

Versuche zum Tragverhalten von ultra hochfestem Beton

Anhang zu:

Teil 1 – Materialversuche

Teil 2 - Bauteilversuche

Institut de structures – Construction en béton

**Dipl. Ing. Jörg Jungwirth
Prof. Dr. Aurelio Muttoni**



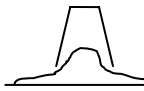


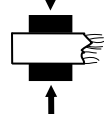

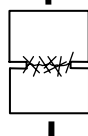
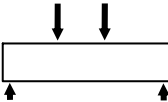
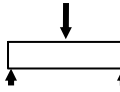

Projekt 00.02, Bericht 00.02.R3a/R4a 2004



ANHANG

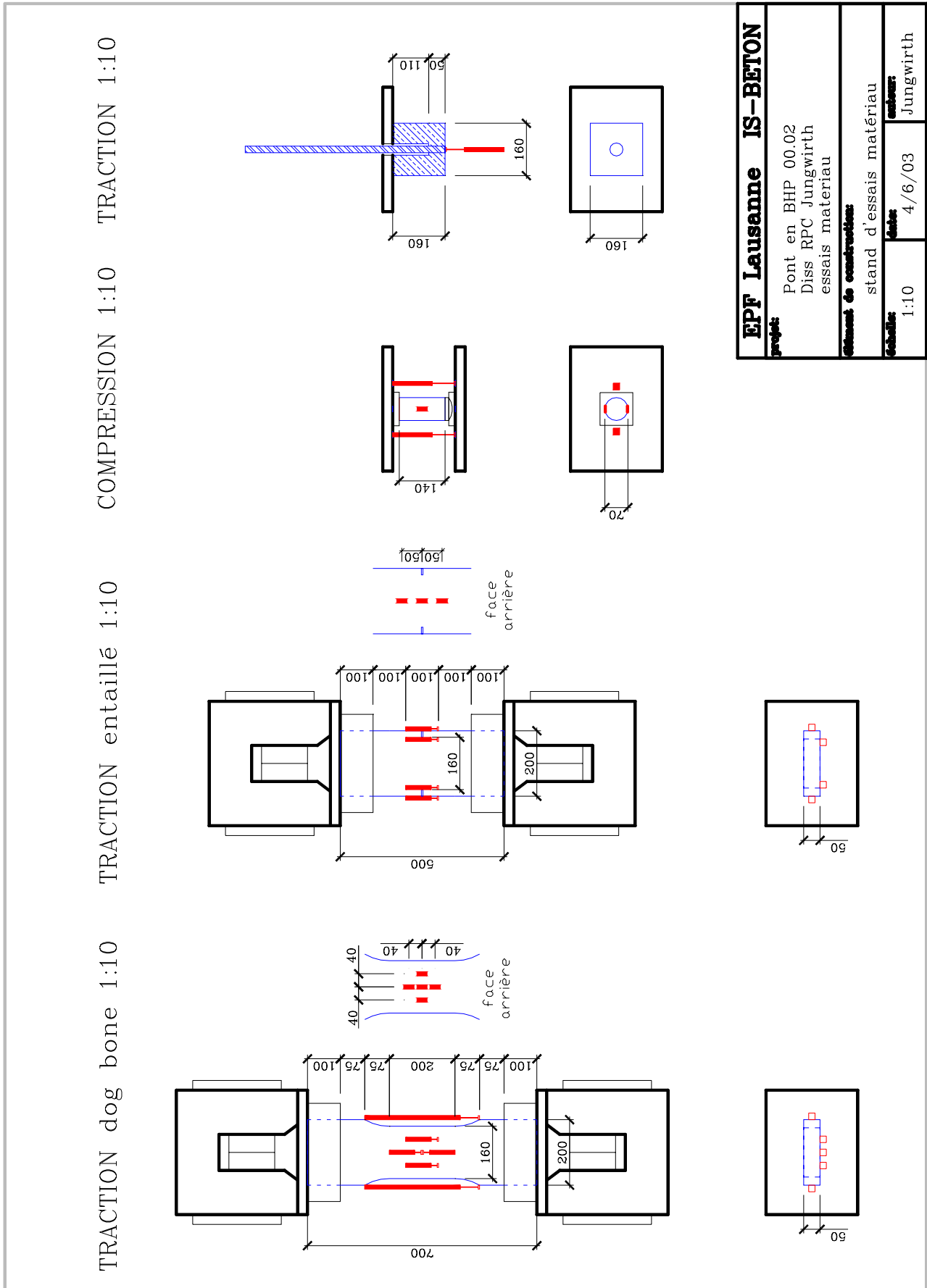
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A.1 ÜBERSICHTSTAFEL DER VERSUCHE

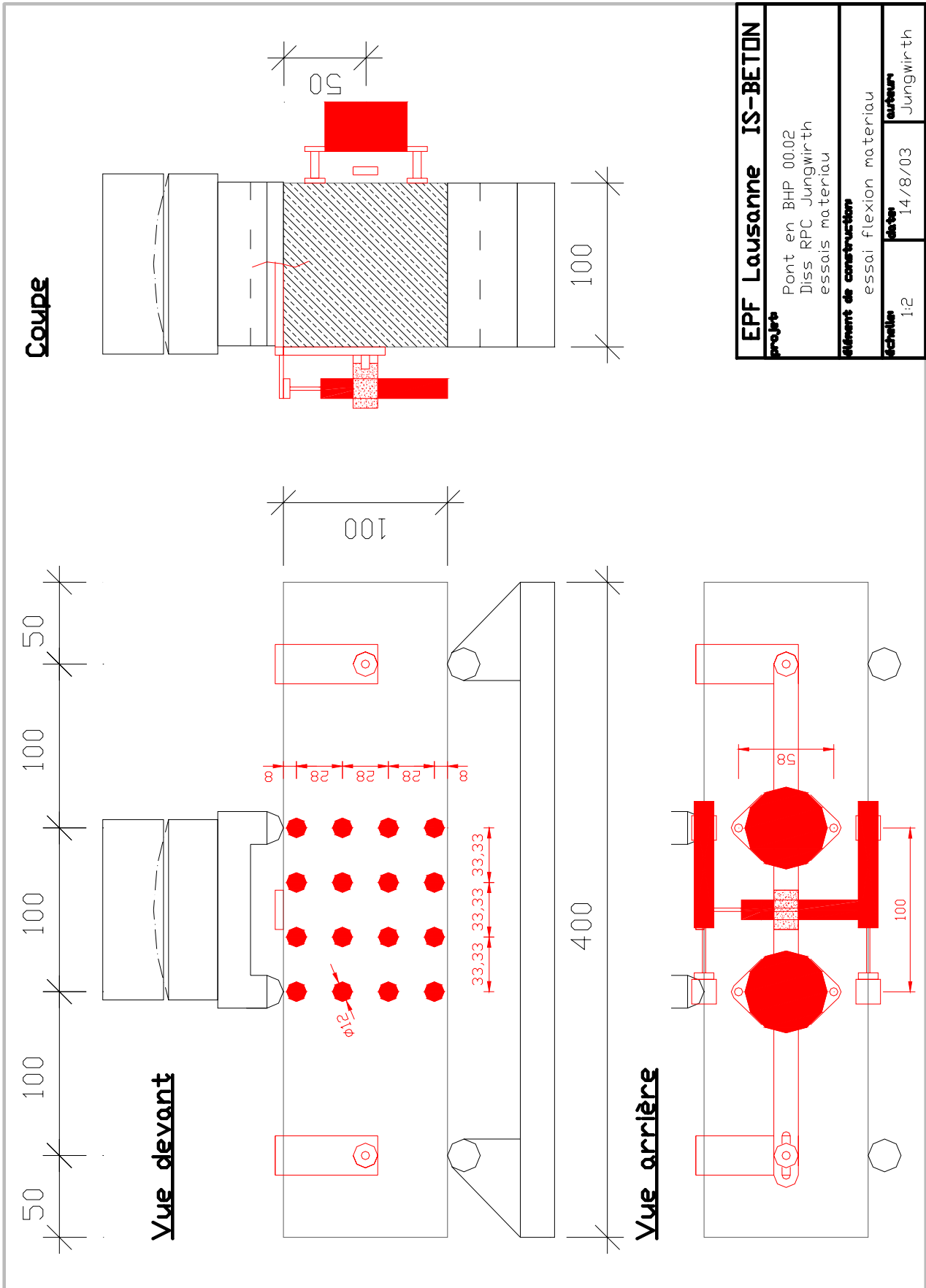
	Schema	Masse	Anzahl	Parameter	Zielsetzung	Anhang
Frischbetonprüfung			je 1	Sollwert: max 5°C über Raumtemp.	Beginn der Hydratation während des Mischvorgangs? Hydratationsprozess	A.3.1
		DIN Zylinder	je 1	Ausbreitmass Sollwert: 60-65 cm nach 2 min	Konsistenz Segregation	A.3.1
		Abrams Zylinder	3	Slump Flow Sollwert: ≥ 65 cm Dauer bis Ø 50 cm	Fliessfähigkeit Vergleich mit SCC	A.3.1
Druck		Ø70 mm x 140 mm	2 x 4 Σ = 8	Faserbewehrt / Unbewehrt	Druckfestigkeit σ - ε Diagramm E-Modul Einfluss der Fasern	A.4.1
		100 mm Kantenlänge	18	24 h, 7 d, 28 d	Druckfestigkeit Zeitabhängige Festigkeitsentwicklung Vergleich mit Lieferant	A.
		40 x 40 x ≈80 mm	je 3 Σ = 66	Bei allen Mischerchargen	Druckfestigkeit Überprüfung der einzelnen Mischerchargen	A.3.1
Zug		700 x 160 x 50 mm	4	Faserbewehrt / Unbewehrt	Zugfestigkeit σ - ε Diagramm Rissbildung Einfluss der Fasern	A.5.1
		500 x 200 x 50 mm	3	-	Rissöffnungsverhalten Faserausziehverhalten Verbundverhalten mit Fasern	A.5.2
Biegung		100 x 100 x 400 mm	3	-	Biegezugfestigkeit M-κ Diagramm Rissbildung Relation Zugversuch - Biegeversuch	A.6.1
		40 x 40 x 160 mm	je 3 Σ = 66	Bei allen Mischerchargen	Biegezugfestigkeit Überprüfung der einzelnen Mischerchargen	A.3.1
Verbund		160 mm Kantenlänge	3x3 Σ = 9	Bewehrung Ø12 mm, Ø20 mm Spannstahl Ø15.7 mm	Verbundverhalten mit Bewehrung Krafteinleitungslänge	A.7

A.2 PLÄNE UND MESSEINRICHTUNG

A.2.1 MATERIALVERSUCHE (ZUG, DRUCK, FASER-PULLOUT, STAB-PULLOUT)

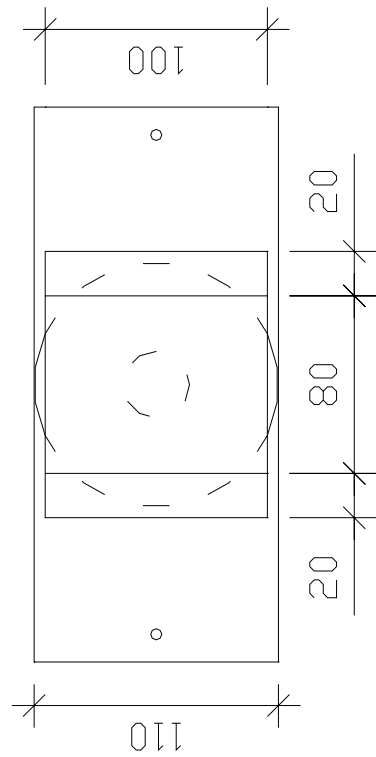
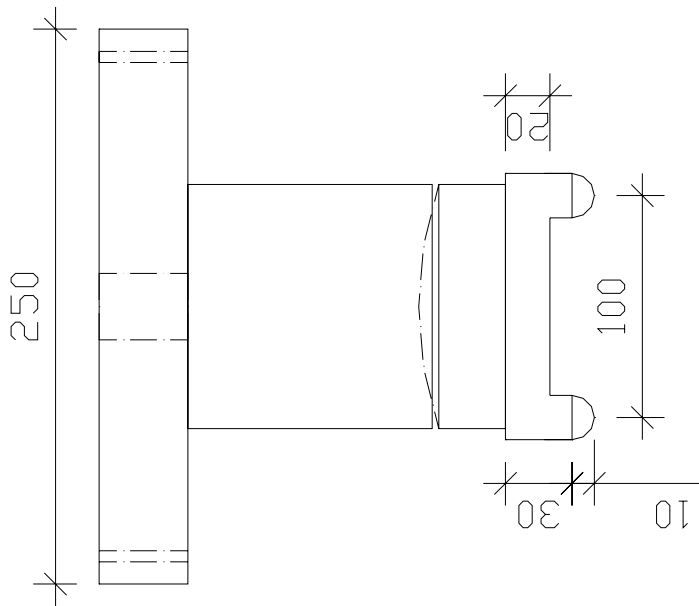
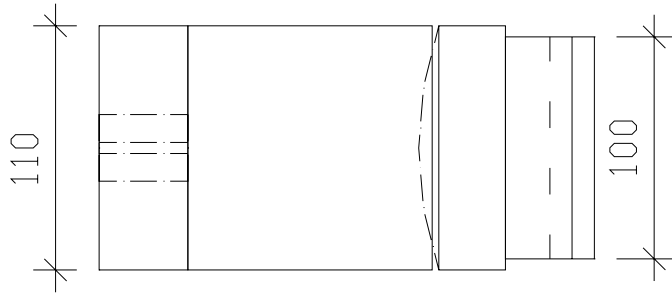


A.2.2 MATERIALVERSUCH BIEGUNG



EPF Lausanne IS-BETON	
projet Pont en BHP 00.02 Diss RPC Jungwirth essais materiau	
élément de construction essai flexion materiau	
échelle 1:2	date 14/8/03
	auteur Jungwirth

A.2.3 MATERIALVERSUCH BIEGUNG: LASTEINLEITUNG OBEN



EPF Lausanne IS-BETON

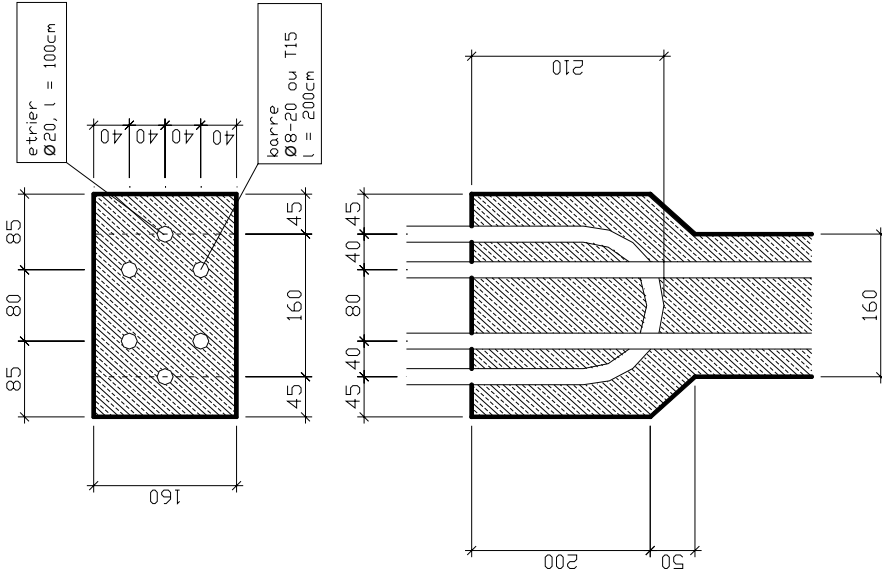
projet: diss RPC Jungwirth
Serie d'essais 1

élément de construction:
dispositif 4 pointe

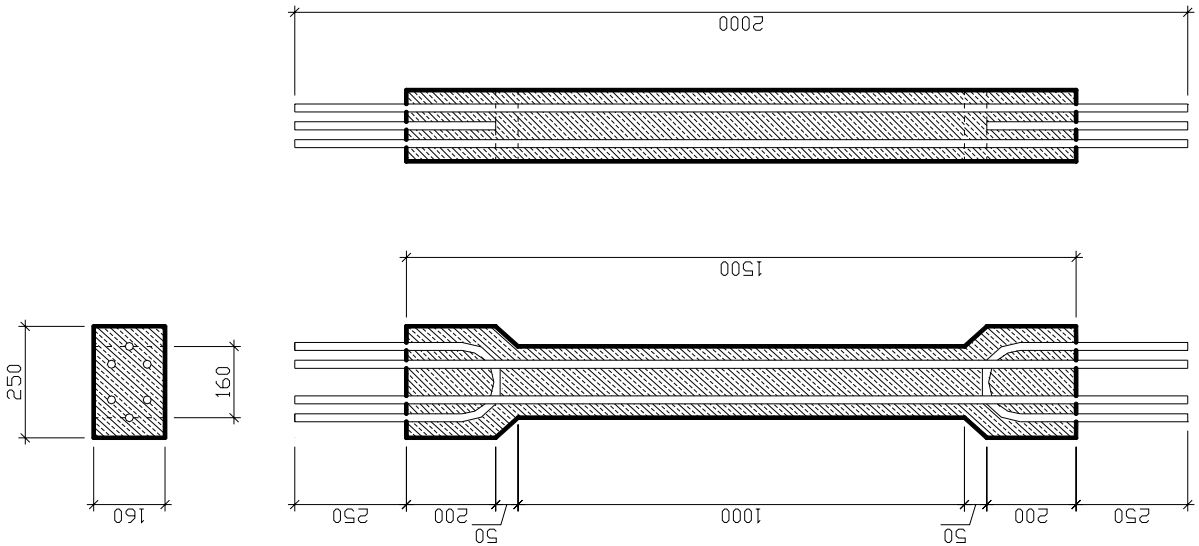
échelle: 1:2 date: 3/4/03 auteur: Jungwirth

A.2.4 BAUTEILVERSUCHE: PROBEKÖRPER

DETAIL 105



EPROUVEITE traction 100



EPF Lausanne IS-BETON

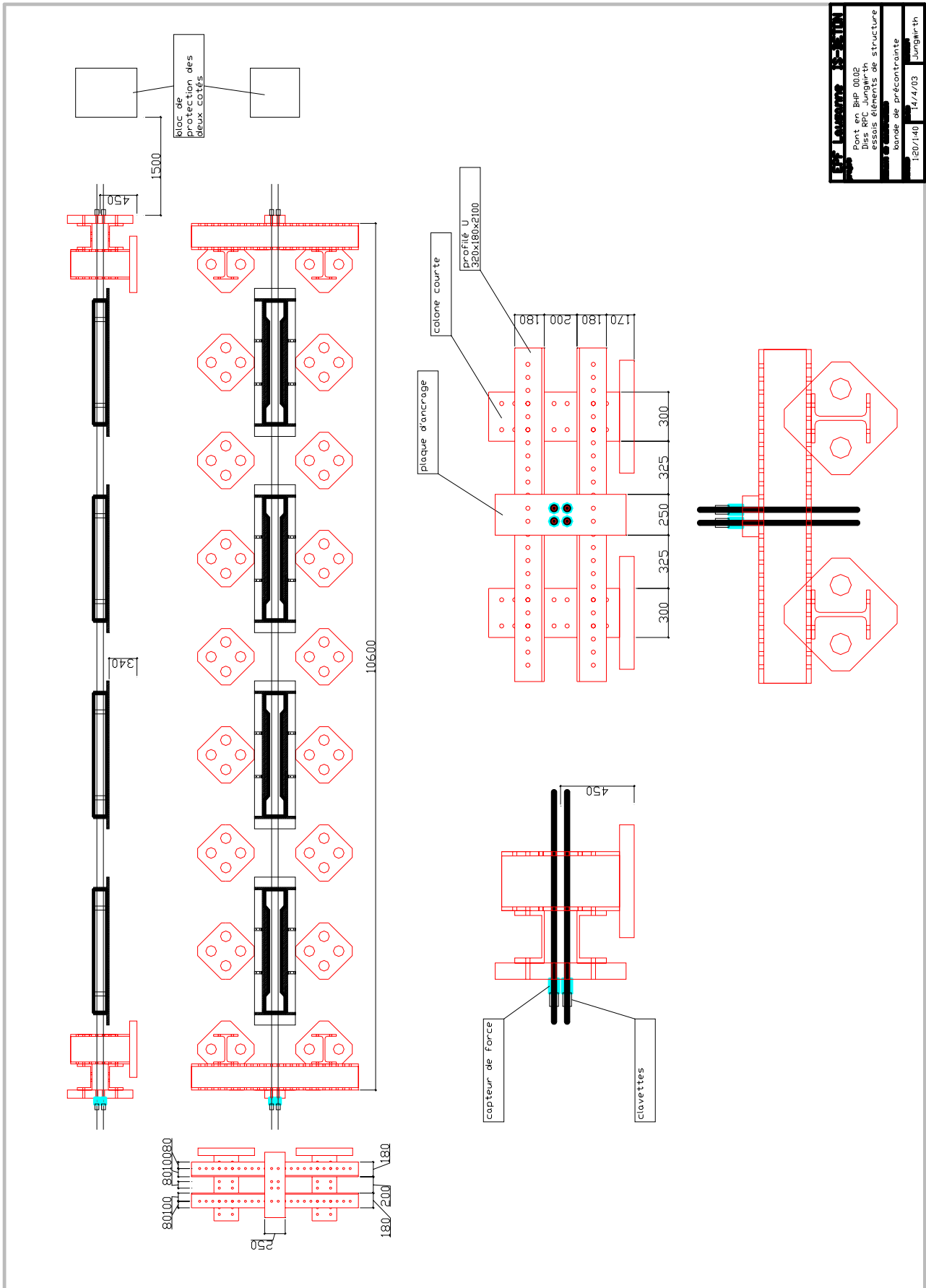
projeté Diss RPC Jungwirth
Serie d'essais 1

élément de construction

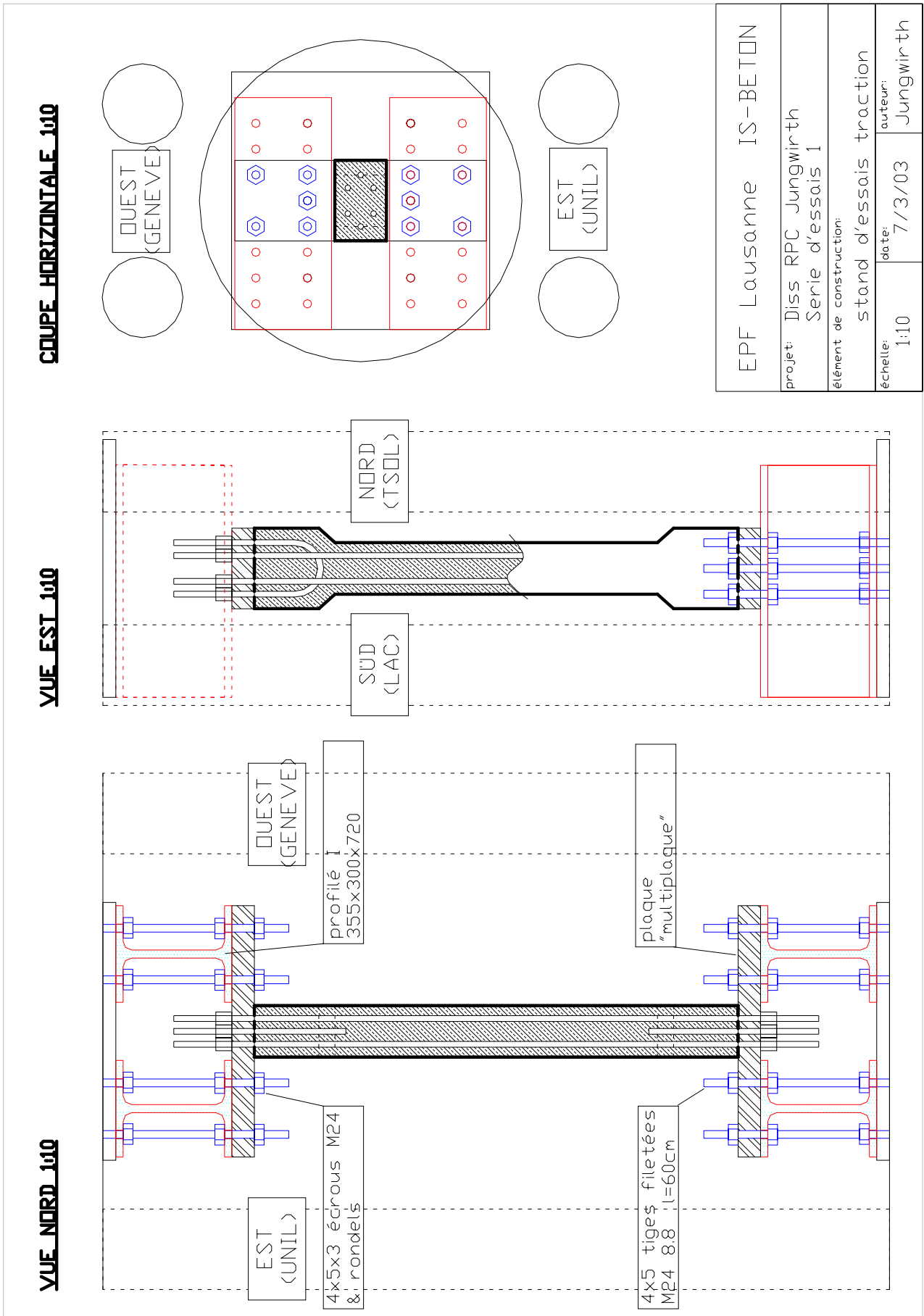
dimensions epruvettes

échelle	1:10	date	17/2/03	auteur	Jungwirth
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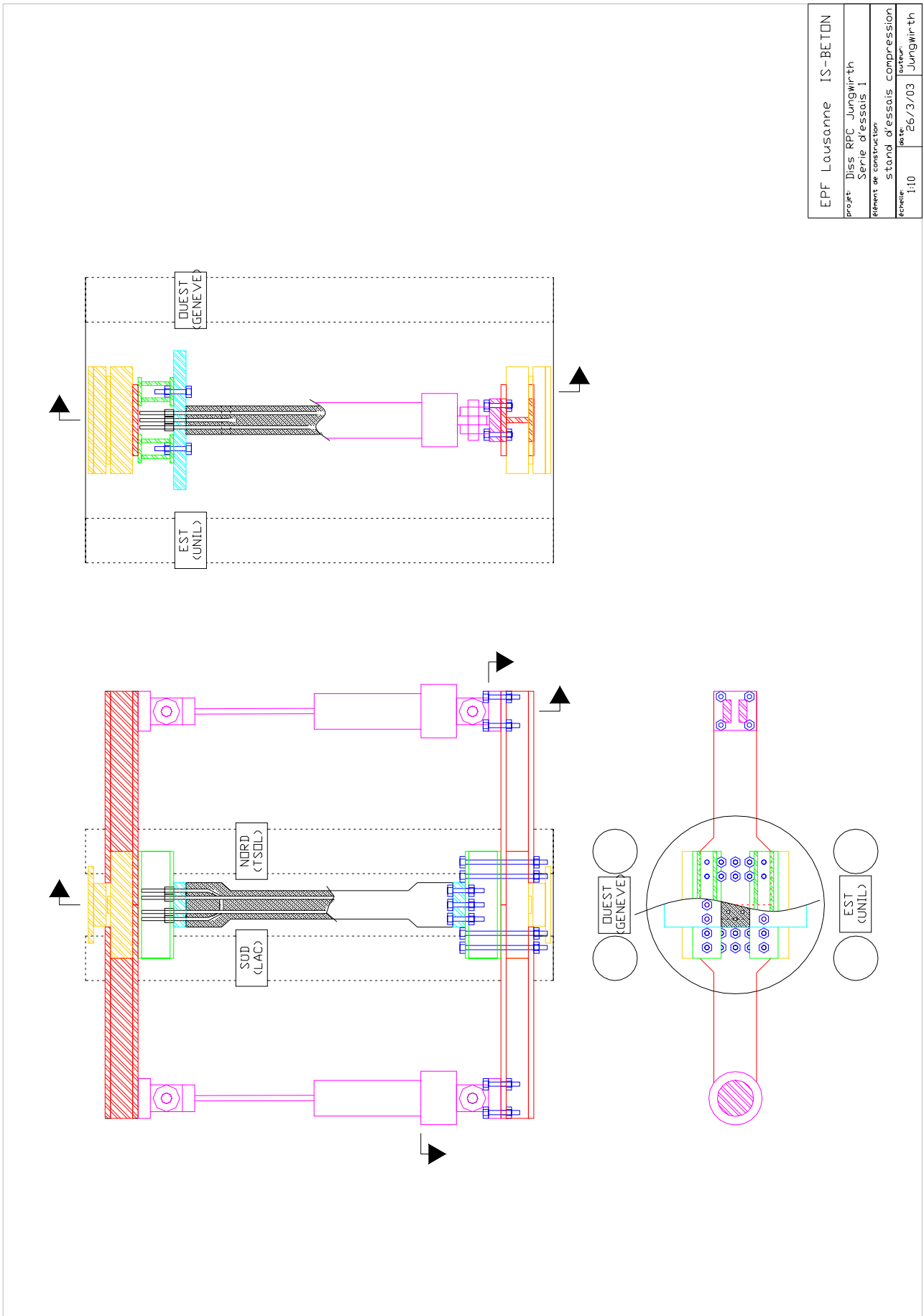
A.2.5 BAUTEILVERSUCHE: SPANNRAHMEN



A.2.6 BAUTEILVERSUCHE ZUG: VERSUCHSSTAND

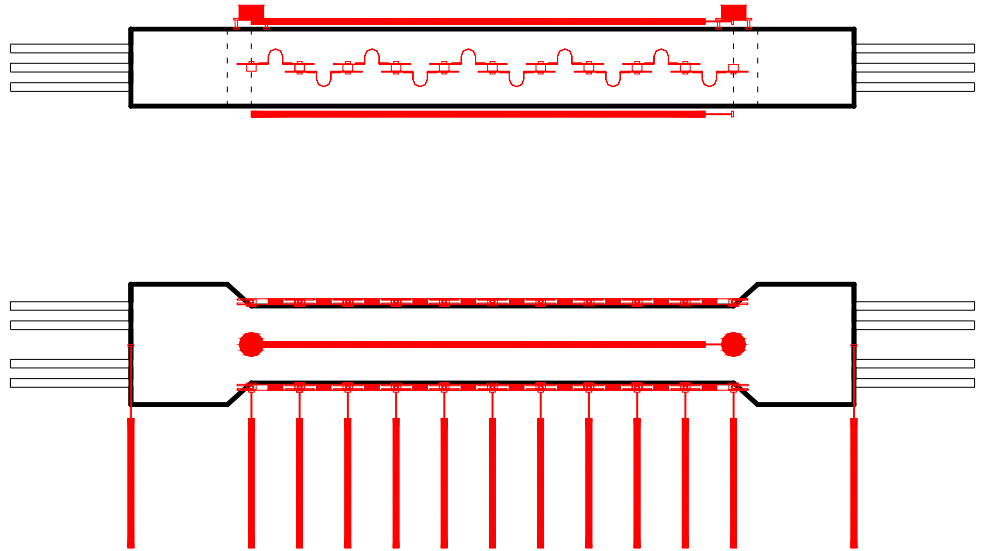
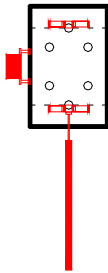


A.2.7 BAUTEILVERSUCHE DRUCK: VERSUCHSSTAND

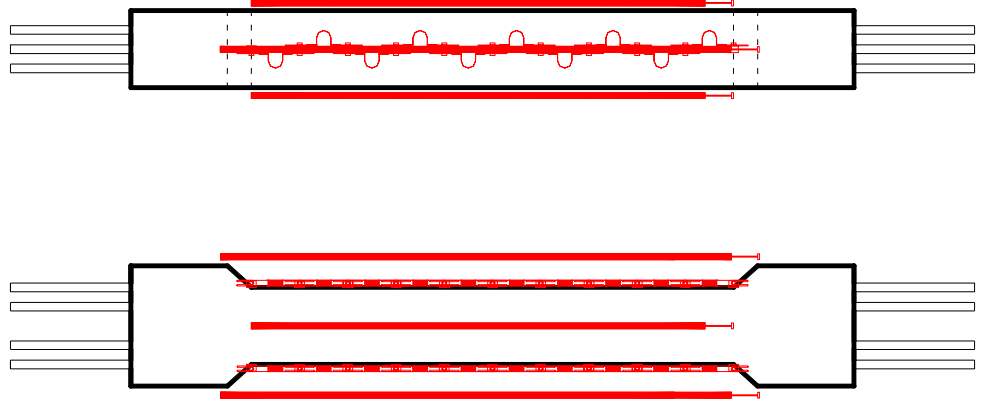
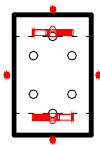


EPF Lausanne IS-BETON	
Projet: Dis: RPC Jungwirth	
Série d'essais: I	
Élément de construction: stand d'essais compression	
Echelle: 1:10	Auteur: 26/3/03 Jungwirth

EPROUVETTE compression 1u10



EPROUVETTE traction 1u10



EPF Lausanne IS-BETON	
projet Pont en BHP 00:02 Diss RPC Jungwirth essais éléments de structure	
élément de construction plan des capteurs	
échelle 1:10	date 1/6/04
auteur Jungwirth	

A.3 WERKSTOFF

A.3.1 ÜBERSICHT ALLER MISCHERCHARGEN UND DER HERGESTELLTEN PRÜFKÖRPER

Charge	Allgemein			Frischbeton		3 Punkt			QS Prisma			Würfel	Probekörper			
	Menge	add H2O	SerieNR	Temp	Aus DIN	T Ø50	max Abrams	3 Punkt	Ø	Druck	Ø			Druck	Ø	
1																
2																
3																
4																
5																
6																
7																
8																
9	10	5..5		22.6	60								ja	Würfel C22-25		
10																
11																
12	20	7.5..5		26	63	20	70						ja	Würfel C34-35,C37-39		
13a	20	5..5		25	62			12.35	13.5	13.79	13.21	347	369	357	358	Würfel C45-53
13b	30	5..5		26.4	65			16.91	17.05	14.83	16.26	373	392	390	385	Zylinder Z18-23, Würfel C45-53
14	35	5..5		24.8	64			12.8	13.61	11.91	12.77	375	381	374	377	Pullout Stab S1-6
15	20	5..5		24	73	13	67									Balken P13-15, Zugelement T1-3
16	20	5..5		20	79			10.4	8.95	10.86	10.07	313	295	303	304	Pullout Fasern F1-3
17	50	5..5		30.8	59			17.38	14.13	16.96	16.16	389	403	395	396	Zugelement 4-5, Druckzyl 24-27
18	50	5..5		30.9	68			13.86	16.81		15.34	355	390	343	363	Bauteil Zug 1
19	50	5..5		30	64			15.4	12.86	15	14.42	376	378	375	376	Bauteil Zug 2
20	50	5..5		31	65			13.44	12.65	16.53	14.21	362	391	407	387	Bauteil Zug 3
21	50	2.5..96246		29	66			12.02	14.88	16.9	14.60	409	402	373	395	Bauteil Zug 4
22	50	2.5..96246		33	70			14.53	16.34	20.66	17.18	427	354	404	395	Bauteil Druck 1
23	50	2.5..96246		34	68			14.97	18.03	16.03	16.34	349	419	334	367	Bauteil Druck 2
24	50	2.5..96246		32	65			13.93	17.51	16.75	16.06	423	419	424	422	Bauteil Druck 3
25	50	2.5..96246		30	67			16.28	17.03	18.29	17.20	417	430	383	410	Bauteil Druck 4
26	50	2.5..96246		33.7	67			18.05	20.22	13.85	17.37	413.5	412.8	406.8	411	Bauteil Druck 5
27	50	2.5 ?		35.3	56			15.24	20.44	14.34	16.67	411.3	417.6	385.5	405	Bauteil Zug/Druck Spannbett 1
28	50	2.5..96246		35.8	56			19.95	15.49	19.22	18.22	394.2	413.4	410.3	406	Bauteil Zug/Druck Spannbett 2
29	50	5..96246		33.5	70			14.09	14.9	18.72	15.90	406.2	402.7	402.5	404	Bauteil Zug/Druck Spannbett 3
30	50	2.5..96246		33	65			18.76	22.31	22.52	21.20	425.4	431.2	396.4	418	Bauteil Zug/Druck Spannbett 4
31	20	2.5..96246		33.5	57			17.02	16.38	19.92	17.77	424.5	408.7	395.2	409	Bauteil Zug/Druck Spannbett 5

A.3.2 BETONPRÜFUNGSFORMULAR

Nr Charge	Datum	Zeit

Ponts en BUHP 00.02 Jörg Jungwirth

Betonrezept	Menge	Mix / 1m ³	Mix 5l	Mix 10l	Mix 20l	Mix 50l	Mischdauer		
		[kg]	[kg]	[kg]	[kg]	[kg]		Ges.	
		Premix	2355	11.775	23.55	47.1	117.75	1min	
	Serien Nr	Wasser	195	0.975	1.95	3.9	9.75	3min	1min
		Fliessmittel	44.6	0.223	0.446	0.892	2.23	5min	4min
		Stahlfasern	195	0.975	1.95	3.9	9.75	3min	9min
	Zus. Wasser	Gesamt	2789.6	13.948	27.896	55.792	139.48		12min
		+5l Wasser		0.025	0.05	0.1	0.25		
	+10l Wasser		0.05	0.1	0.2	0.5			
Bemerkung:									

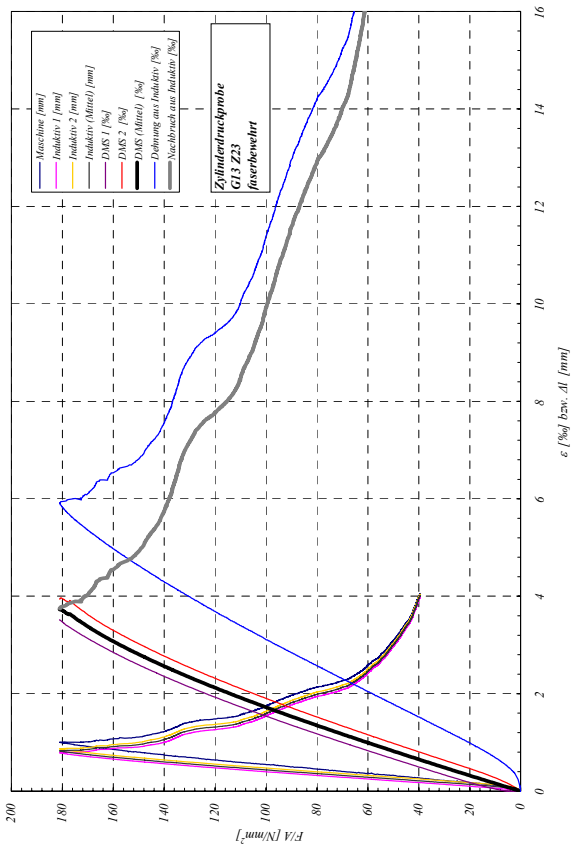
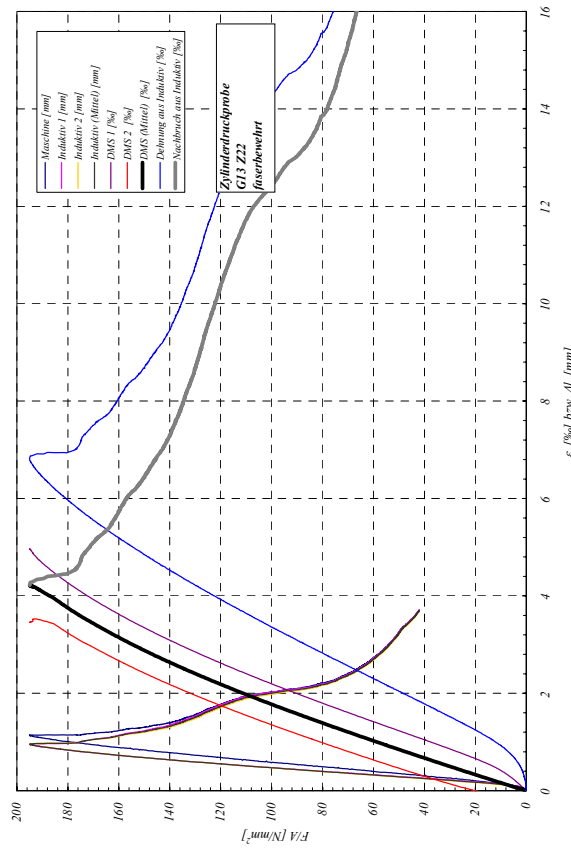
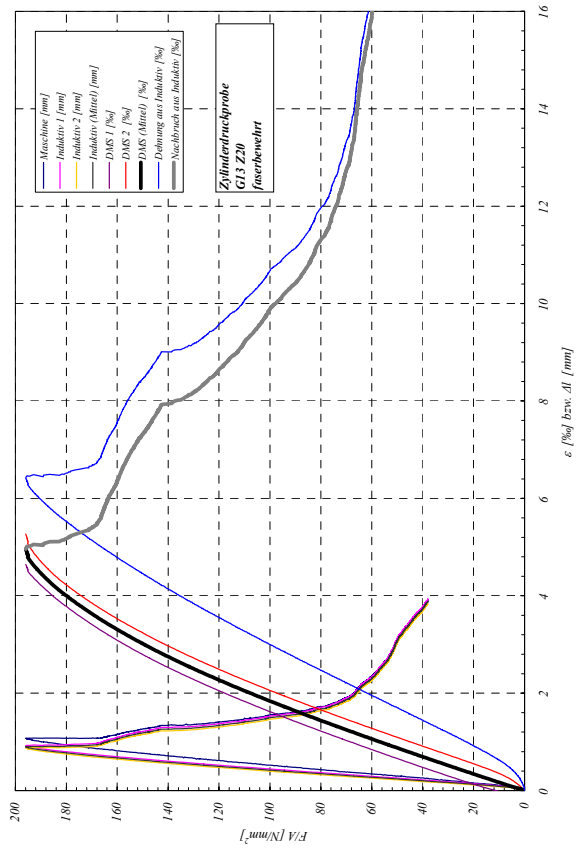
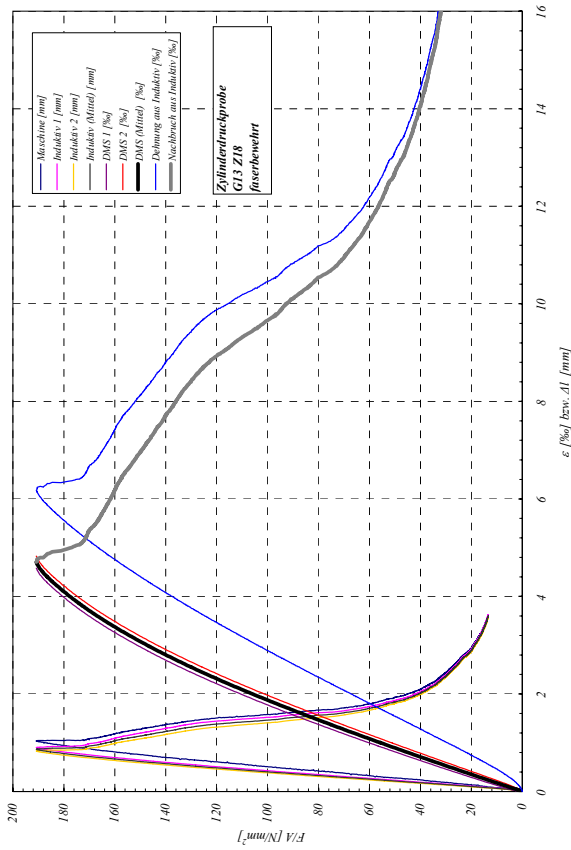
Frischbeton	Temperatur	Ausbreitmass DIN	Slump Flow		Segregation
	[°C]	[cm]	TØ50	Ømax	
			[sec]	[cm]	[-]
Bemerkung:					

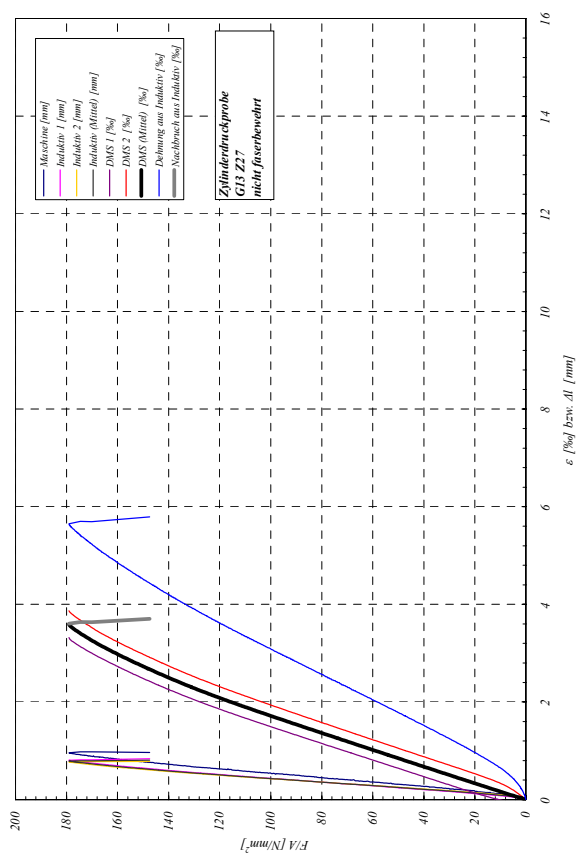
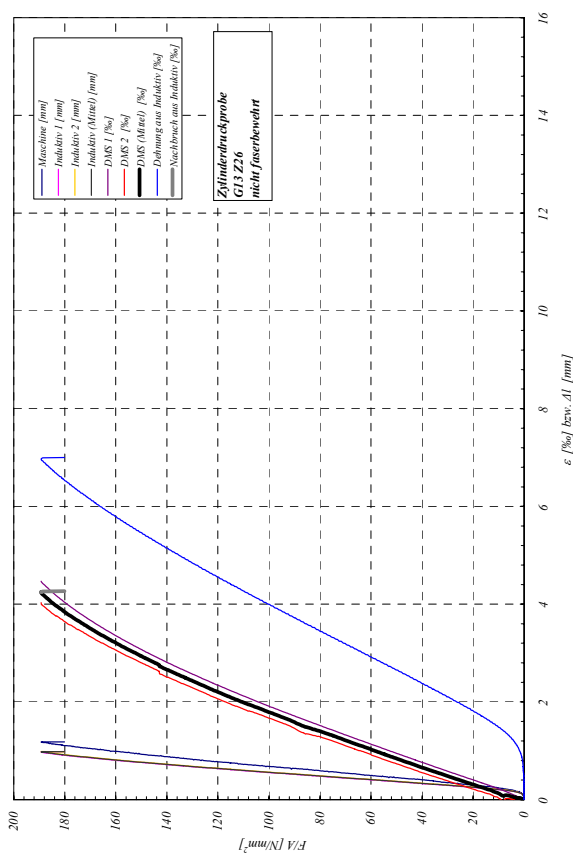
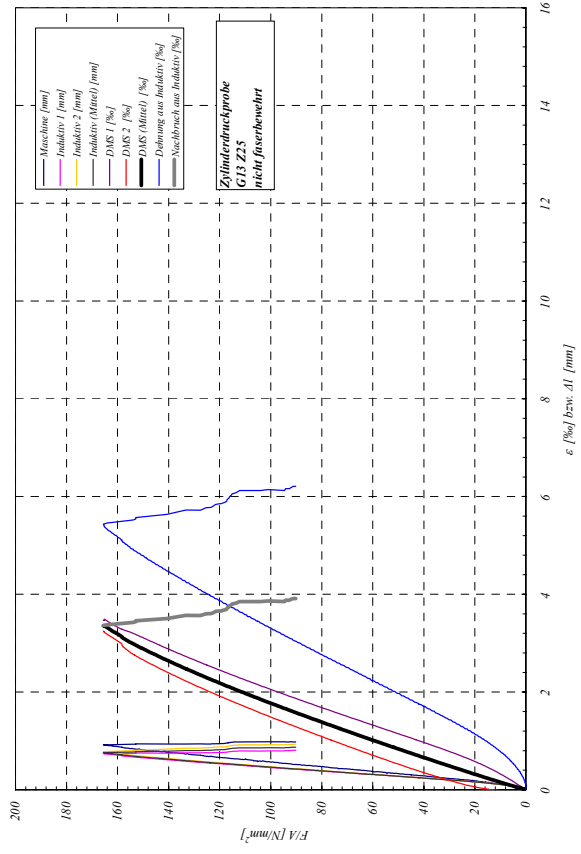
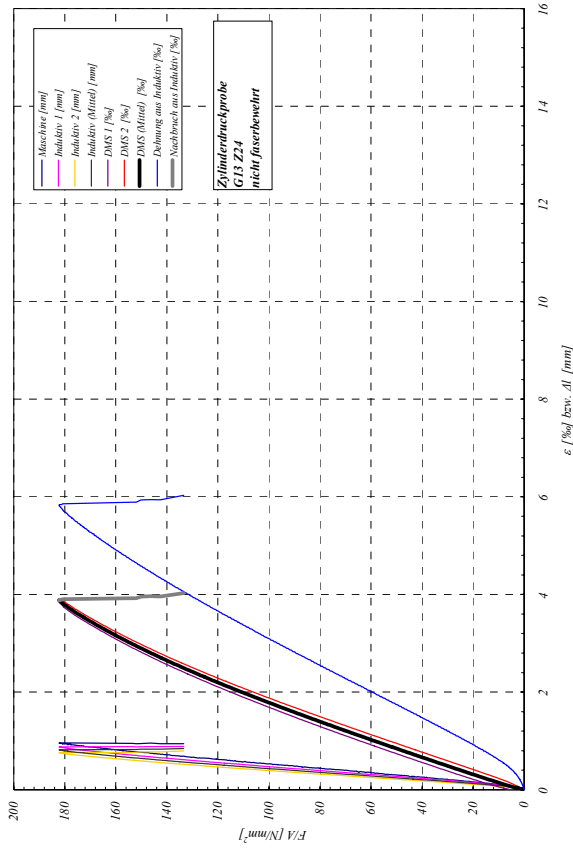
Festbeton	Ausschaldatum	Würfel				Prisma			
		Probe Nr	24h	48h	7d	28d	Probe Nr	3 Punkt	Druck
			[KN]	[KN]	[KN]	[KN]		[KN]	[KN]
	Ausschaltemp.								
Bemerkung:									

Probekörper	Type	Nummer		Wasserbad		Typenliste	
		von	bis	von	bis		
							M – Z: Material Zugversuch
							M – B: Material Biegeversuch
							M – D: Material Druckversuch
							P – S: Pull Out Stab
						P – F: Pull Out Faser	
						B – Z: Bauteil Zug	
						B – D: Bauteil Druck	

A.4 DRUCKVERSUCHE

A.4.1 ZYLINDERDRUCKVERSUCHE



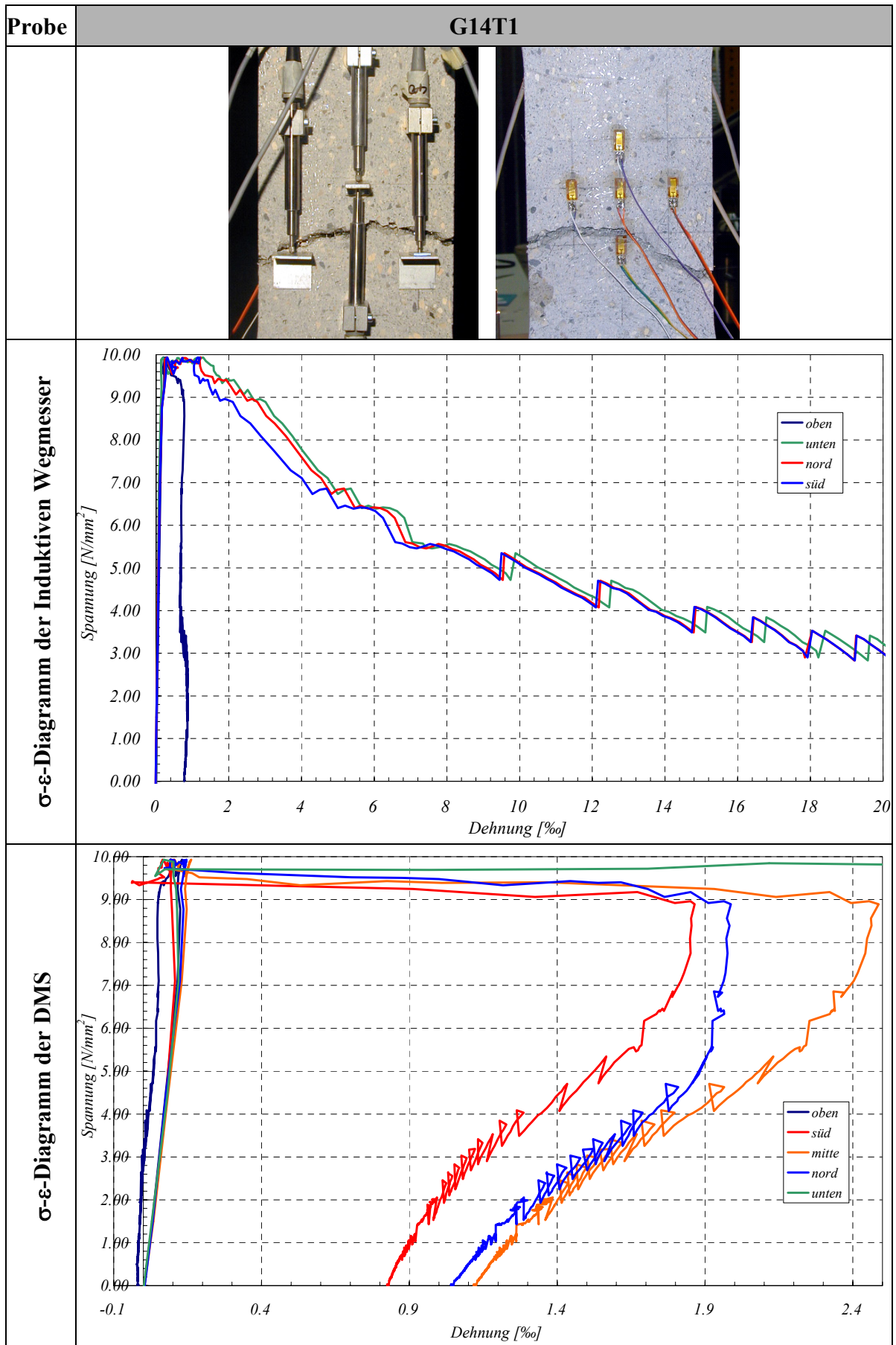


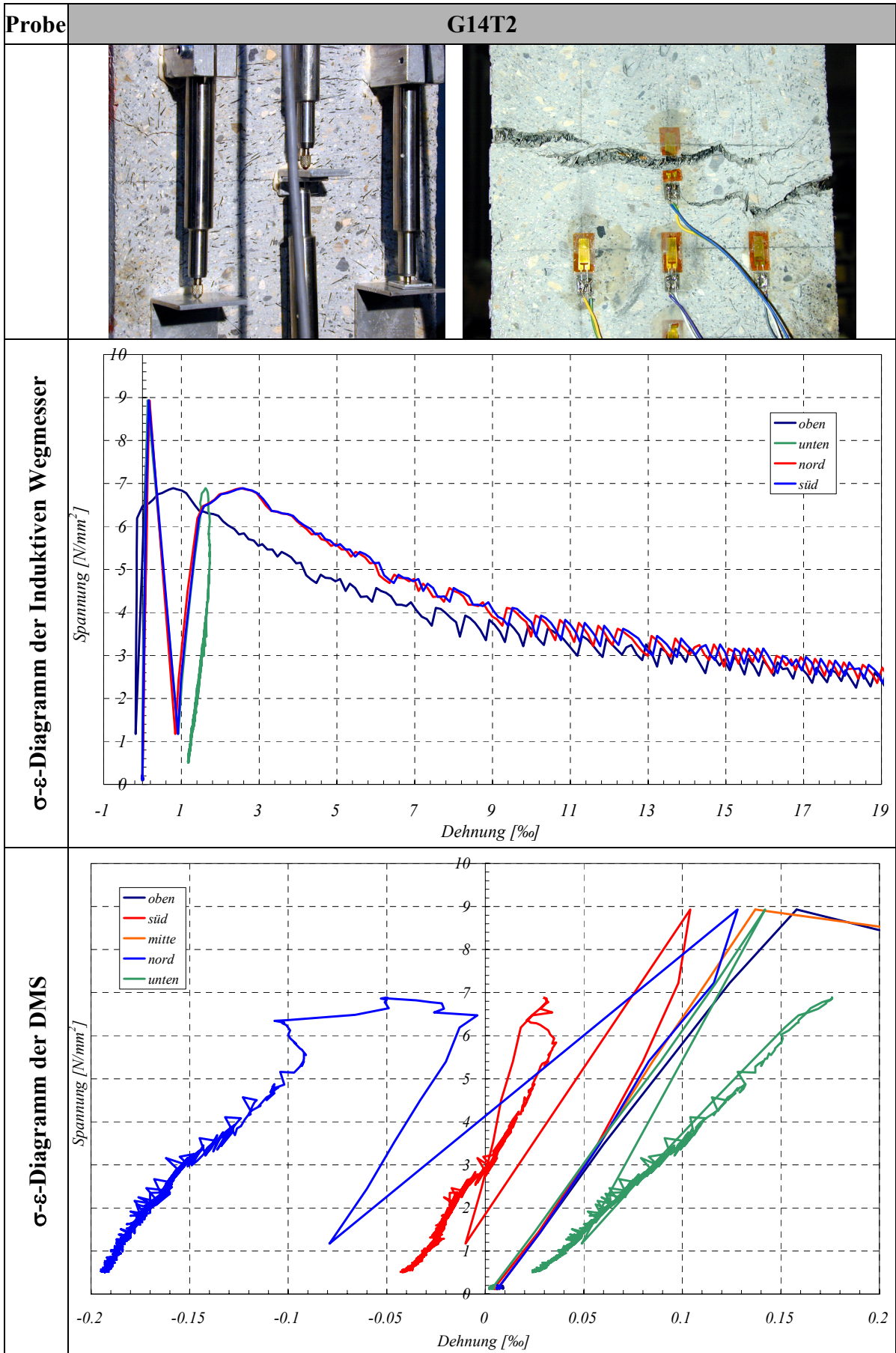
A.4.2 WÜRFELDRUCKVERSUCHE

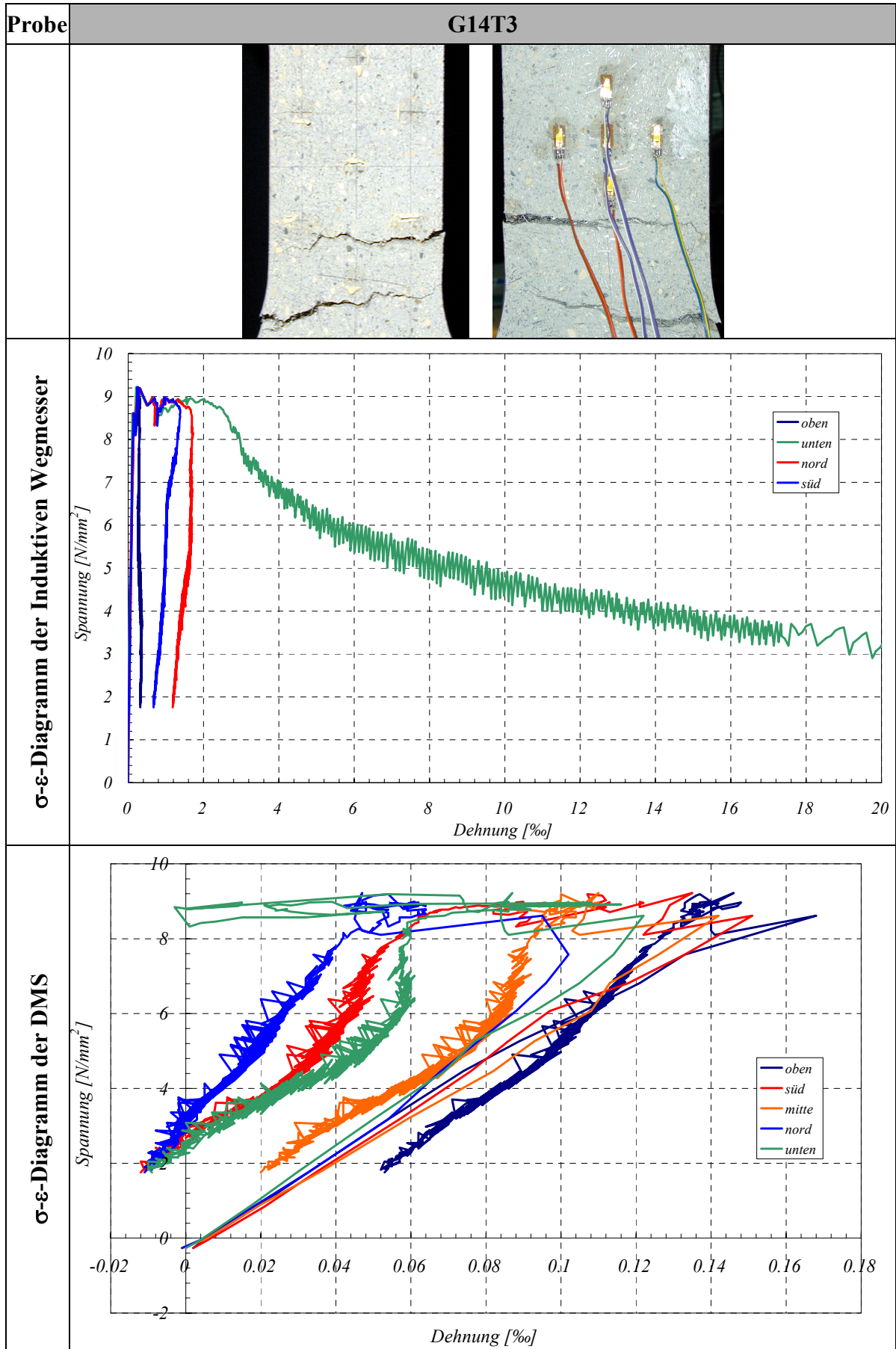
Charge	24h				7d				28d			
	Probe 1	Probe 2	Probe 3	\bar{x}	Probe 1	Probe 2	Probe 3	\bar{x}	Probe 1	Probe 2	Probe 3	\bar{x}
	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]	[MPa]
9	101	113		107	156	163		160				
12	6	8		7					201	211	207	206
13a	65	70	69	68	170	172	172	171	205	189	197	197
\bar{x}				61				166				202
s				-				6				5

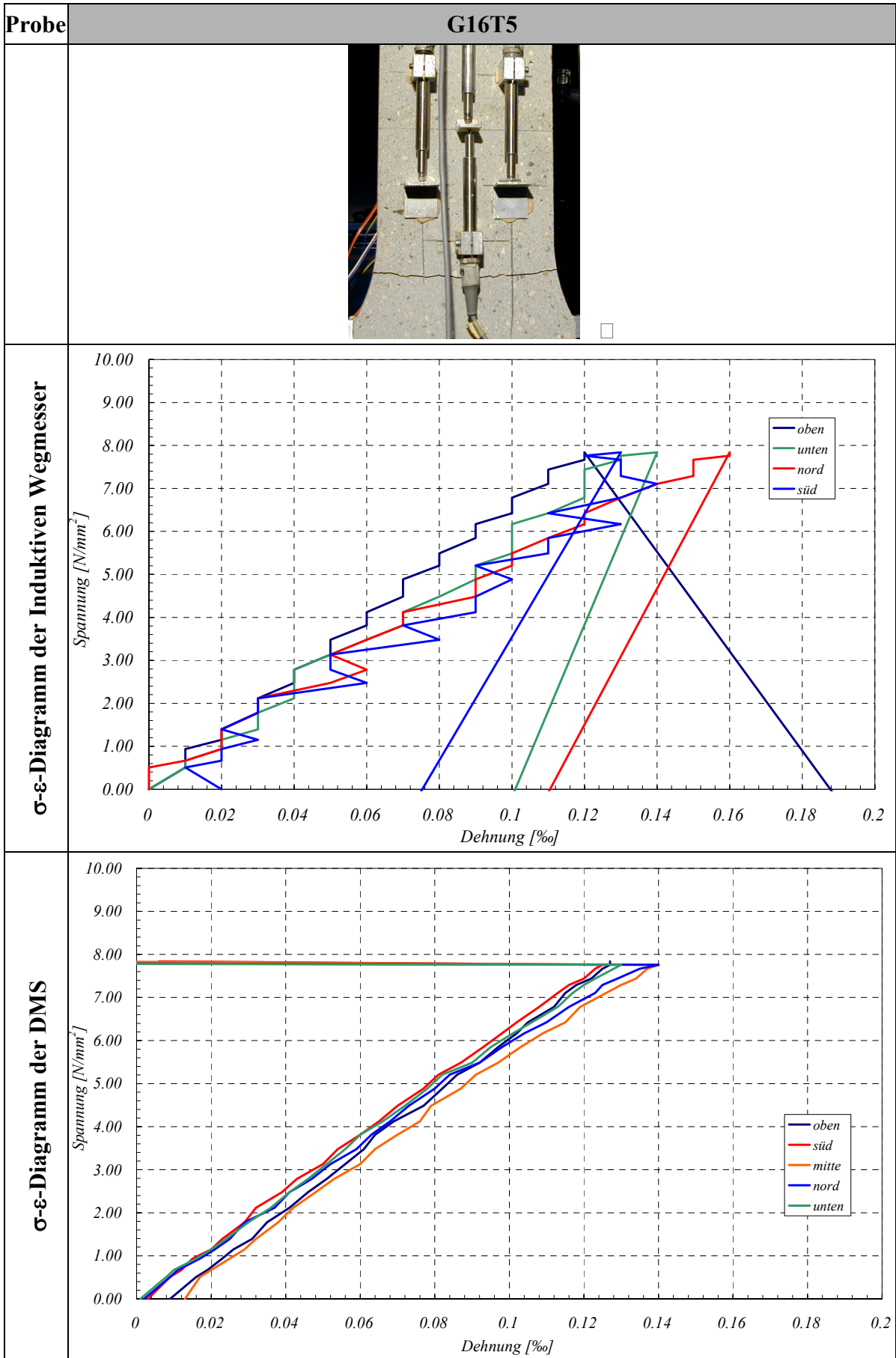
A.5 ZUGVERSUCHE

A.5.1 ZUGVERSUCHE MIT KONSTANTEM QUERSCHNITT



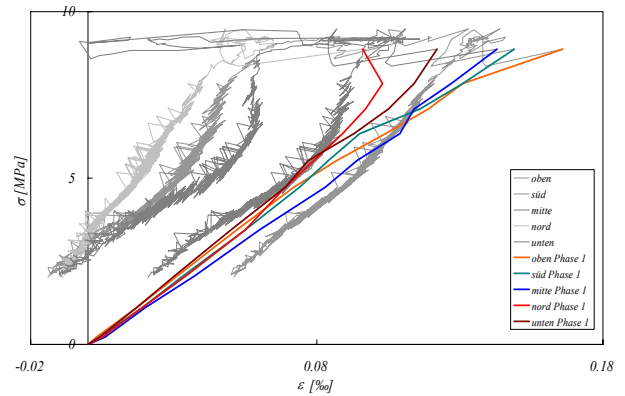
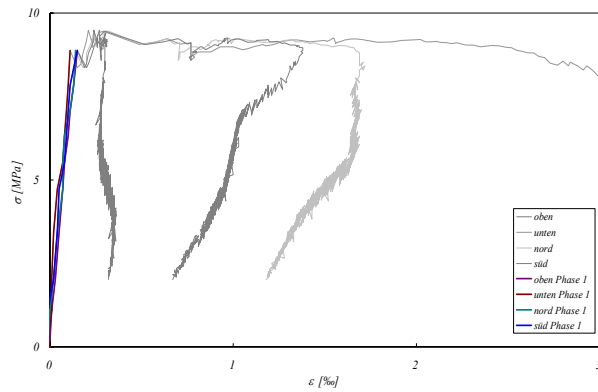




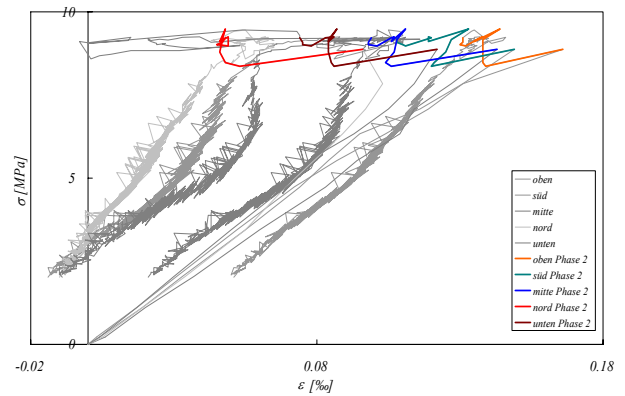
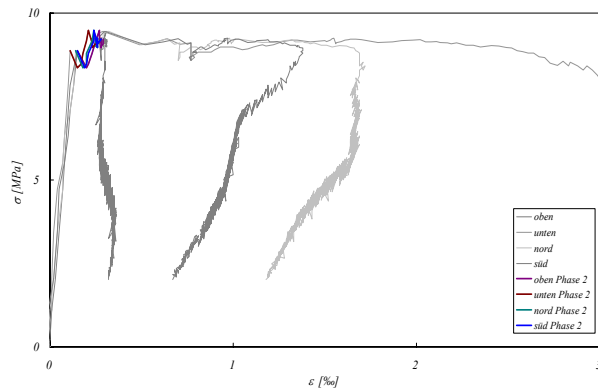


• **ANALYSE G14T3**

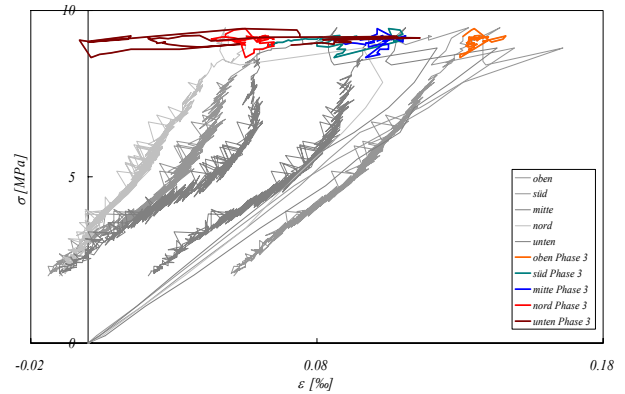
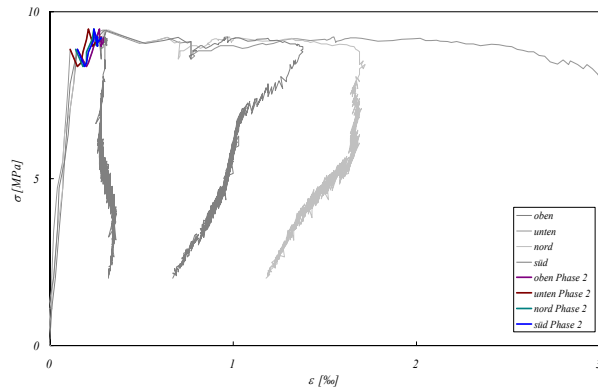
Phase 1: Linear - elastische Verformung – Zementmatrix ungerissen



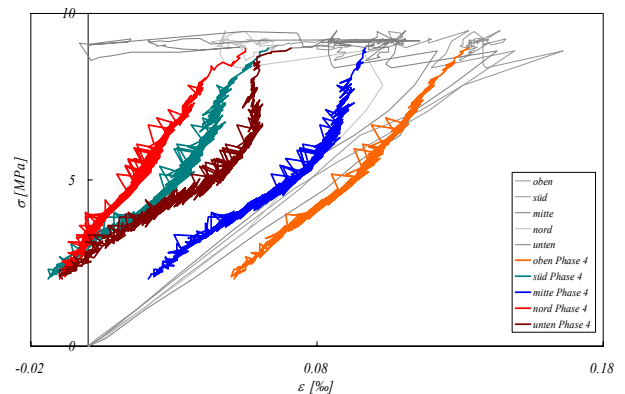
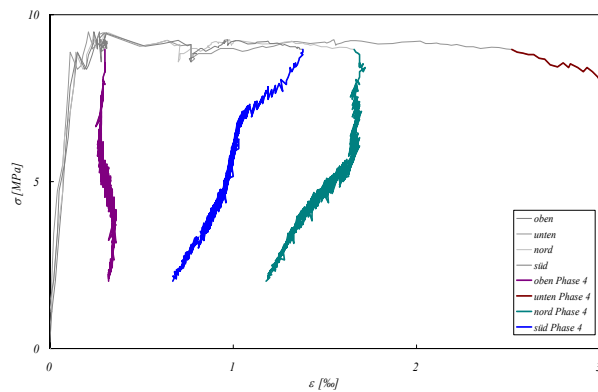
Phase 2: Multirissbildung - Mikrorisse



Phase 3: Öffnung zu Mesorissen – aktivieren der Fasern bis zum Ausriss der Fasern

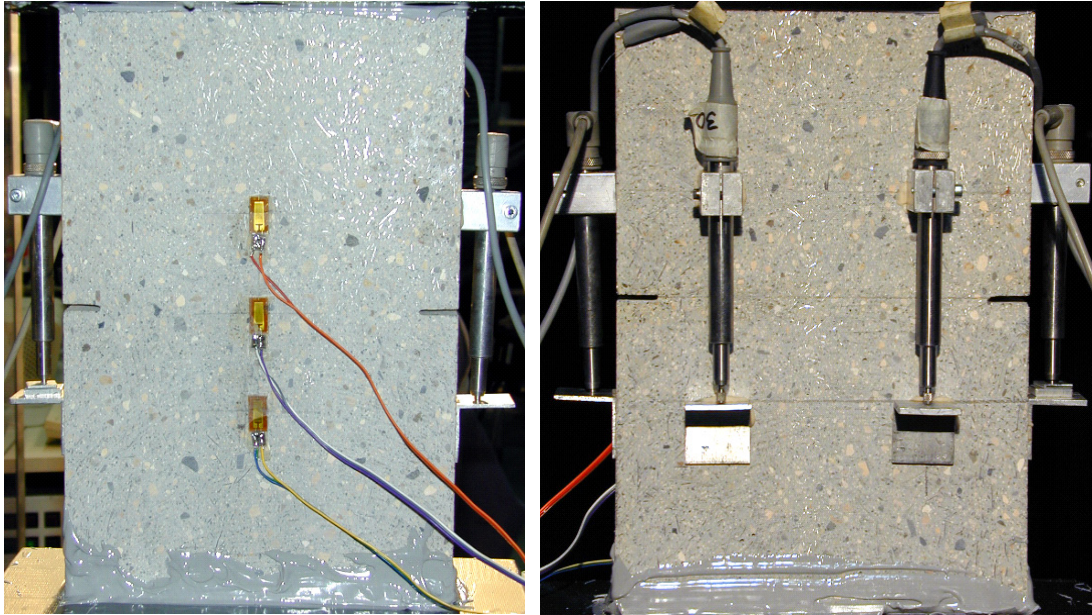


Phase 4: Öffnen von einem oder mehrerer Makrorissen – vorschreitender Ausriss der Fasern

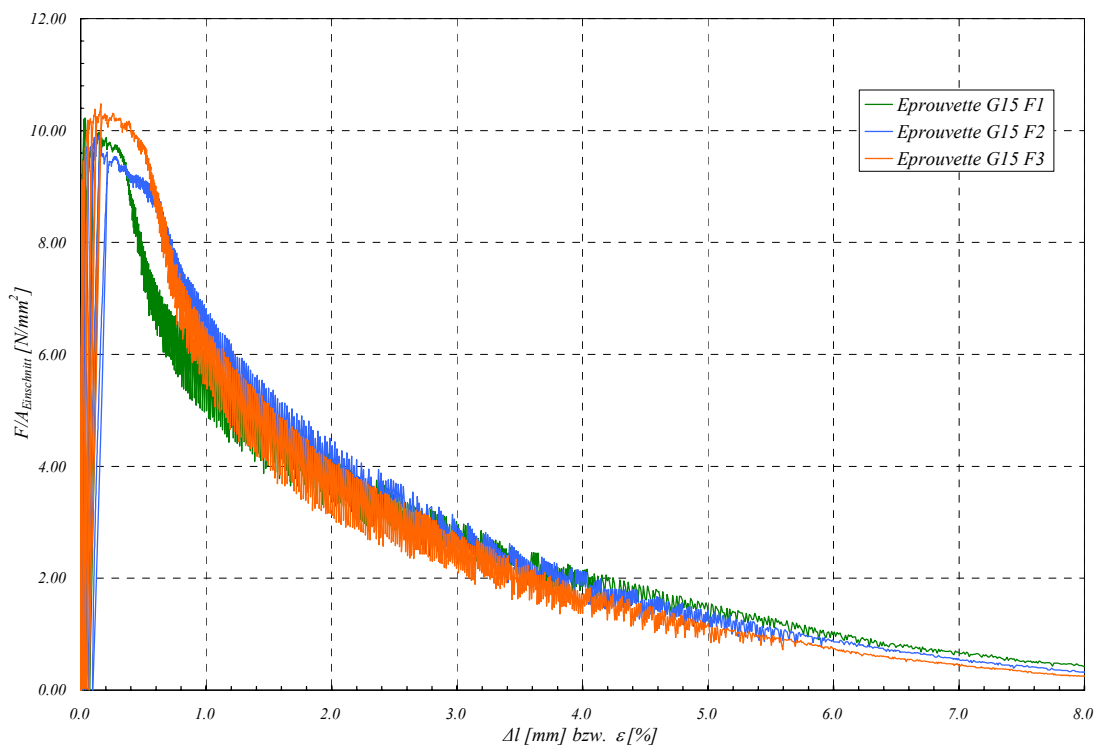


A.5.2 ZUGVERSUCHE MIT GEKERBTER PROBE


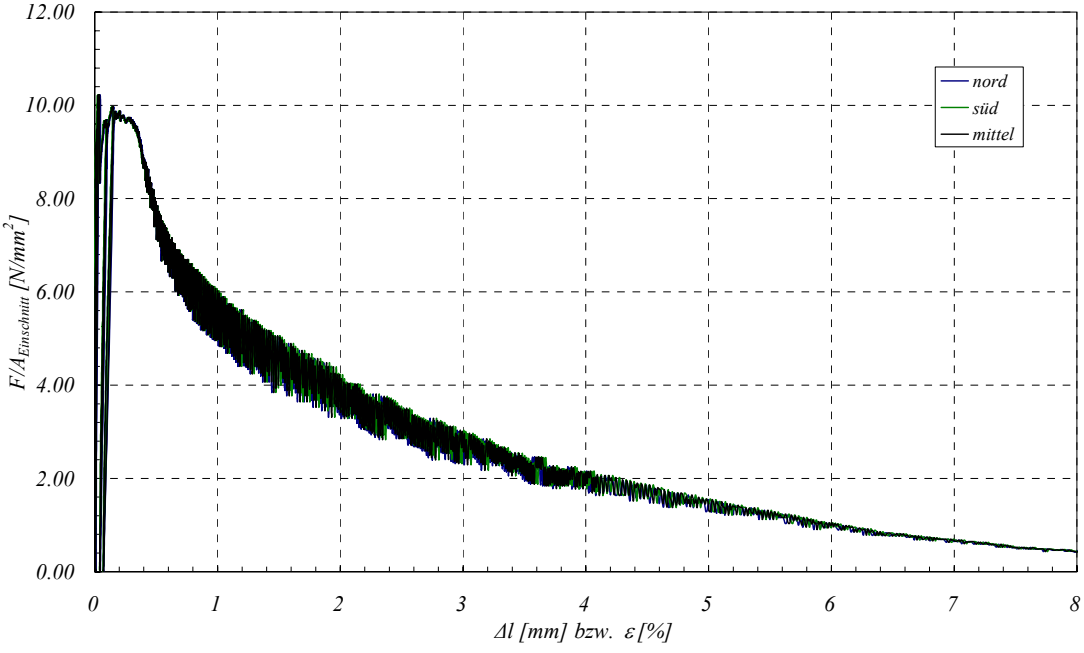
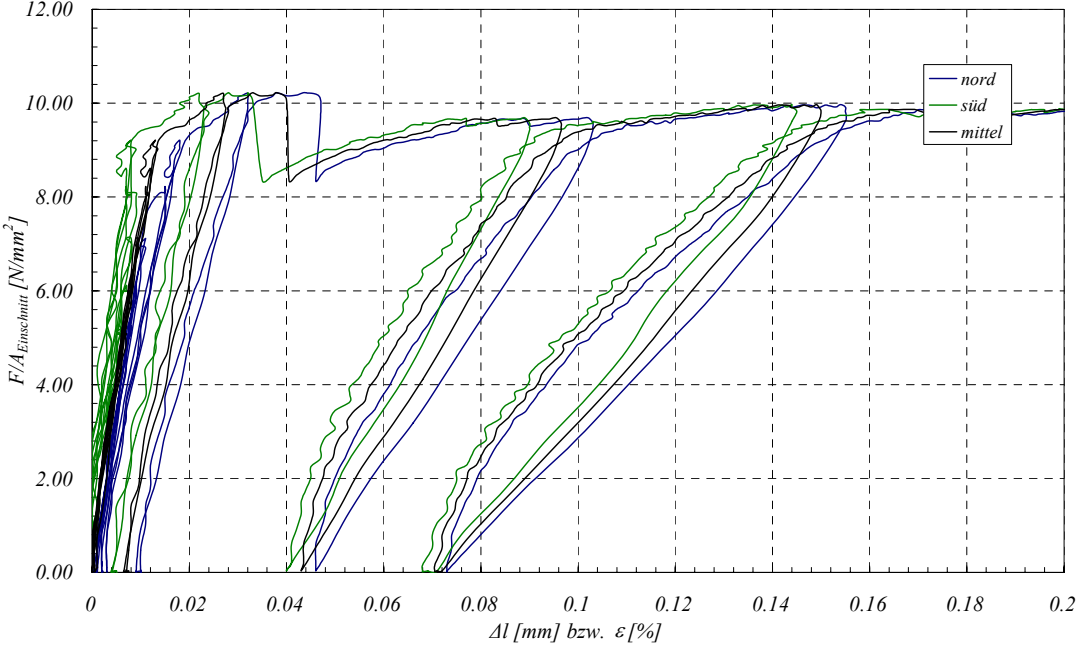
- **FOTOS DER MESSEINRICHTUNG**

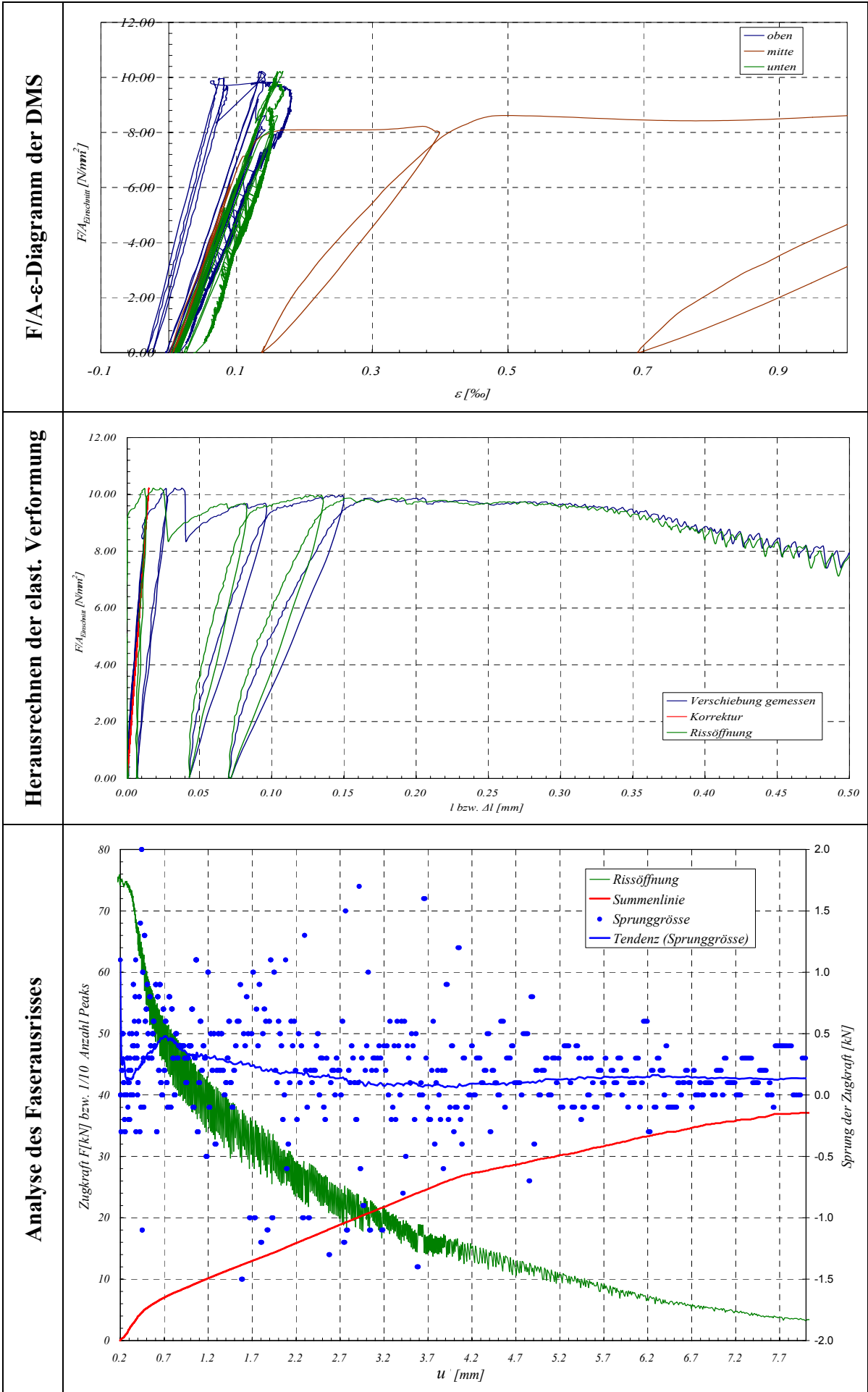


- **SPANNUNGS – VERFORMUNGSKURVE ALLER PROBEN**

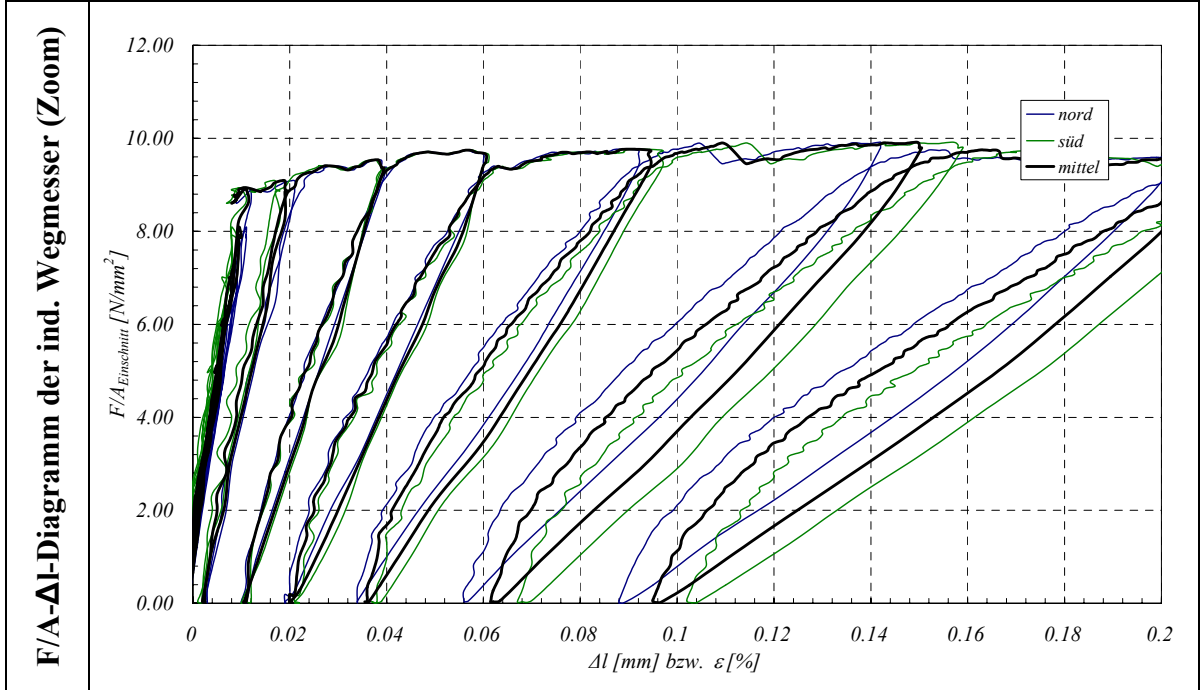
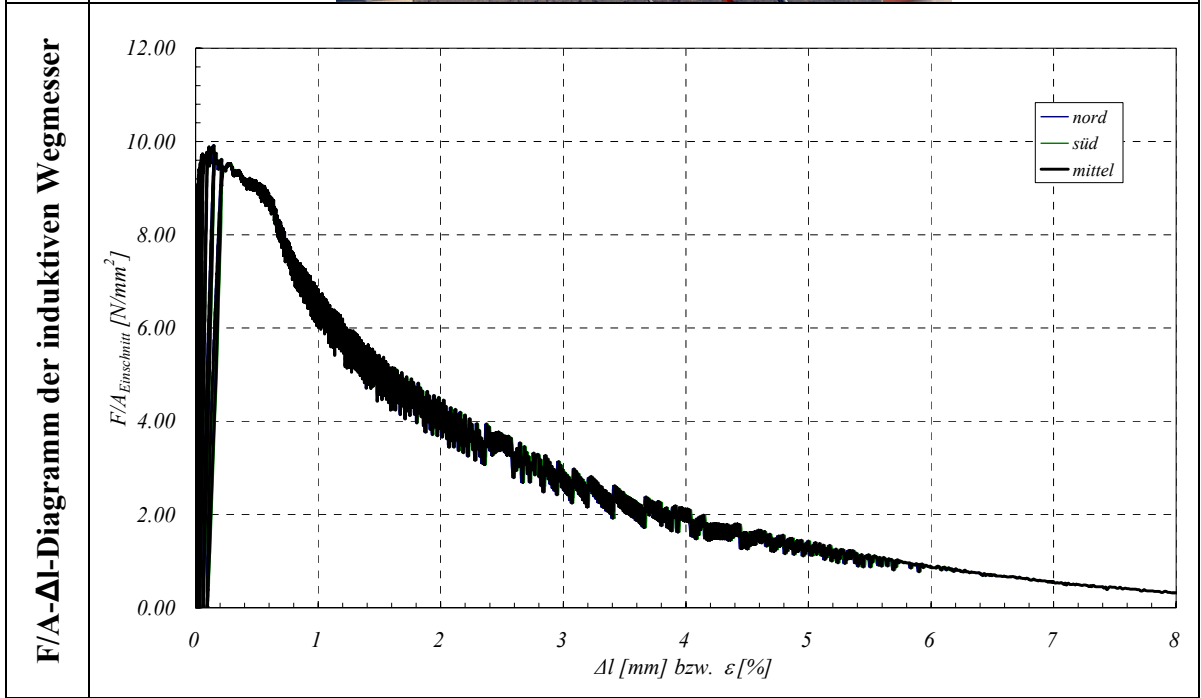
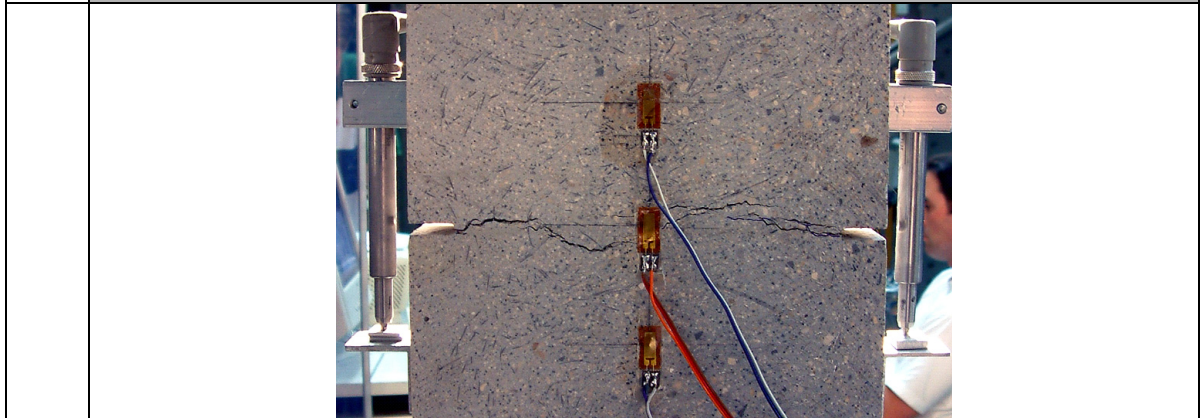


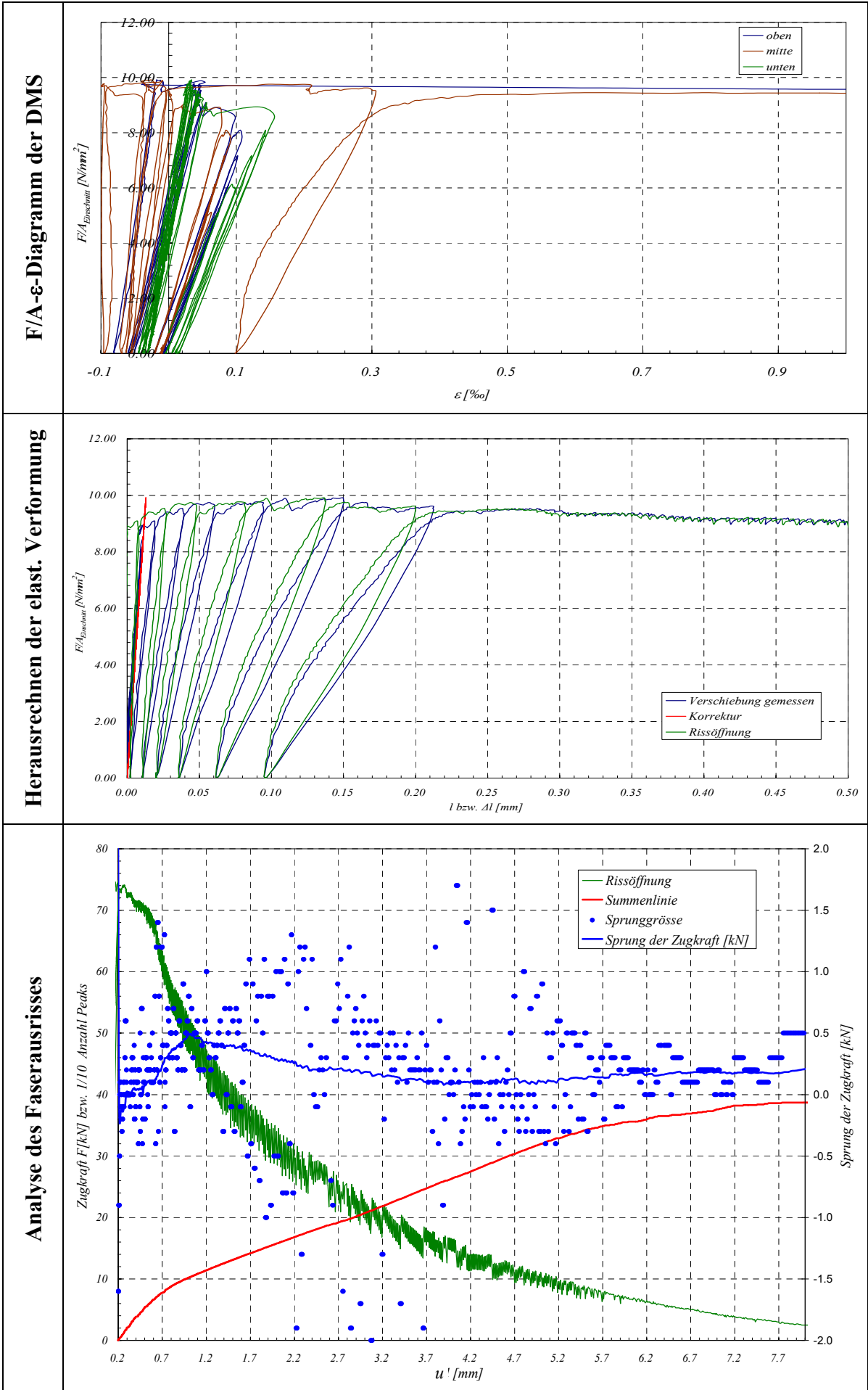
EINZELANALYSE ALLER PROBEN

Probe	G15F1
	
<p>F/A-ΔI-Diagramm der induktiven Wegmesser</p>	
<p>F/A-ΔI-Diagramm der ind. Wegmesser (Zoom)</p>	

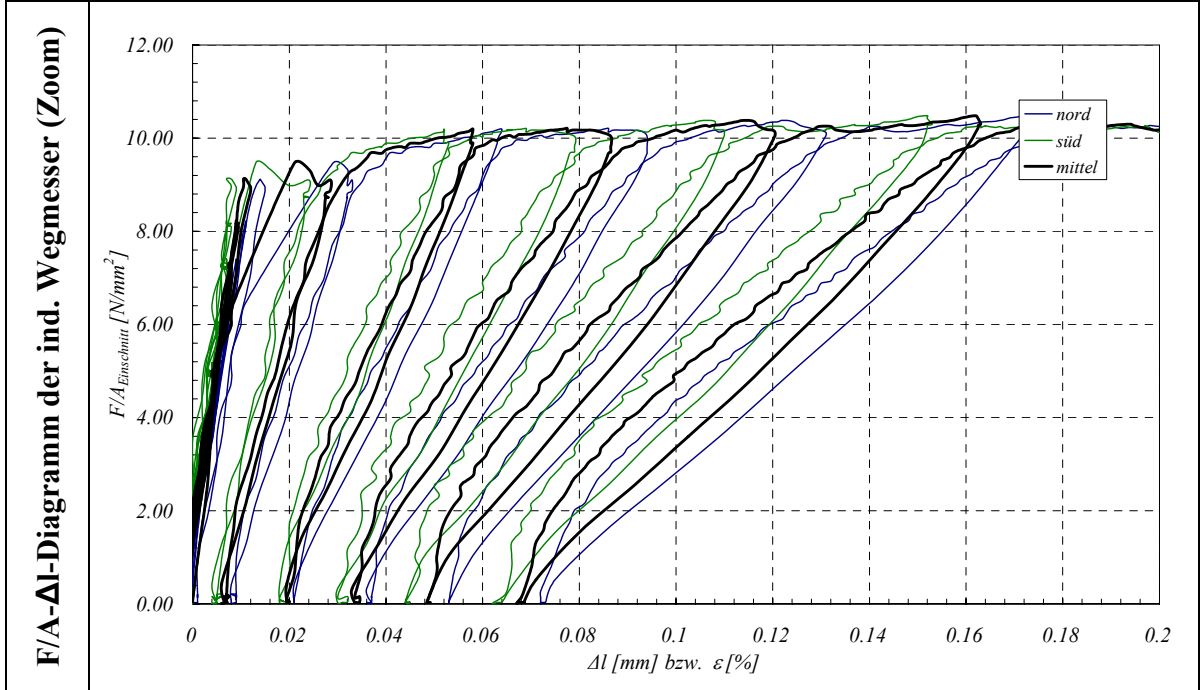
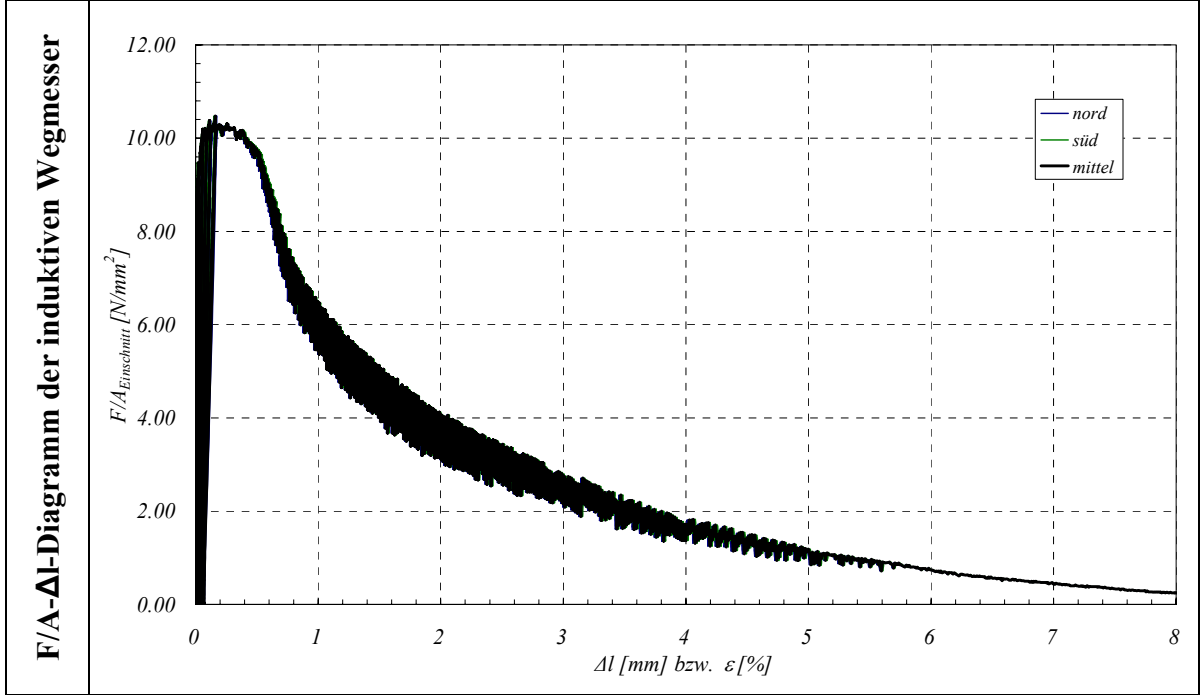
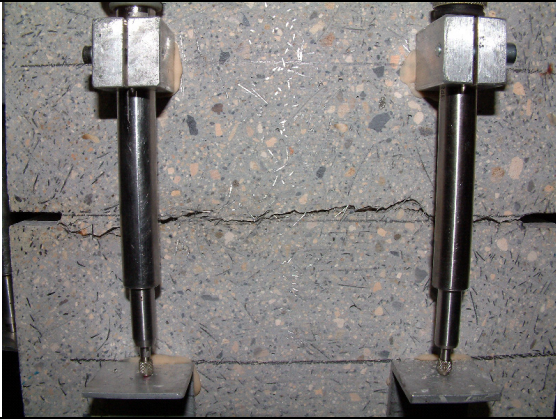


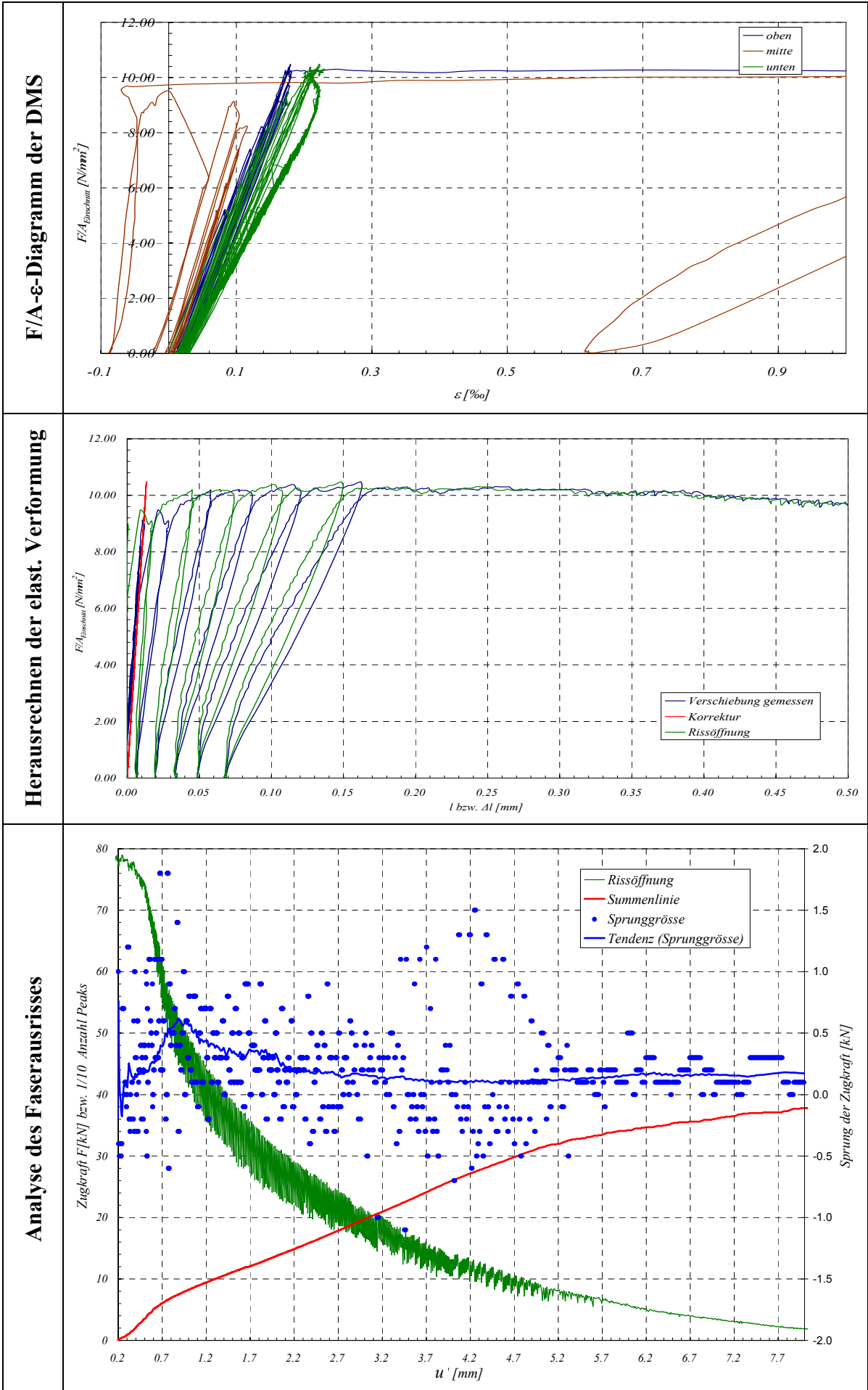
Probe **G15F2**



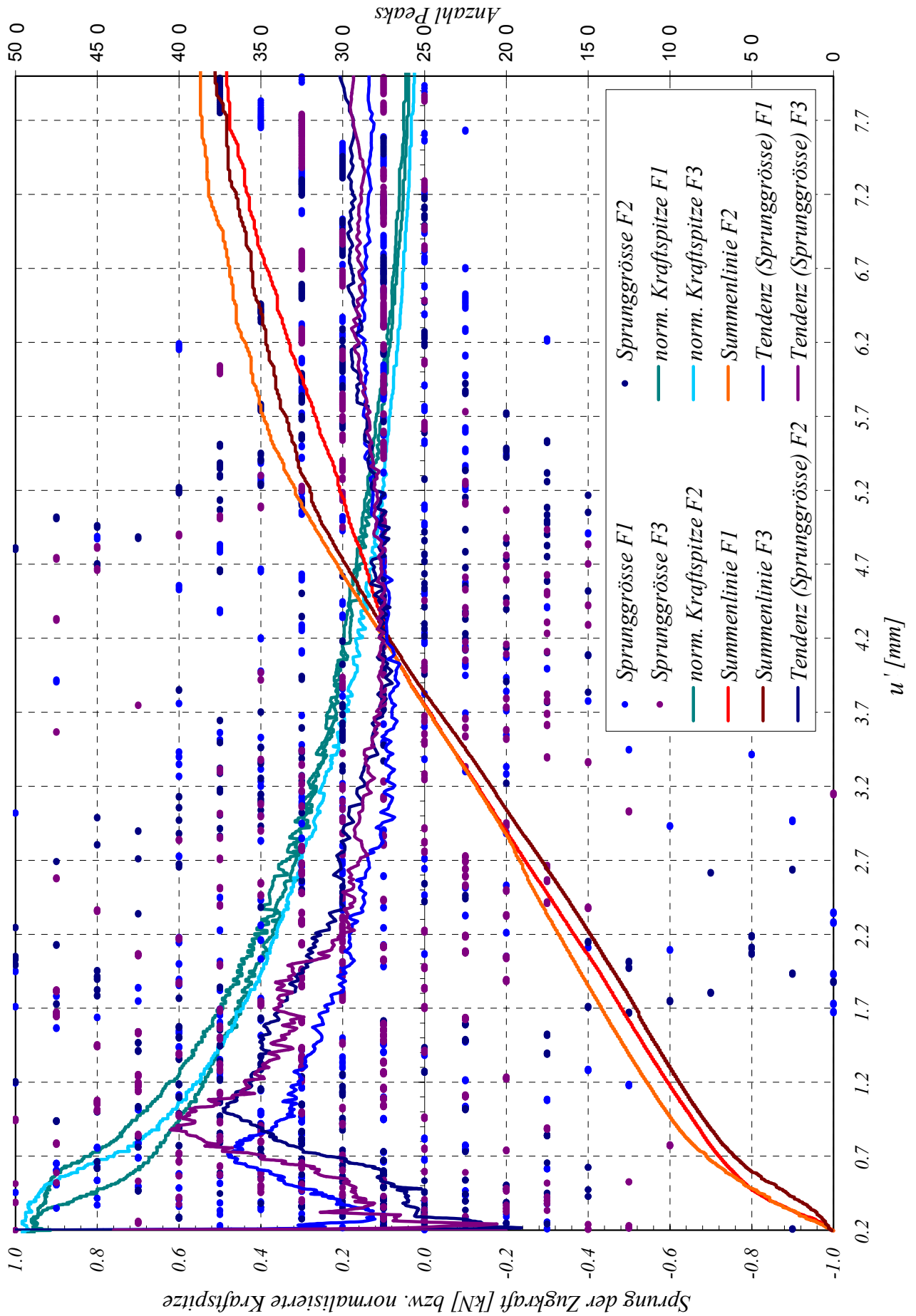


Probe **G15F3**



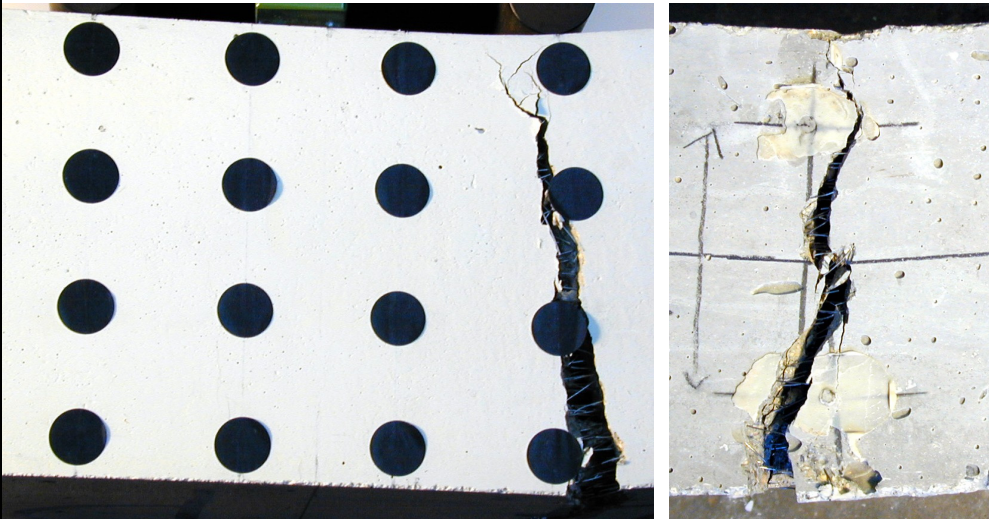
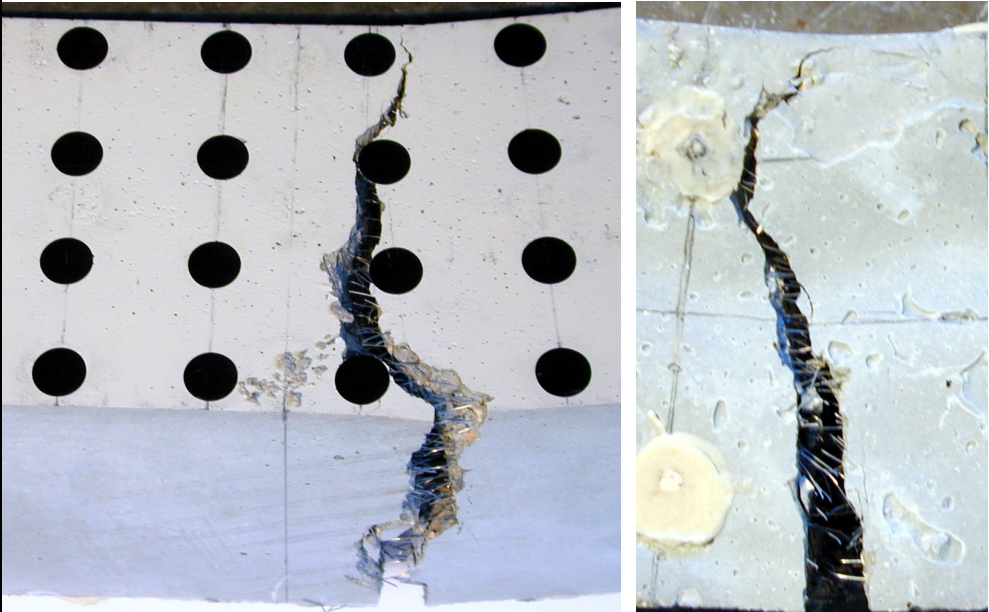
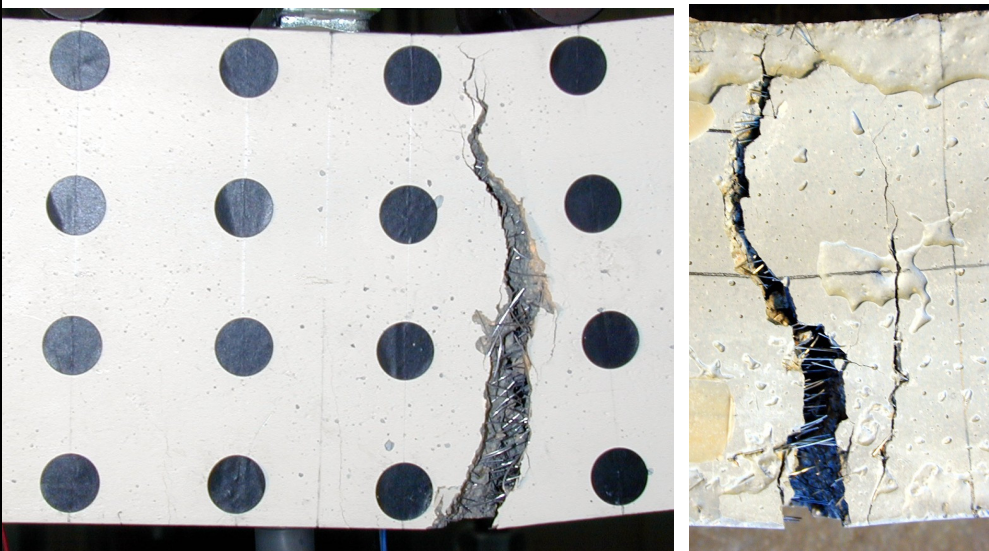


ANALYSE DER GRÖSSE DER SPRÜNGE

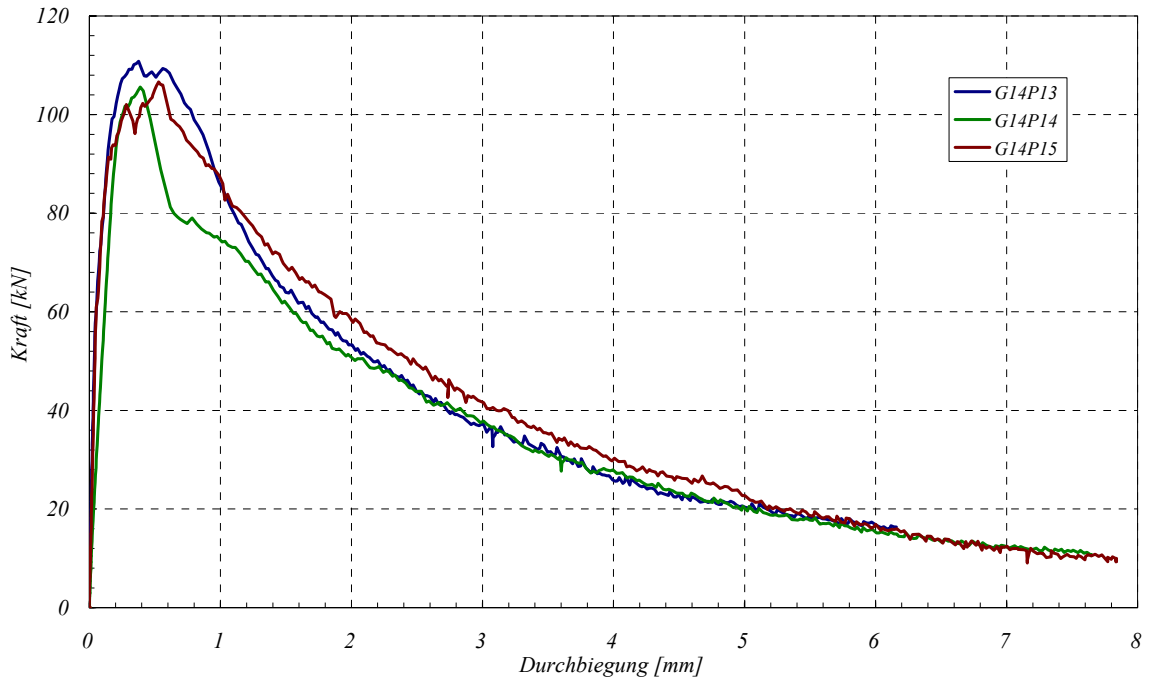


A.6 BIEGEVERSUCHE

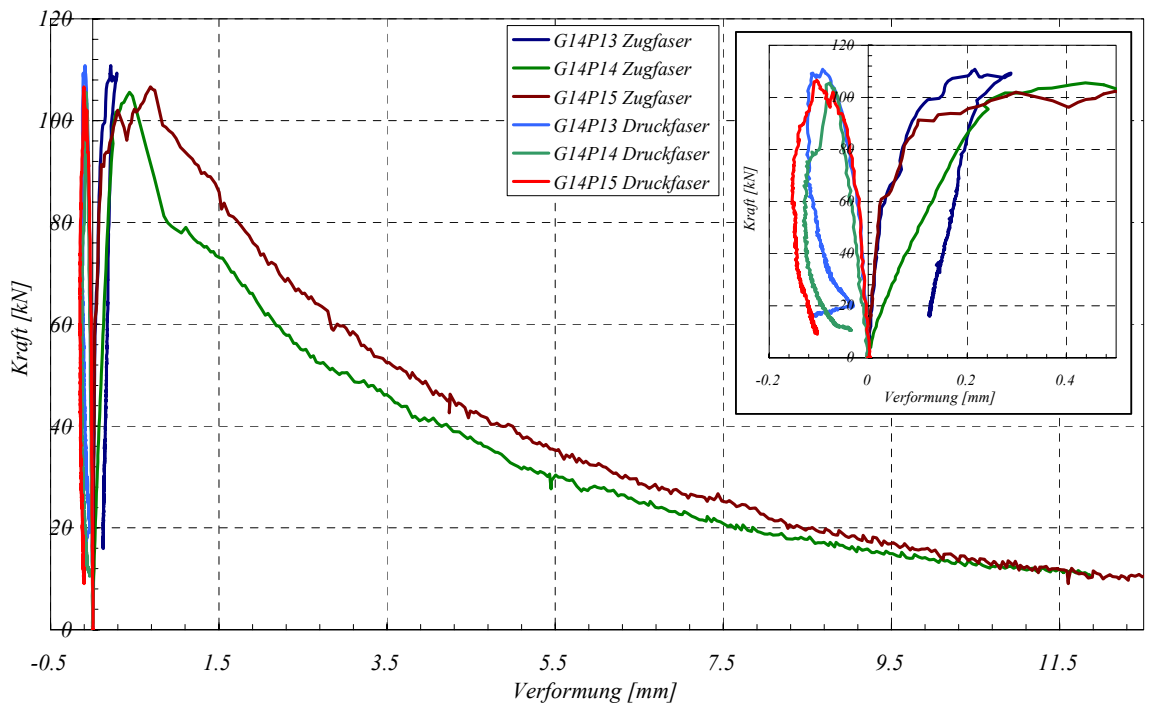
A.6.1 VIER - PUNKT BIEGEVERSUCH

Bruchbilder	
G14P13	
G14P14	
G14P15	

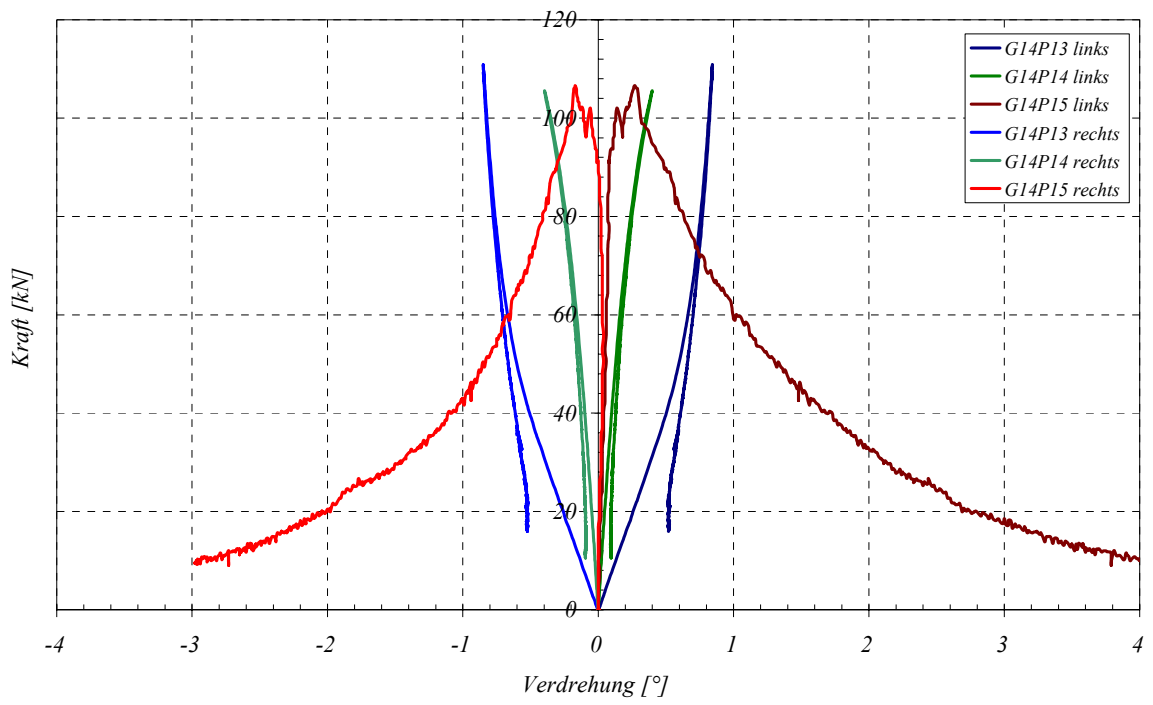
Kraft – Durchbiege (alle Proben)



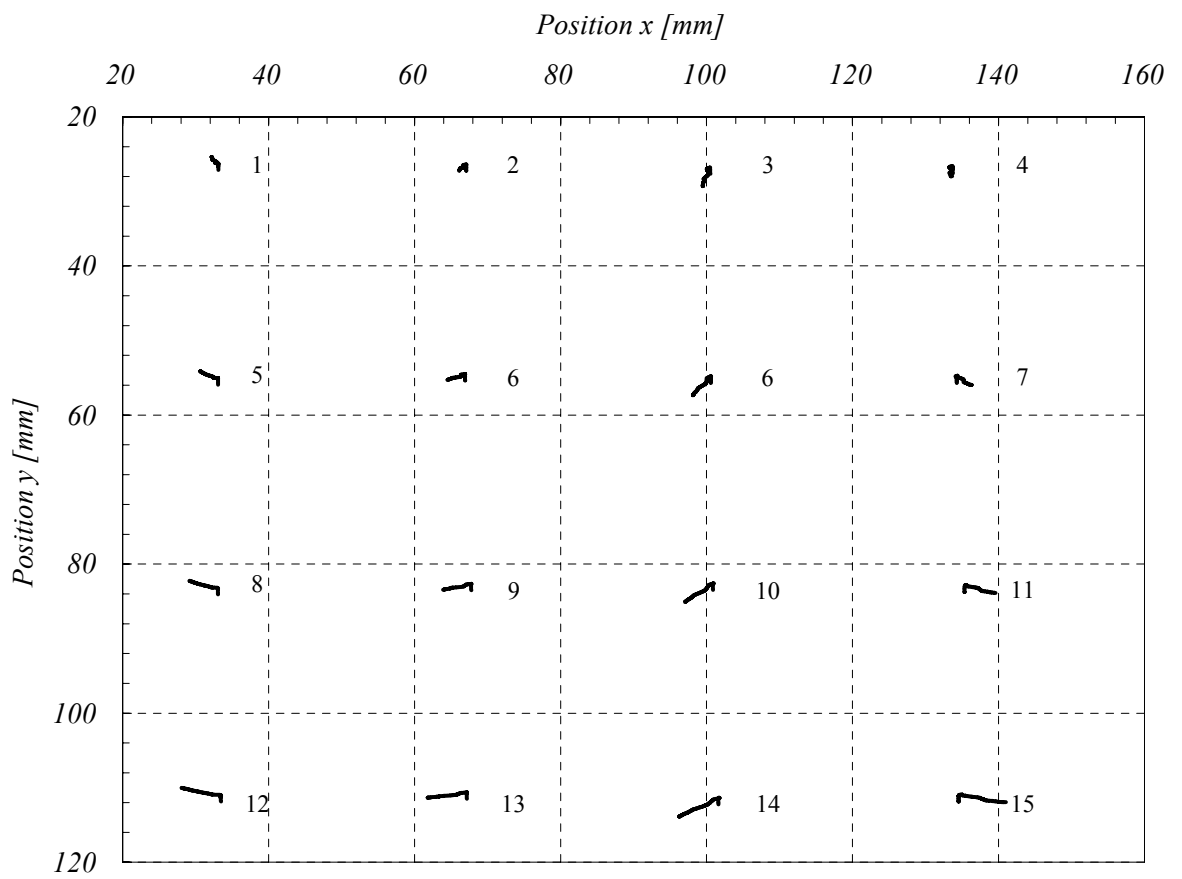
Kraft – Verformung (alle Proben)



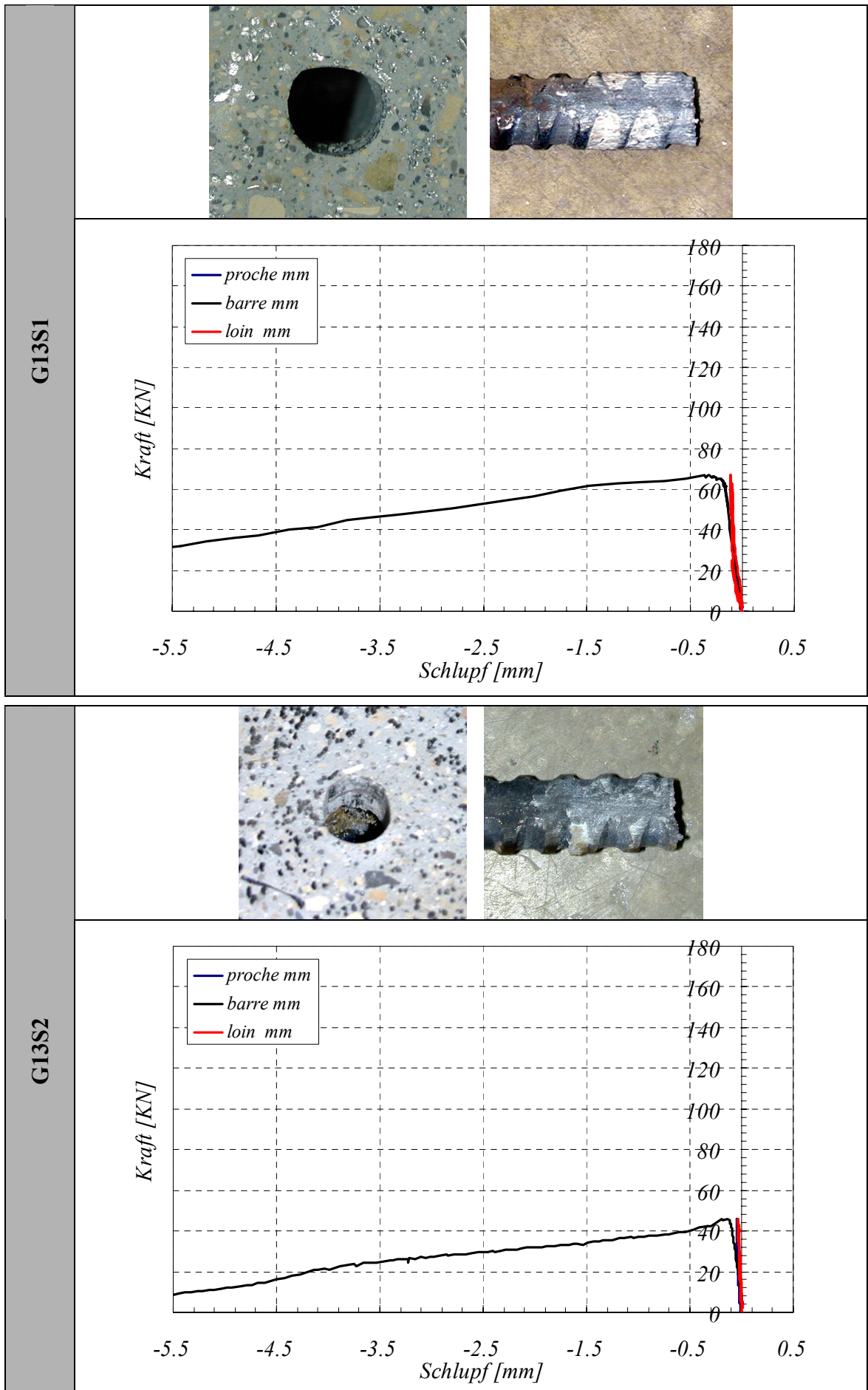
Kraft – Rotation (alle Proben)



Verformungen Videoextensiomter (Probe P15)

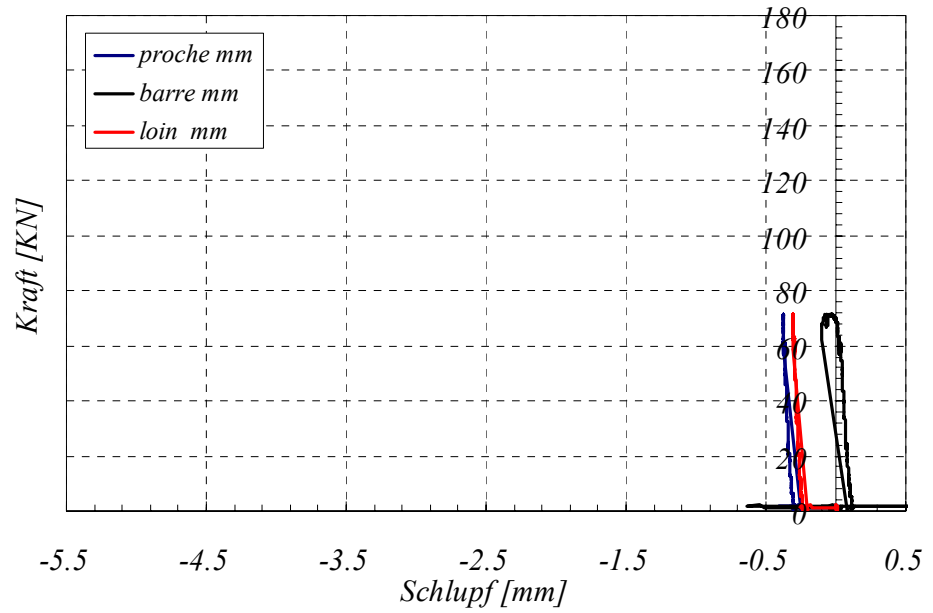


A.7 VERSUCHE MIT BEWEHRUNGSELEMENTEN (AUSZIEHVERSUCH)

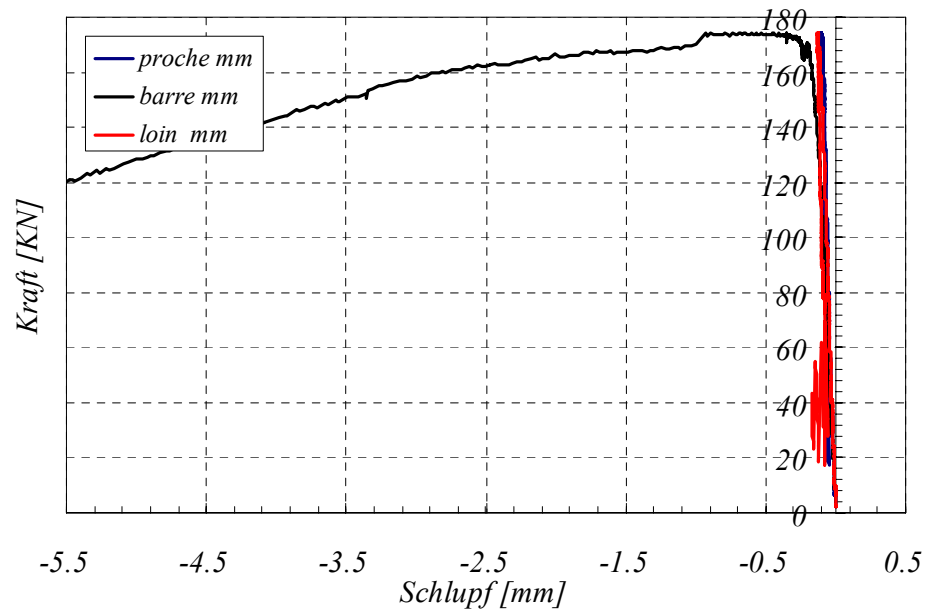


Kein Foto – Bewehrung abgerissen

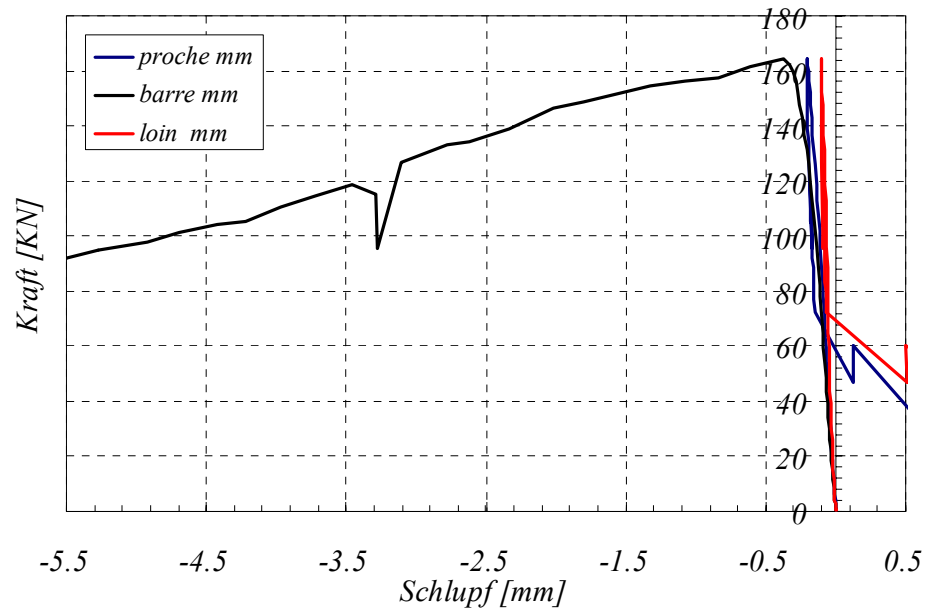
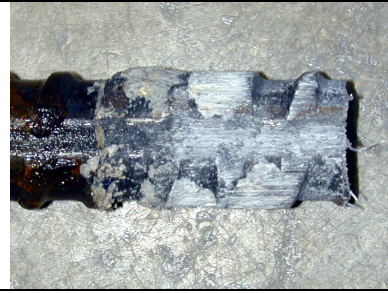
G13S3



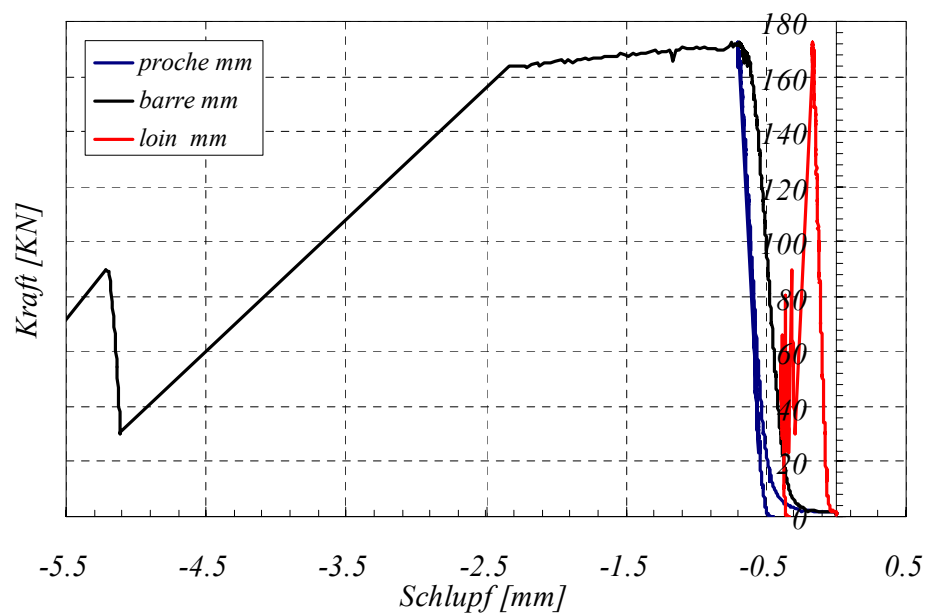
G13S4



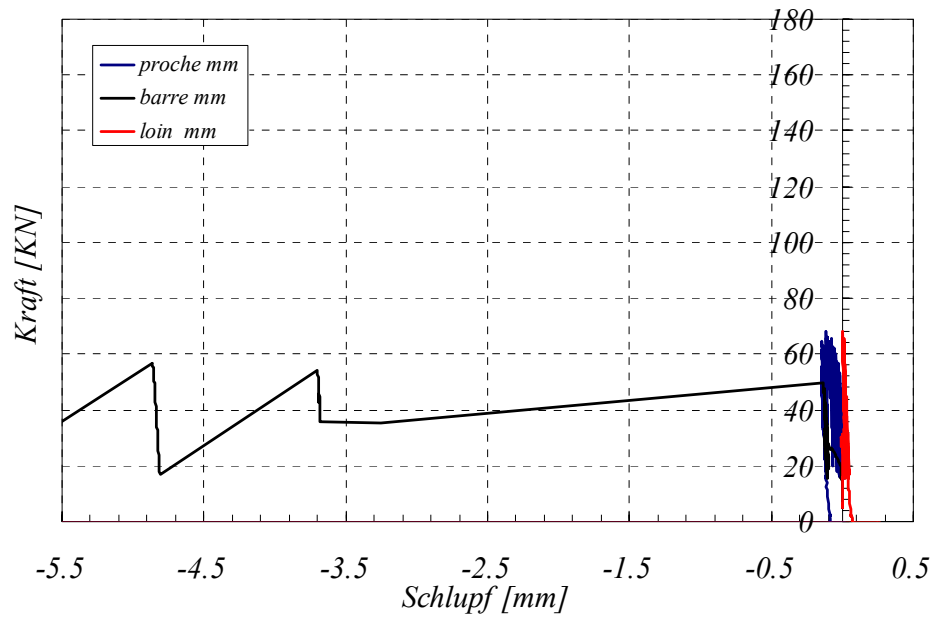
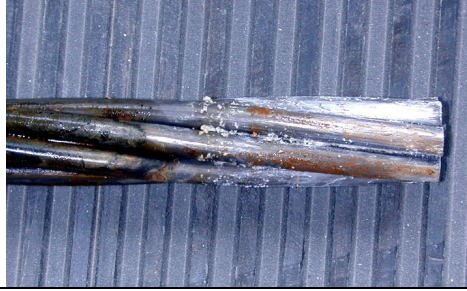
G13S5



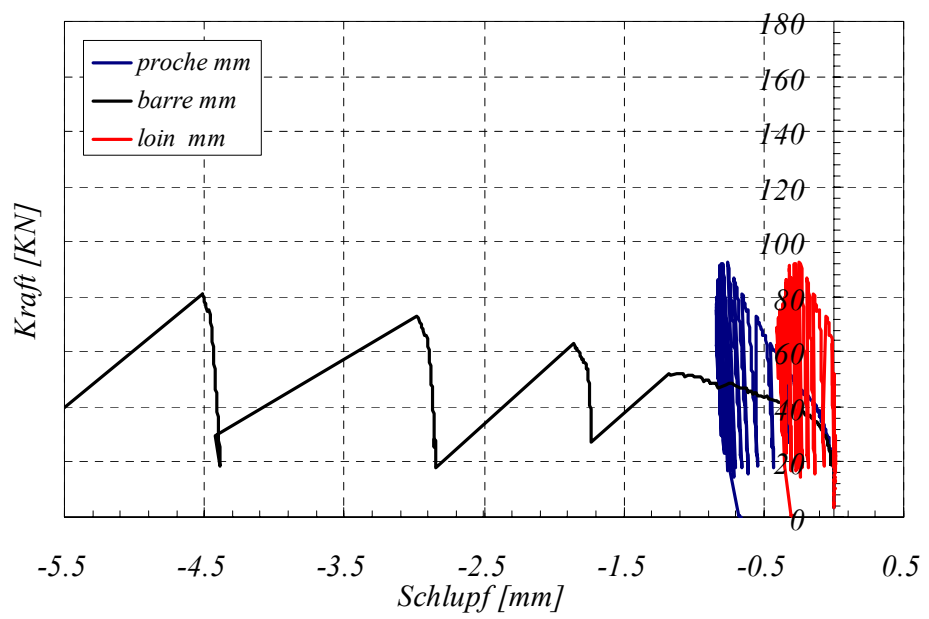
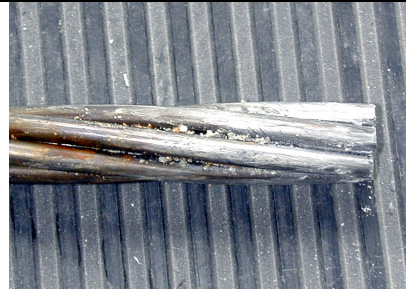
G13S6



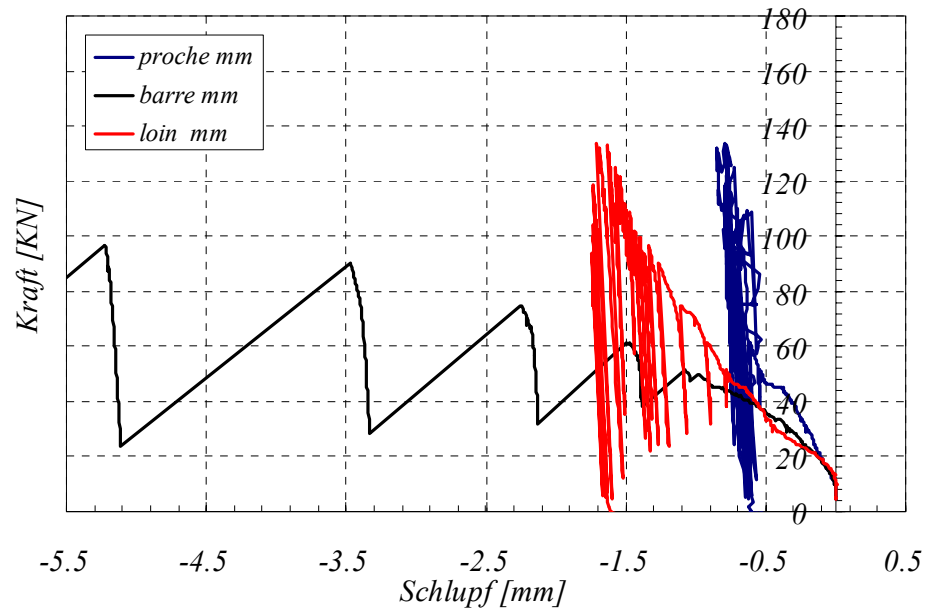
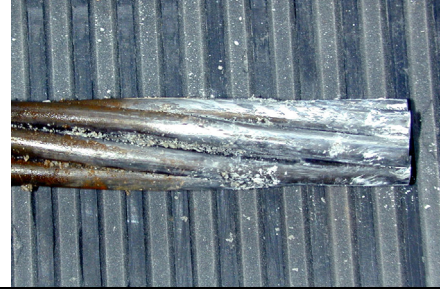
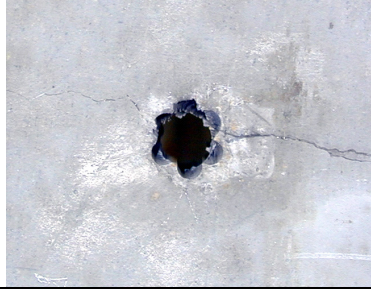
G31S7



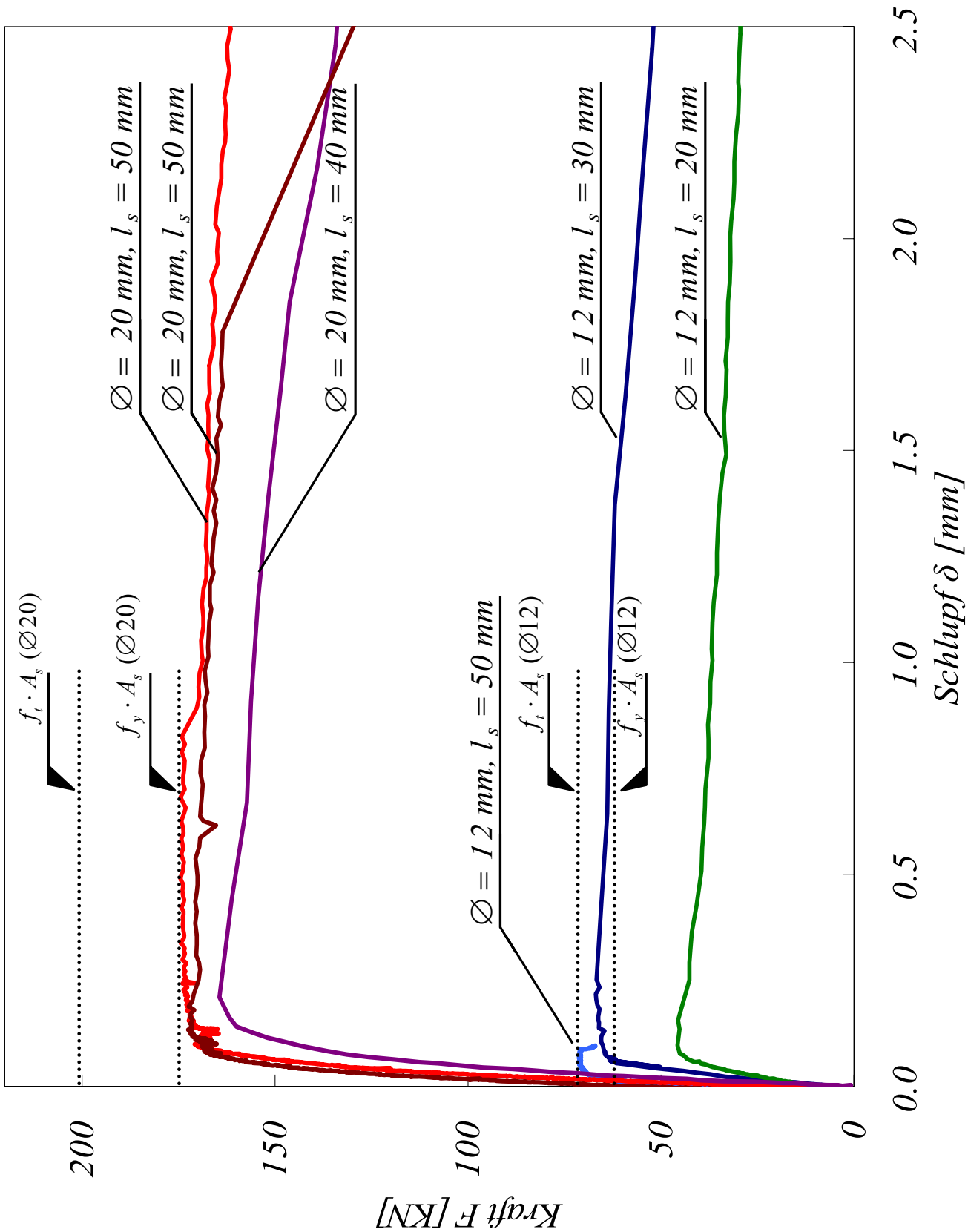
G31S8



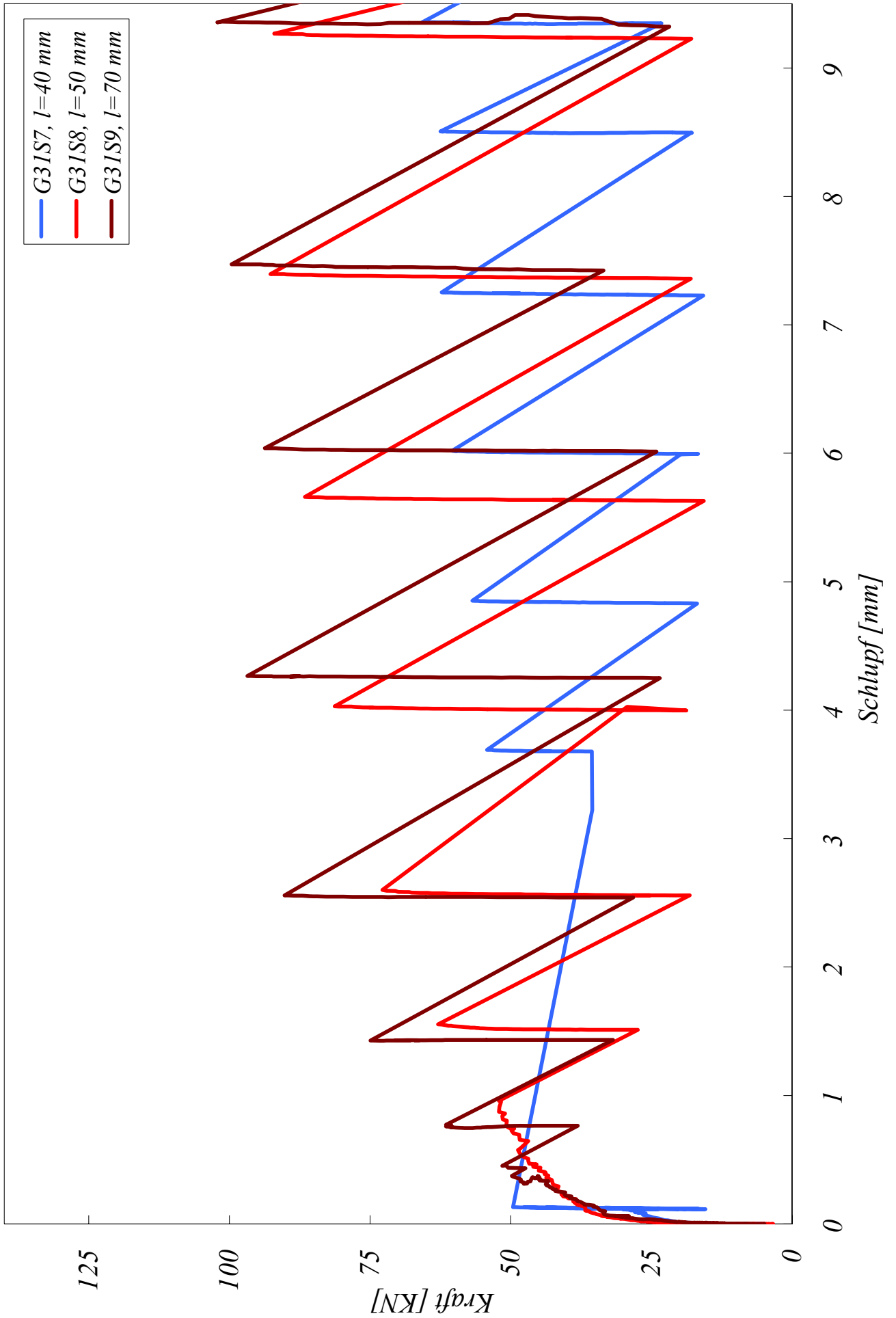
G31S9



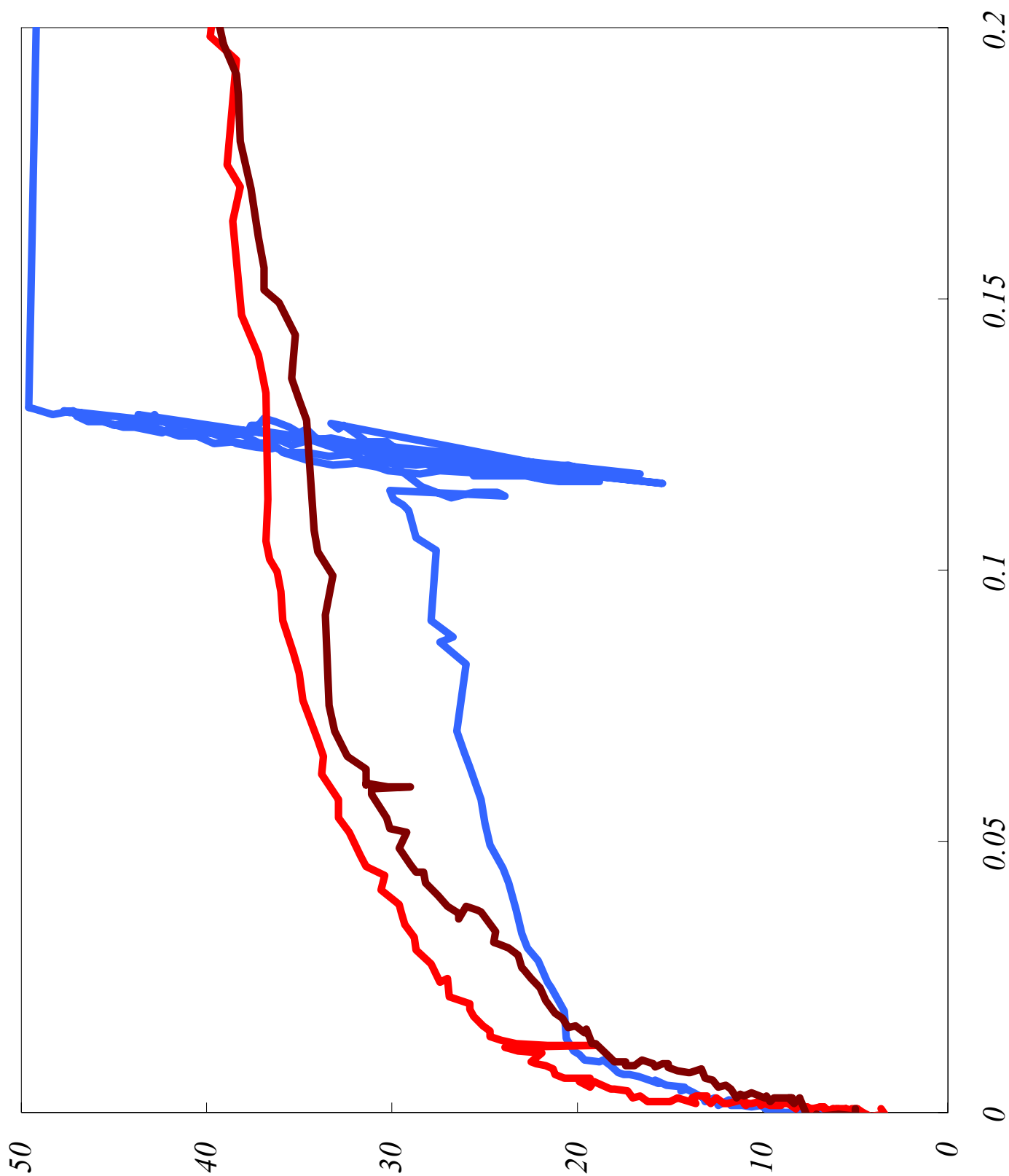
ANALYSE PULLOUT - GEWI BEWEHRUNG



ANALYSE PULLOUT - SPANNLITZEN

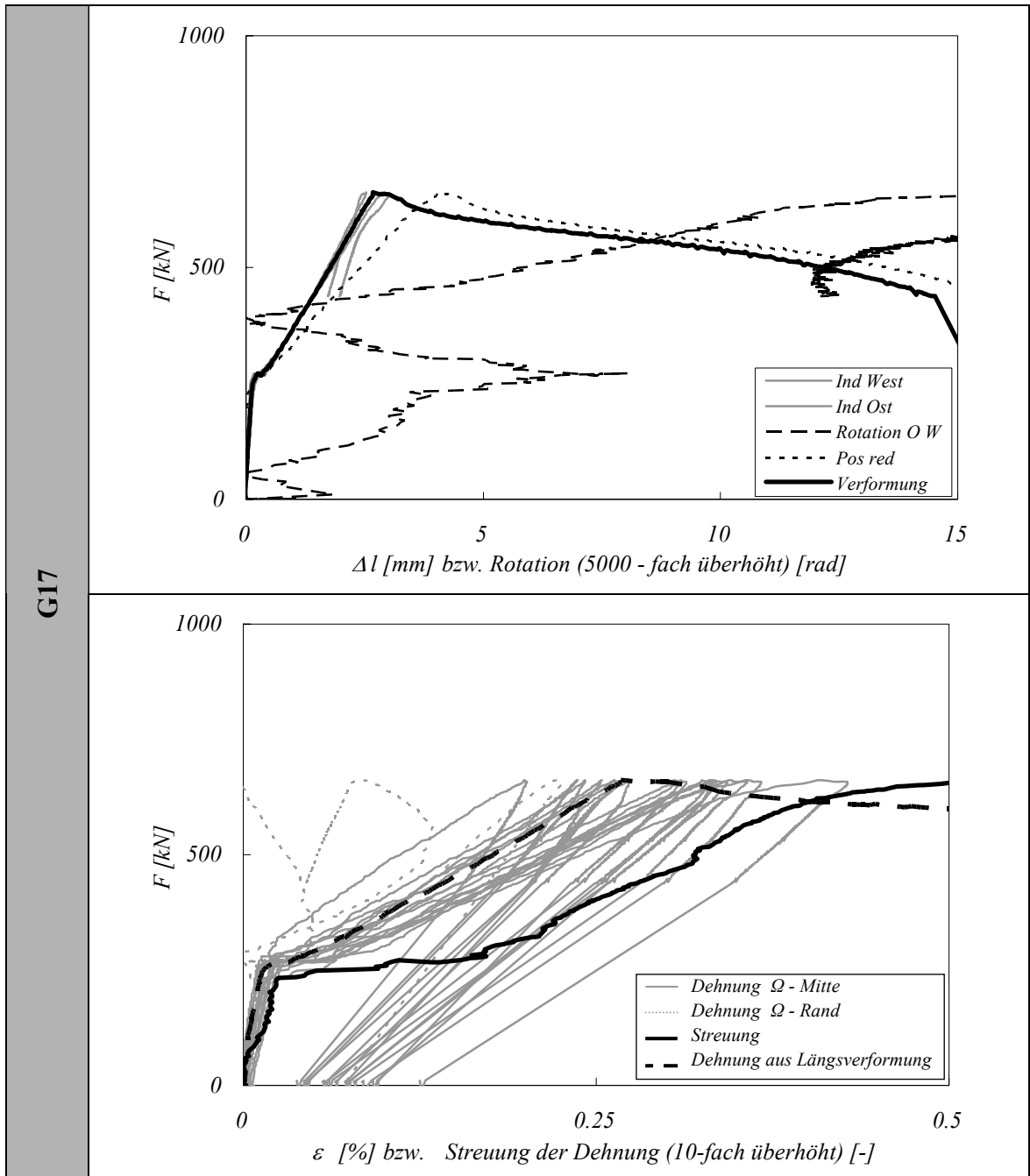


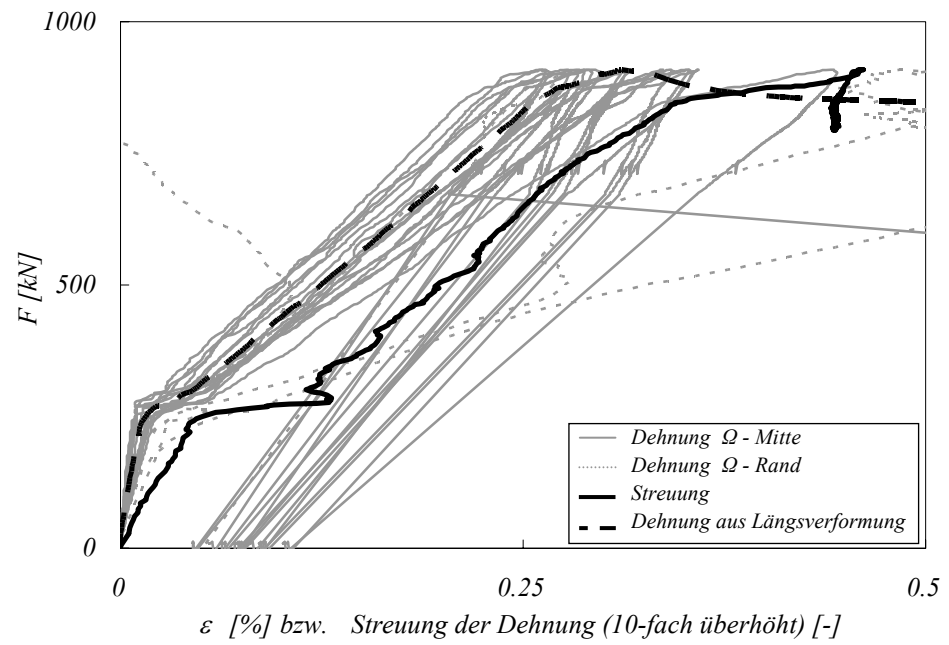
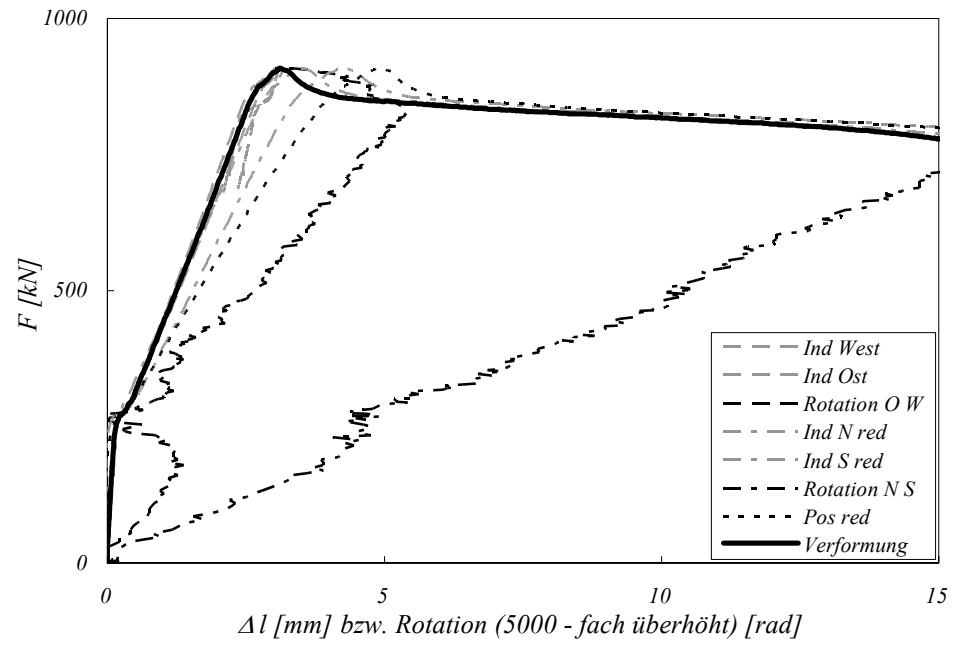
Analyse Pullout – Spannlitzen (Vergrößerung):



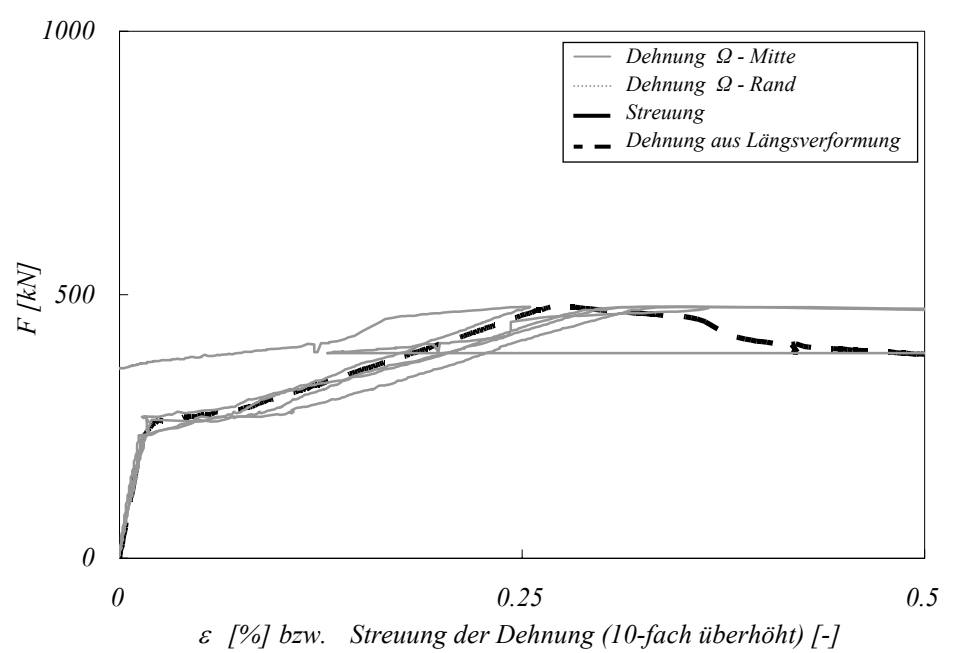
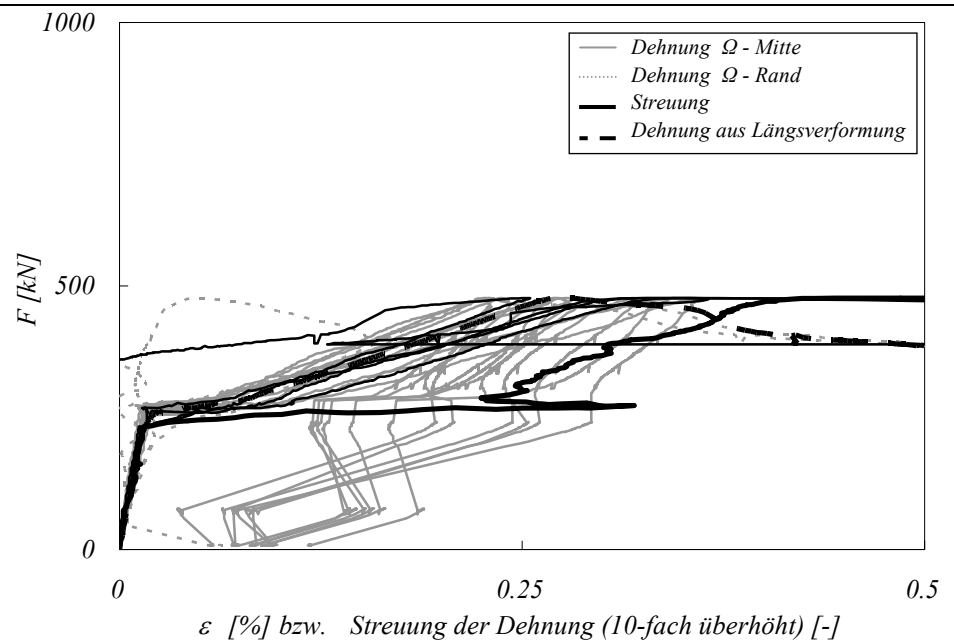
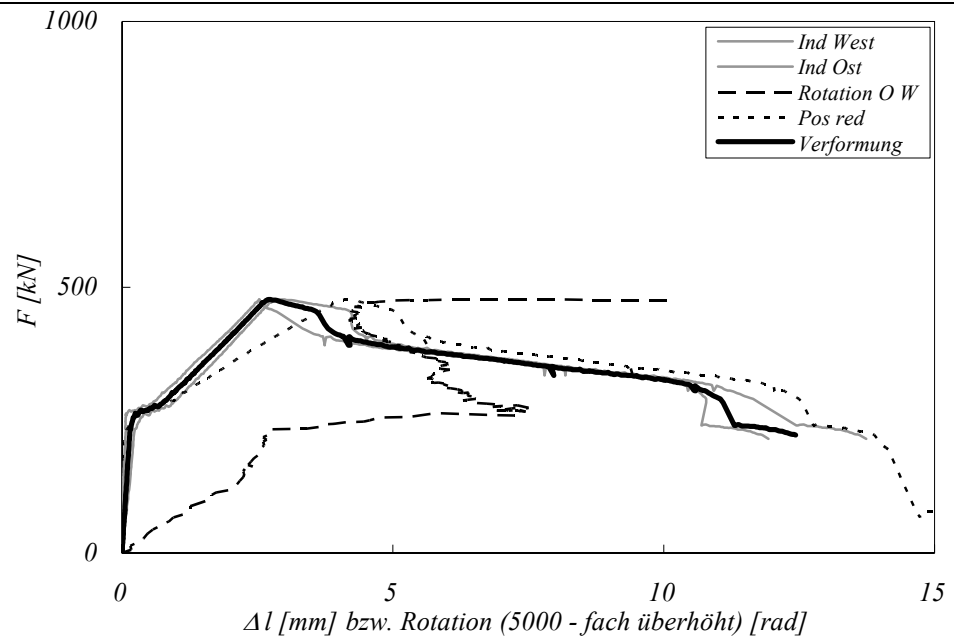
A.8 BAUTEIL ZUGVERSUCHE

A.8.1 DIAGRAMME

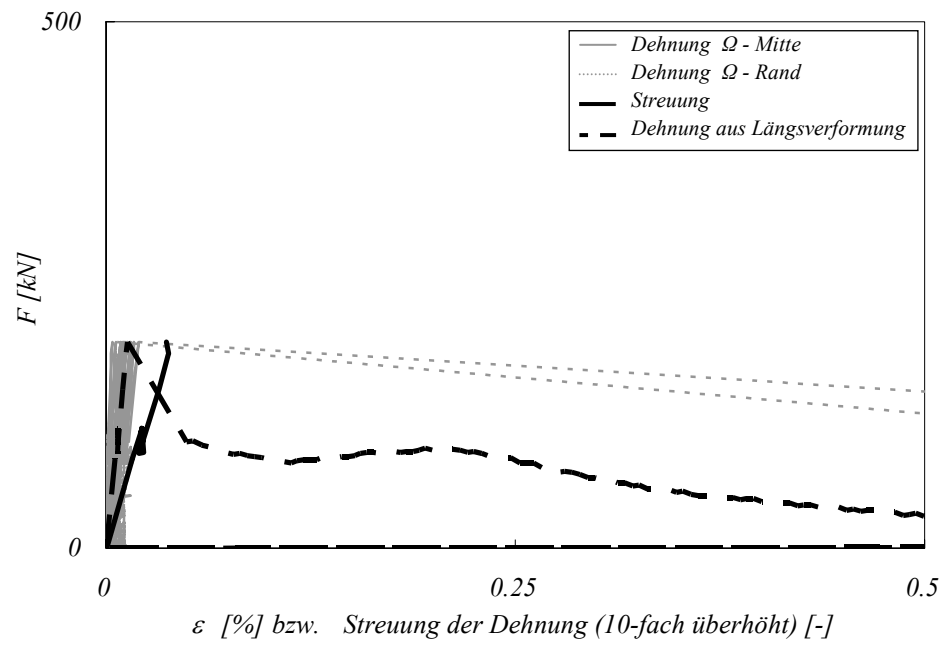
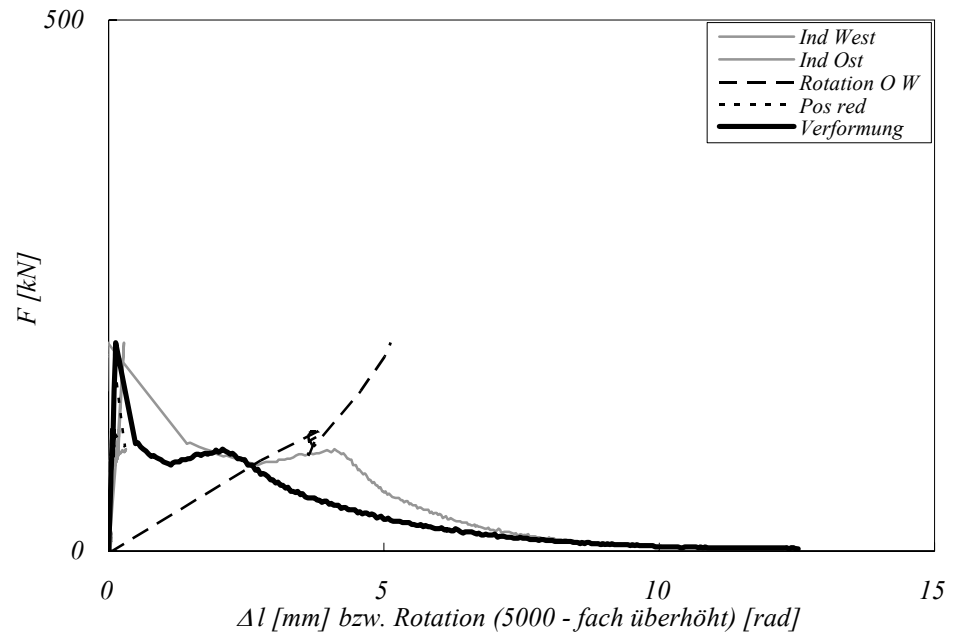


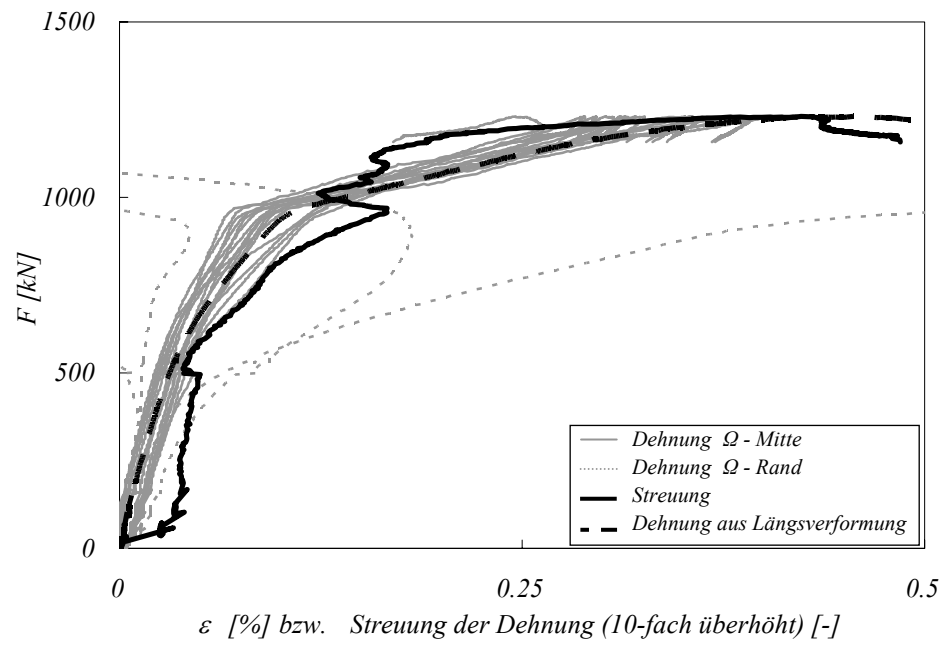
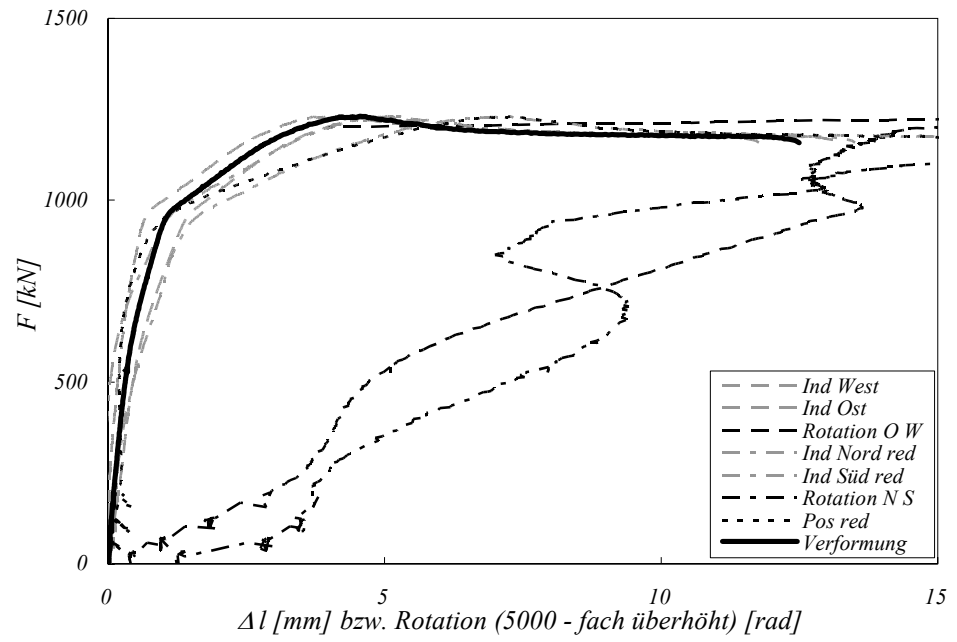


G19



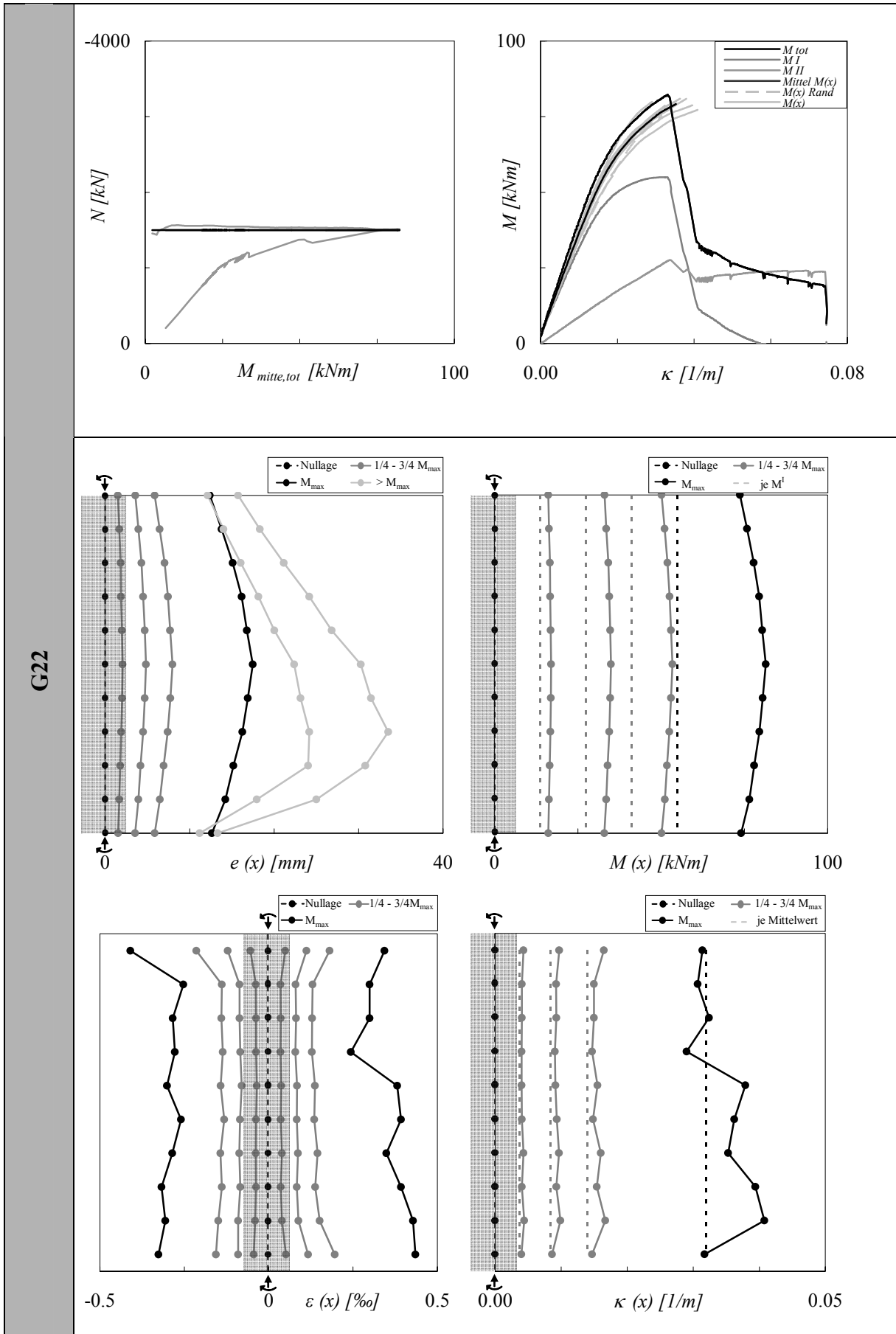
G20

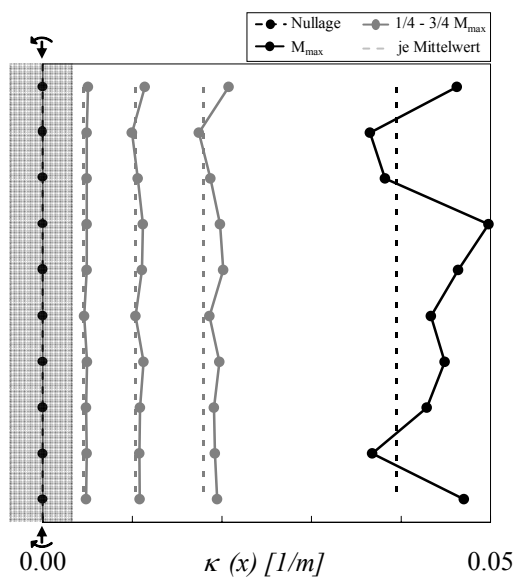
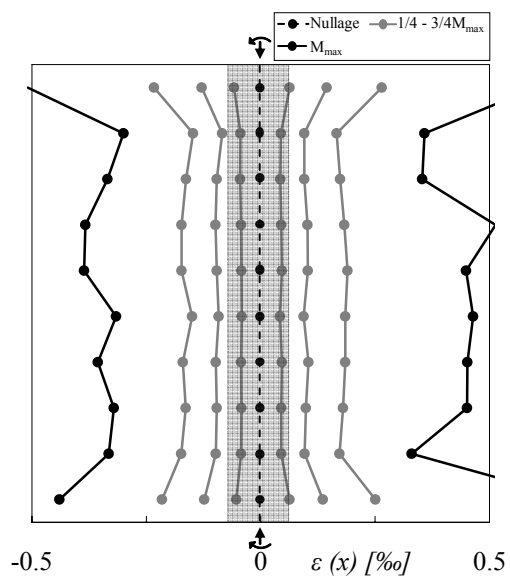
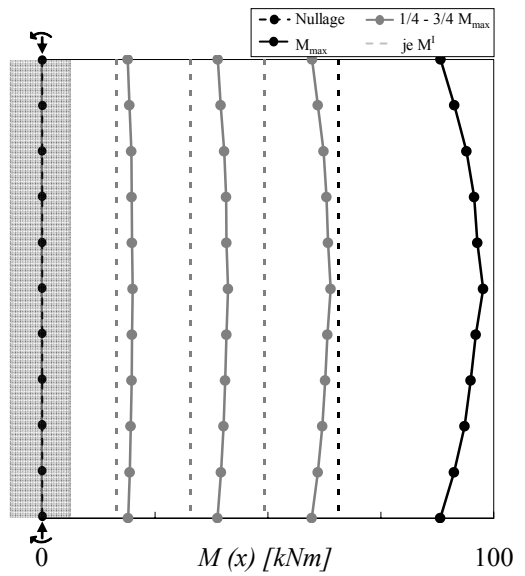
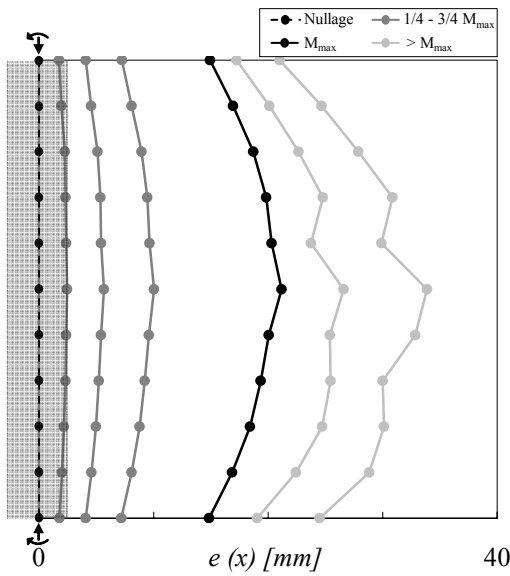
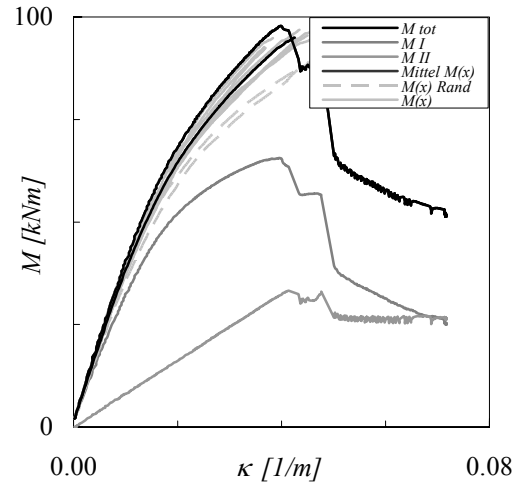
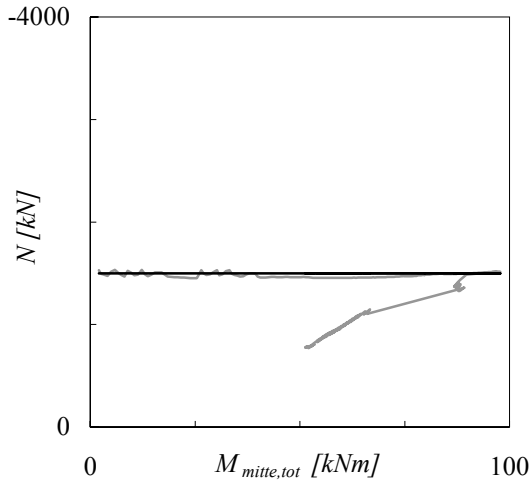


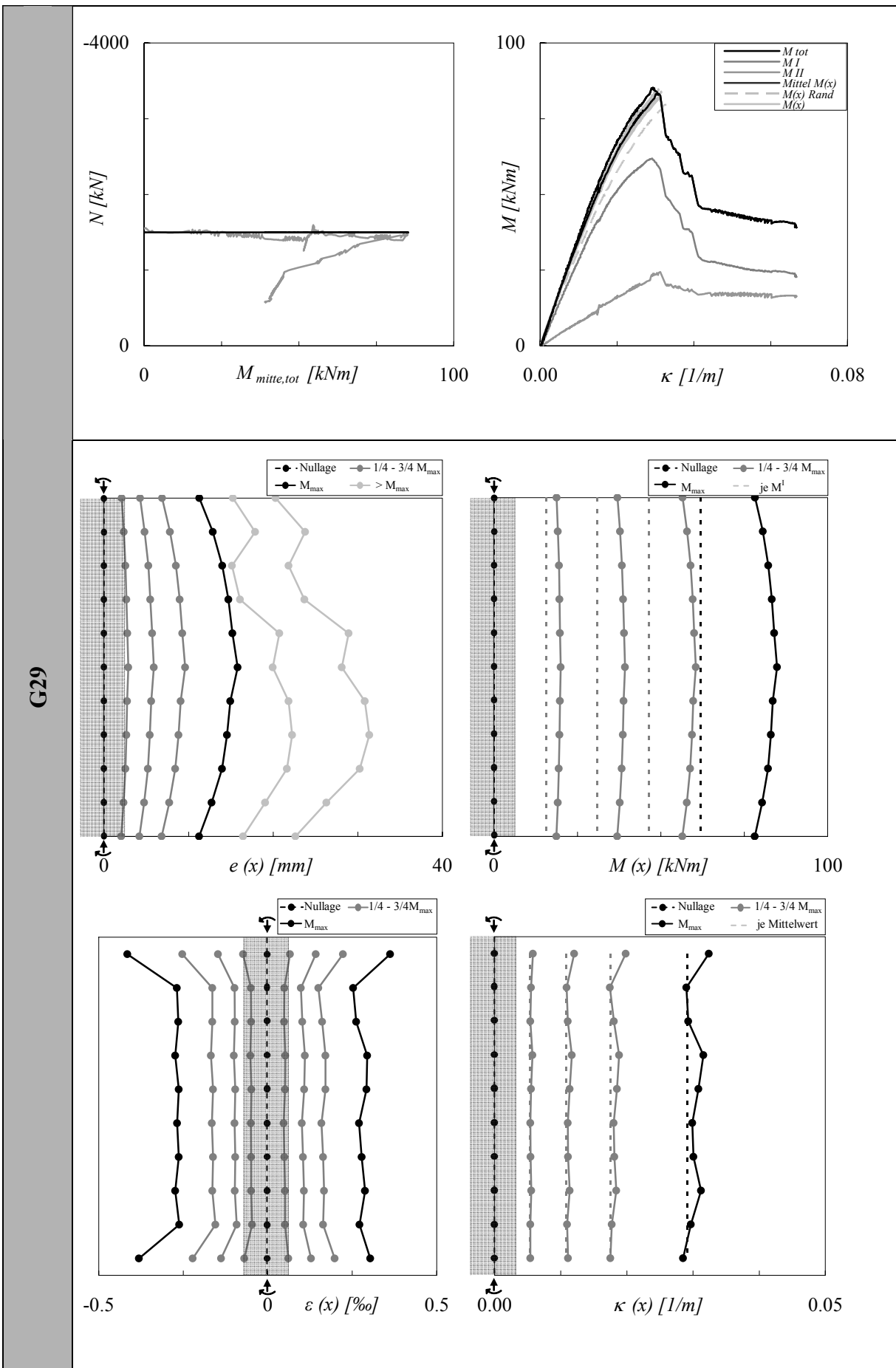


A.9 BAUTEIL DRUCKVERSUCHE

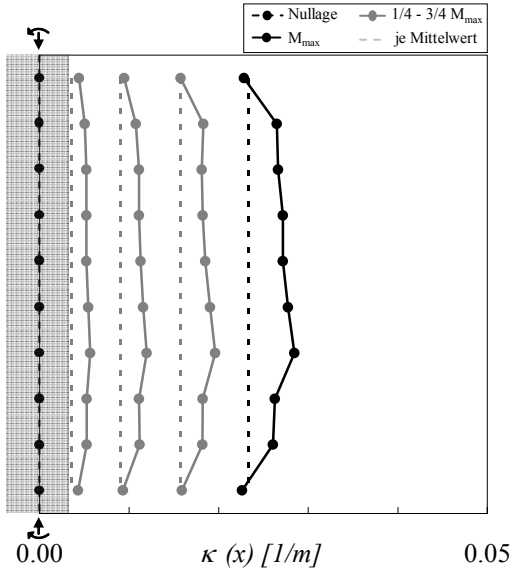
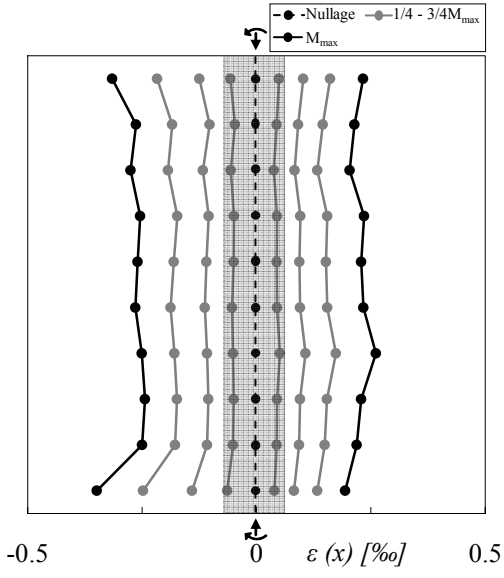
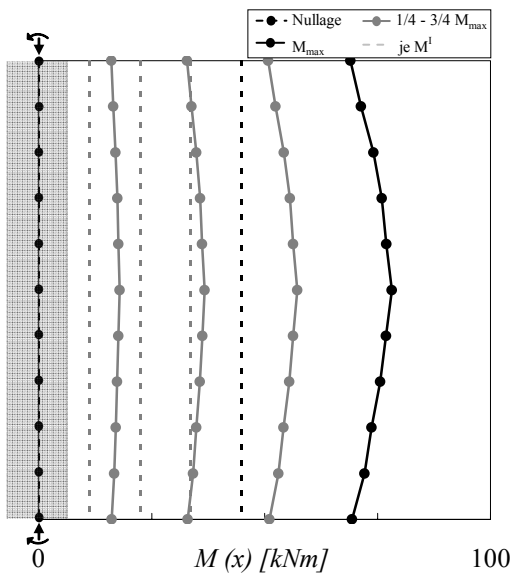
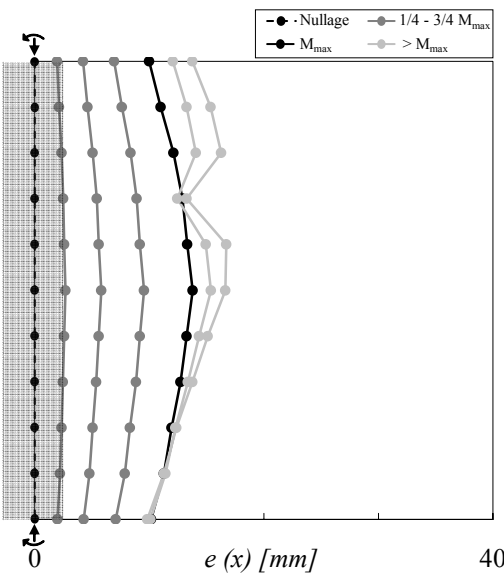
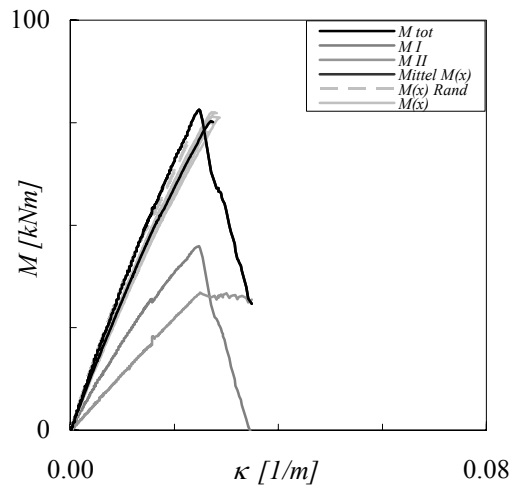
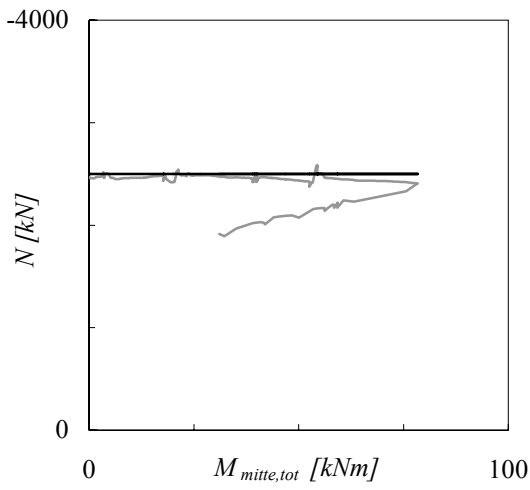
A.9.1 DIAGRAMME



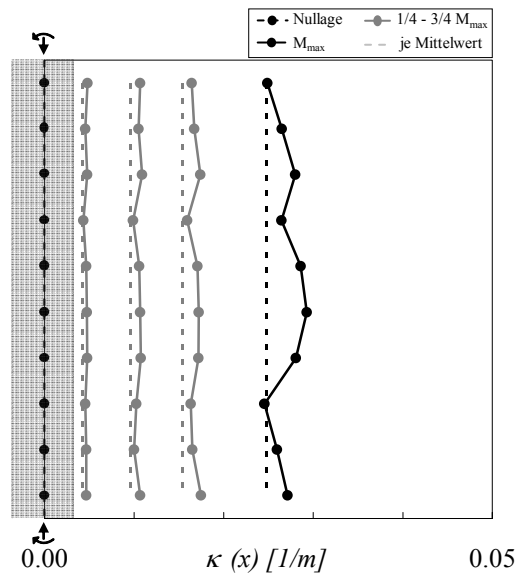
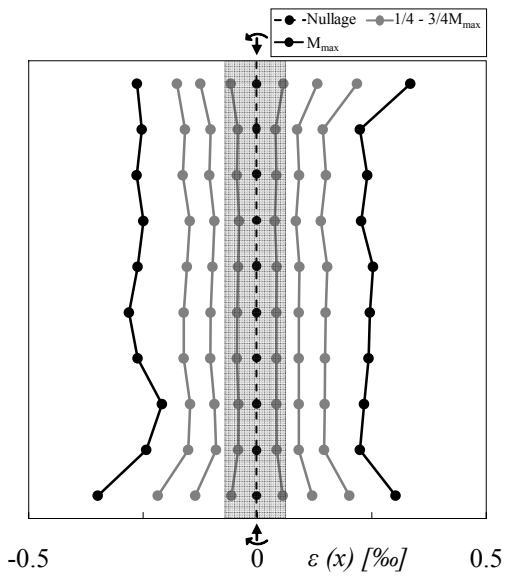
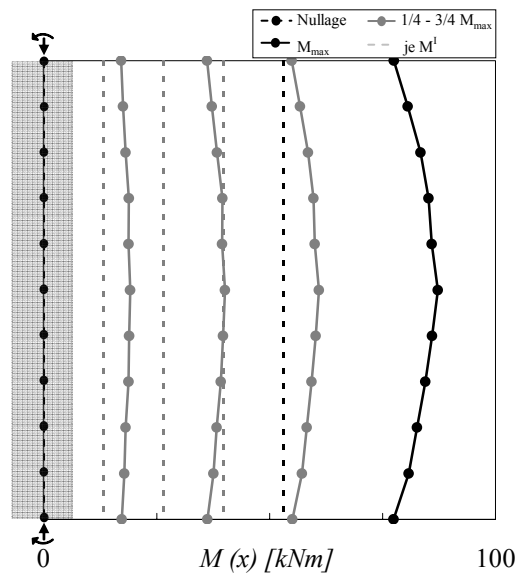
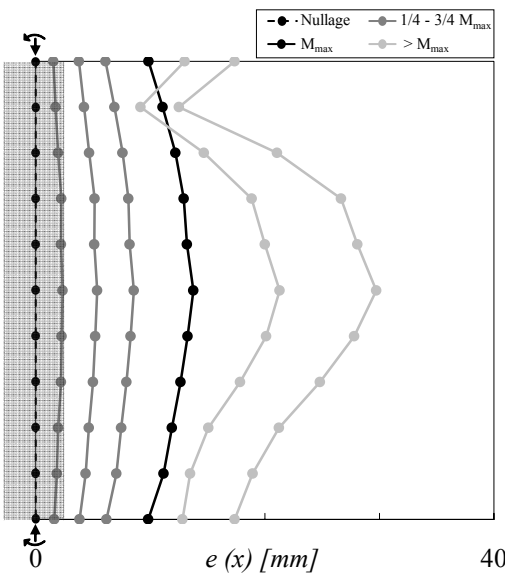
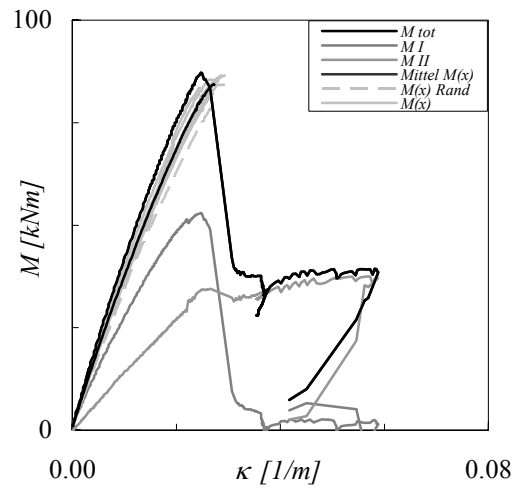
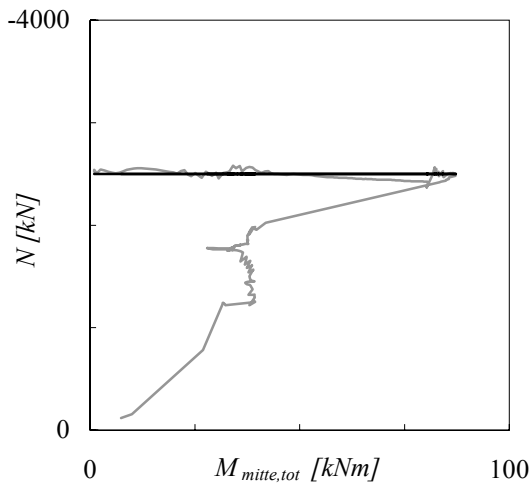




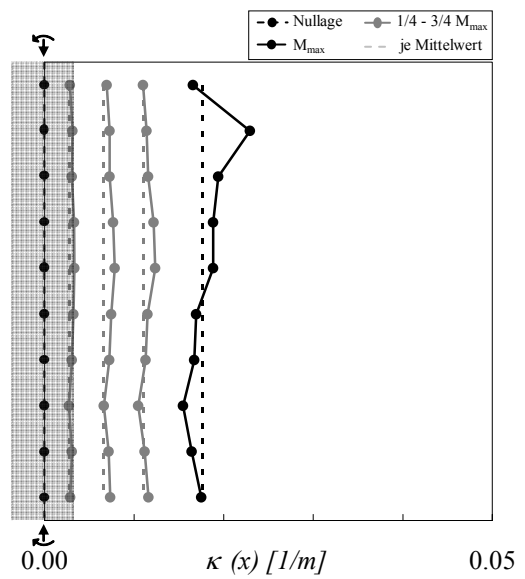
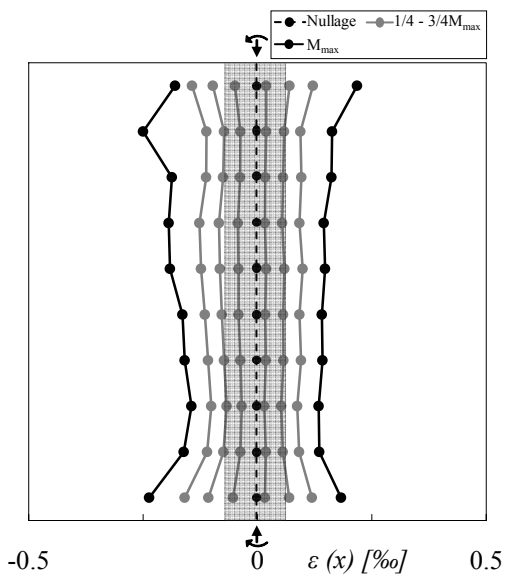
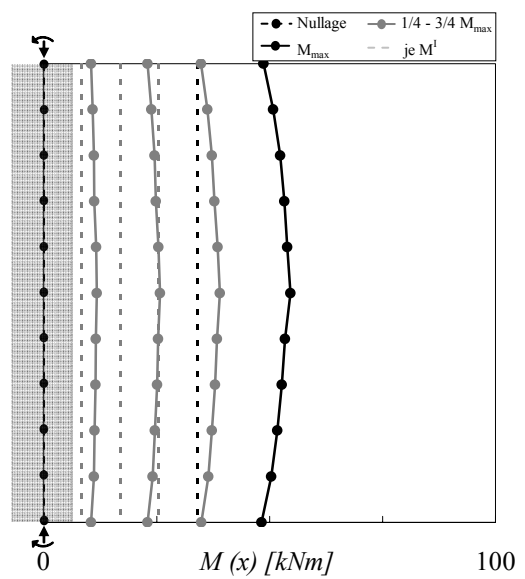
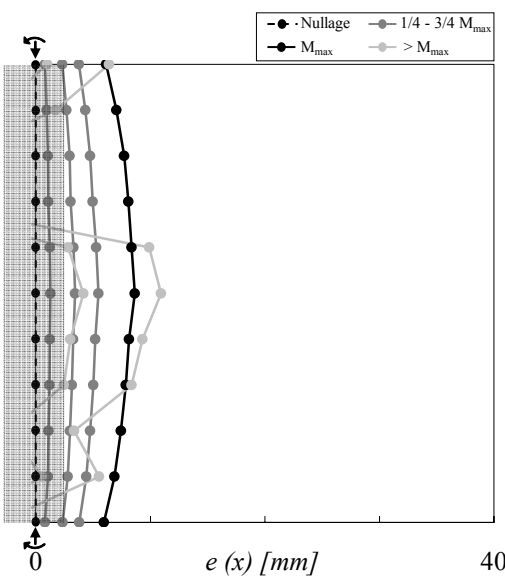
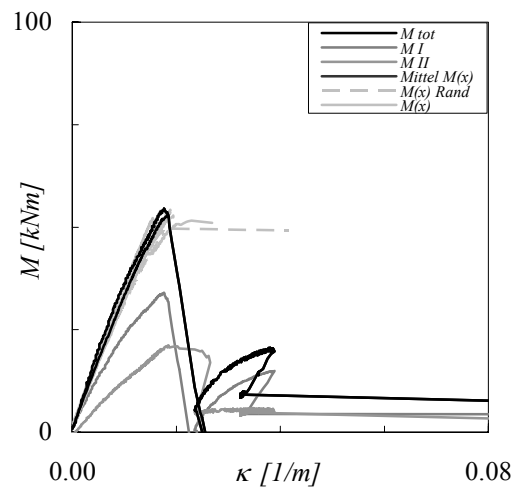
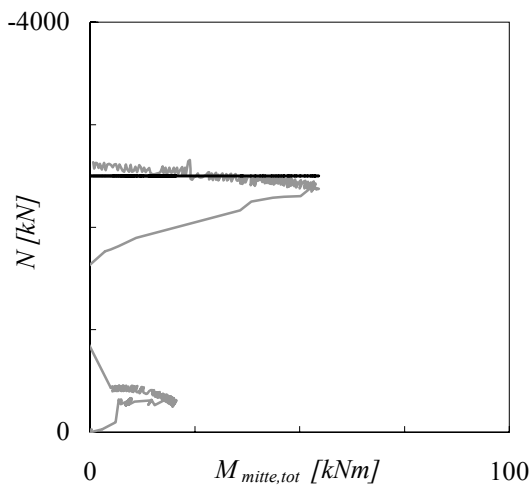
G21



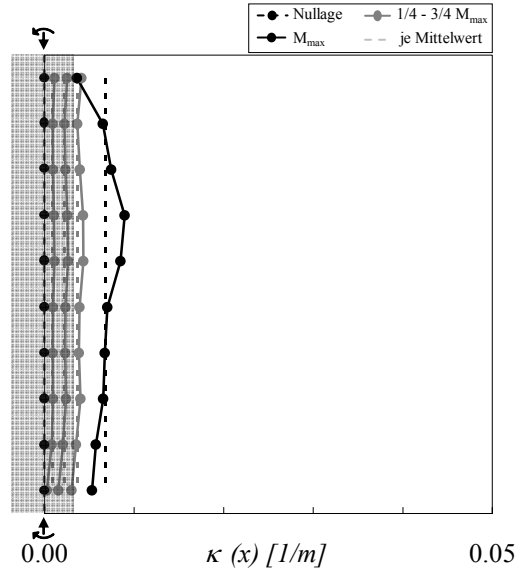
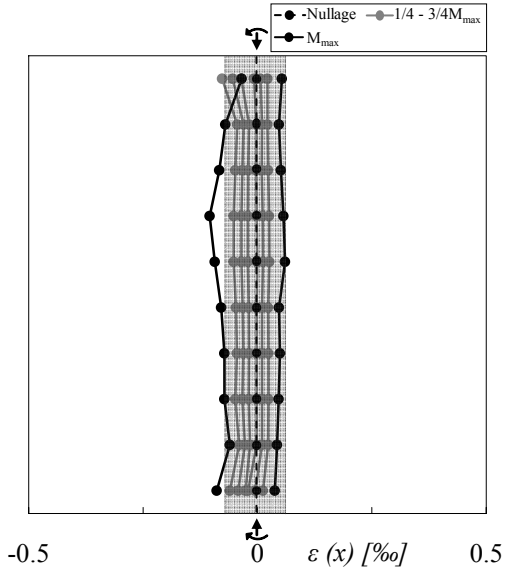
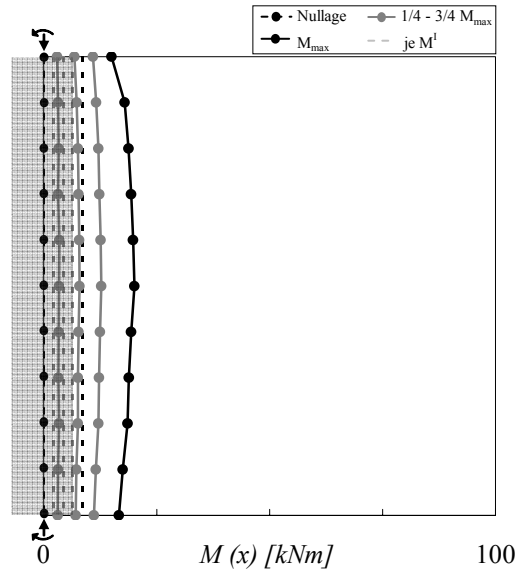
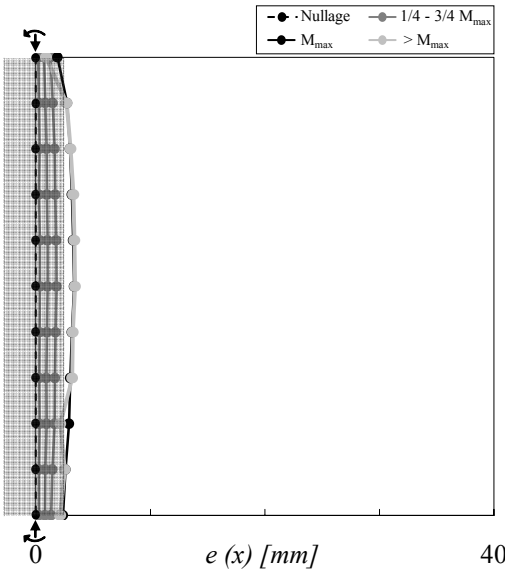
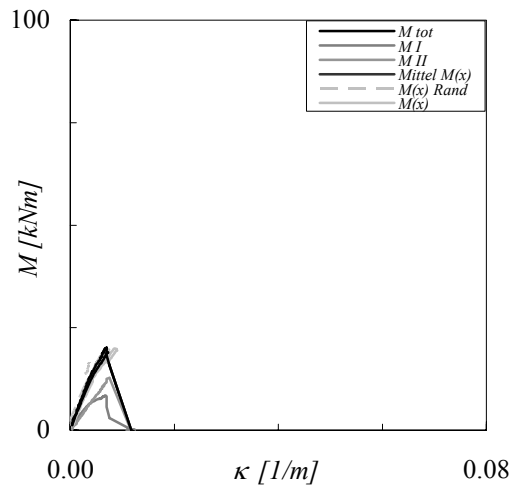
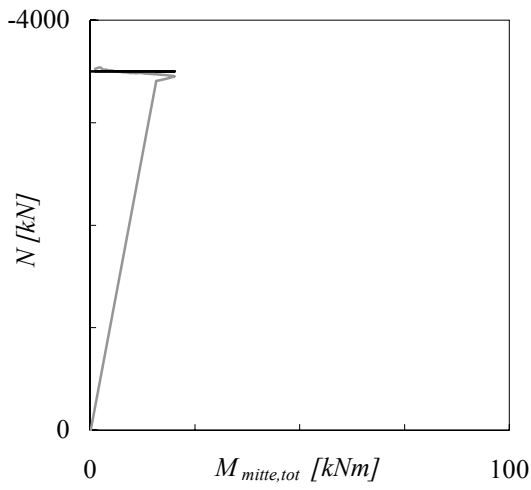
G24



G27



G26



G25

