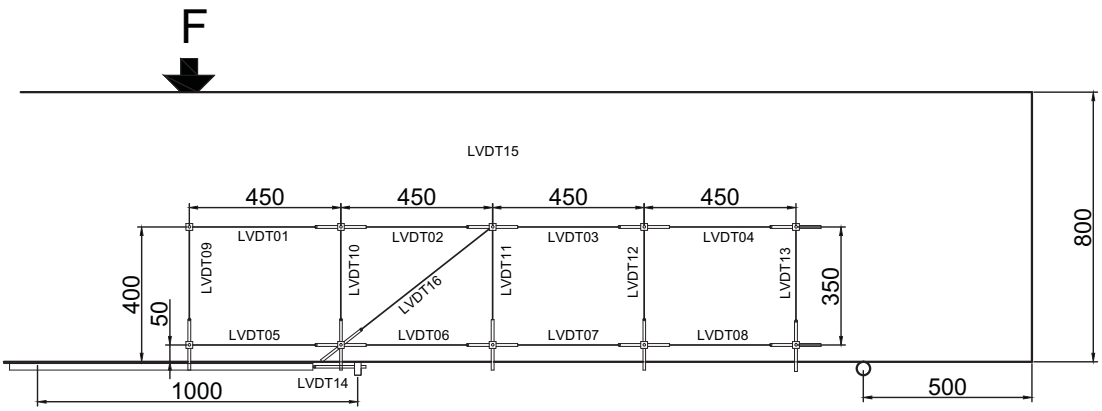


Fig. 5.100.3. LVDT layout and numbering for 800 mm deep beams

5.100.2. Measurement results

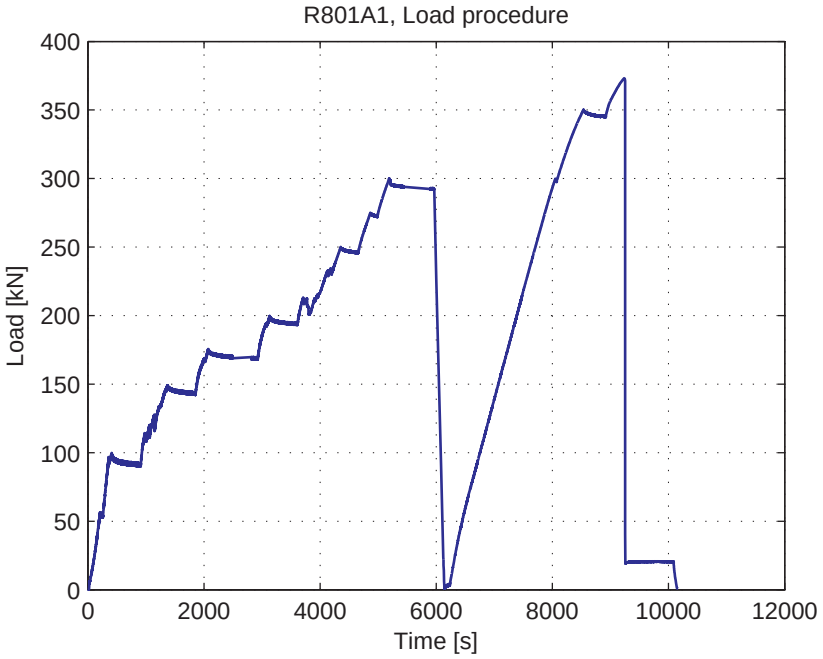


Fig. 5.100.4. Load-Time curve

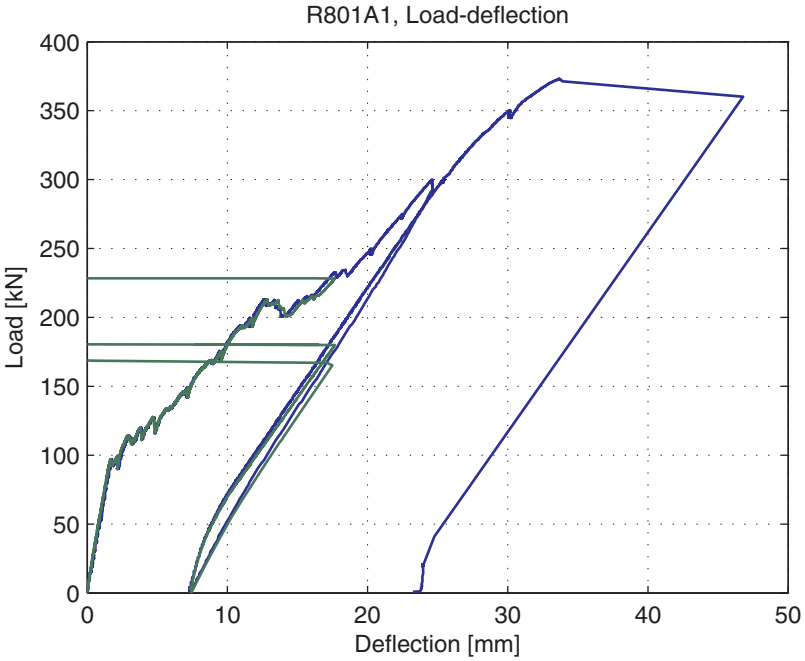


Fig. 5.100.5. Load-deflection curve

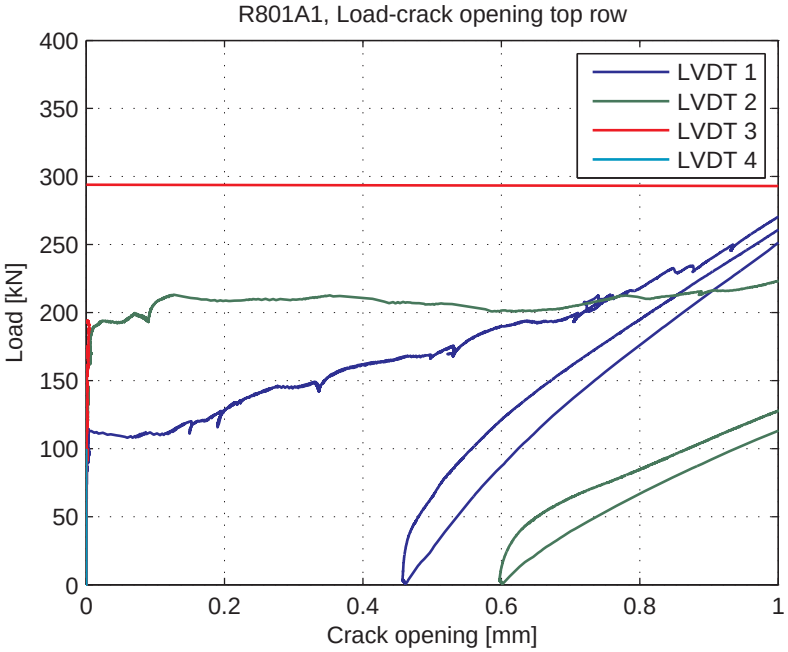


Fig. 5.100.6. Load-Crack opening for LVDT's 1-4 (top row)

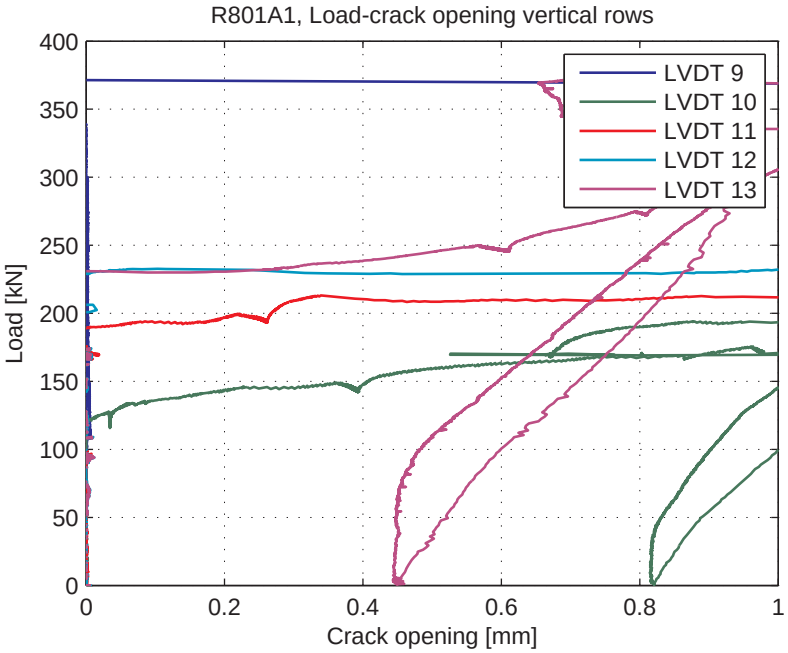


Fig. 5.100.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

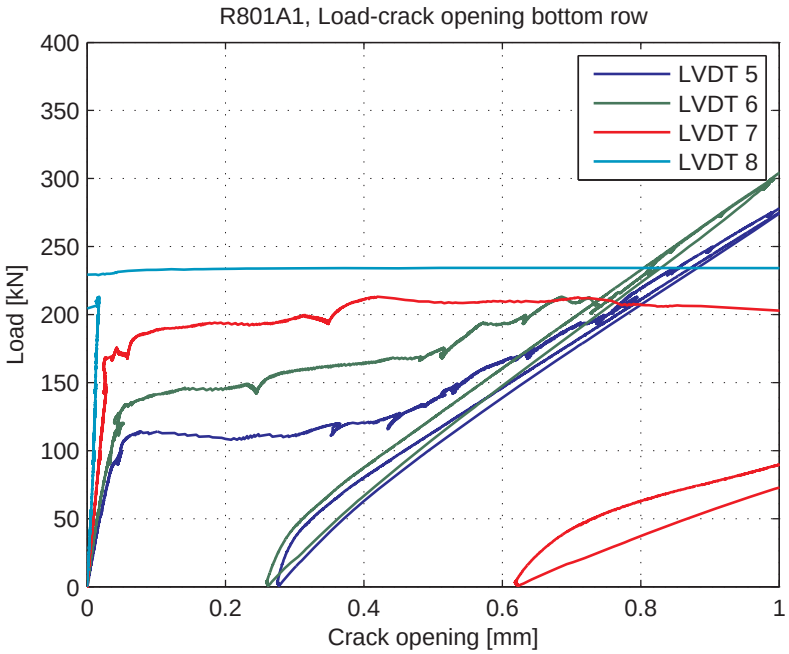


Fig. 5.100.8. Load-Crack opening for LVDT's 5-8 (bottom row)

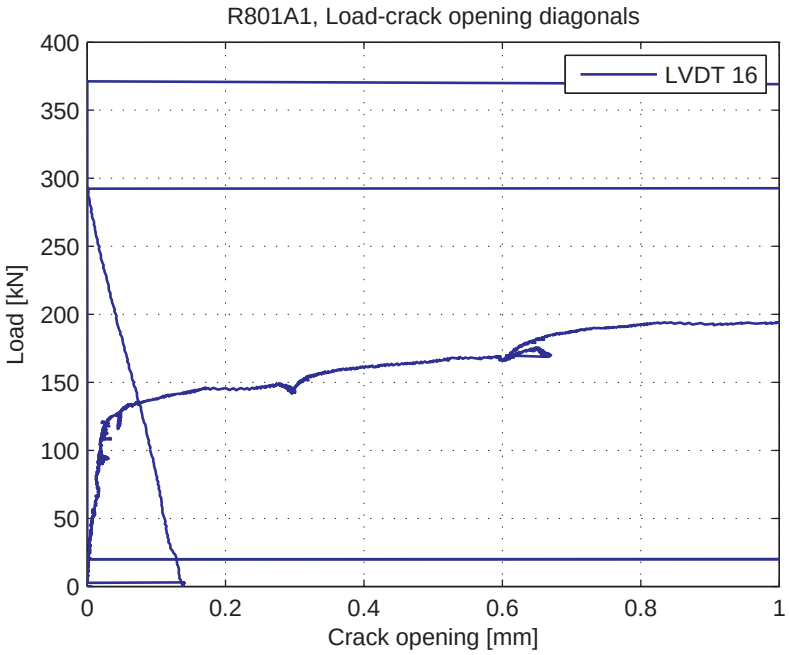


Fig. 5.100.9. Load-Crack opening for LVDT 16 (diagonal)

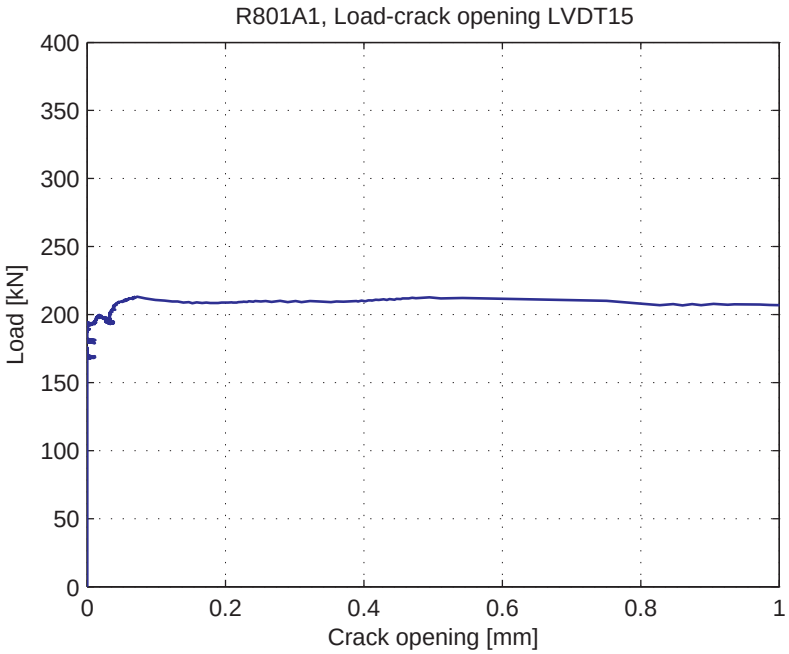


Fig. 5.100.10. Load-Crack opening for LVDT 15

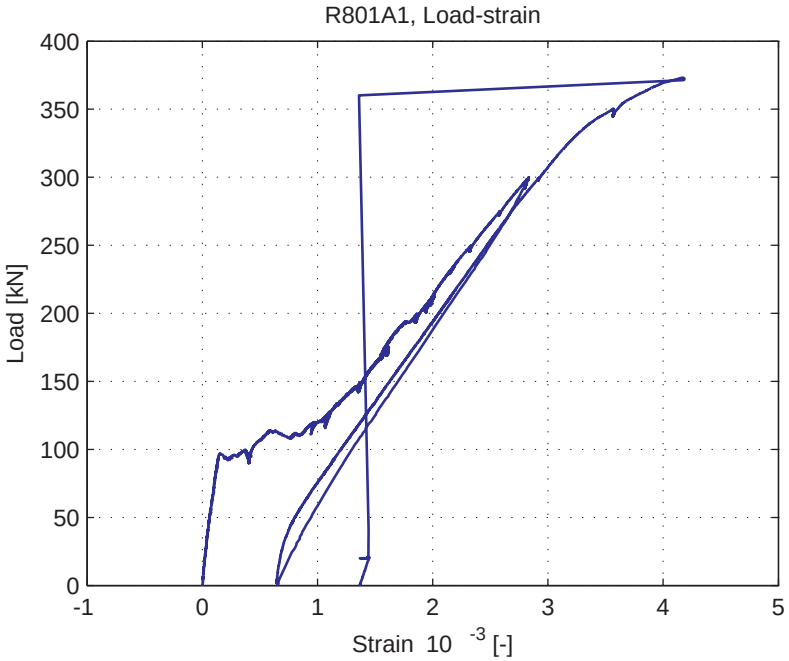


Fig. 5.100.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.101.R801B1

5.101.1. Test properties

Fig. 5.101.1. Crack pattern after failure east side

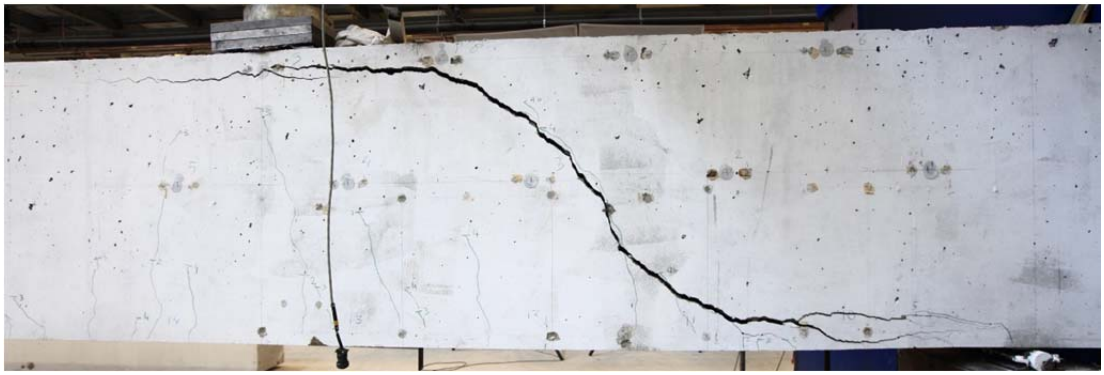


Fig. 5.101.2. Crack pattern after failure west side

Table 5.101.1. Beam properties

Date of test	25-05-2016
Reinforcement	3Ø25 ribbed
Reinforcement ratio	0.64%
a	2000
a / *d*	2.62
Concrete cube strength at testing	91.1 MPa
Peak load	204.8 kN
Failure mode	Shear

Table 5.101.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Support at 7.2m. Old crack damaged the beam to heavily for the support.
1	50	
2	0	
3	50	
4	0	
5	50	
6	0	
7	100	
8	0	Added LVDT 16, 100mm measuring length over crach under load.
9	100	
10	0	
11	100	
12	0	
13	150	
14	0	
15	150	
16	0	
17	150	
18	0	
19	200	
20	0	
21	200	
22	0	
23	200	
24	0	
25	200	
26	0	
27	230	Load was increased in steps of 10kN. The peak load was reached at 230kN. After that step, the load level dropped. Further increase of deflection resulted in shear failure at 219 kN.

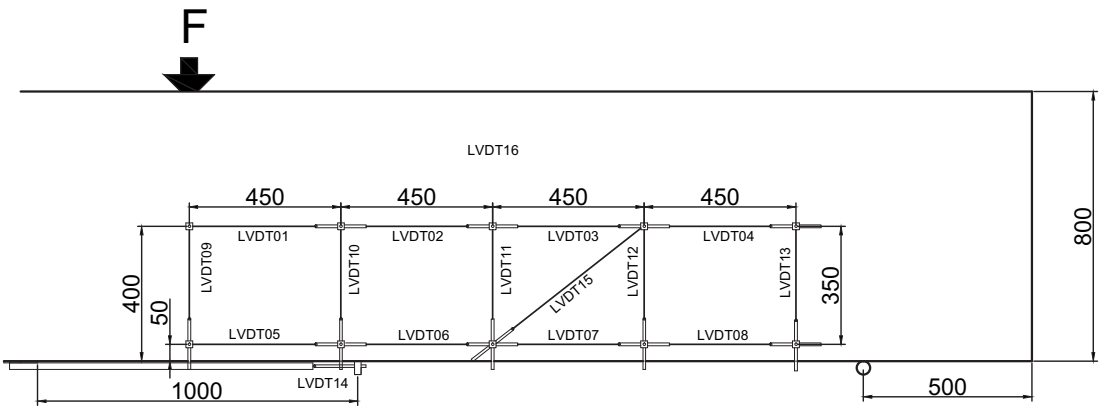


Fig. 5.101.3. LVDT layout and numbering for 800 mm deep beams

5.101.2. Measurement results

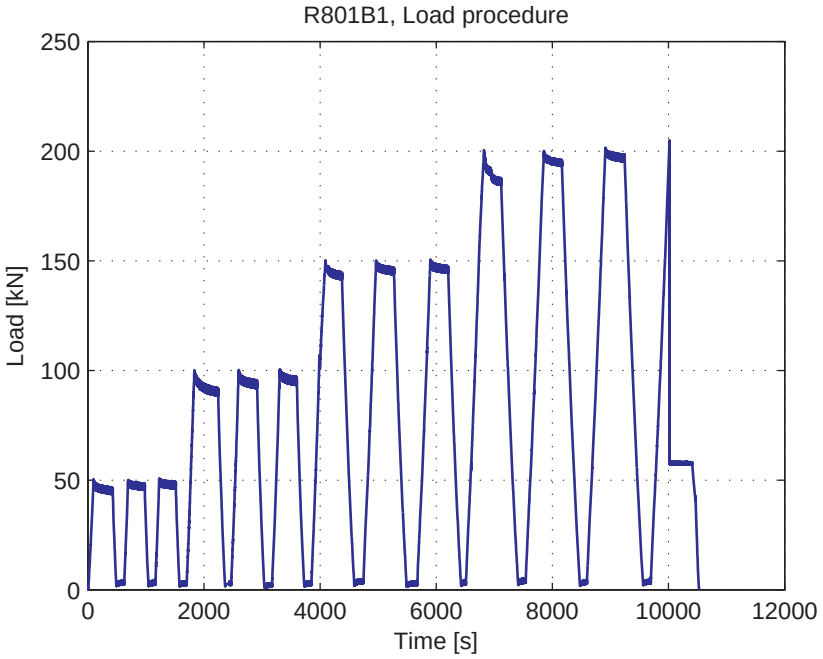


Fig. 5.101.4. Load-Time curve

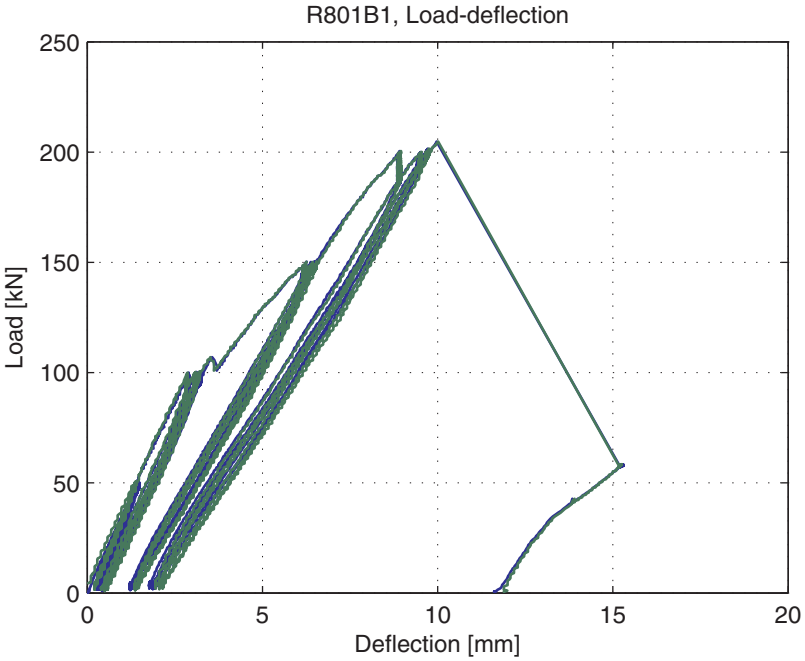


Fig. 5.101.5. Load-deflection curve

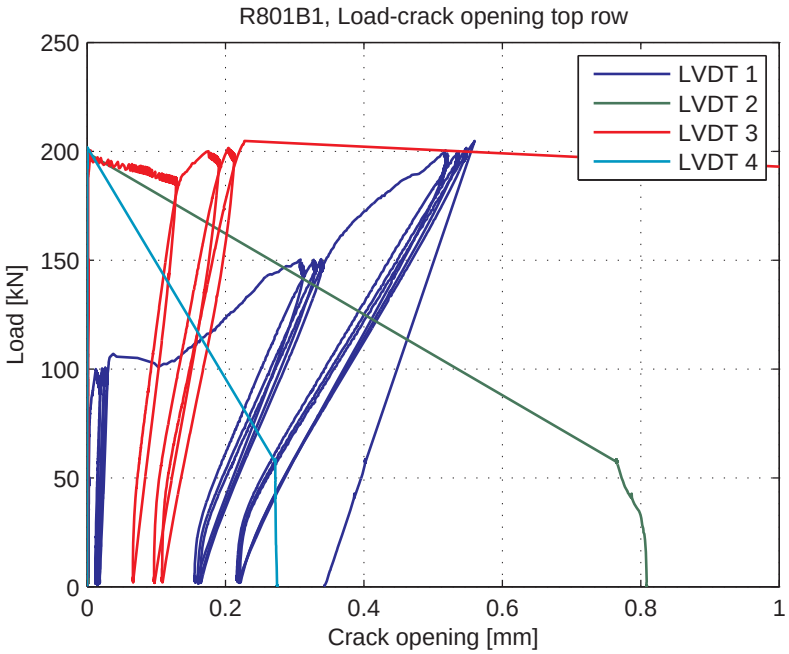


Fig. 5.101.6. Load-Crack opening for LVDT's 1-4 (top row)

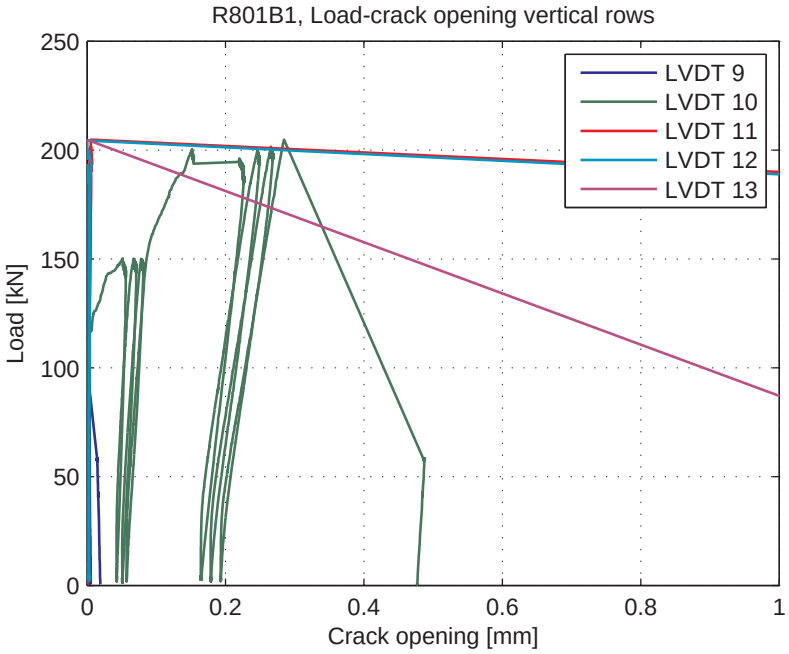


Fig. 5.101.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

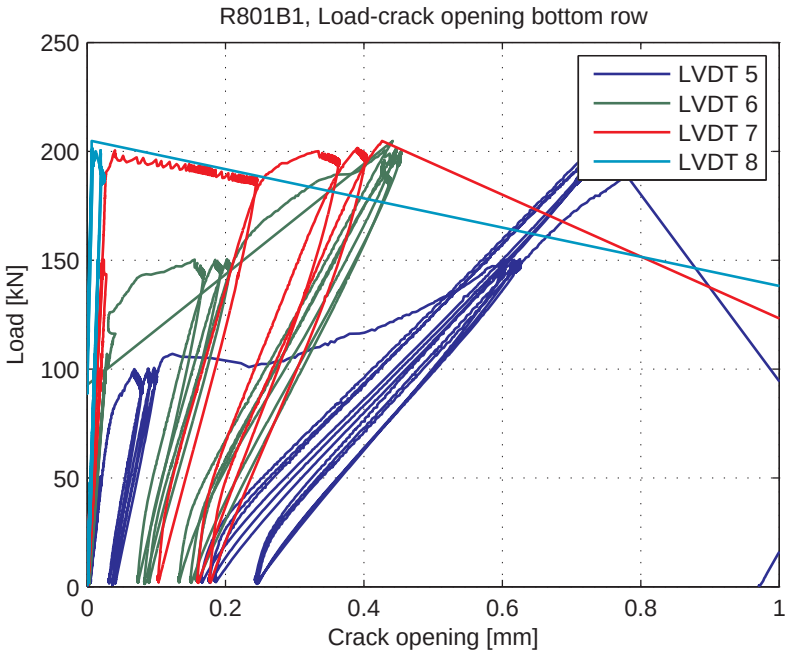


Fig. 5.101.8. Load-Crack opening for LVDT's 5-8 (bottom row)

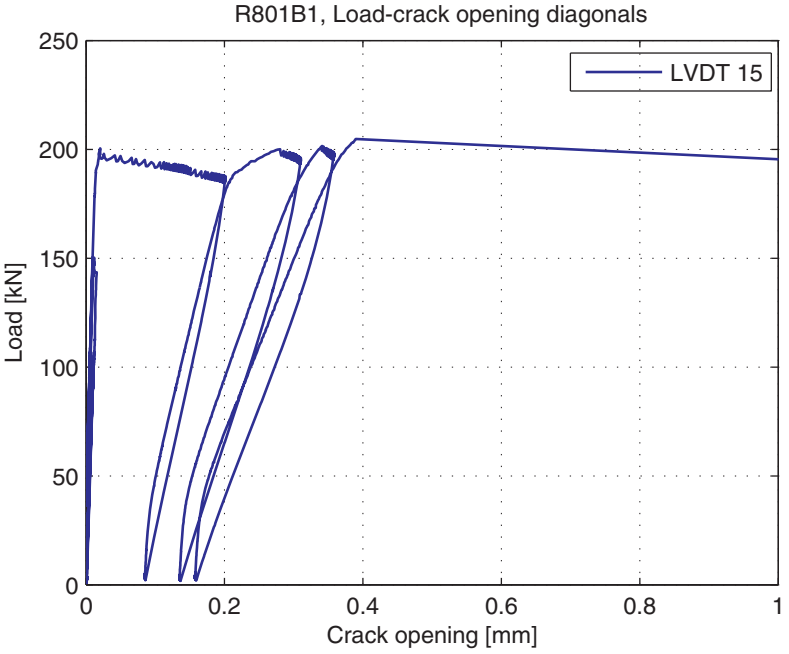


Fig. 5.101.9. Load-Crack opening for LVDT 16 (diagonal)

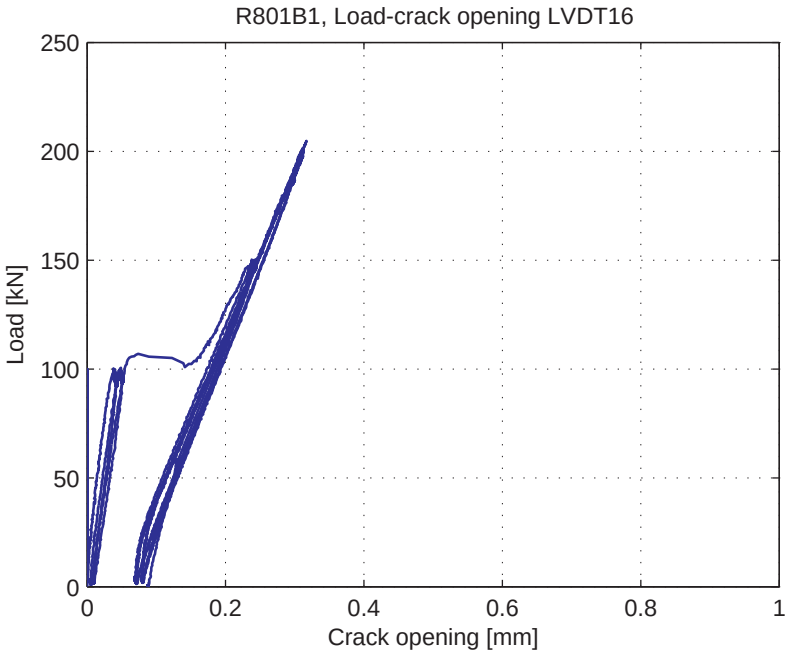


Fig. 5.101.10. Load-Crack opening for LVDT 16

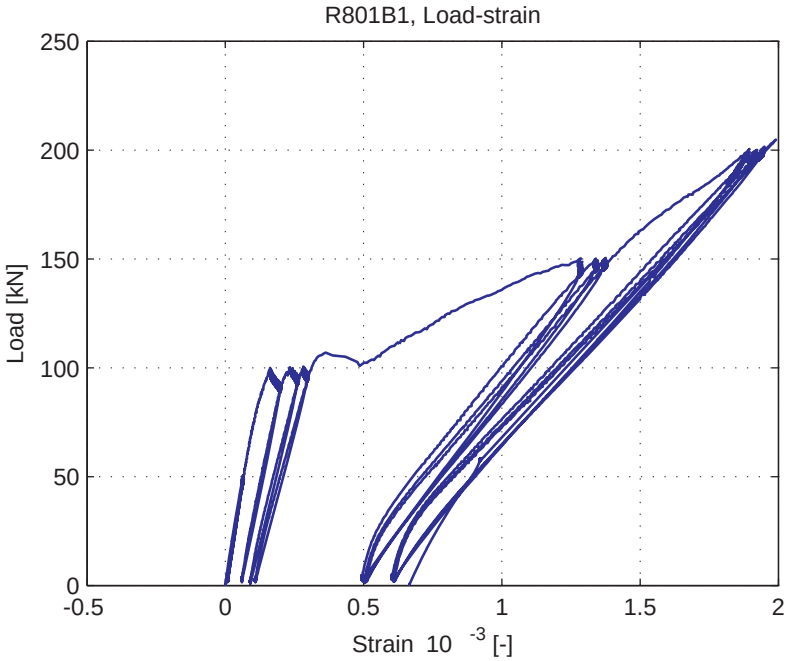


Fig. 5.101.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.102.R802A1

5.102.1. Test properties

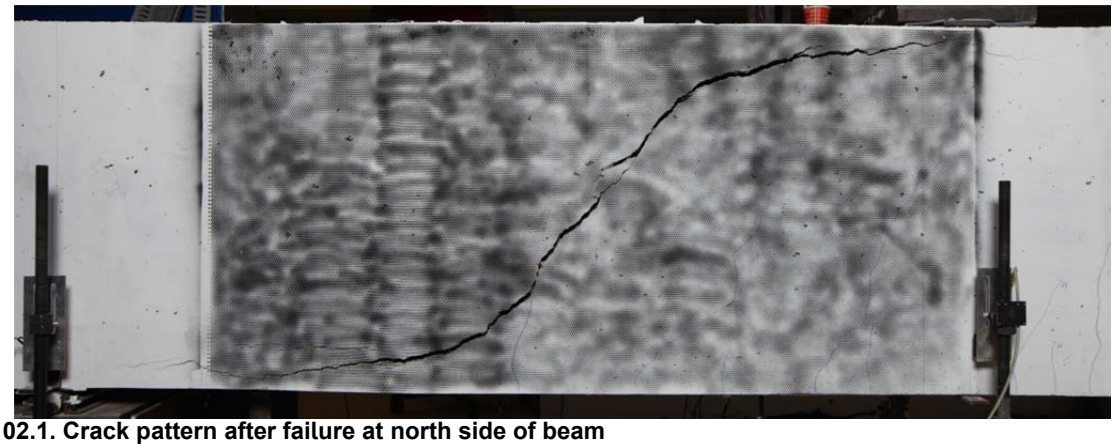


Fig. 5.102.1. Crack pattern after failure at north side of beam

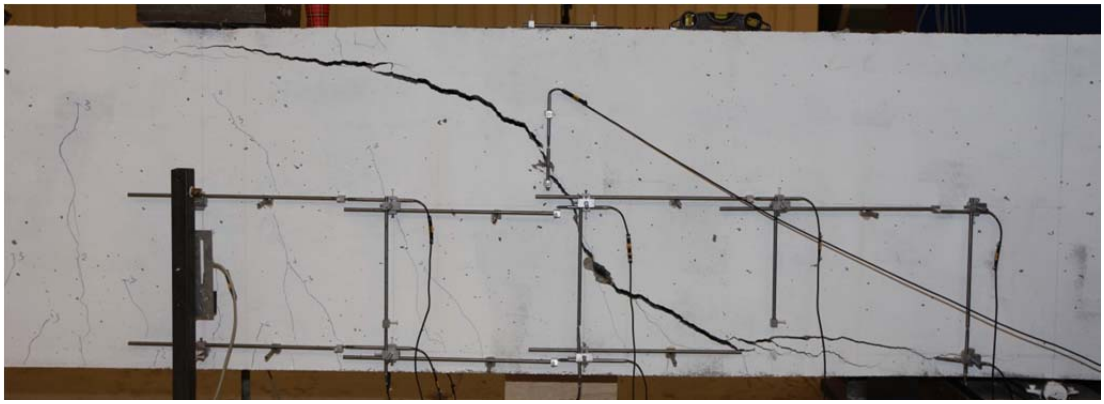


Fig. 5.102.2. Crack pattern after failure and LVDT layout at south side of beam

Table 5.102.1. Beam properties

Date of test	30-11-2015
Reinforcement	6Ø20 ribbed
Reinforcement ratio	0.83%
a	2000 mm
a / *d*	2.65
Concrete cube strength at testing	75.8 MPa
Peak load flexural / shear	219.4 kN
Failure mode	Shear

Table 5.102.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	100	
3	115	Testing of LVDT's, change of numbers, stopped measurements
4	150	
5	200	Added LVDT 16
6	0	Unloaded to 0kN, not measured
7	200	
8	219.4	Shear failure

Table 5.102.3. Location LVDT's used for crack opening measurements

LVDT	Distance from support [mm]	Distance from bottom beam [mm]
16	1190	450

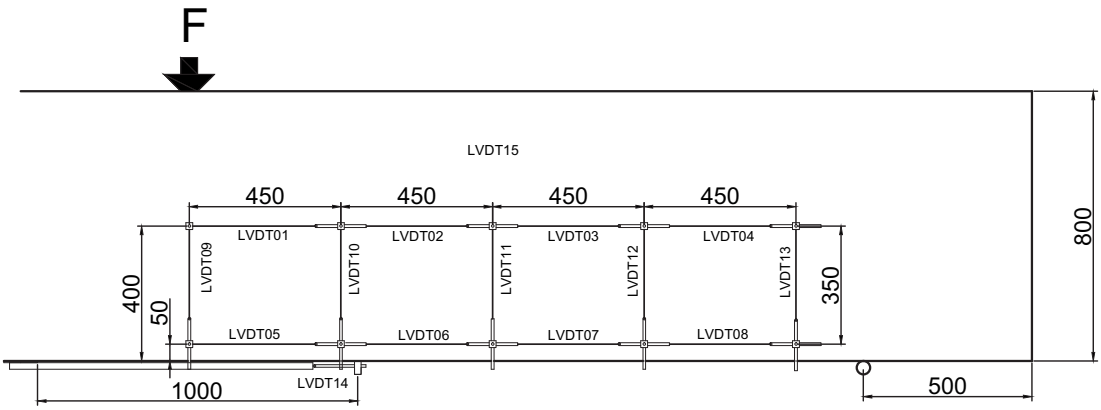


Fig. 5.102.3. LVDT layout and numbering for 800 mm deep beams

5.102.2. Measurement results

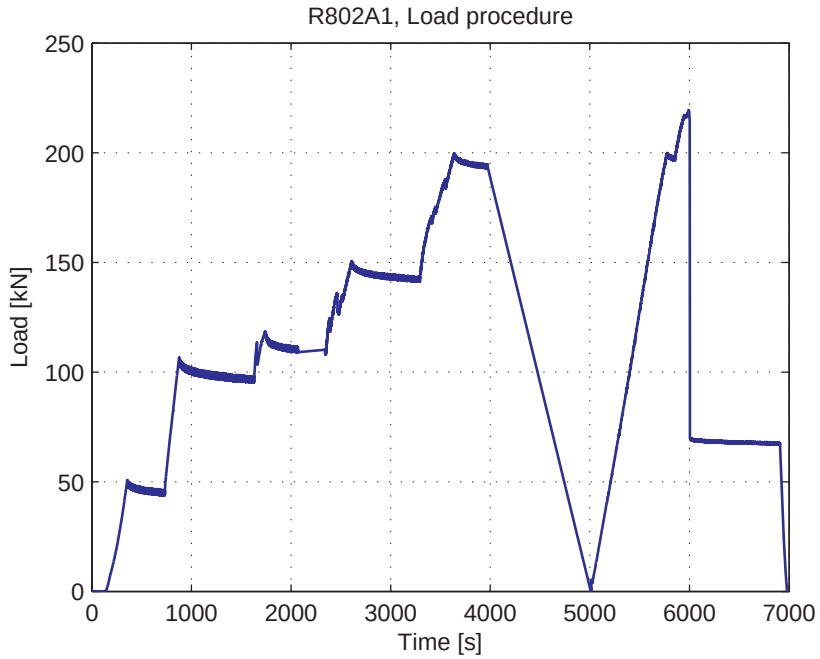


Fig. 5.102.4. Load-Time curve

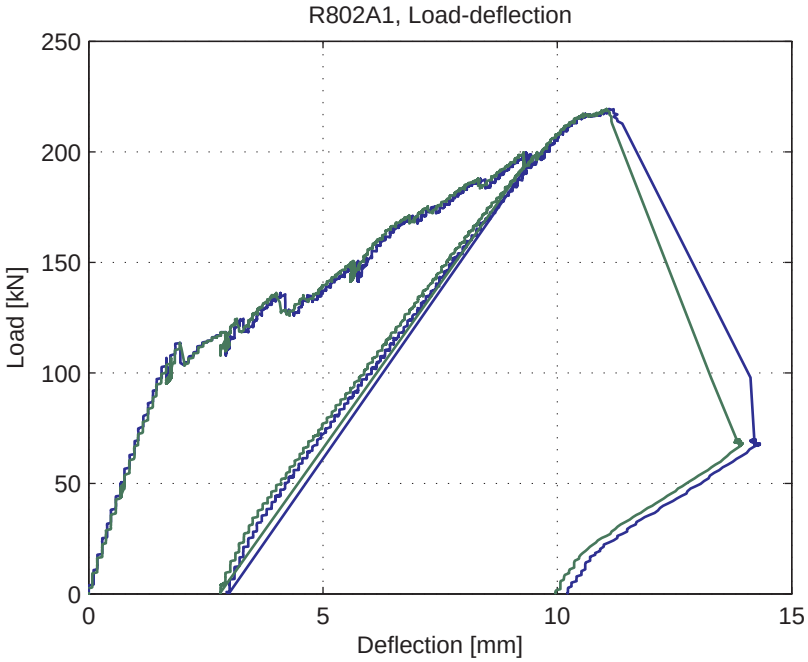


Fig. 5.102.5. Load-deflection curve

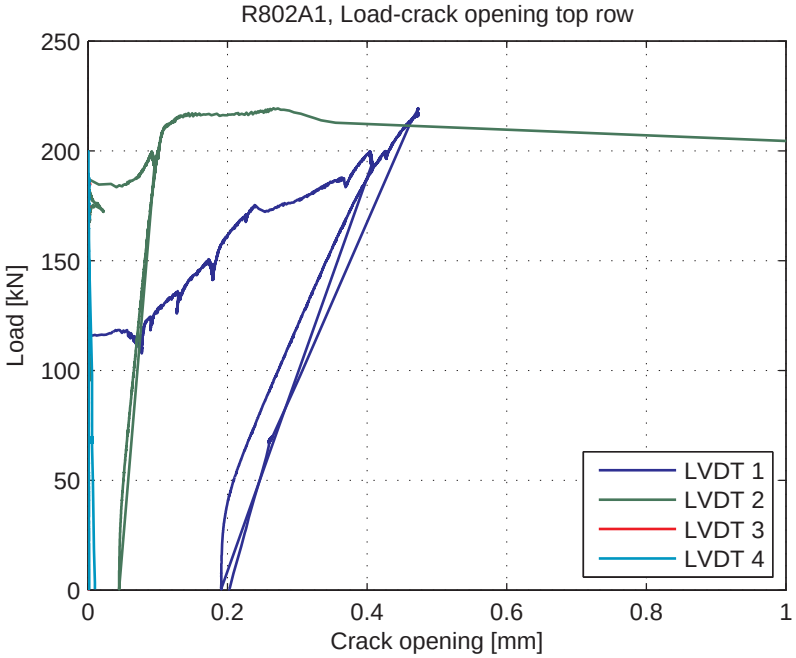


Fig. 5.102.6. Load-Crack opening for LVDT's 1-4 (top row)

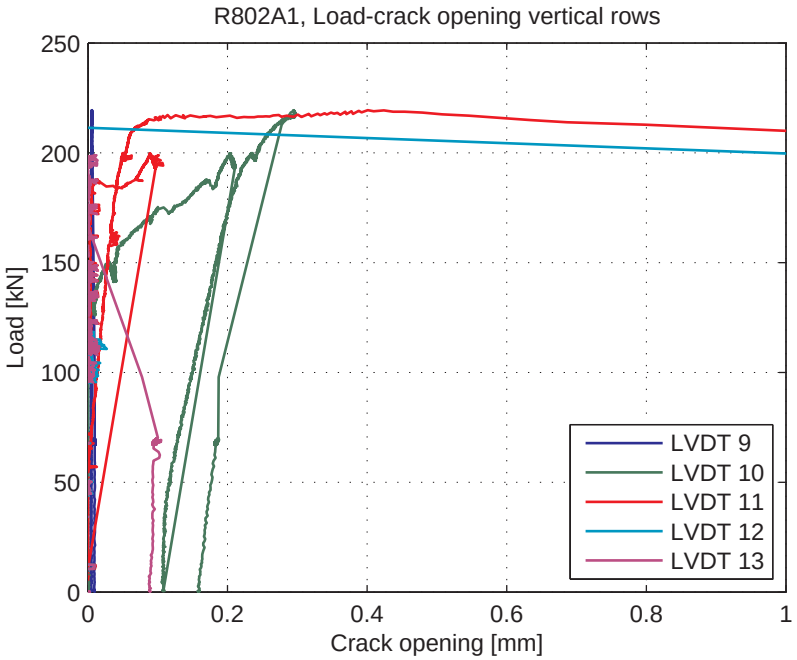


Fig. 5.102.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

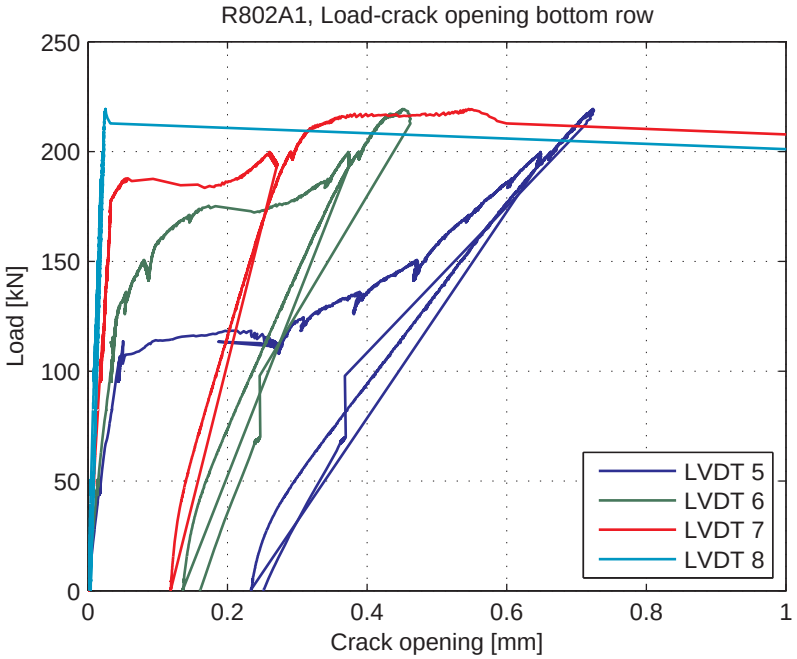


Fig. 5.102.8. Load-Crack opening for LVDT's 5-8 (bottom row)

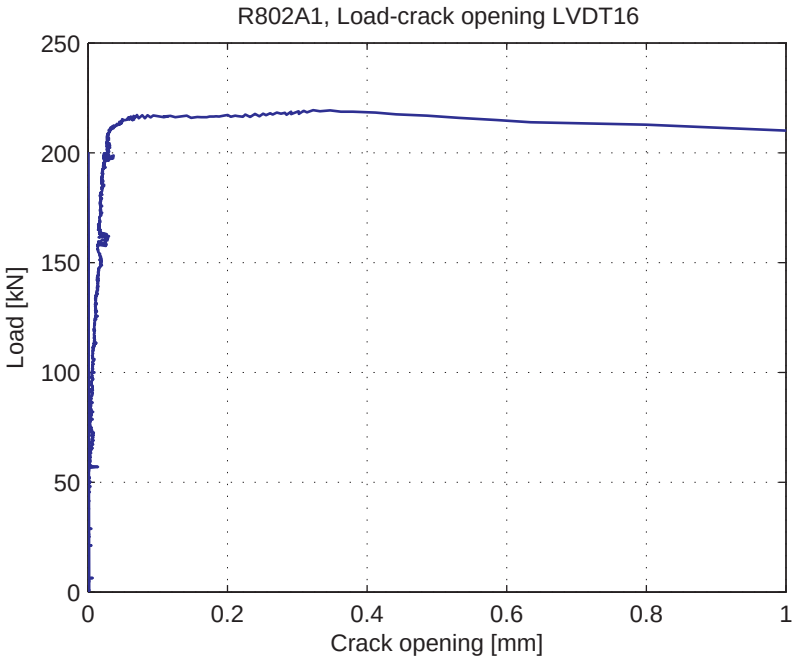


Fig. 5.102.9. Load-Crack opening for LVDT 16

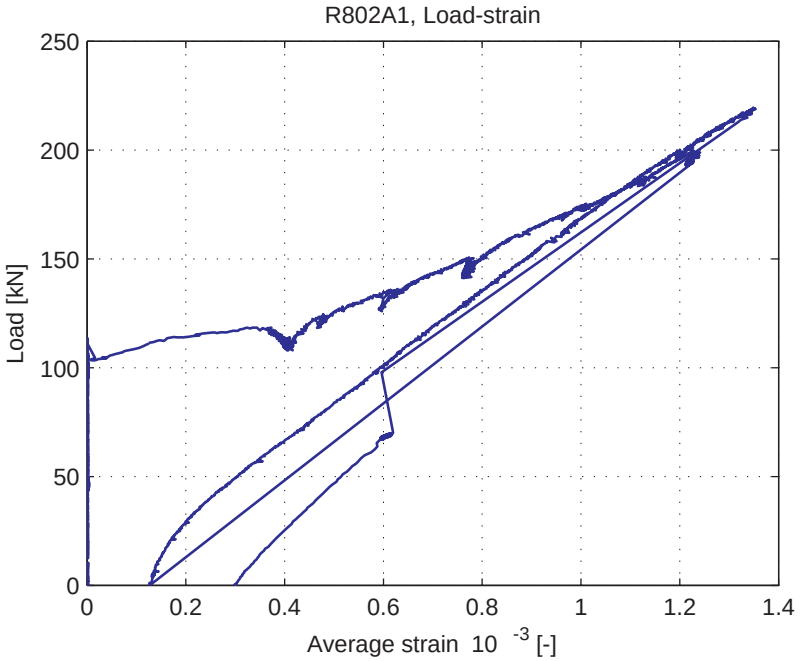


Fig. 5.102.10. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.103. R802B1

5.103.1. Test properties

Fig. 5.103.1. Crack pattern after failure at north side of beam

Fig. 5.103.2. Crack pattern after failure and LVDT layout at south side of beam

Table 5.103.1. Beam properties

Date of test	11-12-2015
Reinforcement	6Ø20 ribbed
Reinforcement ratio	0.83%
a	2000 mm
a / *d*	2.65
Concrete cube strength at testing	75.8 MPa
Peak load	375.0 kN
Failure mode	Shear

Table 5.103.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	
1	50	
2	100	
3	150	
4	200	
5	0	Added LVDT 15
6	200	
7	250	
8	270	First shear crack at 270.2 kN, back to 230 kN
9	375.0	Shear failure

Table 5.103.3. Location LVDT's used for crack opening measurements

LVDT	Distance from support [mm]	Distance from bottom beam [mm]
15	1580	550

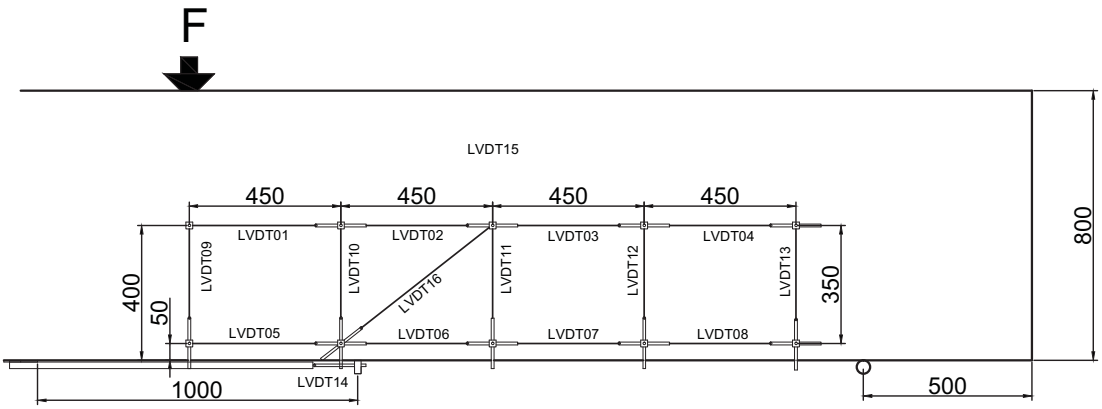


Fig. 5.103.3. LVDT layout and numbering for 800 mm deep beams

5.103.2. Measurement results

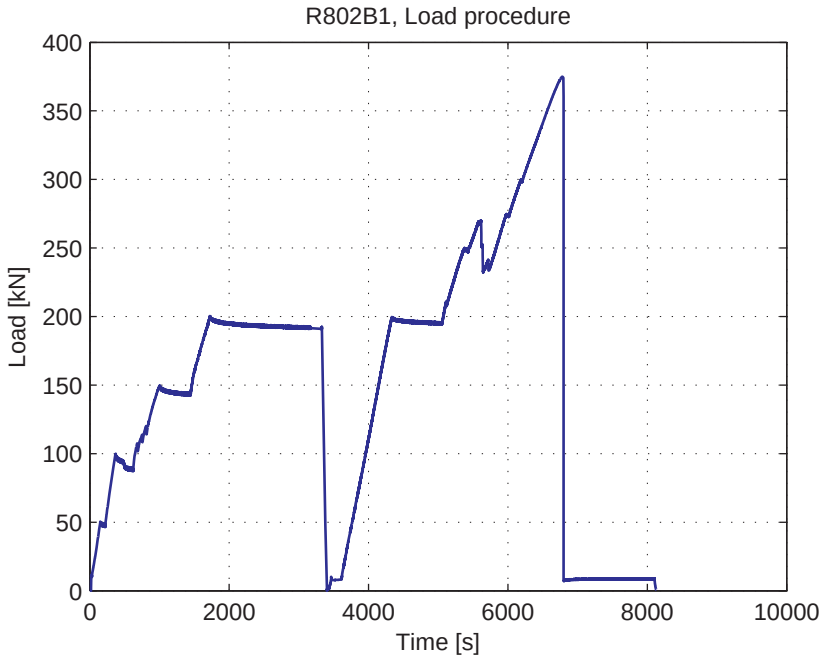


Fig. 5.103.4. Load-Time curve

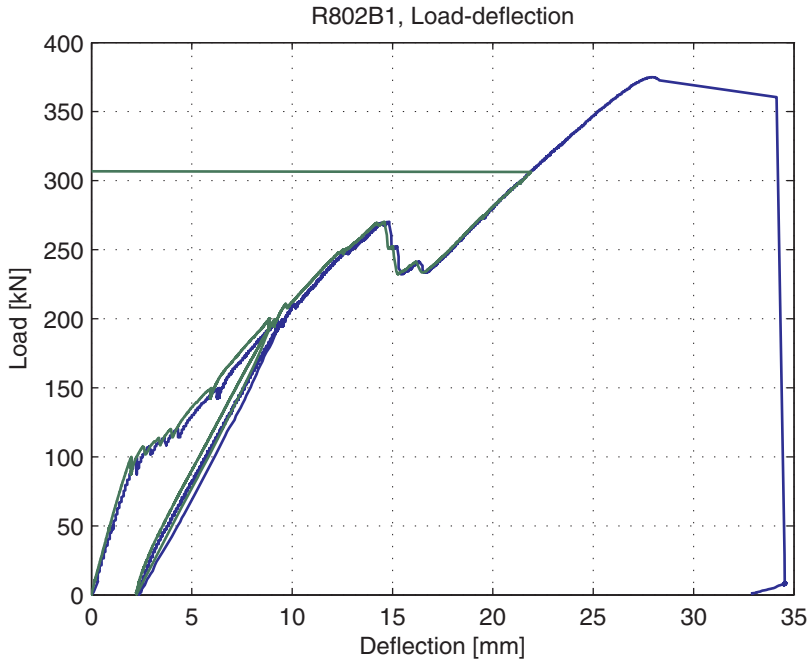


Fig. 5.103.5. Load-deflection curve

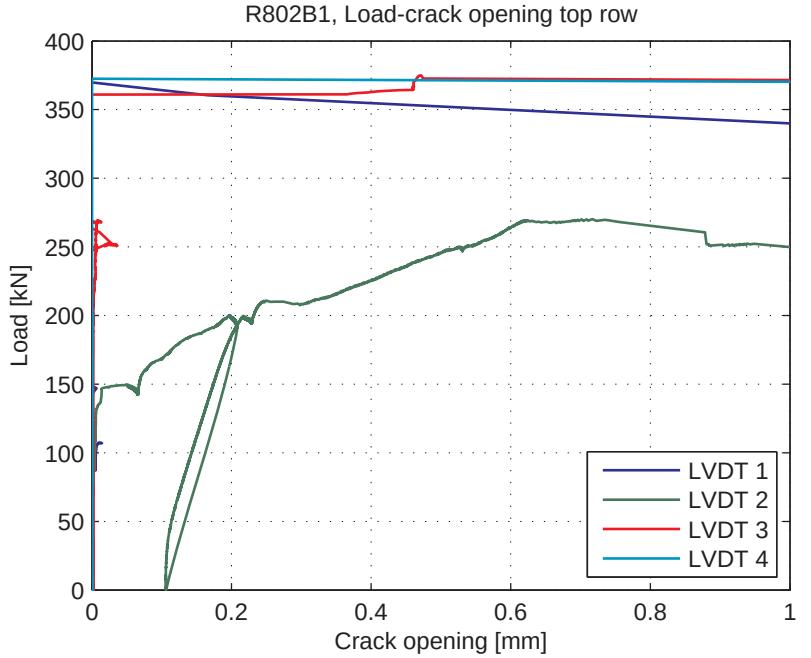


Fig. 5.103.6. Load-Crack opening for LVDT's 1-4 (top row)

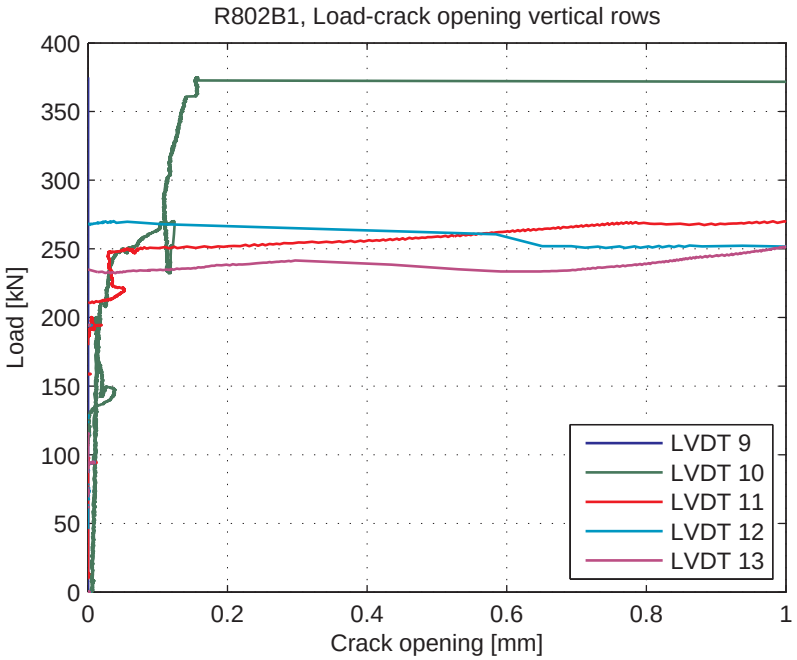


Fig. 5.103.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

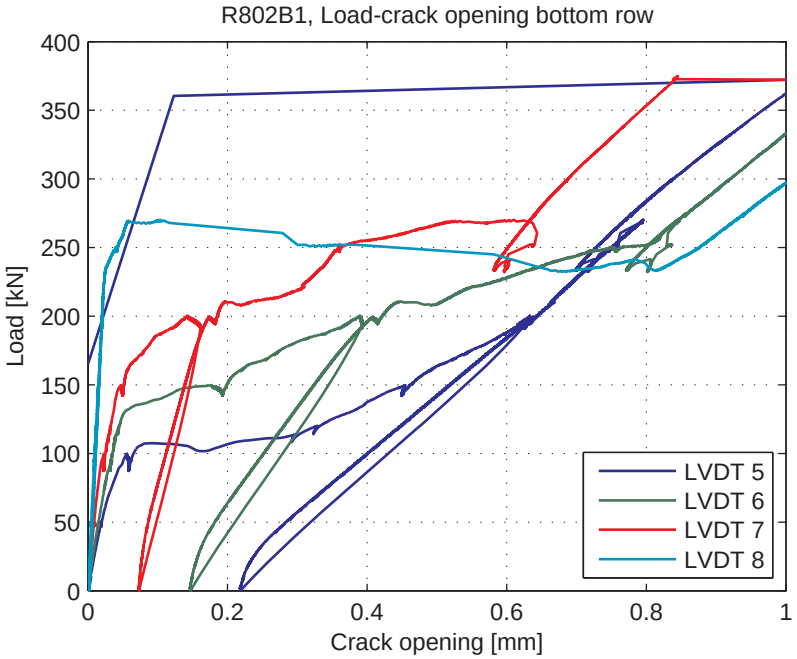


Fig. 5.103.8. Load-Crack opening for LVDT's 5-8 (bottom row)

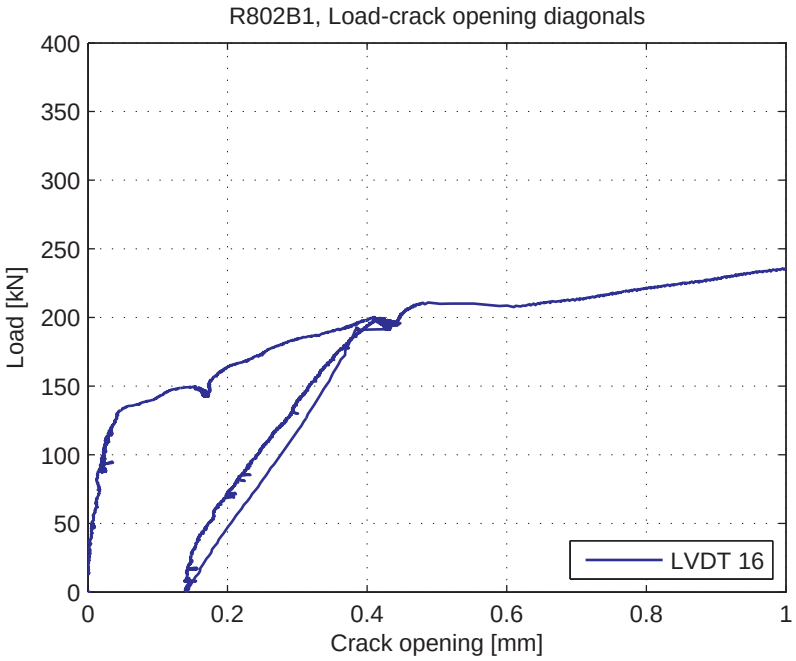


Fig. 5.103.9. Load-Crack opening for LVDT 16 (diagonal)

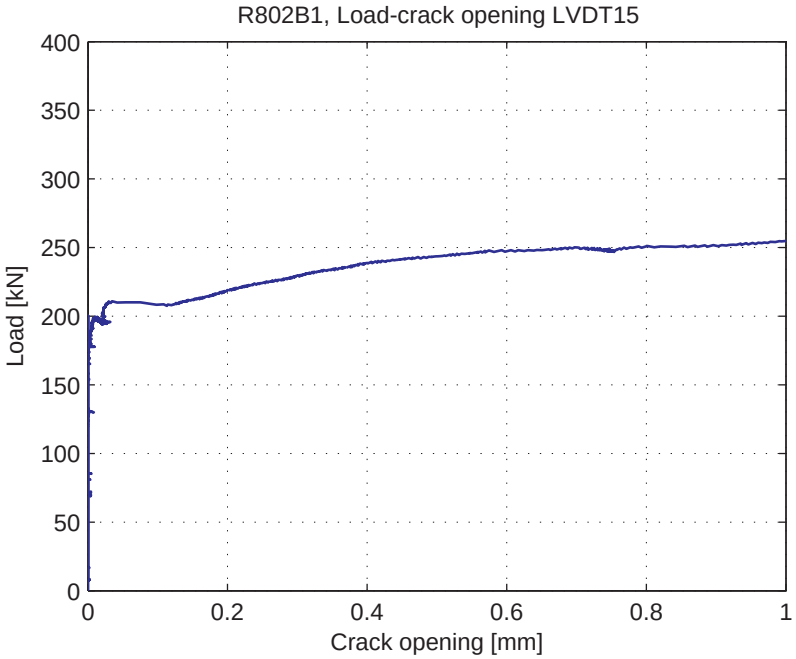


Fig. 5.103.10. Load-Crack opening for LVDT 15

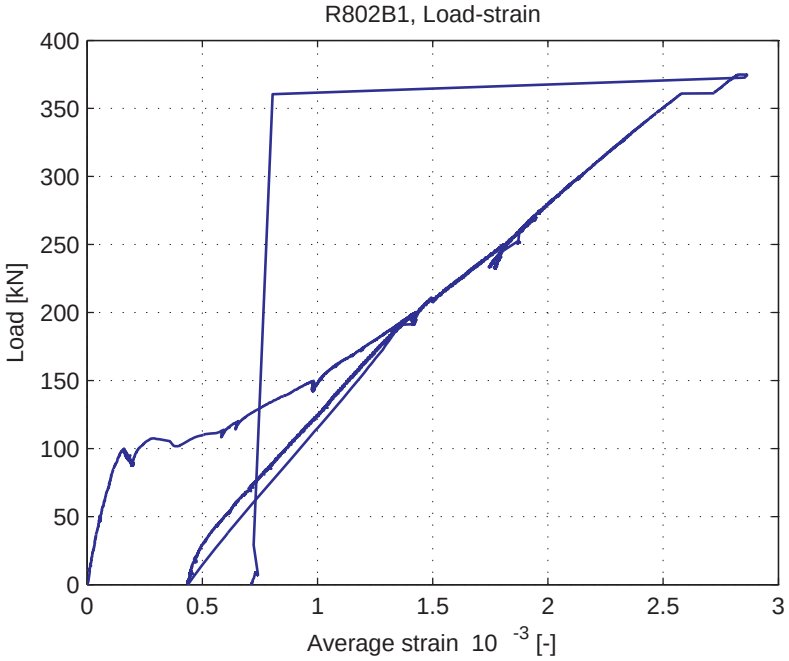


Fig. 5.103.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.104. R803A1

5.104.1. Test properties

Fig. 5.104.1. Crack pattern after failure at east side of beam

Fig. 5.104.2. Crack pattern after failure and LVDT layout at west side of beam

Table 5.104.1. Beam properties

Date of test	03-06-2016
Reinforcement	6Ø20 ribbed
Reinforcement ratio	0.83%
a	3500 mm
a / *d*	4.59
Concrete cube strength at testing	83.3 MPa
Peak load	279.3 kN
Failure mode	Shear

Table 5.104.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements. Grid extended with LVDT15 and LVDT16 on rebar (50 mm from bottom) and middle of beamheight.
1	50	
2	0	
3	50	
4	0	
5	50	
6	0	
7	100	
8	0	
9	100	
10	0	
11	100	
12	0	
13	150	
14	0	
15	150	
16	0	
17	150	
18	0	
19	160	
20	170	
21	180	
22	190	
23	200	
24	0	
25	200	
26	0	
27	200	
28	0	
29	210	
30	220	
31	230	
32	270	
33	280	Shear failure

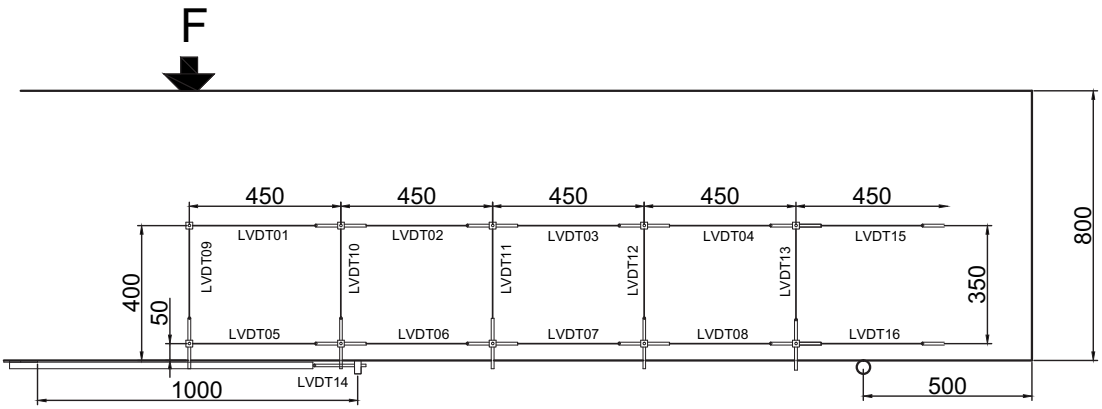


Fig. 5.104.3. LVDT layout and numbering for 800 mm deep beams

5.104.2. Measurement results

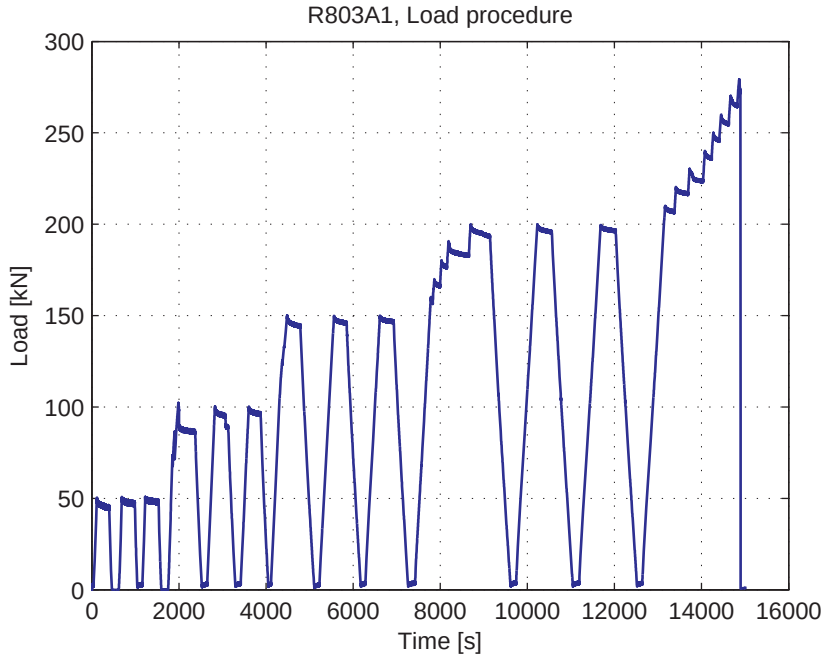


Fig. 5.104.4. Load-Time curve

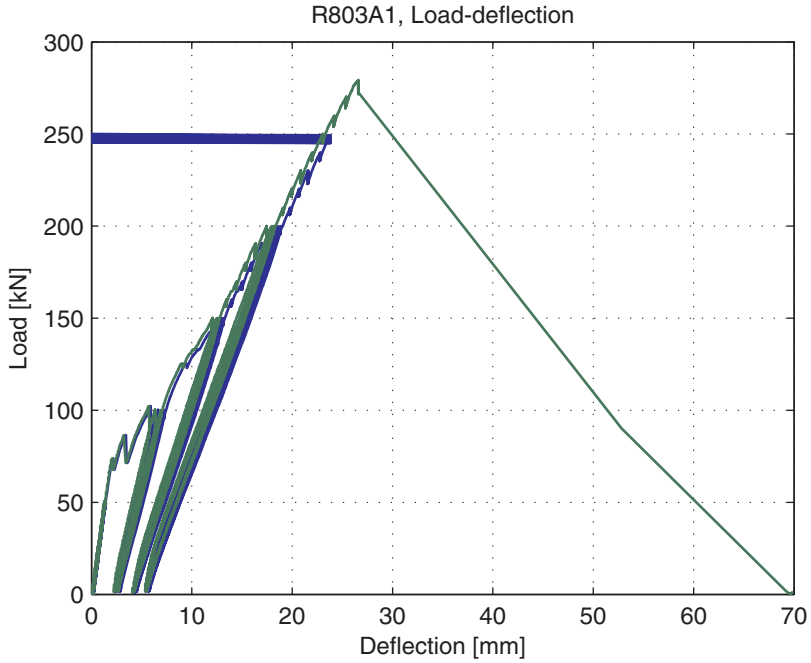


Fig. 5.104.5. Load-deflection curve

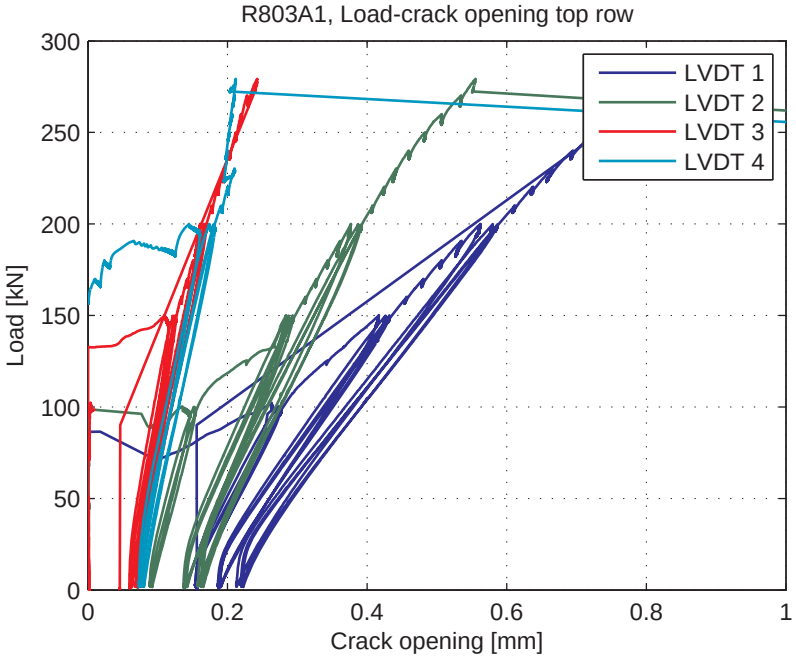


Fig. 5.104.6. Load-Crack opening for LVDT's 1-4 (top row)

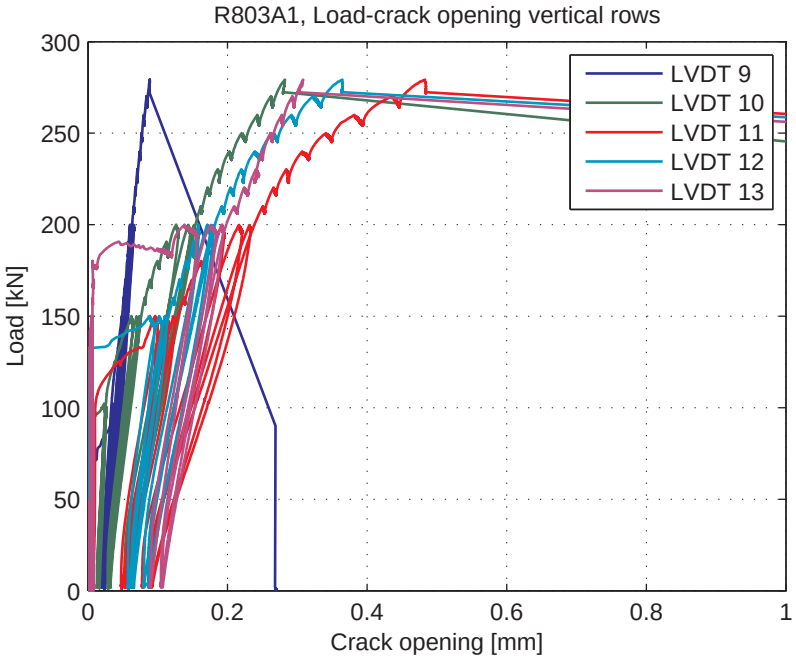


Fig. 5.104.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

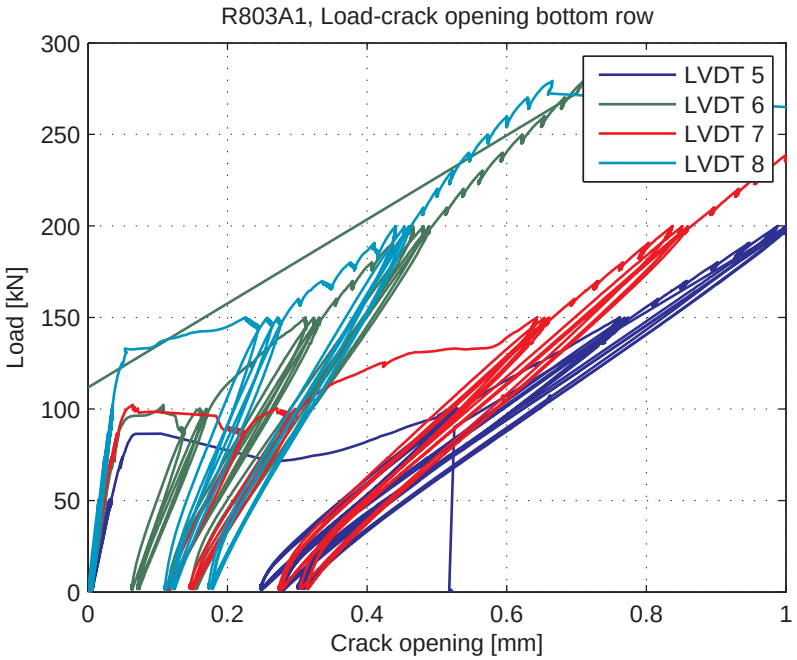


Fig. 5.104.8. Load-Crack opening for LVDT's 5-8 (bottom row)

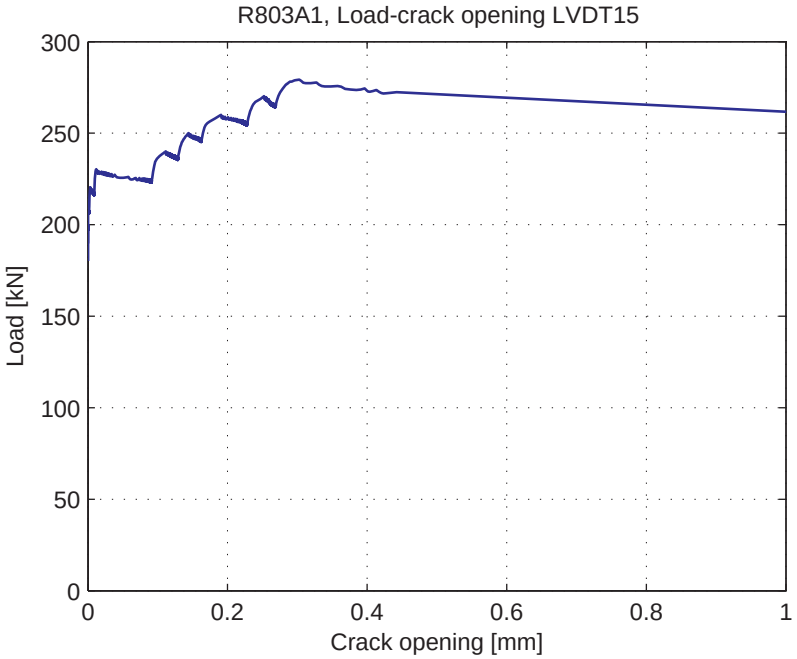


Fig. 5.104.9. Load-Crack opening for LVDT 15

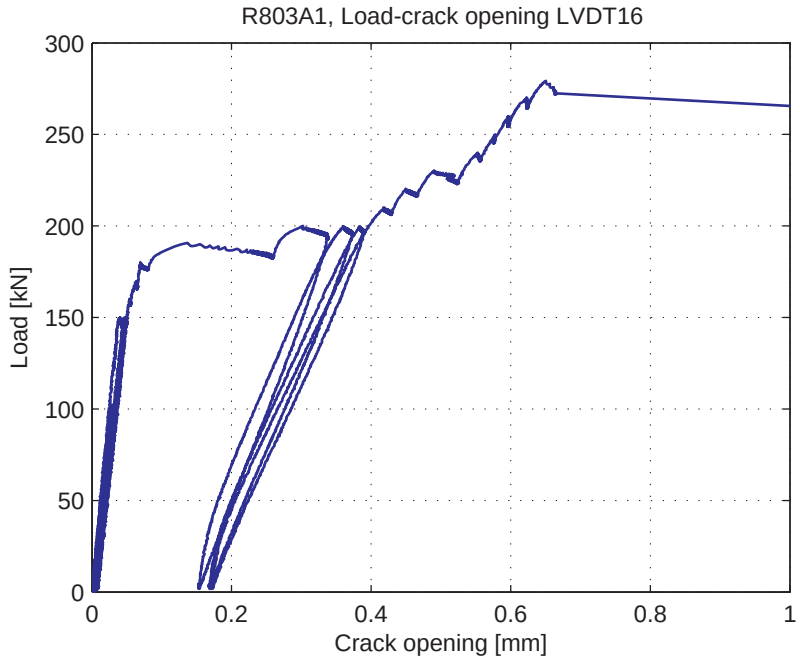


Fig. 5.104.10. Load-Crack opening for LVDT 16

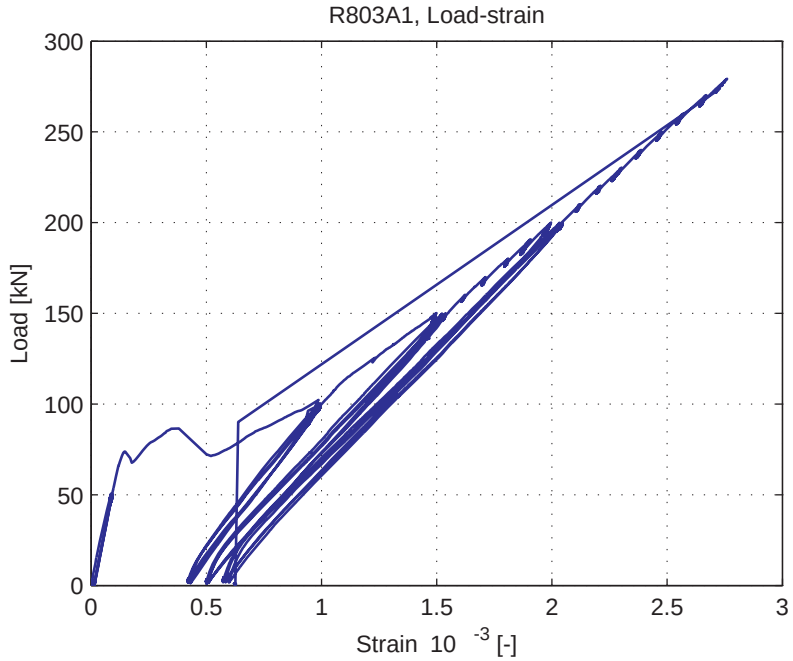


Fig. 5.104.11. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.105. R803B1

5.105.1. Test properties

Fig. 5.105.1. Crack pattern after failure at east side of beam

Fig. 5.105.2. Crack pattern after failure and LVDT layout at west side of beam

Table 5.105.1. Beam properties

Date of test	23-08-2016
Reinforcement	6Ø20 ribbed
Reinforcement ratio	0.83%
a	3500 mm
a / *d*	4.59
Concrete cube strength at testing	83.0 MPa
Peak load	307.9 kN
Failure mode	Shear

Table 5.105.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements. Laser at lower support was replaced. LVDT10 and LVDT16 were switched. Due to damaged beam in test 1, span of specimen was reduced to 7400 mm instead of 8000 mm.
1	50	
2	0	
3	50	
4	0	
5	50	
6	0	
7	100	
8	0	
9	100	
10	0	
11	100	
12	0	
13	150	
14	0	
15	150	
16	0	
17	150	
18	0	
19	160	
20	170	
21	180	
22	190	
23	200	
24	0	
25	200	
26	0	
27	200	
28	0	
29	210	
30	220	
31	230	
32	240	
33	250	
34	0	
35	250	
36	0	
37	250	
38	260	
39	270	
40	280	
41	290	
42	300	
43	307.9	Shear failure

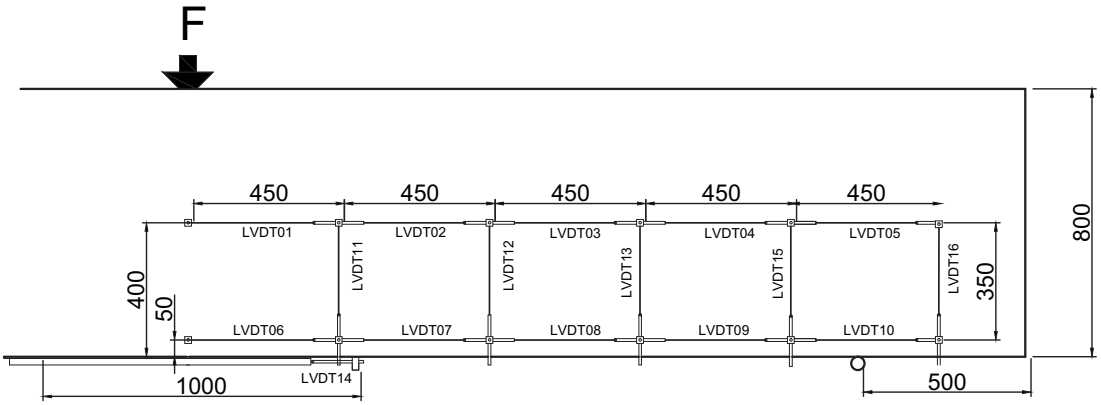


Fig. 5.105.3. LVDT layout and numbering for 800 mm deep beams

5.105.2. Measurement results

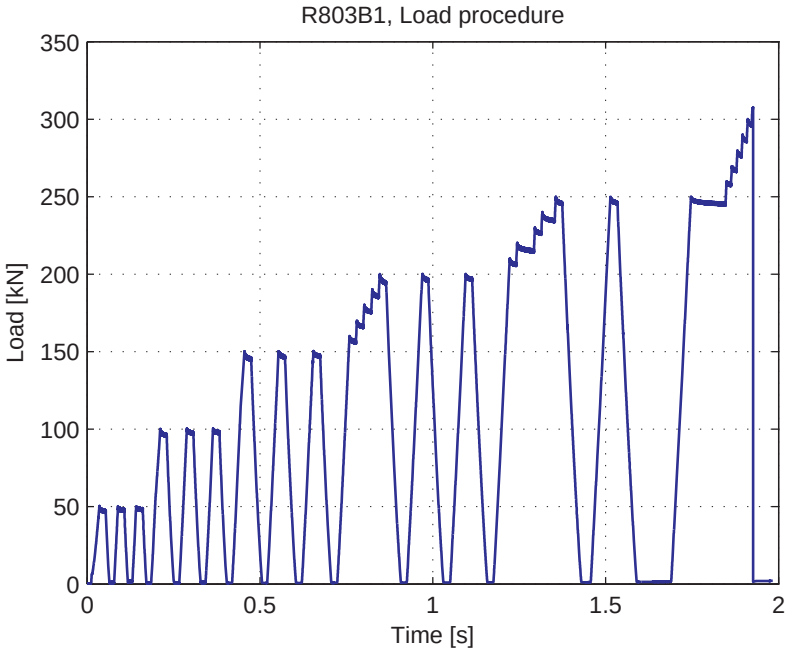


Fig. 5.105.4. Load-Time curve

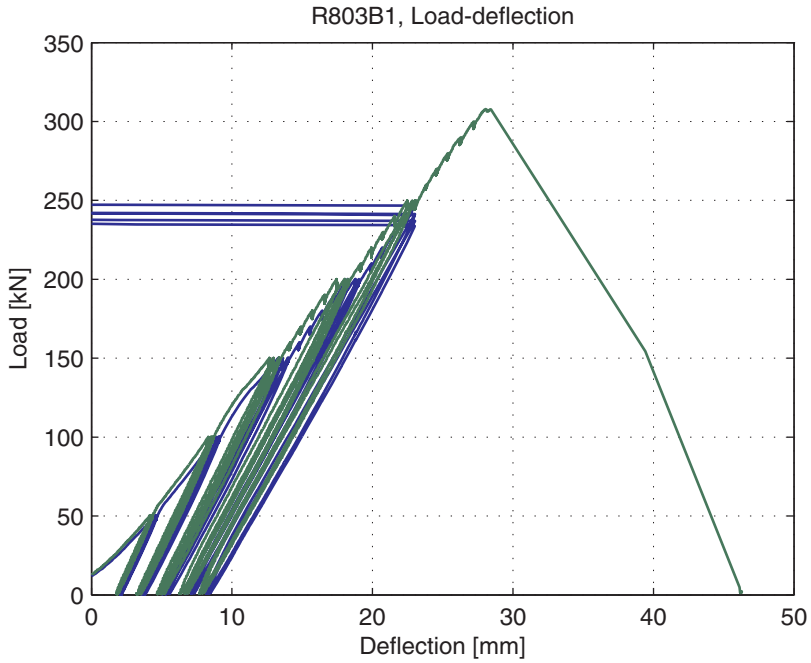


Fig. 5.105.5. Load-deflection curve

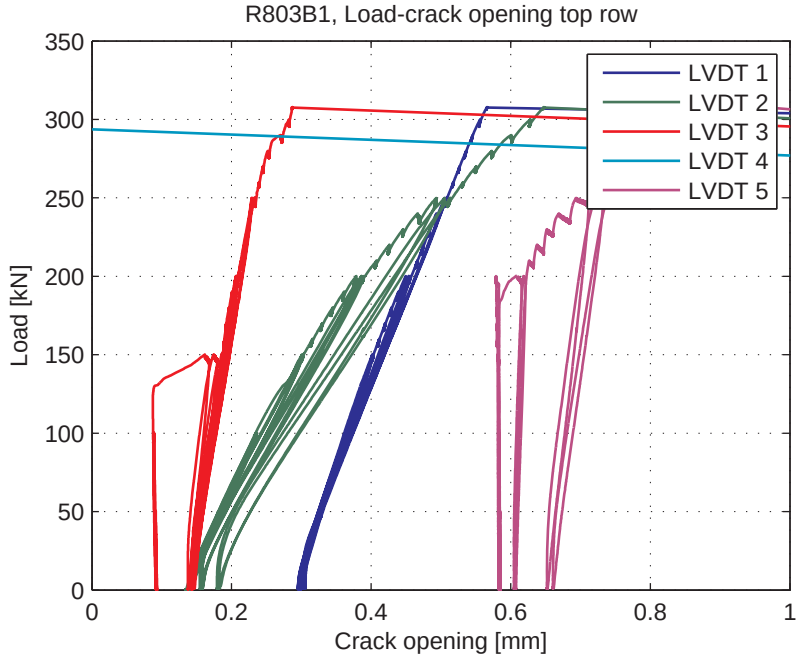


Fig. 5.105.6. Load-Crack opening for LVDT's 1-4 (top row)

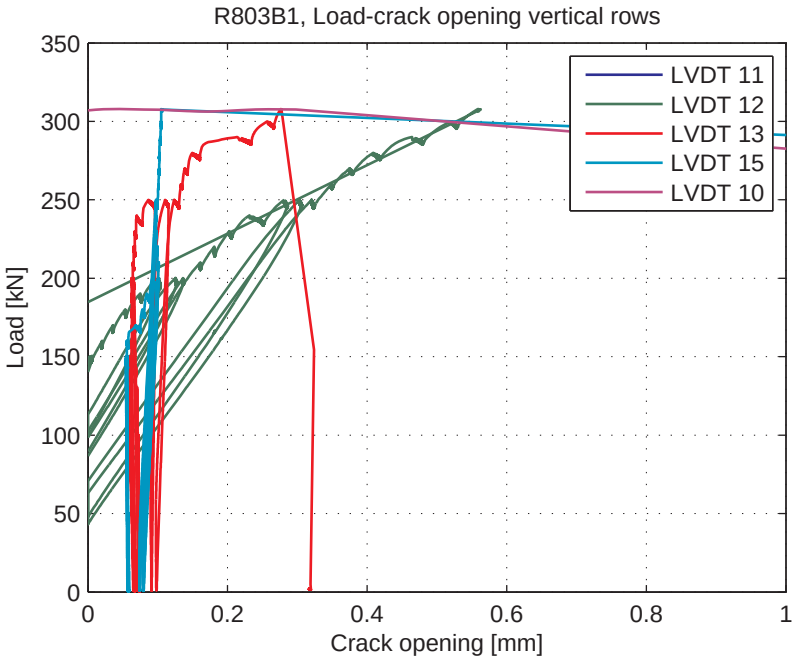


Fig. 5.105.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

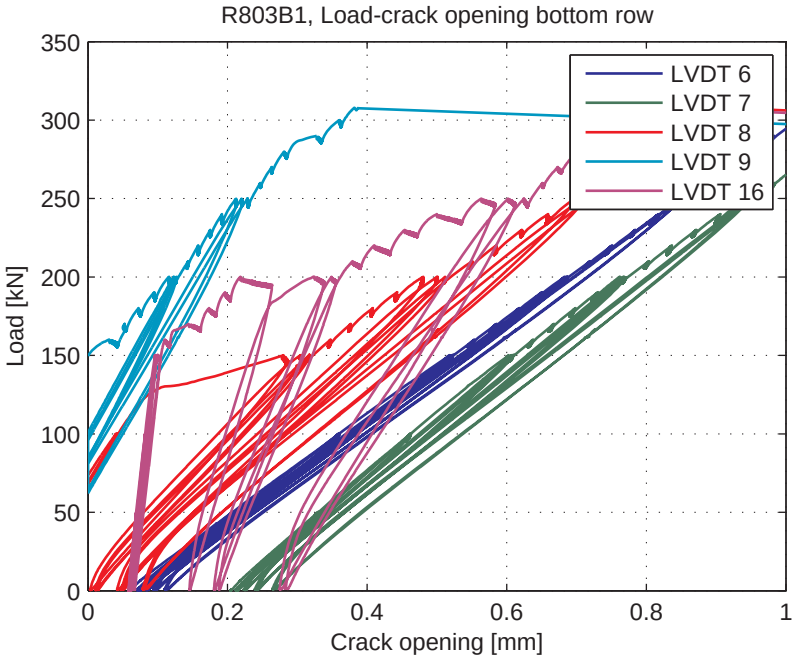


Fig. 5.105.8. Load-Crack opening for LVDT's 5-8 (bottom row)

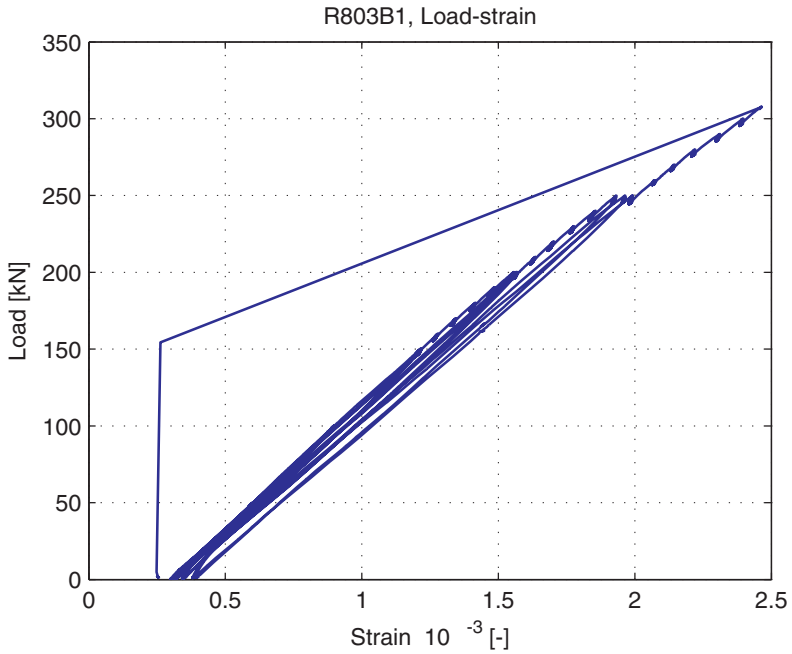


Fig. 5.105.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.106. R804A1

5.106.1. Test properties

Fig. 5.106.1. Crack pattern after failure at east side of beam

Fig. 5.106.2. Crack pattern after failure and part of LVDT layout at west side of beam

Table 5.106.1. Beam properties

Date of test	16-06-2016
Reinforcement	3Ø25
Reinforcement ratio	0.64%
a	3500 mm
a / *d*	4.64
Concrete cube strength at testing	85.1 MPa
Peak load	269.4 kN
Failure mode	Shear

Table 5.106.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements. LVDT15 diagonal in grid 4.
1	50	
2	0	
3	50	
4	0	
5	50	
6	0	
7	100	
8	0	
9	100	
10	0	
11	100	
12	0	
13	100	
14	110	
15	120	
16	130	
17	140	
18	150	
19	0	
20	150	
21	0	
22	150	
23	0	
24	150	
25	160	
26	170	
27	180	
28	190	
29	200	
30	0	
31	200	
32	0	
33	200	
34	0	
35	200	
36	210	
37	220	
38	230	
39	240	
40	250	
41	260	
42	269	Shear at 269 kN

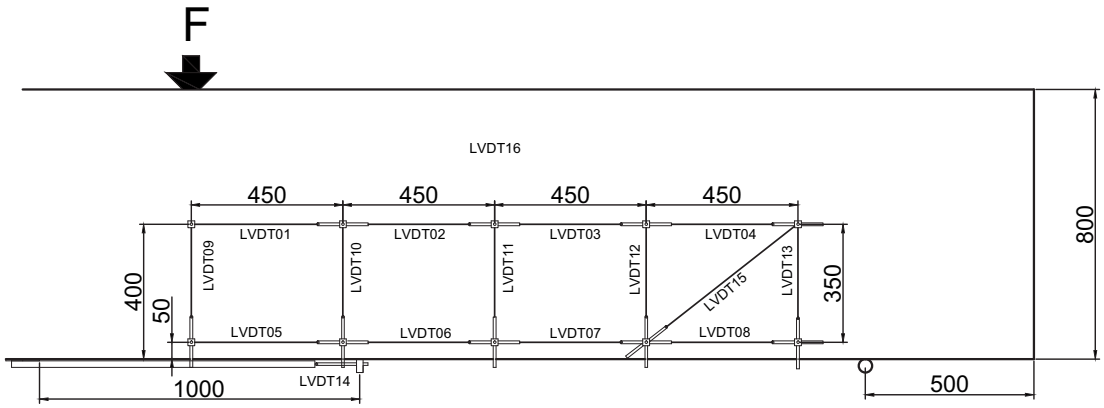


Fig. 5.106.3. LVDT layout and numbering for 800 mm deep beams

5.106.2. Measurement results

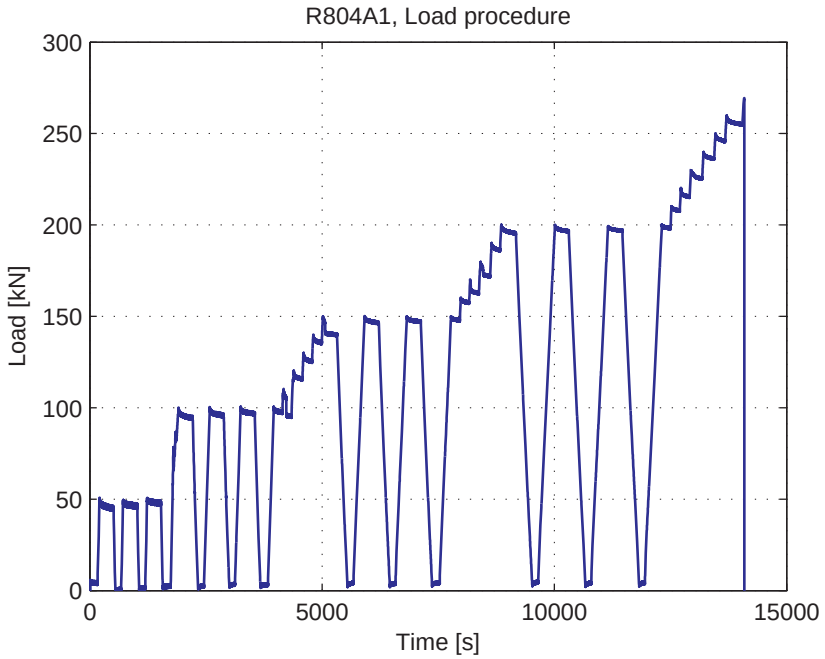


Fig. 5.106.4. Load-Time curve

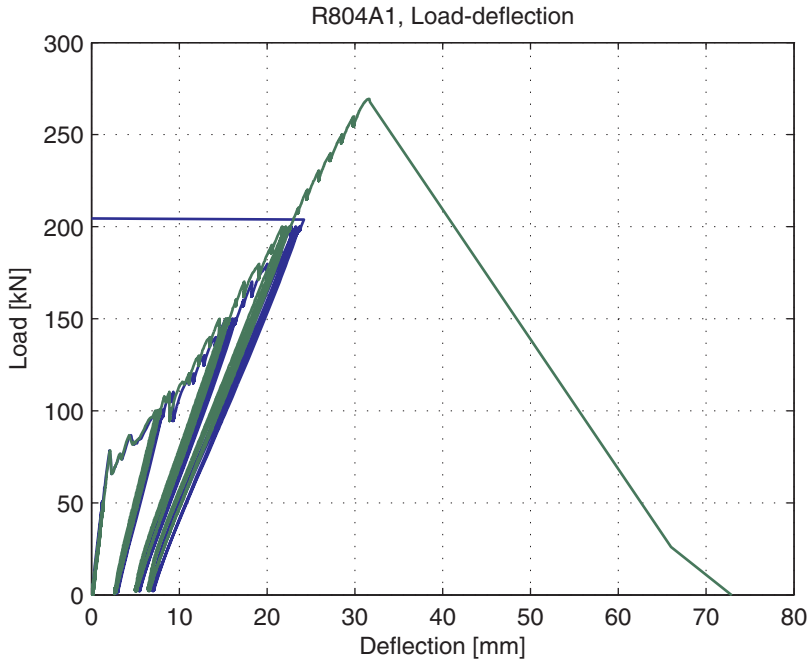


Fig. 5.106.5. Load-deflection curve

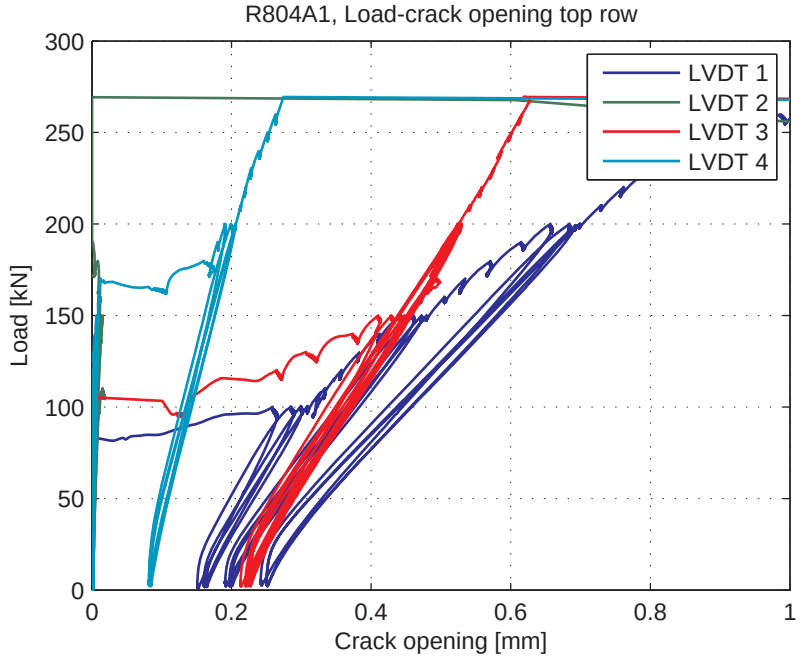


Fig. 5.106.6. Load-Crack opening for LVDT's 1-4 (top row)

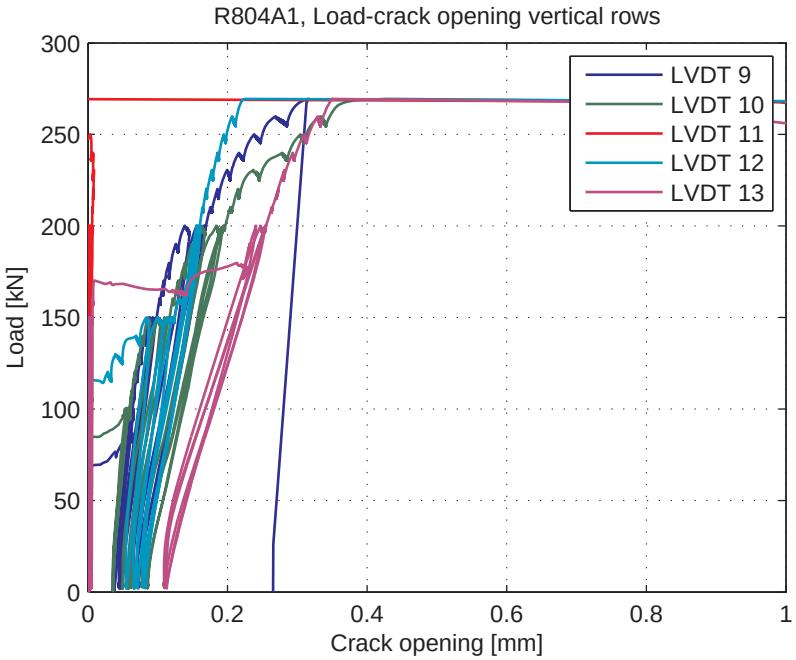


Fig. 5.106.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

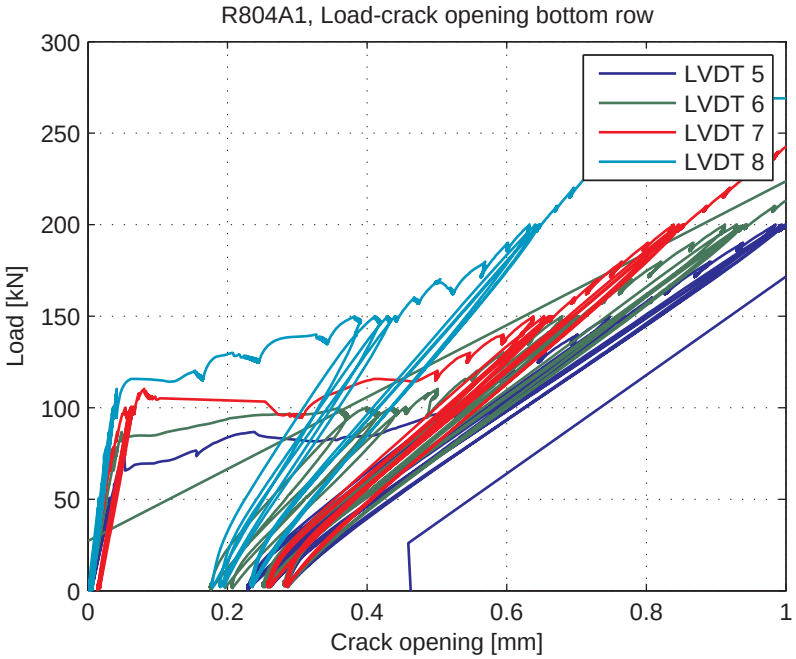


Fig. 5.106.8. Load-Crack opening for LVDT's 5-8 (bottom row)

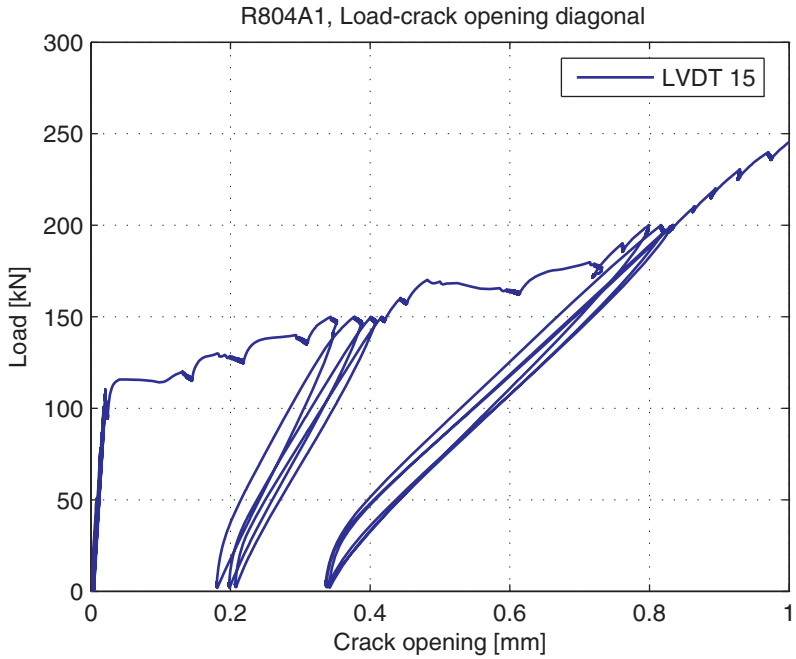


Fig. 5.106.9. Load-Crack opening for LVDT 15 (diagonal)

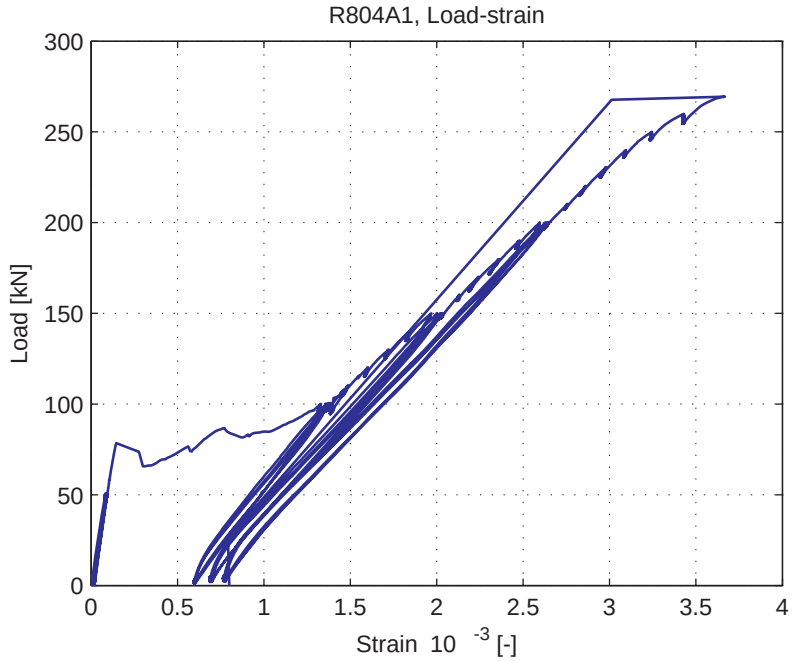


Fig. 5.106.10. Average strain over 1m length, measured at bottom of specimen (LVDT 14)

5.107. R804B1

5.107.1. Test properties

Fig. 5.107.1. Crack pattern after failure at east side of beam

Fig. 5.107.2. Crack pattern after failure and part of LVDT layout at west side of beam

Table 5.107.1. Beam properties

Date of test	08-08-2016
Reinforcement	6Ø20 (2 layers)
Reinforcement ratio	0.83%
a	3500 mm
a / *d*	4.64
Concrete cube strength at testing	85.1 MPa
Peak load	249.9 kN
Failure mode	Shear

Table 5.107.2. Load steps

Load step	Load [kN]	Miscellaneous
0	0	Applied load cycles for Acoustic Emission measurements. Beam was strengthened on other side with 3 pairs of threaded steel.
1	50	
2	0	
3	50	
4	0	
5	50	
6	0	Added another steel plate 20mm to extend the maximum displacement of the load cell. The plate itself is deformed, therefore an additional reduction of global stiffness is expected. With the same loading speed a slower increase of load is expected.
7	100	
8	0	
9	100	
10	0	
11	105	
12	0	
13	150	
14	0	
15	150	
16	0	
17	153	
18	0	The glue of the node at LVDT11 was not properly done. As a result, a large deformation was found at LVDT11. This dit not affect the other LVDT's
19	154	
20	160	
21	170	
22	180	
23	190	
24	200	
25	0	
26	200	
27	0	
28	200	
29	0	
30	210	
31	220	
32	230	
33	240	
34	250	Shear failure

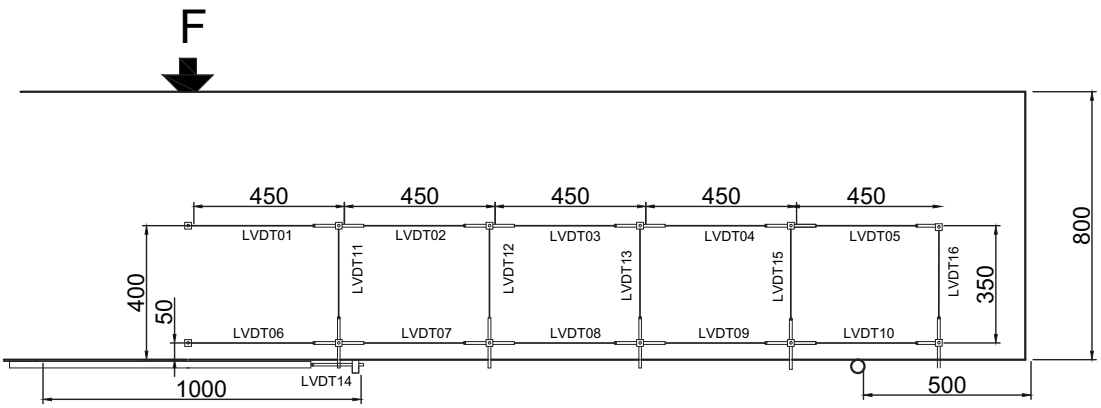


Fig. 5.107.3. LVDT layout and numbering for 800 mm deep beams

5.107.2. Measurement results

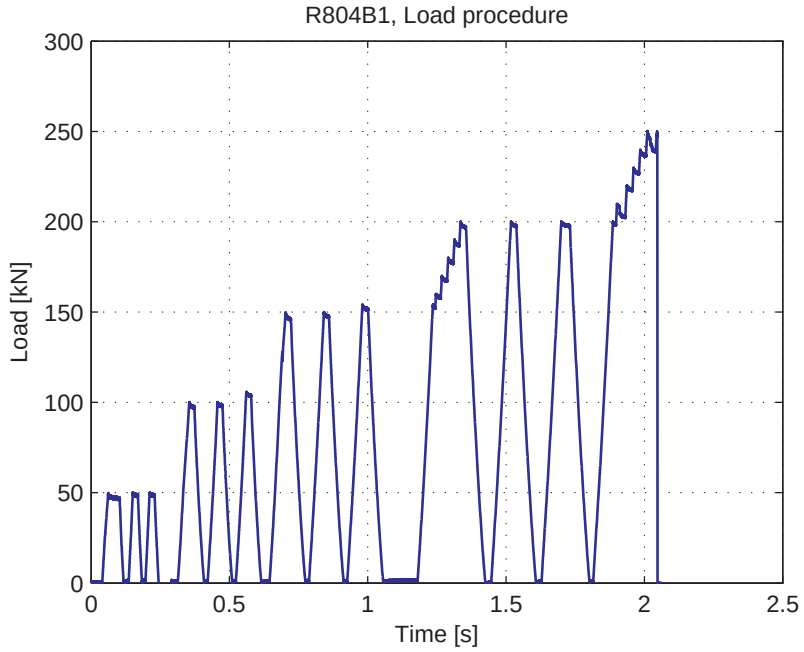


Fig. 5.107.4. Load-Time curve

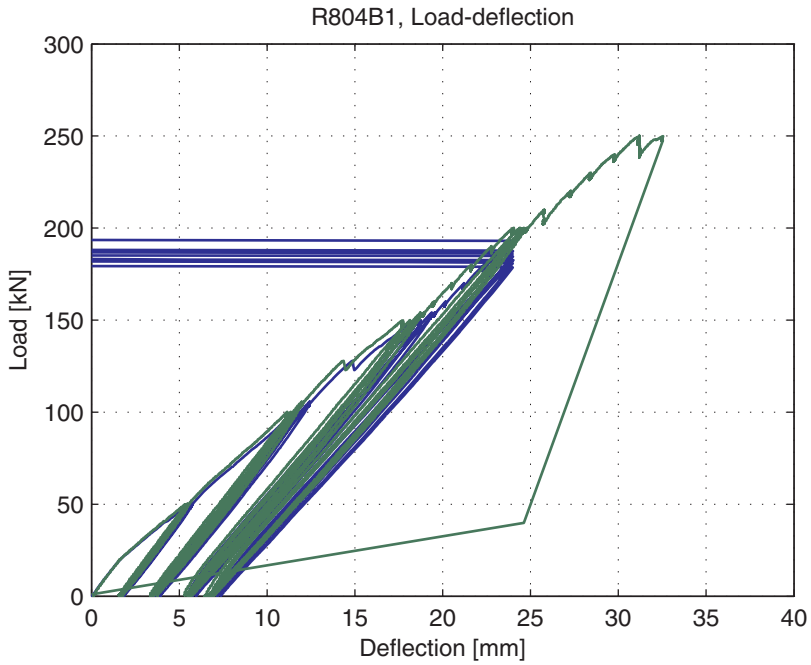


Fig. 5.107.5. Load-deflection curve

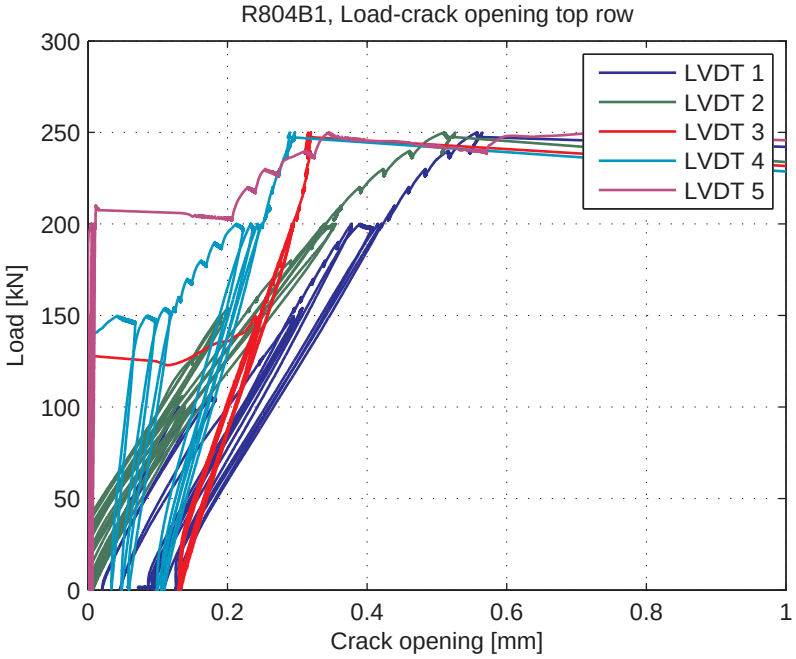


Fig. 5.107.6. Load-Crack opening for LVDT's 1-4 (top row)

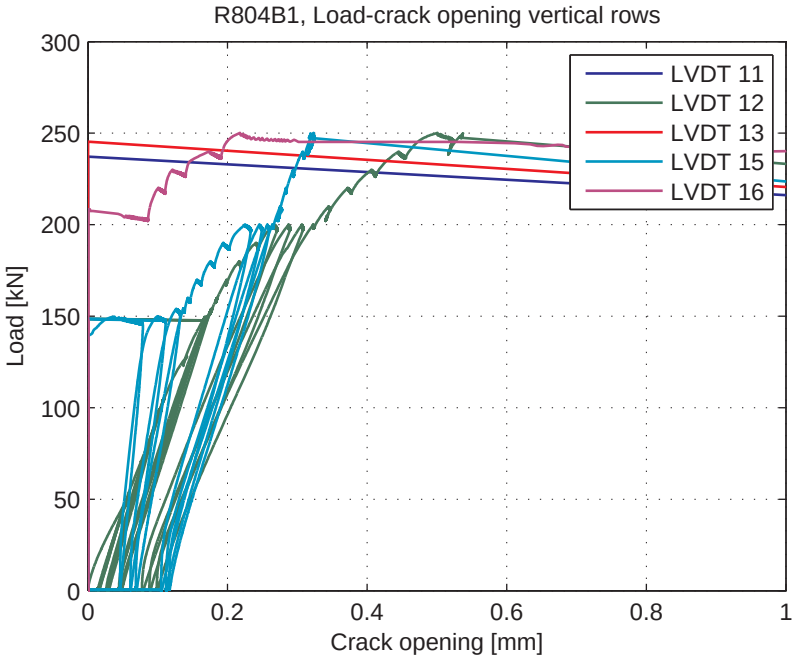


Fig. 5.107.7. Load-Crack opening for LVDT's 9-13 (vertical LVDT's)

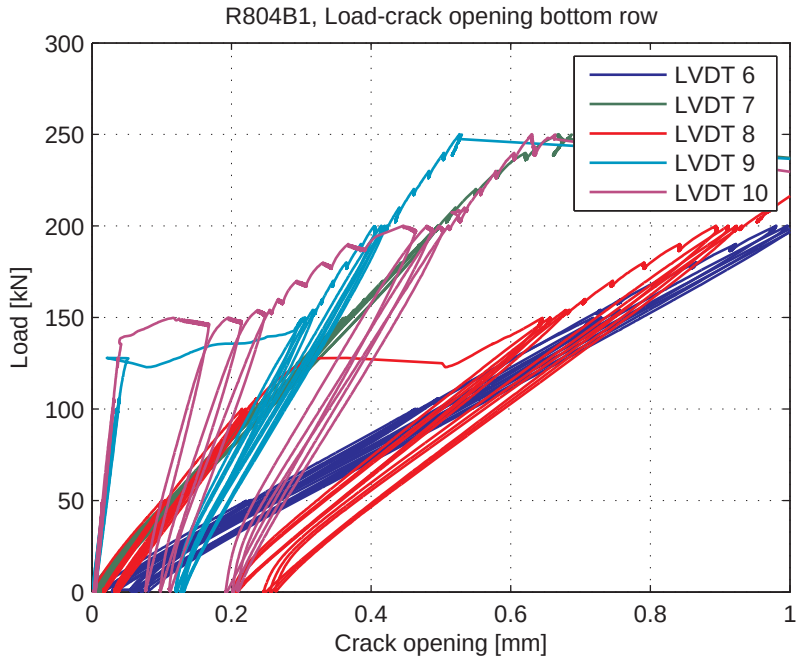


Fig. 5.107.8. Load-Crack opening for LVDT's 5-8 (bottom row)

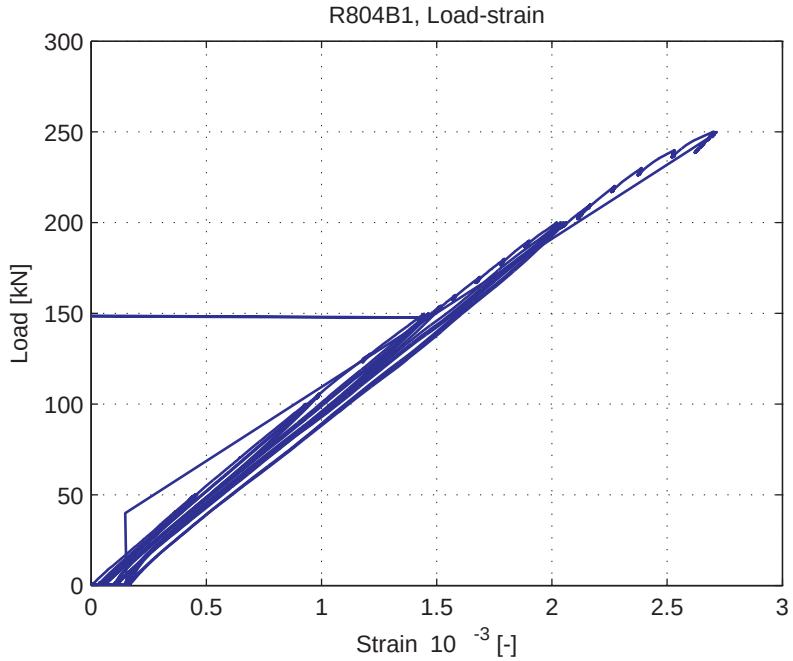


Fig. 5.107.9. Average strain over 1m length, measured at bottom of specimen (LVDT 14)