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DEPARTMENT OF CIVIL ENGINEERING
AALBORG UNIVERSITY

Data report on Rørdal Chalk

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Elena Peri
Benjaminn Nordahl Nielsen

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Aalborg University
Department of Civil Engineering
Division of Structures, Materials and Geotechnics

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Data report on Rørdal Chalk

by

Søren Dam Nielsen
Elena Peri
Benjaminn Nordahl Nielsen

Month 2018

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Description of sample collection

Collection from Rørdal

The tested material is chalk and has been collected from Aalborg Portlands chalk quarry in Rørdal the 4th of December 2017. The material was excavated during the night between the 3rd and 4th of December and 12 blocks of chalk were taken from the surface in the morning. The material was not exposed to sun and no mist was observed. For each block of chalk a sample for water content was taken before the remaining material were sealed in a plastic bag. The figures below show the environment where the samples has been collected. The 12 blocks were then sealed in plastic bags and stored at a constant temperature of 7°C.

Performed tests

This data report presents results from the following geotechnical tests:

- Classification Tests (CLA)
- Oedometer Tests (CON)
- Unconfined Compression Tests (UCT)

Test Numbering

Oedometer tests, Unconfined Compression Tests and Triaxial Tests are given a four-digit test no. The tests number consist of xxyy, where xx refers to the block sample it originated from and yy which is a consecutive number of tests on that specific block sample.

Classification

Resume

Parameter	symbol	value	Unit
Water content	w	28	%
Total density	ρ_t	2.11	Mg/m^3
Specific gravity	G_s	2.7	-
Void ratio	e	0.84	-
Porosity	n	46	%
Unit weight (in-situ)	γ	20.7	kN/m^3
Dry density	ρ_d	1.65	Mg/m^3

Water Content

The water content of the chalk I calculated as

$$w = \frac{m_w}{m_s}$$

m_w is the mass of water and m_s is the mass of the solids (the soil grains). The material for water content of each block sample were taken on location, and must be very similar to the in-situ water content. The water contents are presented below, resulting in a mean water content of 28%.

Block sample	01	02	03	04	05	06	07	08	09	10	11	12
Water content [%]	29	32	21	24	30	32	25	29	28	25	27	31

Test no.	Natural water content	Water content after testing
0101	29%	29%
0102	29%	29%
0103	29%	31%
0104	29%	28%
0901	28%	31%
0902	28%	32%
1101	27%	28%
1102	27%	31%
0903	28%	-
1001	25%	-
1103	27%	-
1201	31%	-

Total Density

The total density is calculated as

$$\rho_t = \frac{m_t}{V_t}$$

where m_t is the total sample (soil and water) mass and V_t is the total volume of the sample (voids and solids).

Specific Gravity

The specific gravity is calculated as

$$G_s = \frac{\gamma_s}{\gamma_0}$$

where γ_s is the unit weight of the solid part (soil grain) and γ_0 is the unit weight of pure (demineralized) water at 4°C.

Void Ratio

The void ratio is calculated as

$$e = \frac{G_s \rho_w}{\rho_d} - 1$$

where V_v is the volume of voids and V_s is the volume of solids.

Porosity

The porosity is calculated as

$$n = \frac{e}{1 + e}$$

where e is the void ratio.

Unit weight

The unit weight of the chalk is calculated as

$$\gamma = \frac{m_t \, g}{V_t}$$

where m_t is the total mass, V_t is the total volume and g is the acceleration of gravity. The presented unit weights have been measured on samples from Block sample No. 3 on samples with masses of 200-500g.

Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Mean
21.18	20.42	20.86	20.49	20.38	20.81	20.7

Dry density

The dry density of the chalk is calculated as

$$\rho_d = \frac{\rho_t}{1 + w}$$

where m_d is the dry mass and V_t is the total volume.

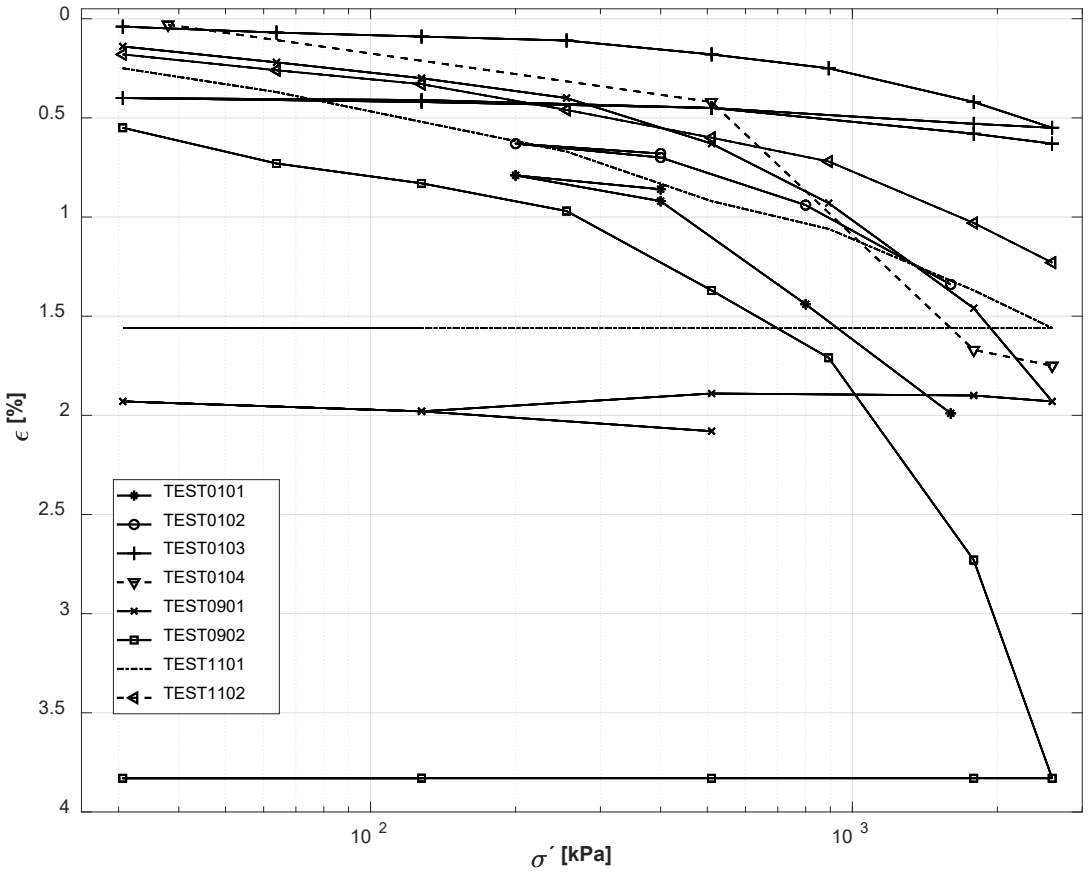
Oedometer tests

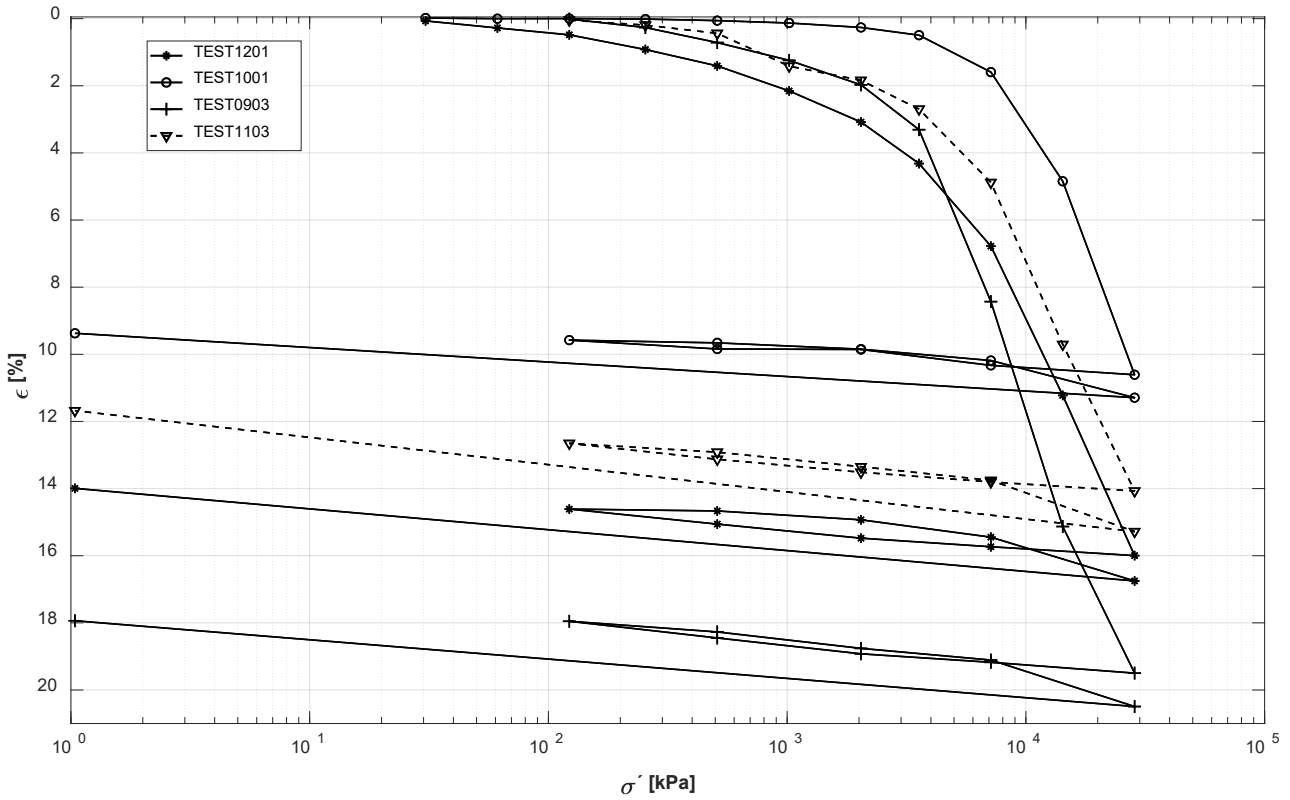
The oedometer tests presented in the data report are all conducted as incremental loaded oedometer tests. Each load step had a duration of 7 days.
The strains adopted are the so-called natural strains, defined as:

$$\varepsilon = \ln\left(\frac{H_0}{H_0 - u_1}\right)$$

Where, H_0 is the initial height of the sample and u_1 is the deformation achieved at each load step.

Test No.	Sample height,H	Sample Diameter, D
0101	35mm	70mm
0102	35mm	70mm
0103	35mm	70mm
0104	35mm	70mm
0901	35mm	70mm
0902	35mm	70mm
0903	20mm	35mm
1001	35mm	35mm
1101	35mm	70mm
1102	35mm	70mm
1103	20mm	35mm
1201	35mm	35mm





1704CON0101		1704CON0102		1704CON0103		1704CON0104	
ε_{tot} [%]	σ [kPa]	ε_{tot} [%]	σ [kPa]	ε_{tot} [%]	σ [kPa]	ε_{tot} [%]	σ [kPa]
0.86	400	0.68	400	0.04	30.6	0.03	38
0.79	200	0.63	200	0.07	63.8	0.42	510
0.92	400	0.70	400	0.09	127.6	1.67	1786
1.44	800	0.94	800	0.11	255.2	1.75	2598
1.99	1600	1.34	1600	0.18	510.3		
				0.25	893.1		
				0.42	1786		
				0.55	2598.4		
				0.53	1786.2		
				0.45	510.3		
				0.42	127.6		
				0.40	30.6		
				0.41	127.6		
				0.45	510.3		
				0.58	1786.2		
				0.63	2595.4		

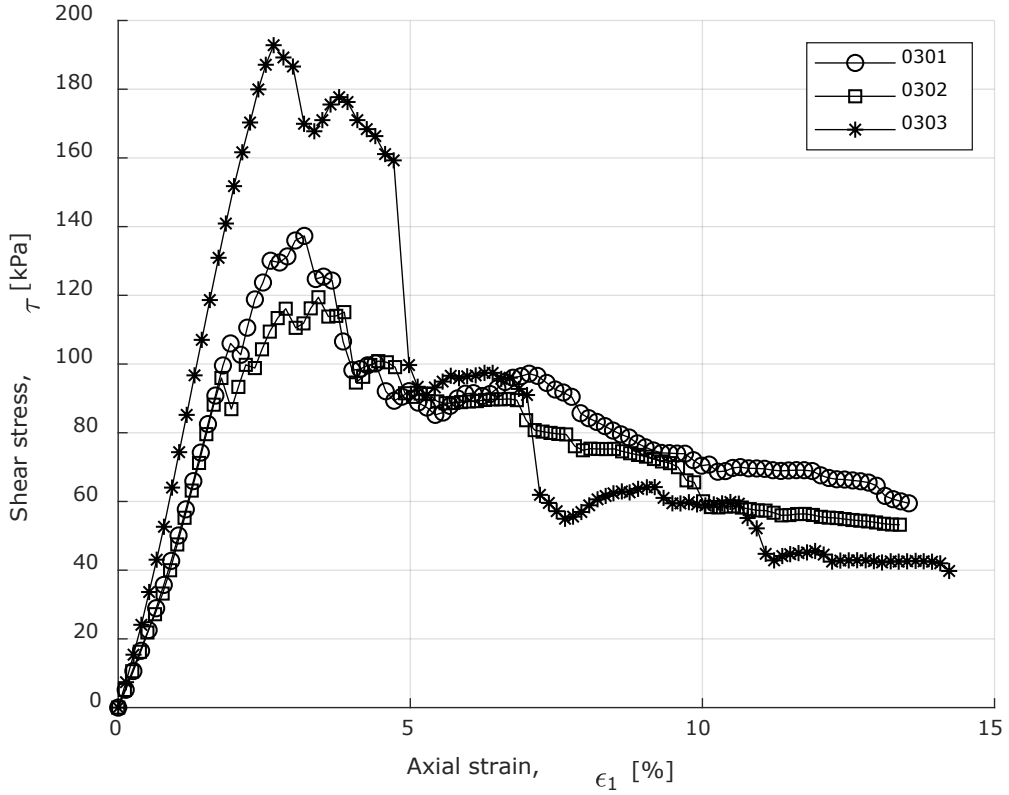
1704CON0901		1704CON0902		1704CON1101		1704CON1102	
ε_{tot} [%]	σ [kPa]	ε_{tot} [%]	σ [kPa]	ε_{tot} [%]	σ [kPa]	ε_{tot} [%]	σ [kPa]
0.14	30.6	0.55	30.6	0.25	30.6	0.18	30.6
0.22	63.8	0.73	63.8	0.37	63.8	0.26	63.8
0.3	127.6	0.83	127.6	0.52	127.6	0.33	127.6
0.4	255.2	0.97	255.2	0.67	255.2	0.46	255.2
0.63	510.3	1.37	510.3	0.92	510.3	0.6	510.3
0.93	893.1	1.71	893.1	1.06	893.1	0.72	893.1
1.46	1786.2	2.73	1786.2	1.37	1786.2	1.03	1786.2
1.93	2598.4	3.83	2598.4	1.56	2598.4	1.23	2598.4
1.9	1786.2	3.83	1786.2	1.56	1786.2		
1.89	510.3	3.83	510.3	1.56	510.3		
1.98	127.6	3.83	127.6	1.56	127.6		
1.93	30.6	3.83	30.6	1.56	30.7		
1.98	127.6	3.83	127.6	1.56	127.6		
2.08	510.3						

1704CON0903		1704CON1001		1704CON1103		1704CON1201	
ε_{tot} [%]	σ [kPa]	ε_{tot} [%]	σ [kPa]	ε_{tot} [%]	σ [kPa]	ε_{tot} [%]	σ [kPa]
0.01	122	0	31	0.05	122	0.07	31
0.27	255	0	61	0.19	255	0.28	61
0.71	510	-0.78	122	0.44	510	0.48	122
1.24	1019	-0.77	255	1.42	1019	0.92	255
1.97	2039	-0.72	510	1.84	2039	1.41	510
3.31	3567	-0.65	1019	2.70	3567	2.15	1019
8.43	7135	-0.52	2039	4.88	7135	3.08	2039
15.13	14270	-0.29	3567	9.71	14270	4.32	3567
19.50	28540	0.81	7135	14.07	28540	6.78	7135
19.18	7135	4.06	14270	13.81	7135	11.22	14270
18.92	2039	9.83	28540	13.51	2039	16.00	28540
18.45	510	9.55	7135	13.13	510	15.73	7135
17.95	122	9.08	2039	12.65	122	15.48	2039
18.27	510	9.06	510	12.91	510	15.06	510
18.76	2039	8.80	122	13.35	2039	14.61	122
19.11	7135	8.88	510	13.76	7135	14.67	510
20.49	28540	9.07	2039	15.28	28540	14.93	2039
17.94	0	9.40	7135	11.68	0	15.45	7135
		10.51	28540			16.75	28540
		8.59	0			13.99	0

Unconfined compression tests

Three unconfined compression tests were conducted according to STANDARD. The dimensions and mass are presented below. The tests were performed with a strain rate of 0.8-0.9%/min.

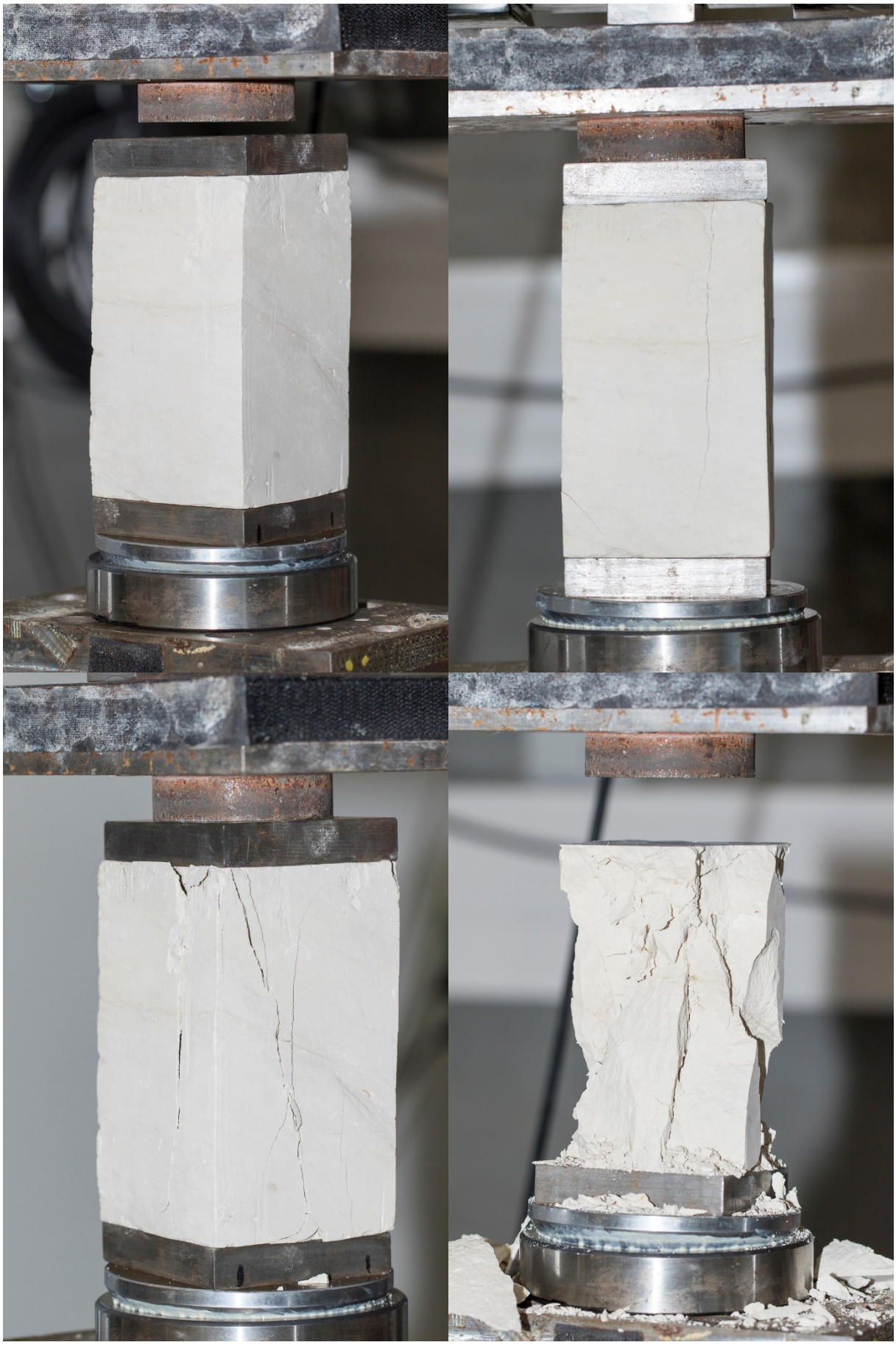
Test No	Height	Cross section	Mass
0301	122mm	71.5mm×70.0mm	1271.2g
0302	123mm	63mm×62mm	993.2g
0303	81mm	45mm×45mm	339.7g



Test No	Peak shear strength [kPa]	Peak shear strain [%]	Water content after test w_f [%]
0301	137	3.4	21%
0302	119	3.2	21%
0303	193	2.7	22%

1704UCT0301			1704UCT0302			1704UCT0303		
t [s]	ε_{tot} [%]	σ [kPa]	t [s]	ε_{tot} [%]	σ [kPa]	t [s]	ε_{tot} [%]	σ [kPa]
1	0.00	0.0	1	0.00	0.0	1	0.00	0.0
2	0.13	10.4	2	0.11	10.3	2	0.13	14.8
3	0.26	21.3	3	0.24	21.2	3	0.26	30.8
4	0.39	33.1	4	0.37	32.5	4	0.40	48.2
5	0.52	45.1	5	0.50	43.7	5	0.53	67.3
6	0.65	57.8	6	0.63	54.4	6	0.66	86.1
7	0.78	71.4	7	0.76	66.4	7	0.78	105.3
8	0.91	85.4	8	0.89	80.0	8	0.92	128.1
9	1.03	100.2	9	1.01	95.0	9	1.04	148.7
10	1.16	115.4	10	1.14	110.5	10	1.17	170.4
11	1.29	131.8	11	1.26	126.3	11	1.31	193.4
12	1.41	148.5	12	1.38	142.4	12	1.43	214.1
13	1.54	165.0	13	1.51	159.2	13	1.57	237.3
14	1.66	181.7	14	1.63	176.3	14	1.72	261.8
15	1.79	199.2	15	1.77	191.9	15	1.84	281.8
16	1.92	212.0	16	1.94	173.8	16	1.98	303.6
17	2.10	205.4	17	2.06	186.7	17	2.12	323.3
18	2.21	221.2	18	2.18	199.5	18	2.26	340.6
19	2.34	237.6	19	2.34	197.7	19	2.40	359.9
20	2.48	247.5	20	2.46	208.6	20	2.53	374.2
21	2.61	260.2	21	2.59	218.9	21	2.66	385.6
22	2.76	259.1	22	2.73	226.8	22	2.83	378.5
23	2.90	262.7	23	2.87	232.2	23	2.99	373.2
24	3.03	271.9	24	3.04	221.1	24	3.18	339.9
25	3.19	274.6	25	3.17	223.7	25	3.36	335.5
26	3.38	249.5	26	3.30	232.4	26	3.49	342.0
27	3.52	250.9	27	3.43	238.9	27	3.63	351.1
28	3.66	248.6	28	3.60	227.6	28	3.78	355.4
29	3.85	213.1	29	3.73	228.1	29	3.93	352.6
30	4.01	196.4	30	3.87	230.2	30	4.09	342.0
31	4.14	197.1	31	4.07	189.2	31	4.25	336.8
32	4.27	199.3	32	4.19	192.6	32	4.40	332.7
33	4.41	200.3	33	4.32	199.5	33	4.57	322.2
34	4.58	184.2	34	4.45	201.7	34	4.72	318.6
35	4.72	178.6	35	4.60	201.0	35	4.98	199.4
36	4.85	181.0	36	4.74	198.2	36	5.13	186.8
37	4.98	184.2	37	4.91	183.0	37	5.28	181.9
38	5.13	177.5	38	5.05	180.9	38	5.42	186.4

The pictures below is taken before, during and after performing the unconfined compression test.



Acknowledgement

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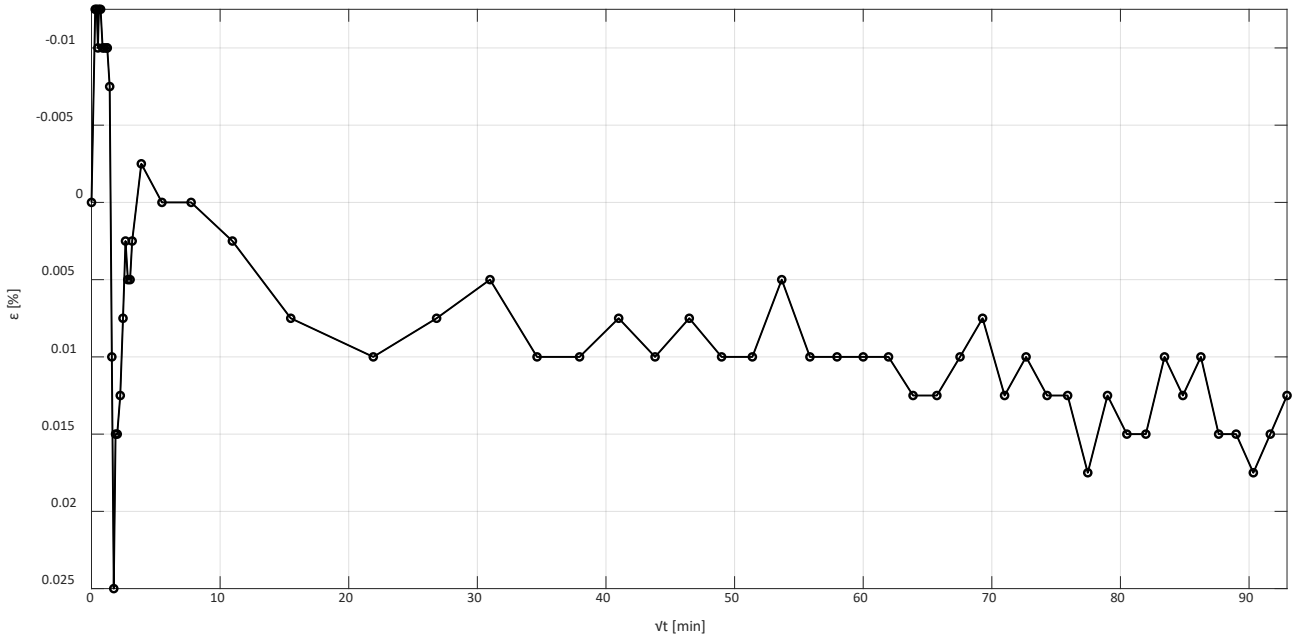
Appendix

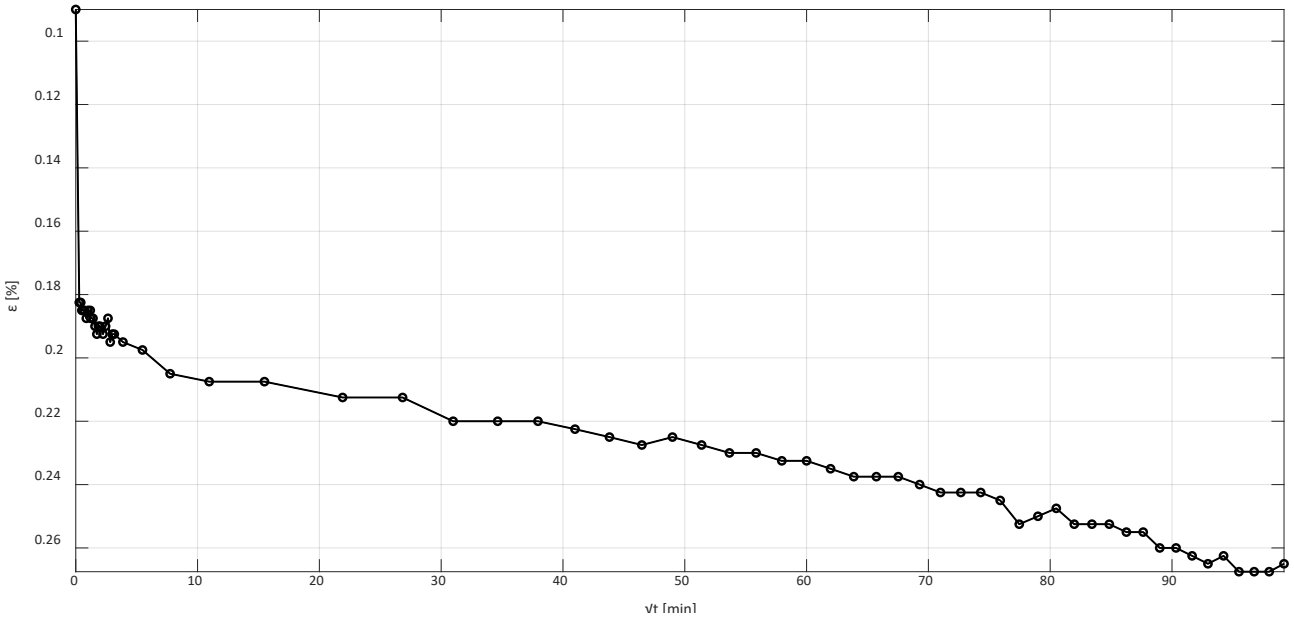
Test 1704CON0903 – Load steps

The results of each load step of Test 1704CON0903 is shown in a √t [min] - ε [%] graph.

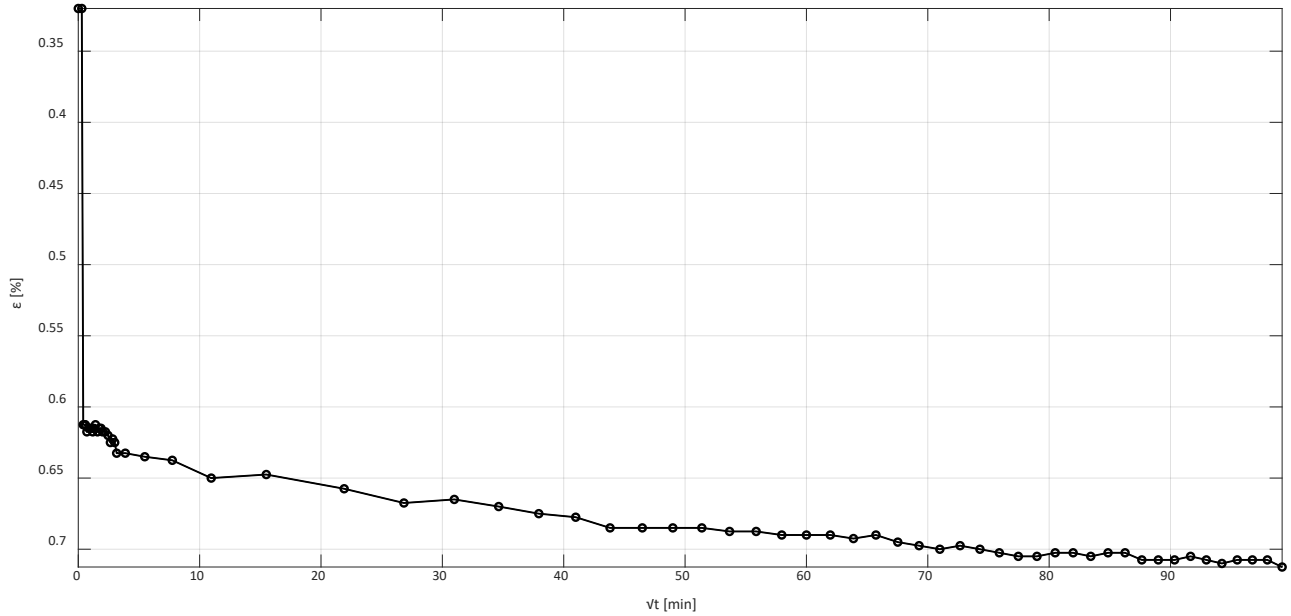
- Phase 1 – σ' = 122 kPa



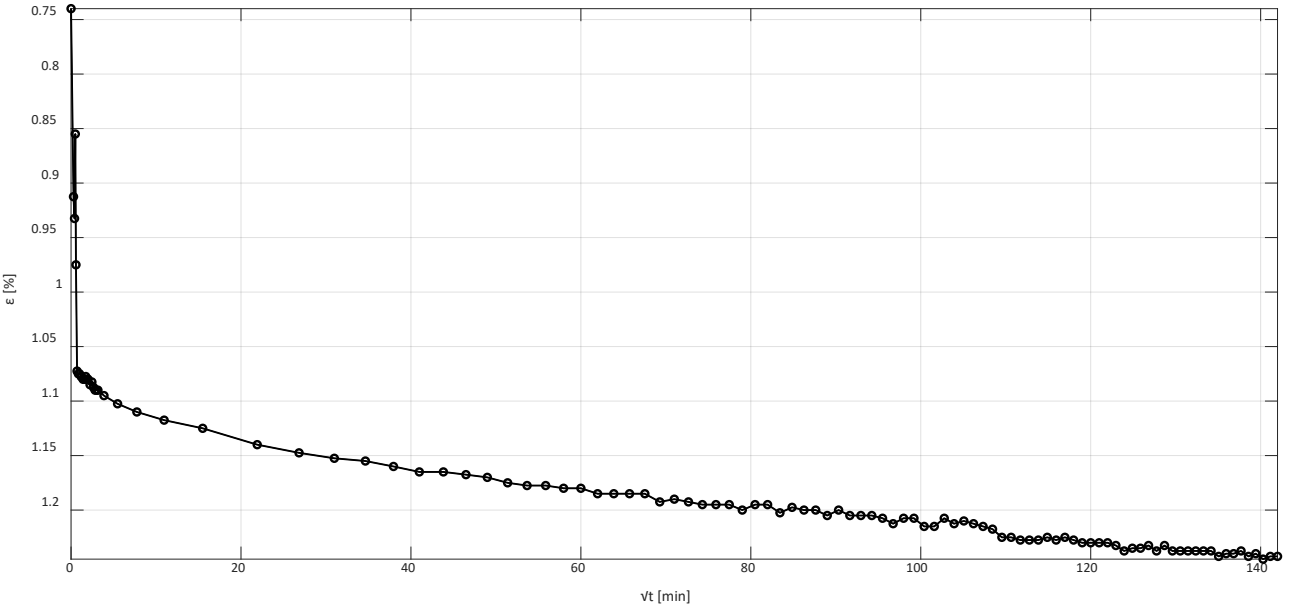
- Phase 2 – σ' = 255 kPa



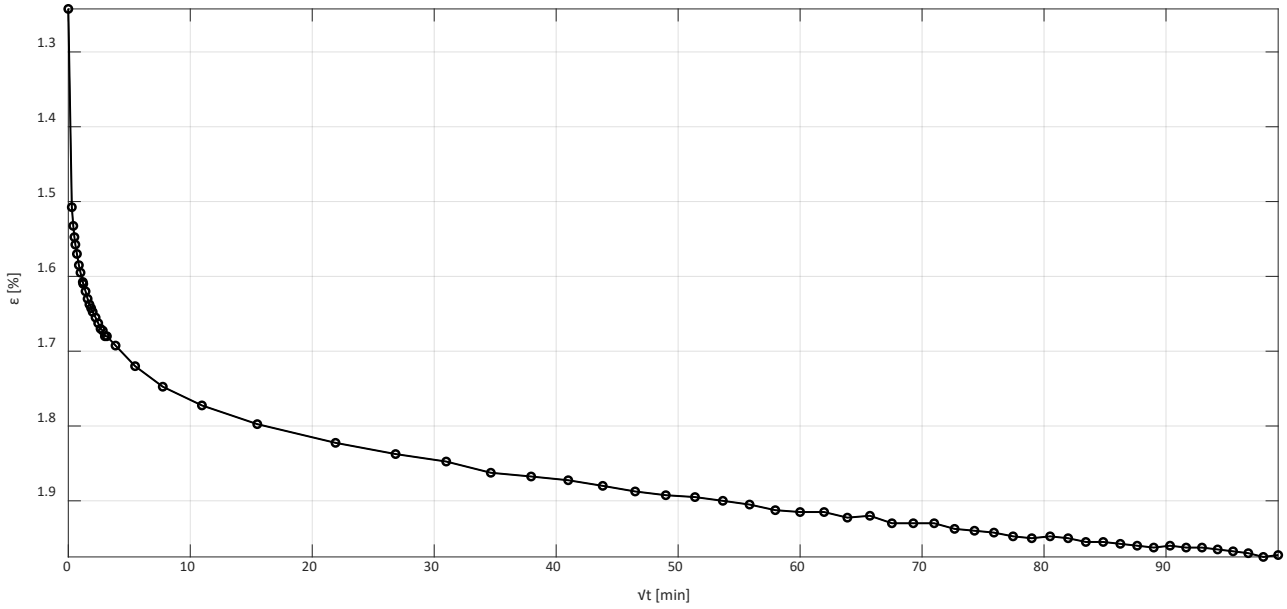
- Phase 3 – σ’ = 510 kPa



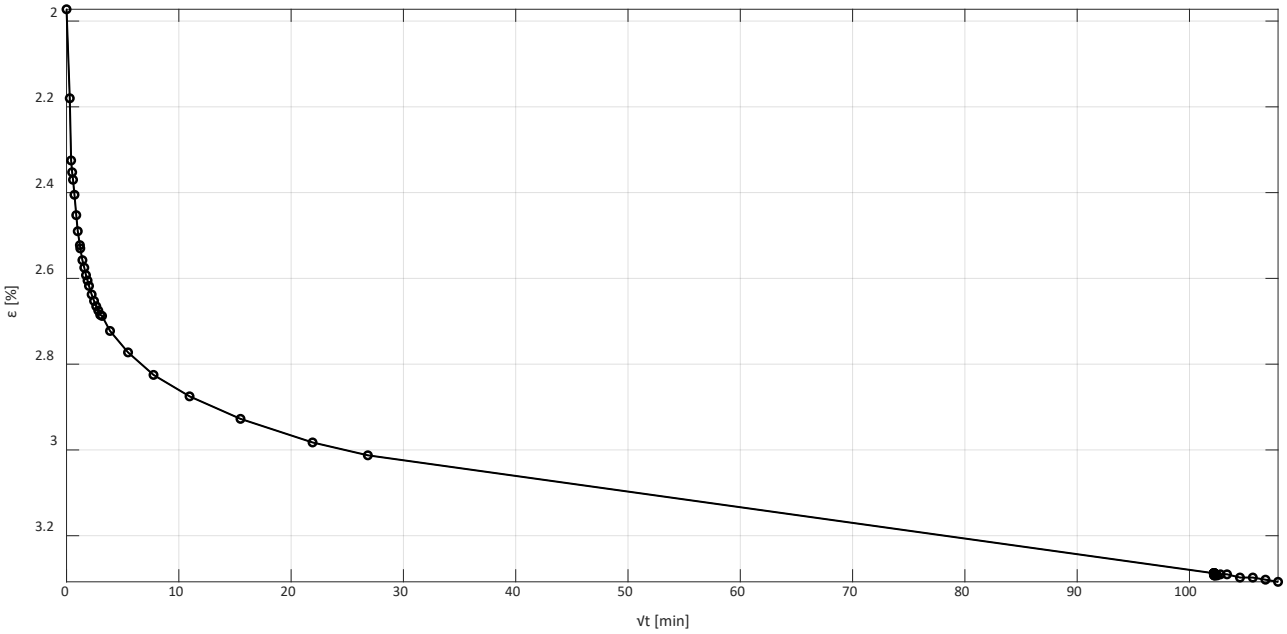
- Phase 4 – σ’ = 1019 kPa



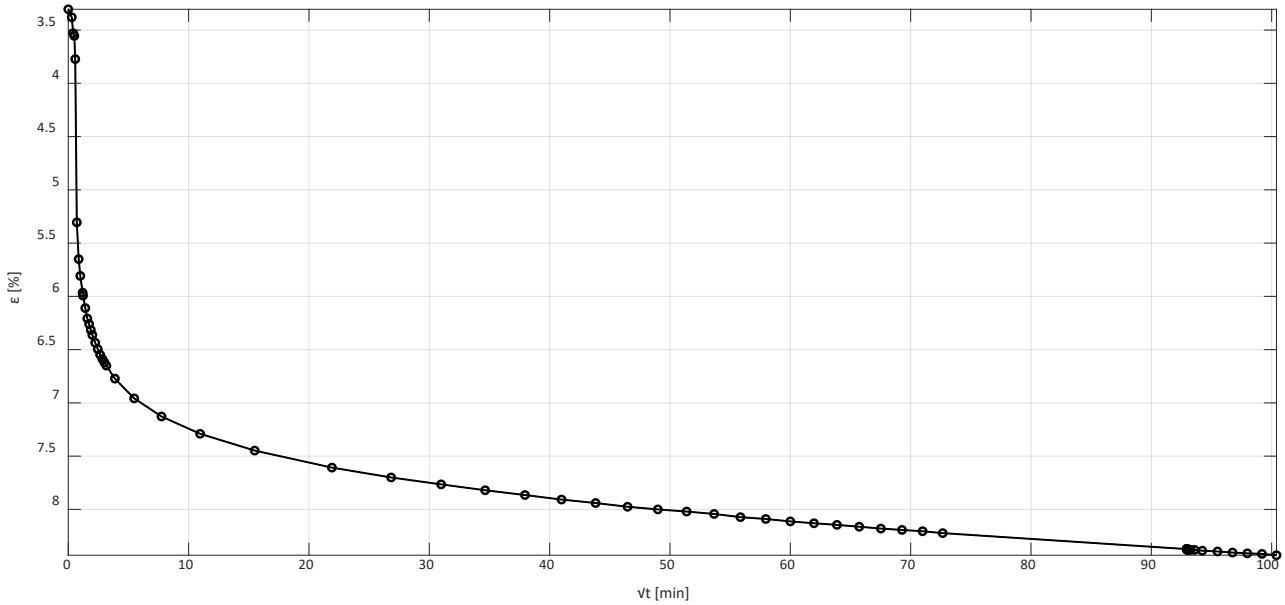
- Phase 5 – σ’ = 2039 kPa



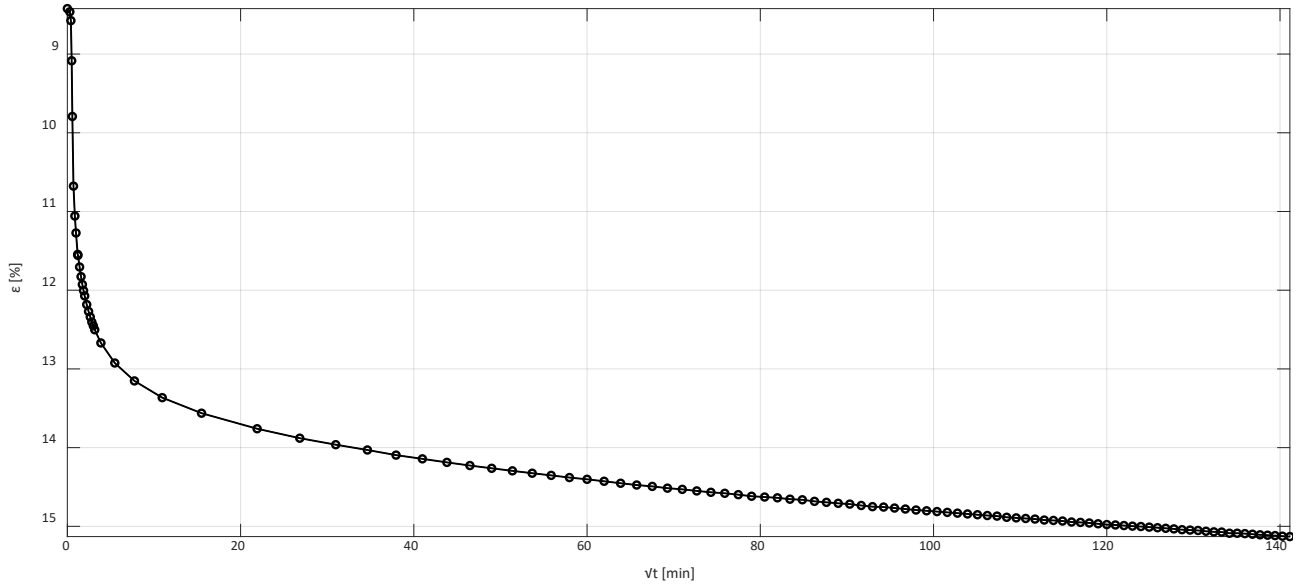
- Phase 6 – σ’ = 3567 kPa



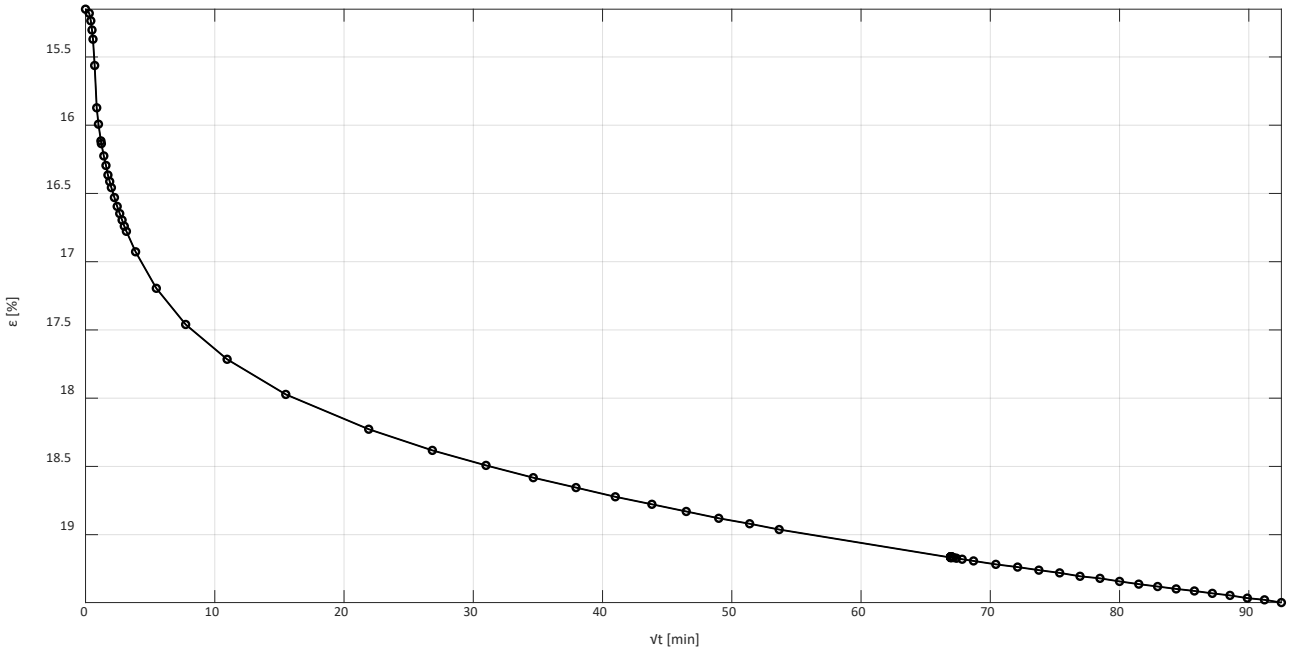
- Phase 7 – σ’ = 7135 kPa



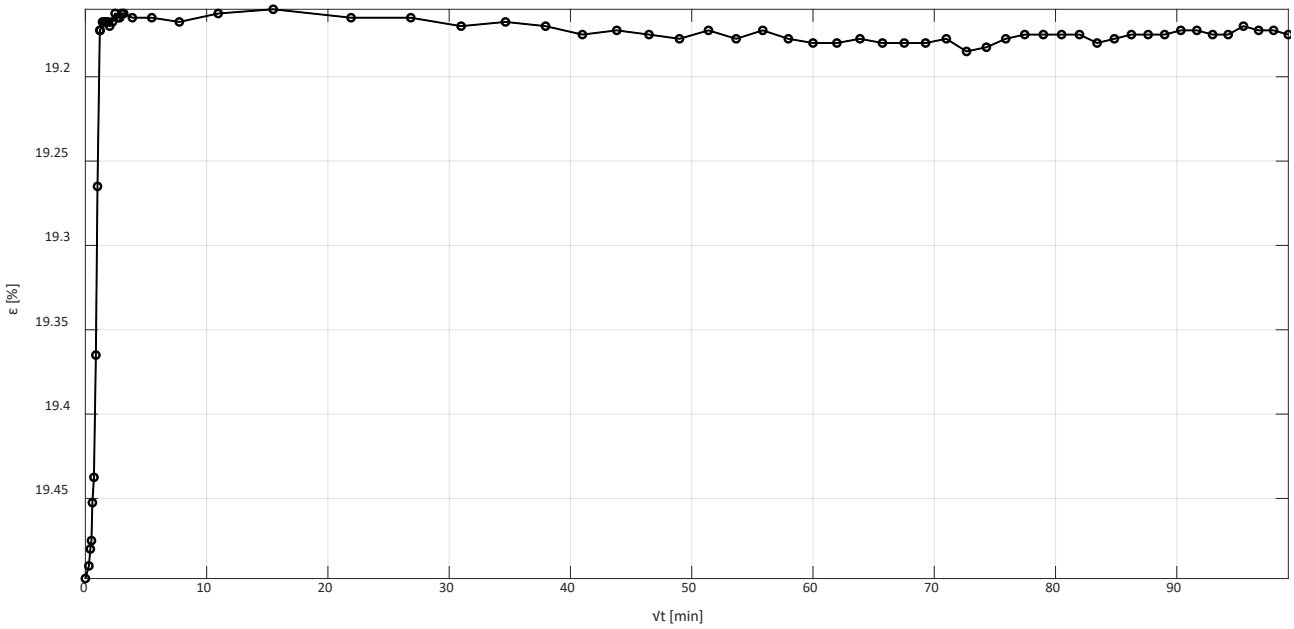
- Phase 8 – σ’ = 14270 kPa



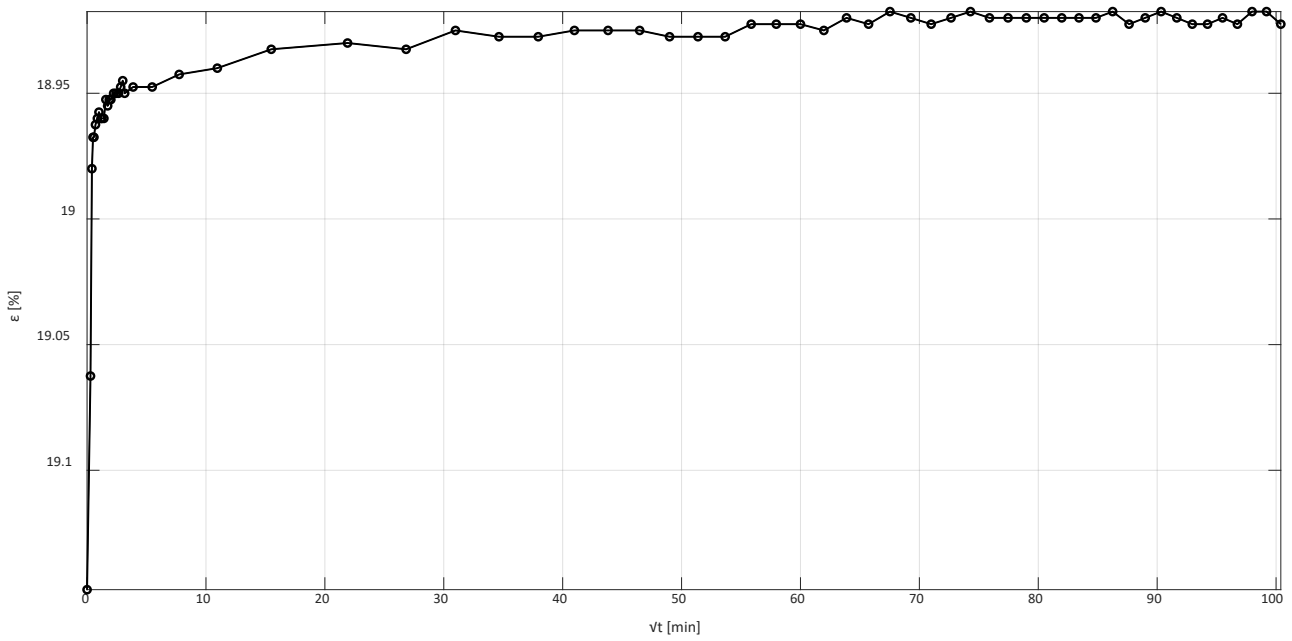
- Phase 9 – σ’ = 28540 kPa



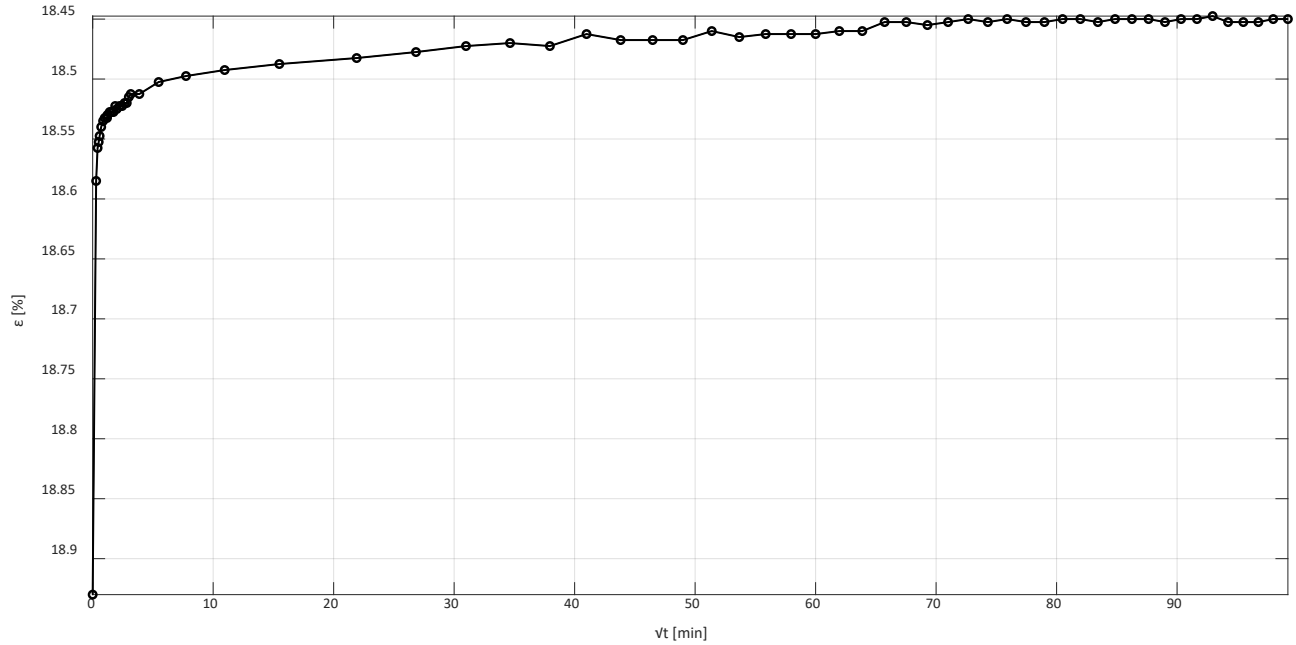
- Phase 10 – σ’ = 7135 kPa



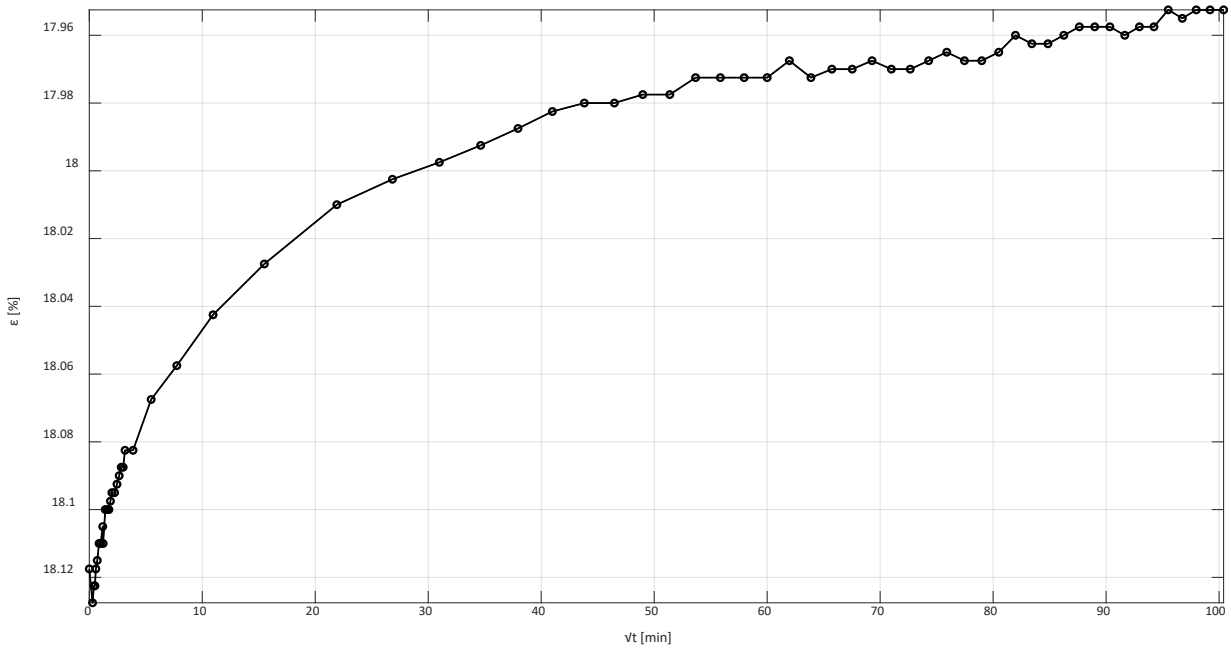
- Phase 11 – σ’ = 2039 kPa



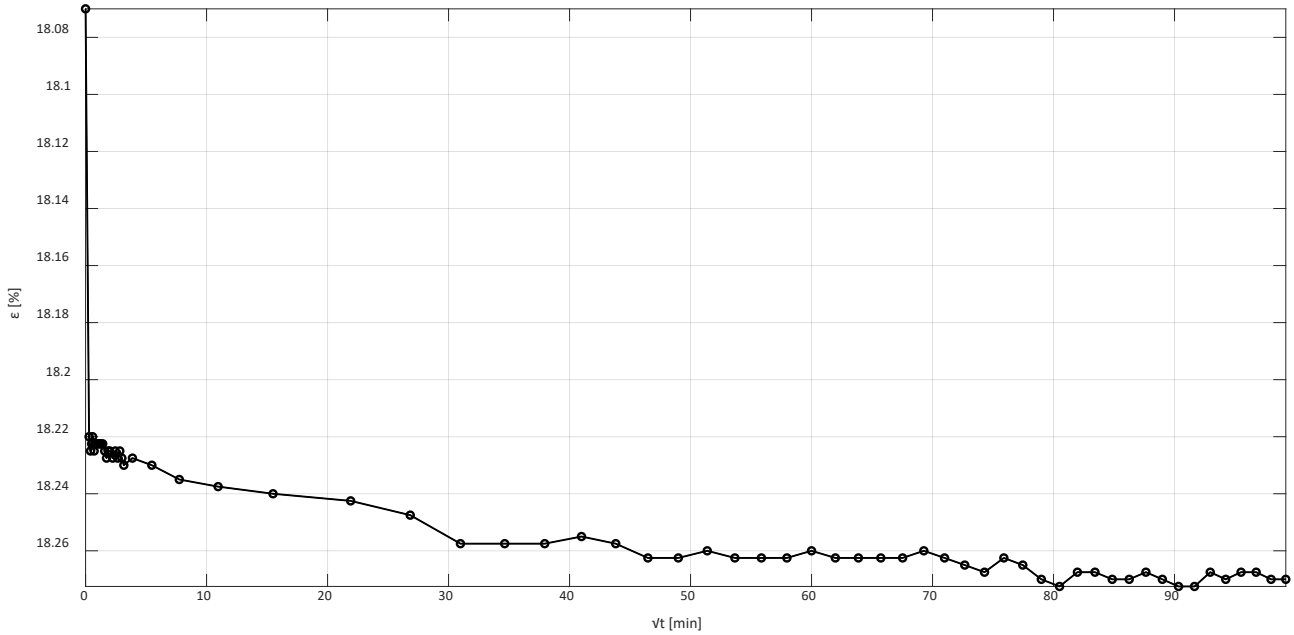
- Phase 12 – σ’ = 510 kPa



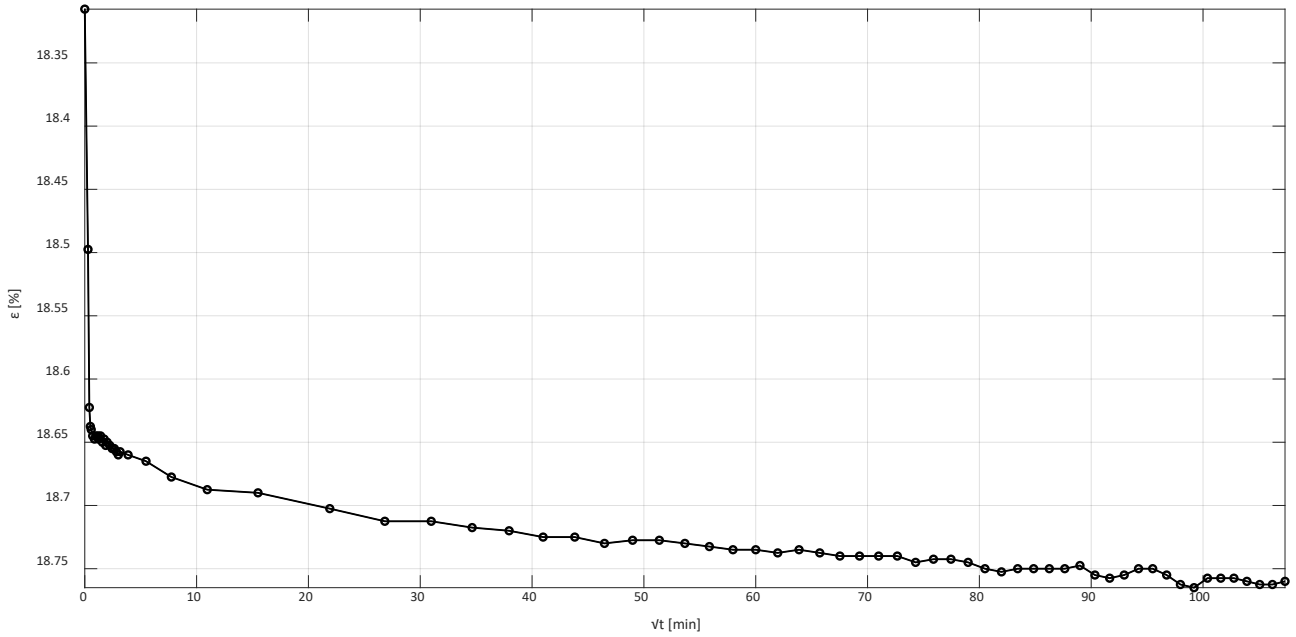
- Phase 13 – σ’ = 122 kPa



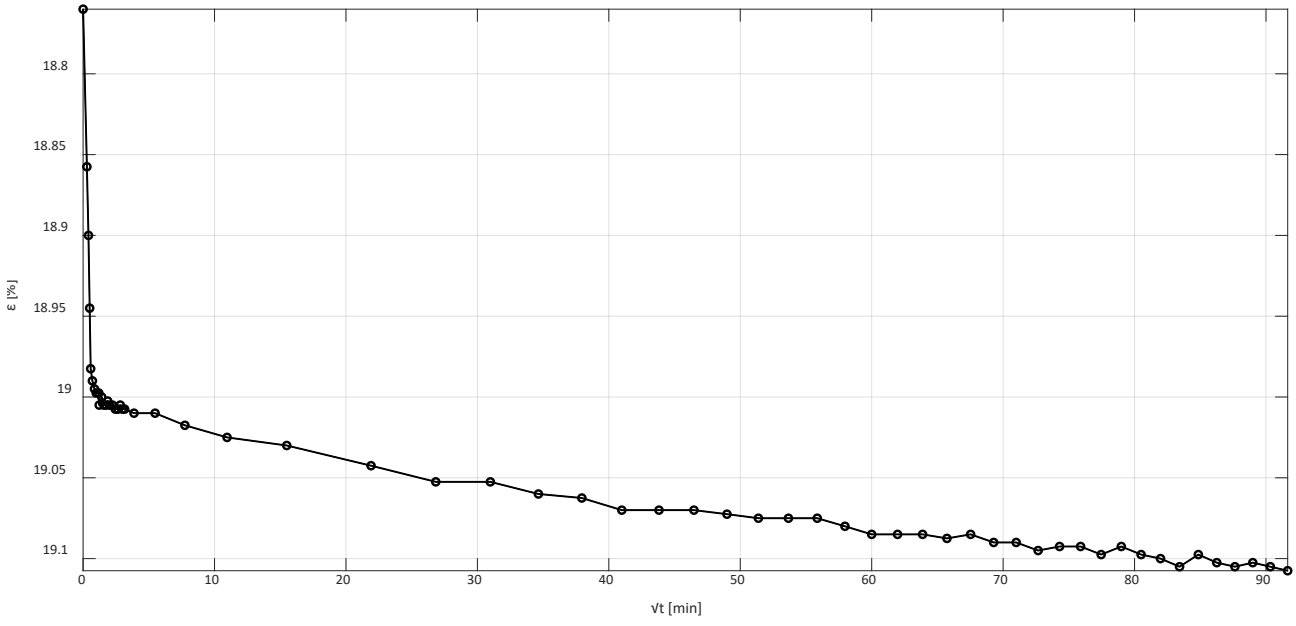
- Phase 14 – σ’ = 510 kPa



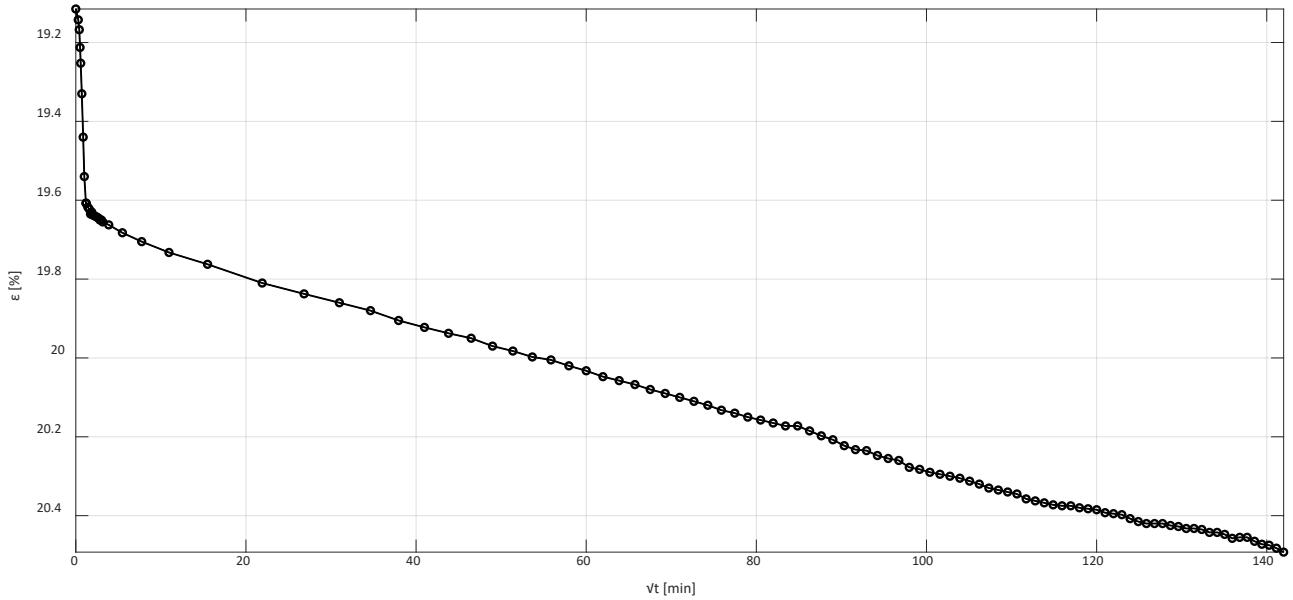
- Phase 15 – σ’ = 2039 kPa



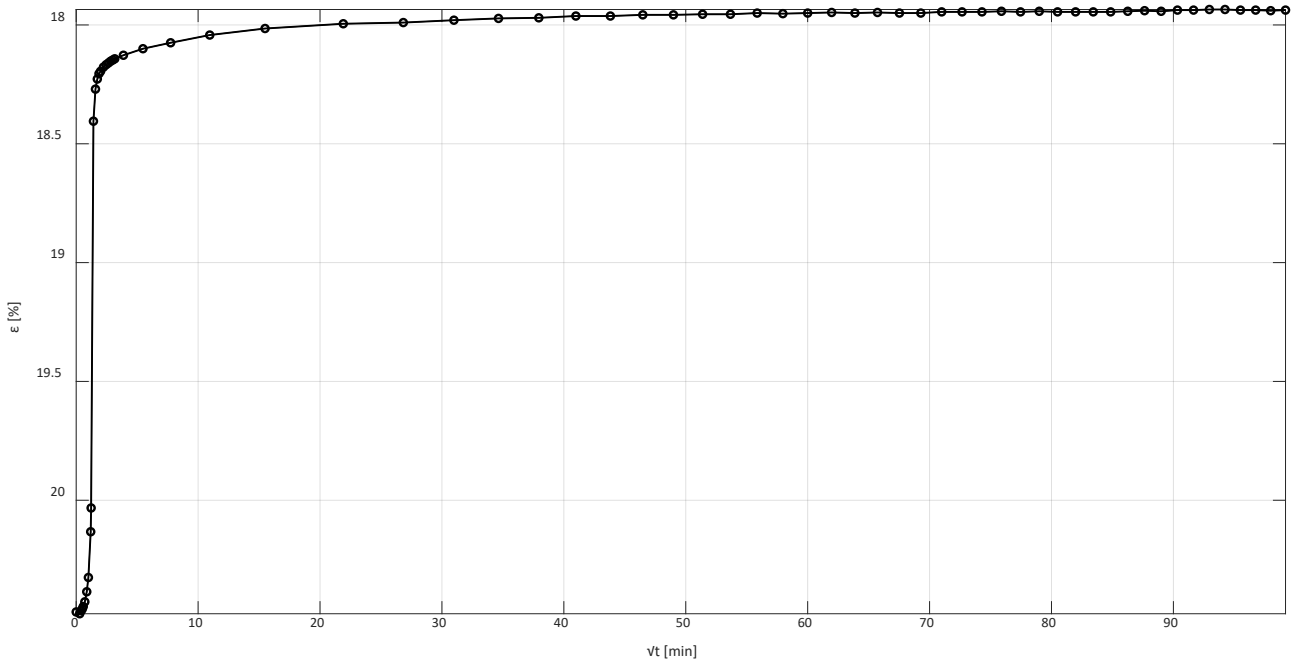
- Phase 16 – σ’ = 7135 kPa



- Phase 17 – σ’ = 28540 kPa



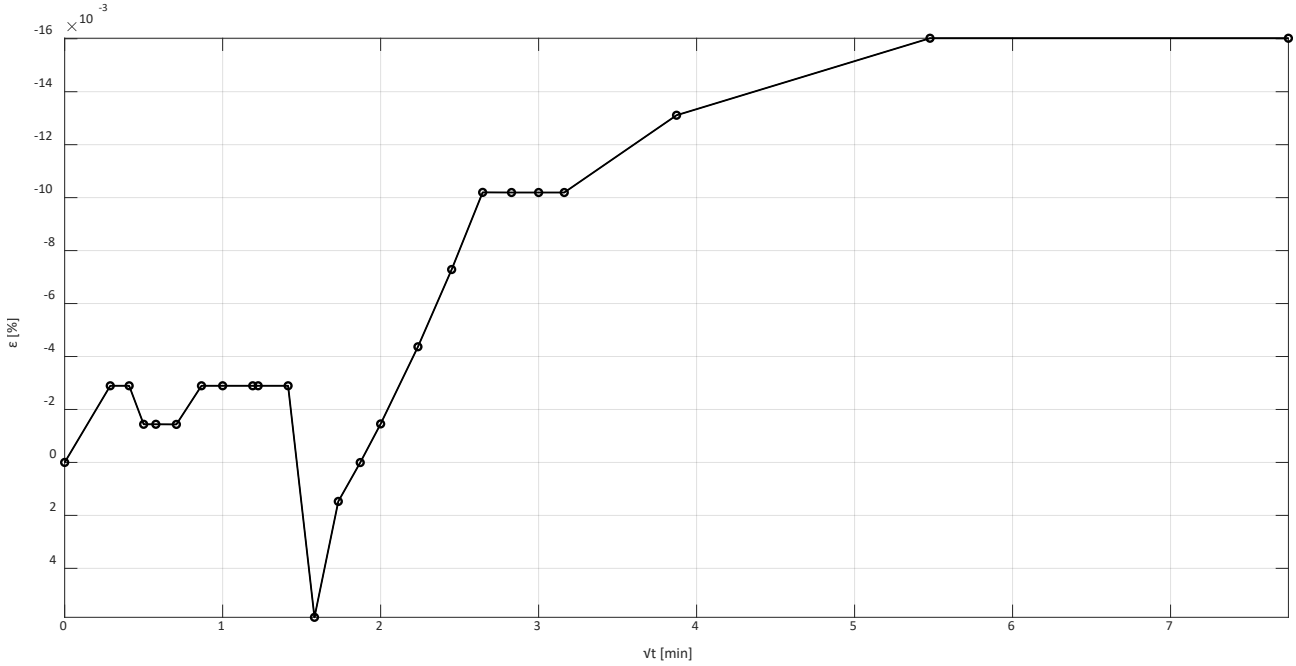
- Phase 18 – σ’ = 0 kPa



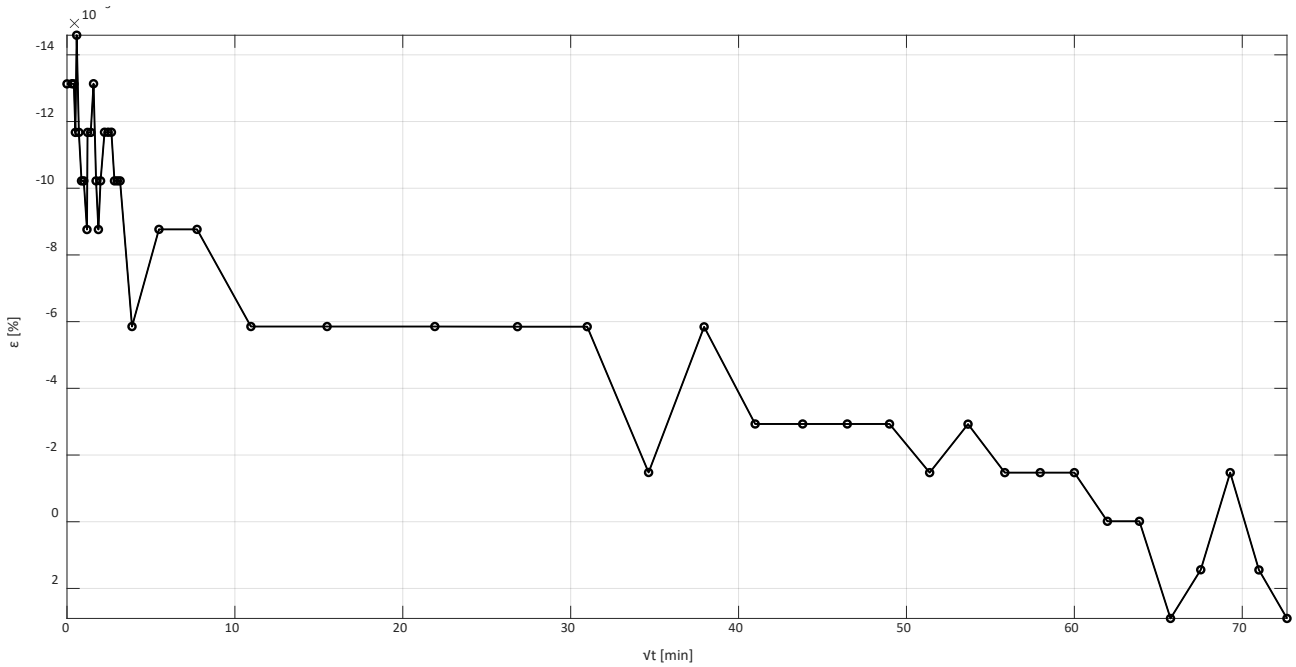
Test 1704CON1001 – Load steps

The results of each load step of Test 1704CON1001 is shown in a √t [min] - ε [%] graph.

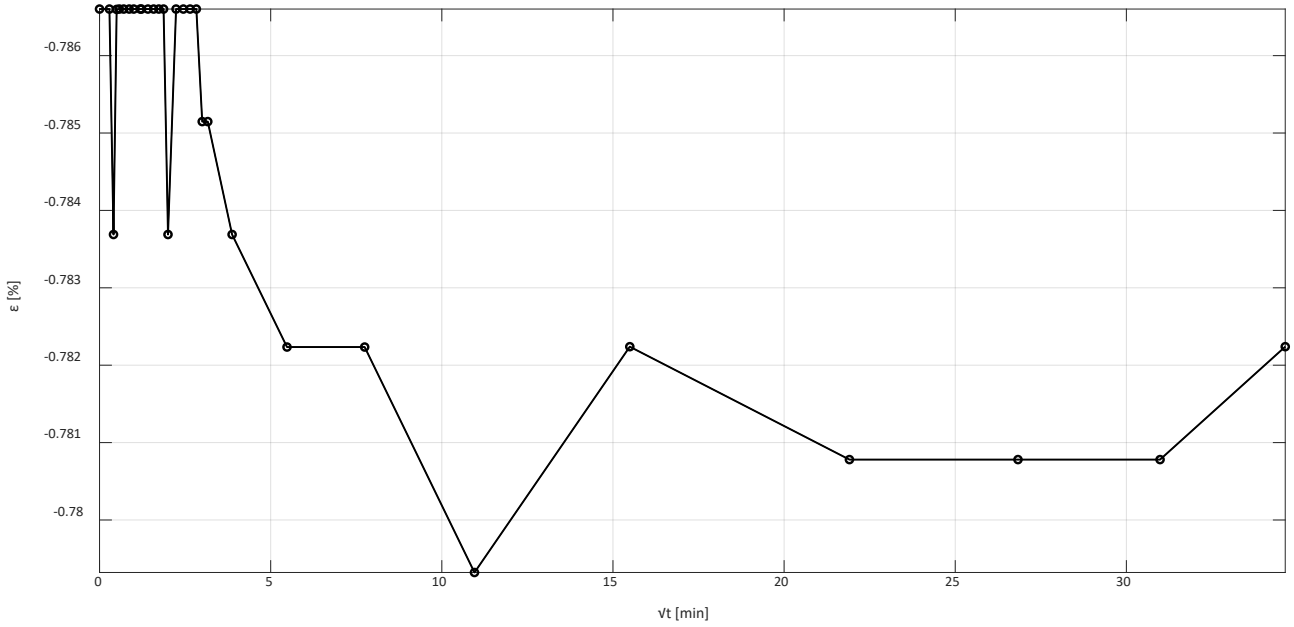
- Phase 1 – σ' = 31 kPa



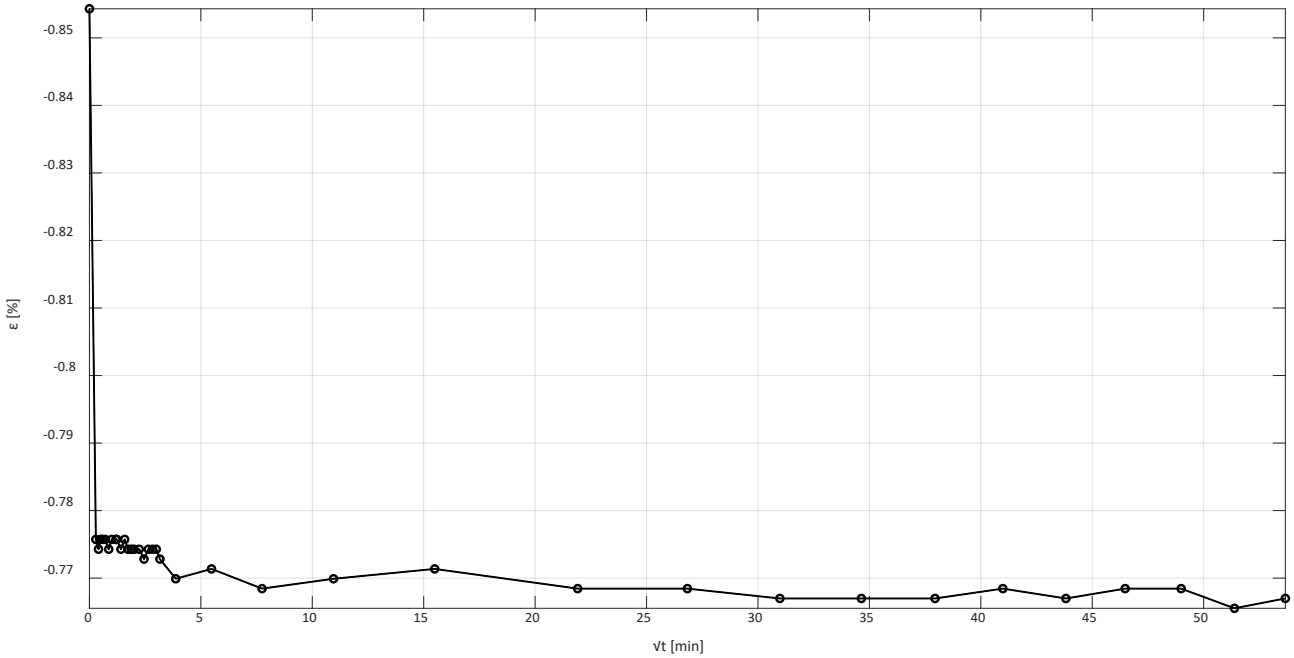
- Phase 2 – σ' = 61 kPa



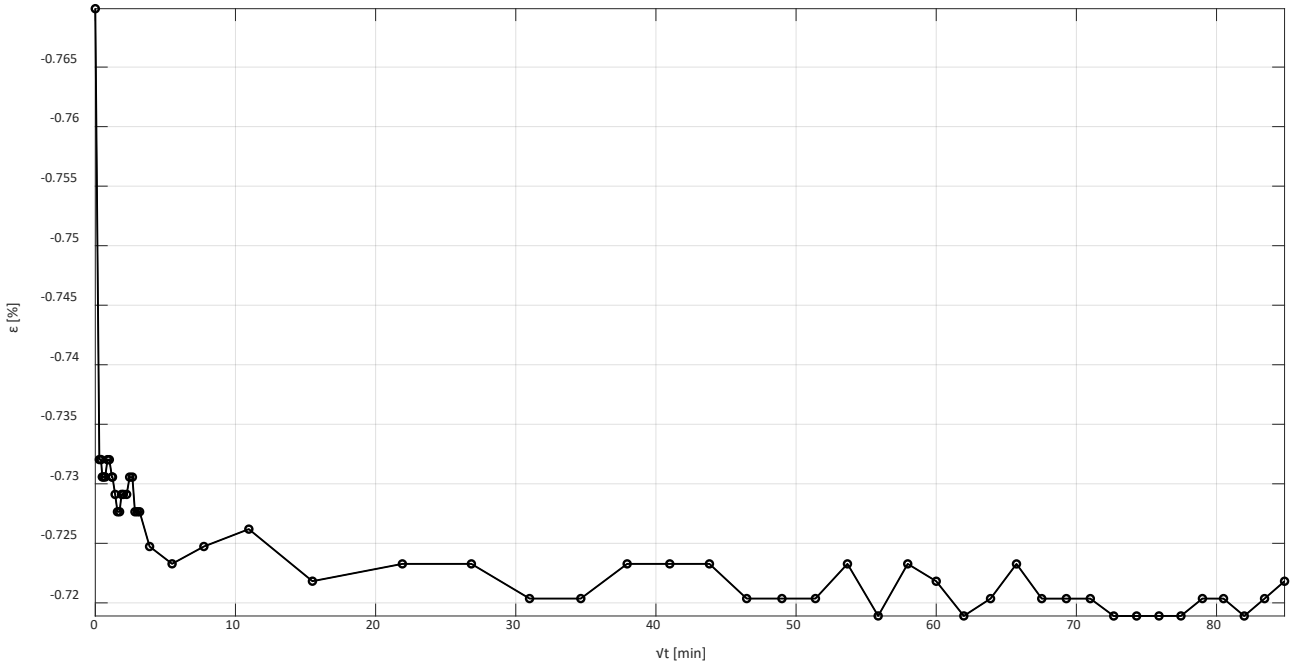
- Phase 3 – σ’ = 122 kPa



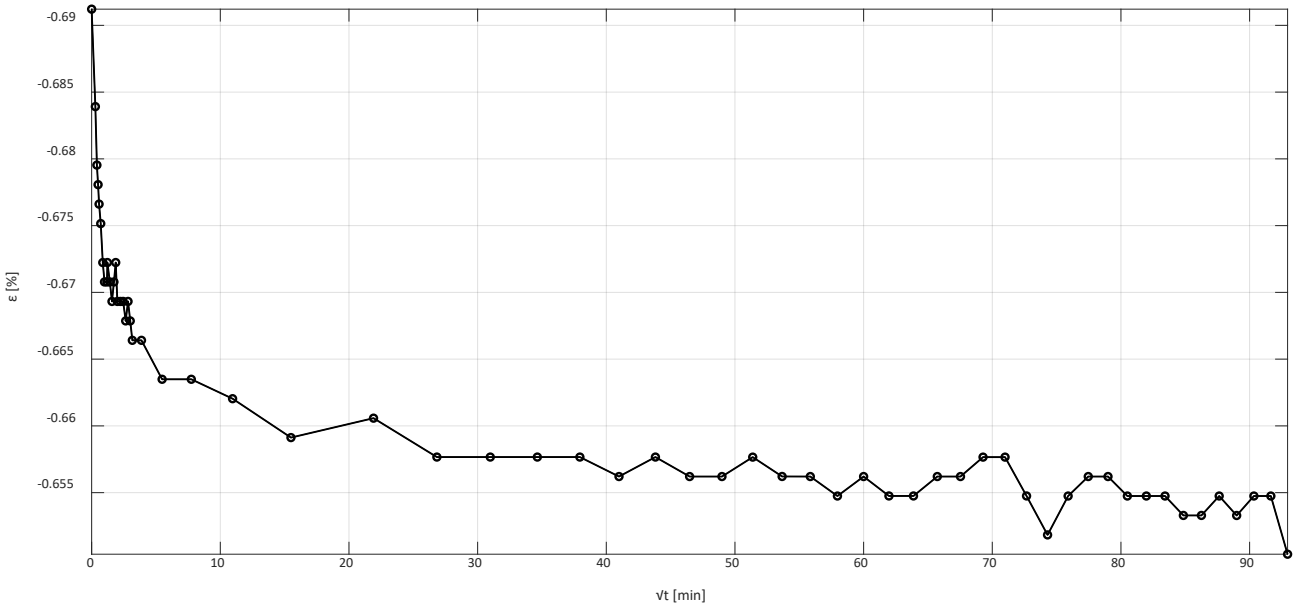
- Phase 4 – σ’ = 255 kPa



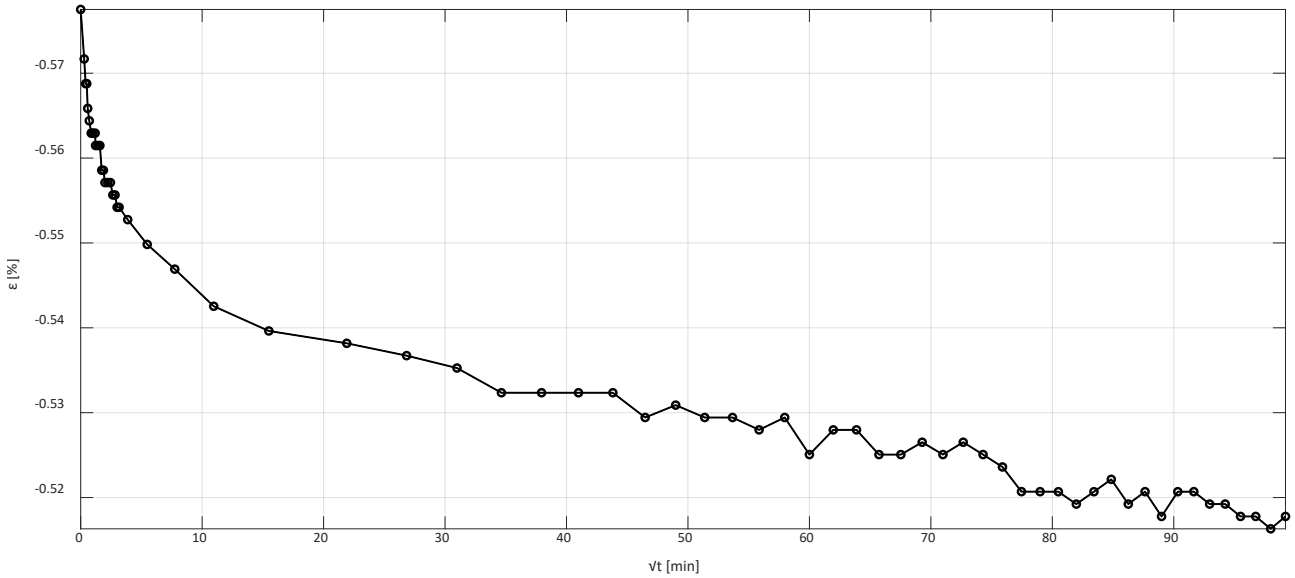
- Phase 5 – σ’ = 510 kPa



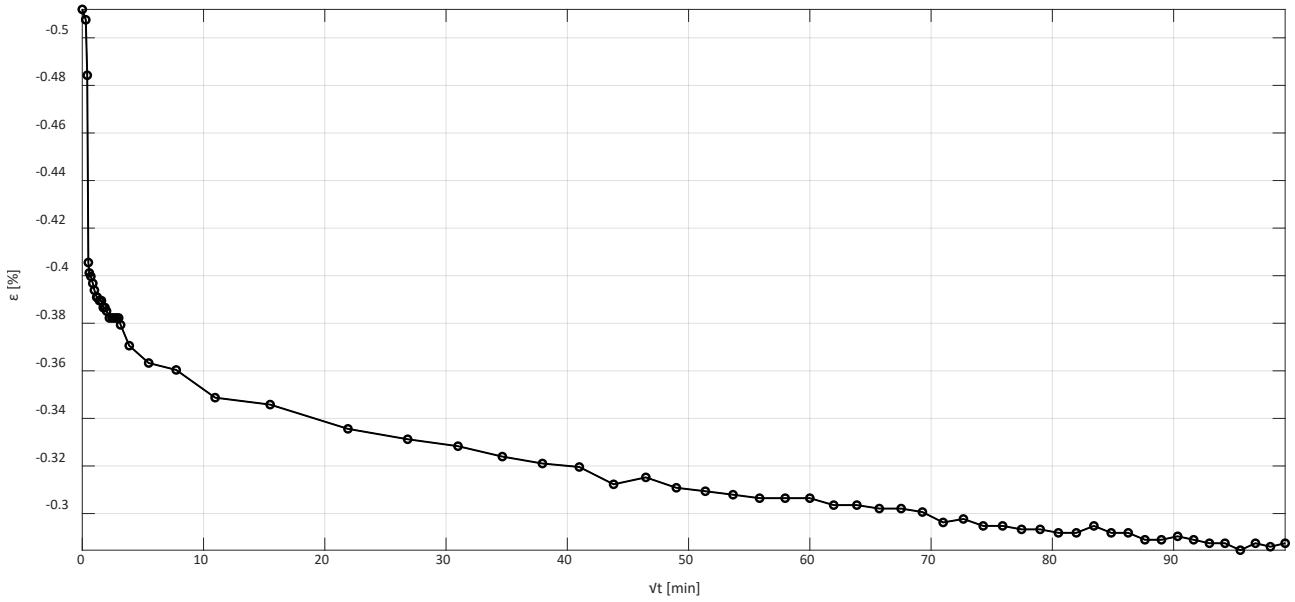
- Phase 6 – σ’ = 1019 kPa



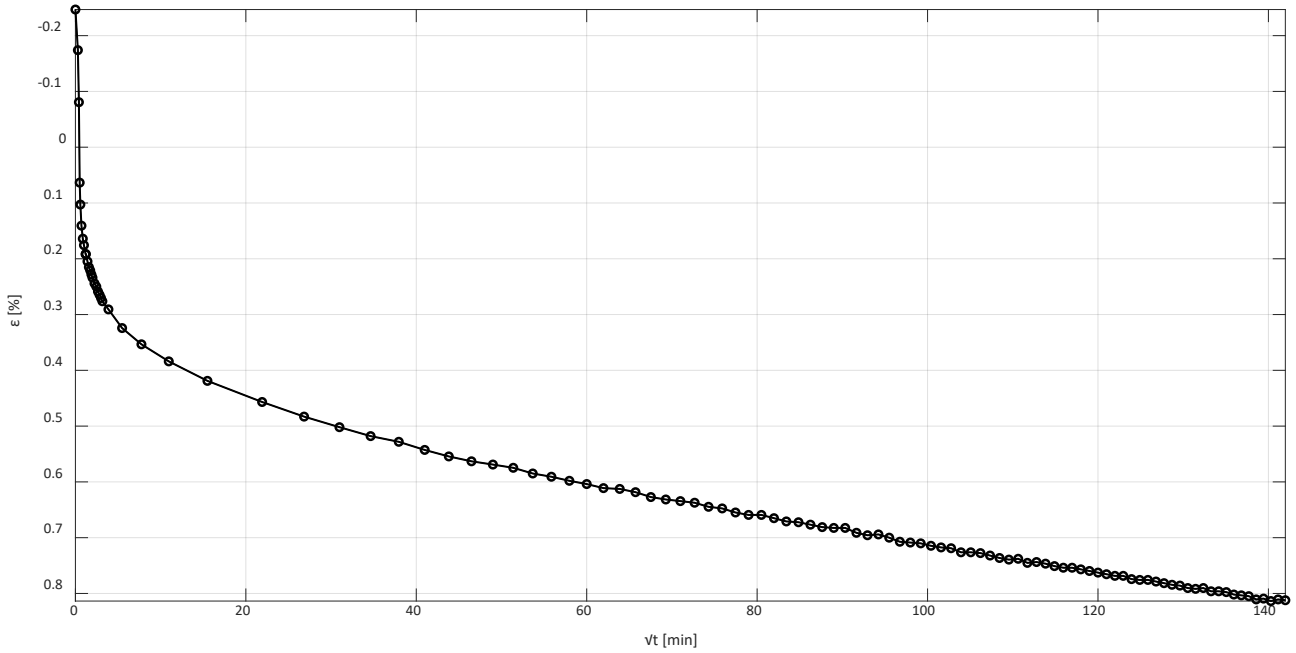
- Phase 7 – σ’ = 2039 kPa



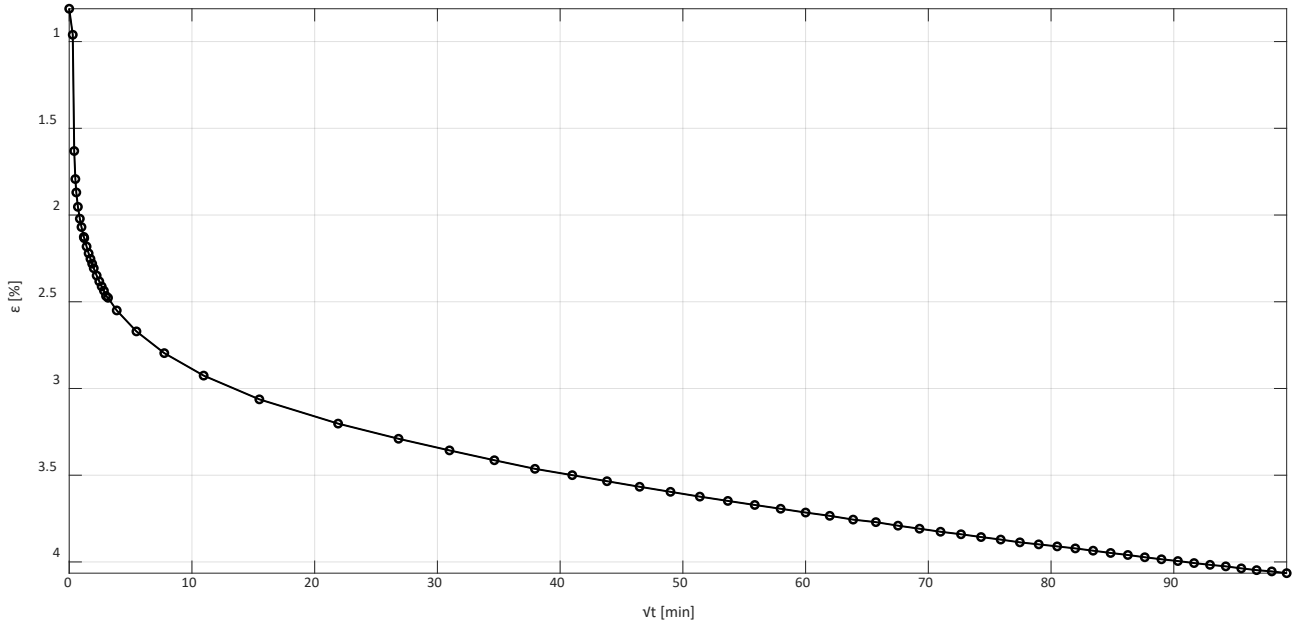
- Phase 8 – σ’ = 3567 kPa



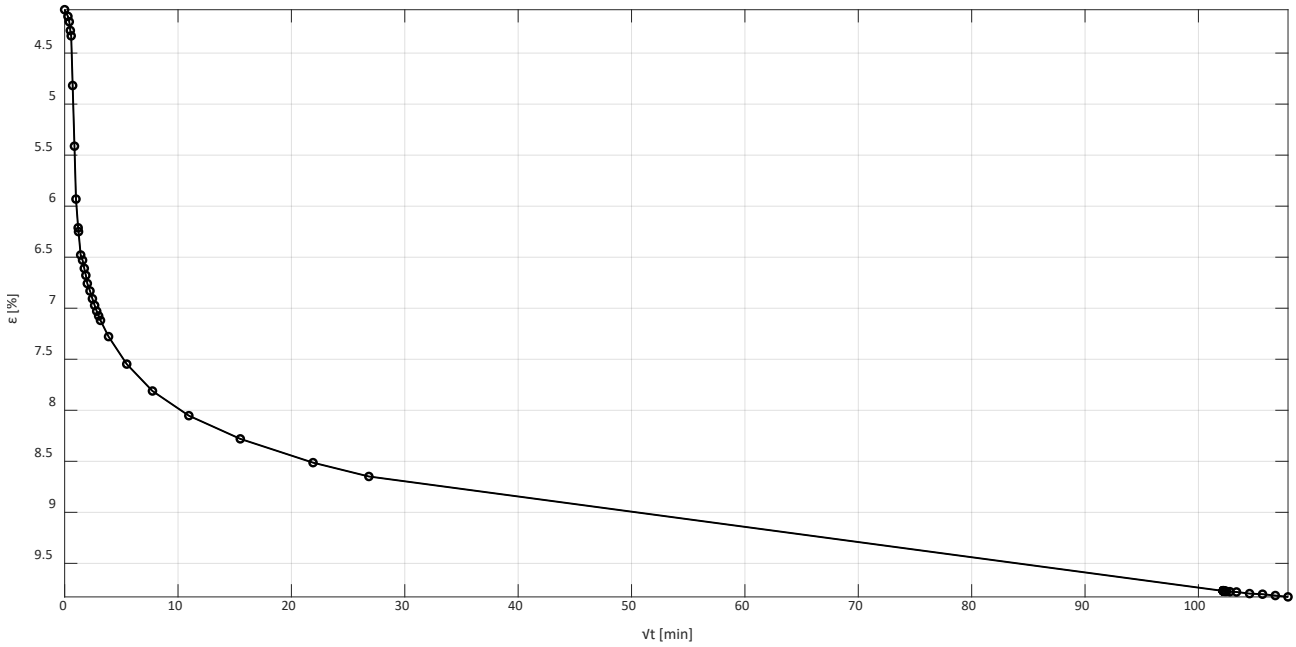
- Phase 9 – σ’ = 7135 kPa



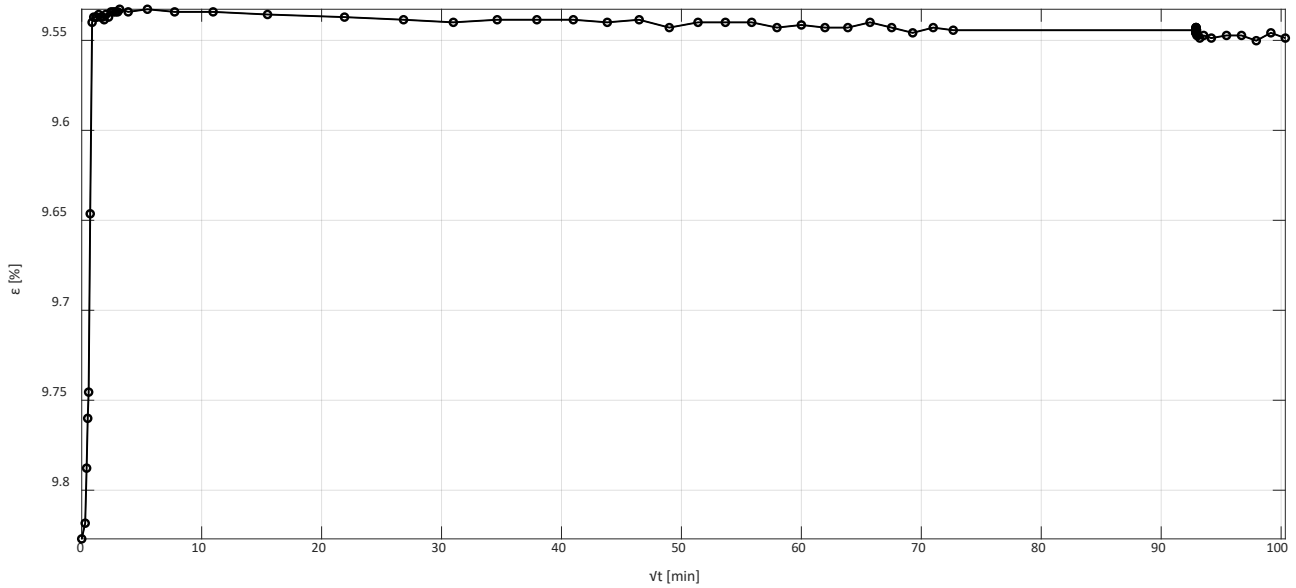
- Phase 10 – σ’ = 14270 kPa



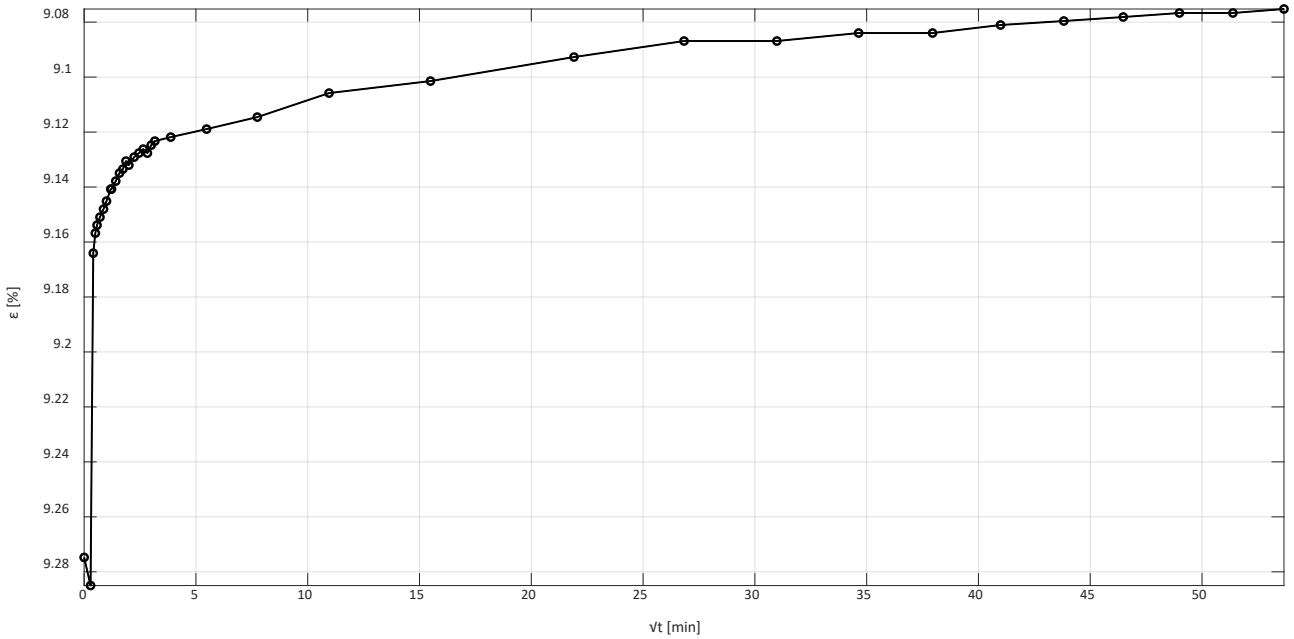
- Phase 11 – σ’ = 28540 kPa



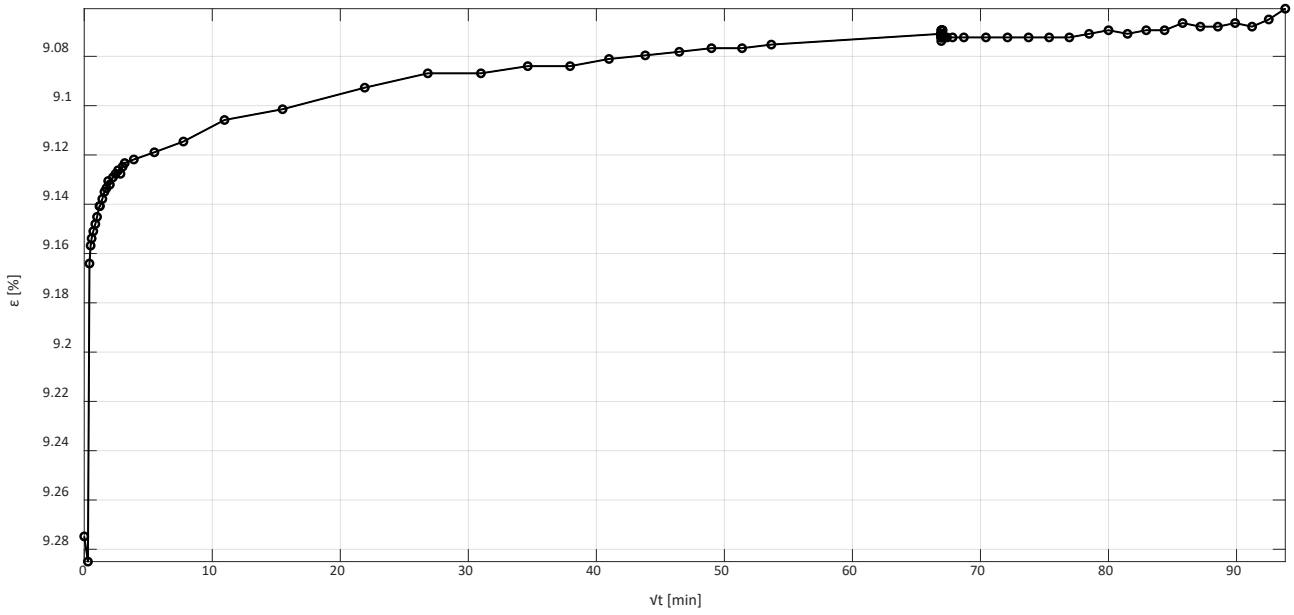
- Phase 12 – σ’ = 7135 kPa



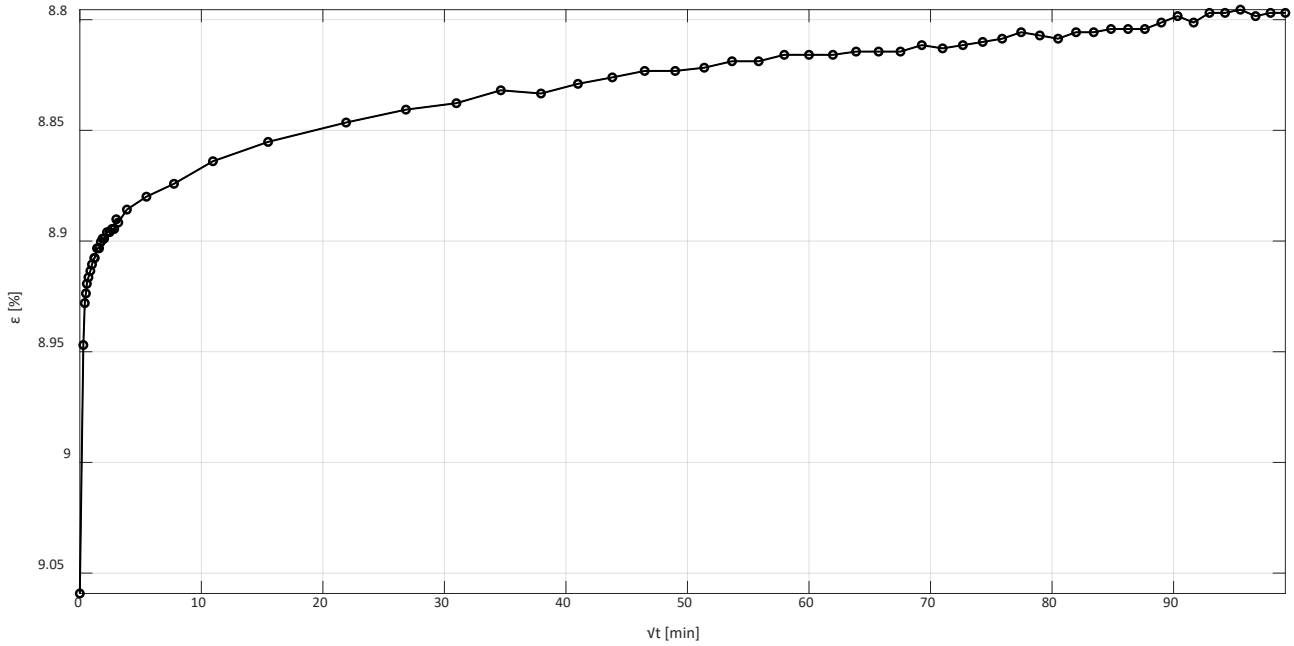
- Phase 13 – σ’ = 2039 kPa



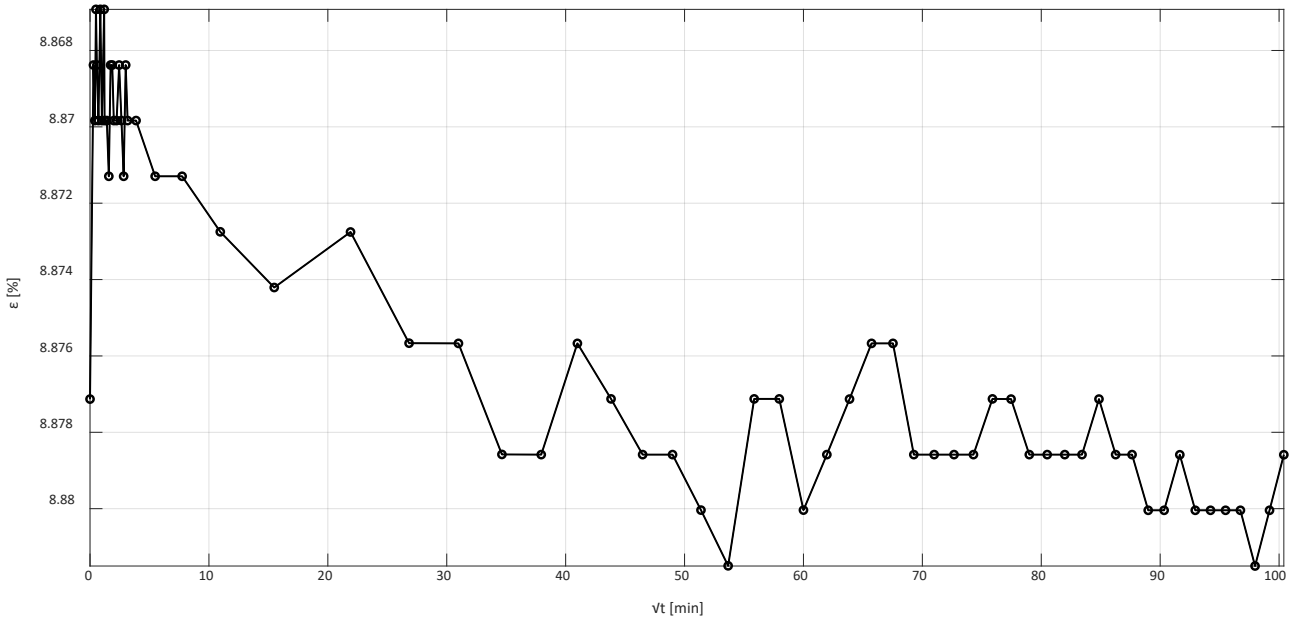
- Phase 14 – σ’ = 510 kPa



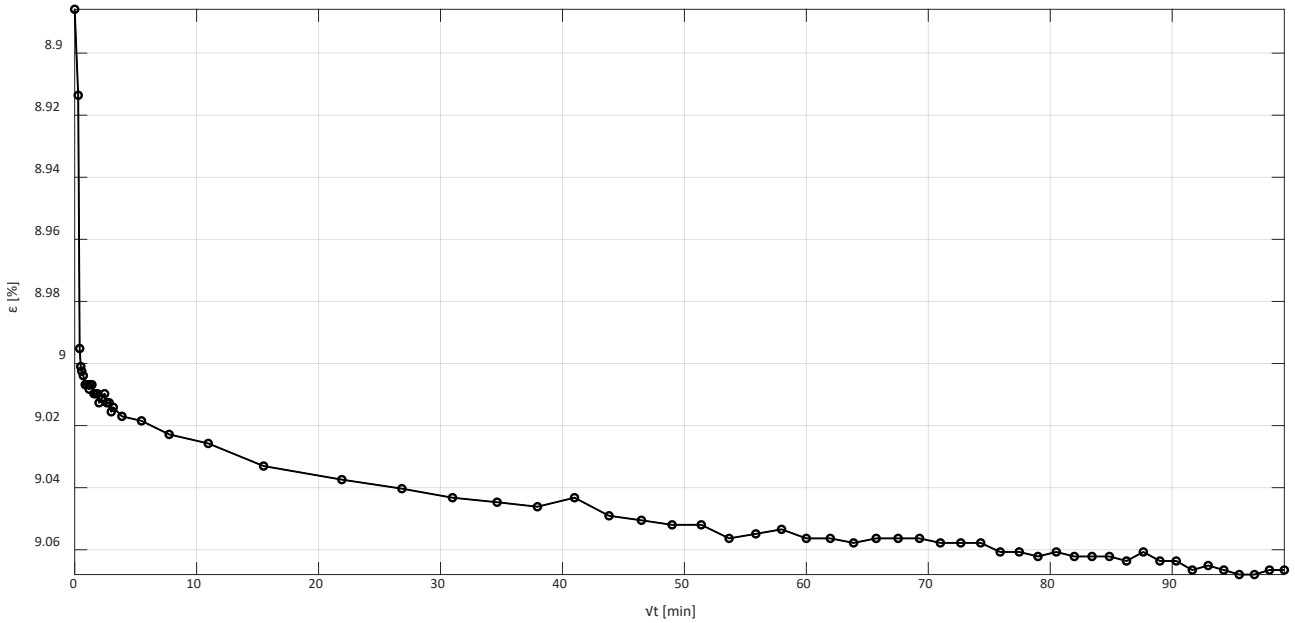
- Phase 15 – σ’ = 122 kPa



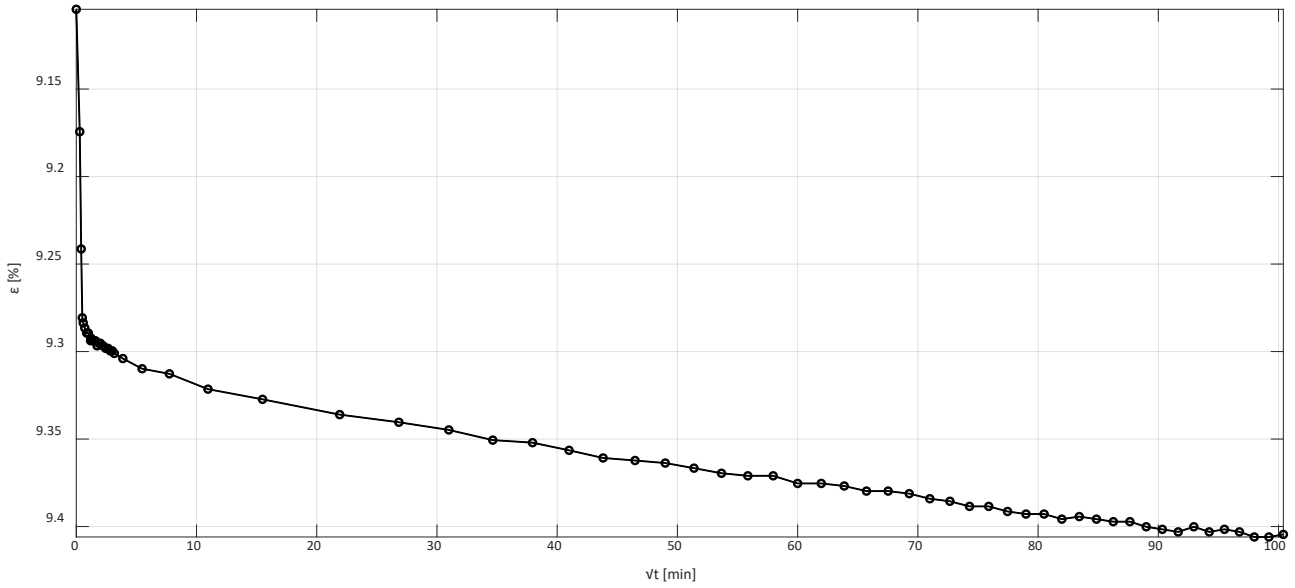
- Phase 16 – σ’ = 510 kPa



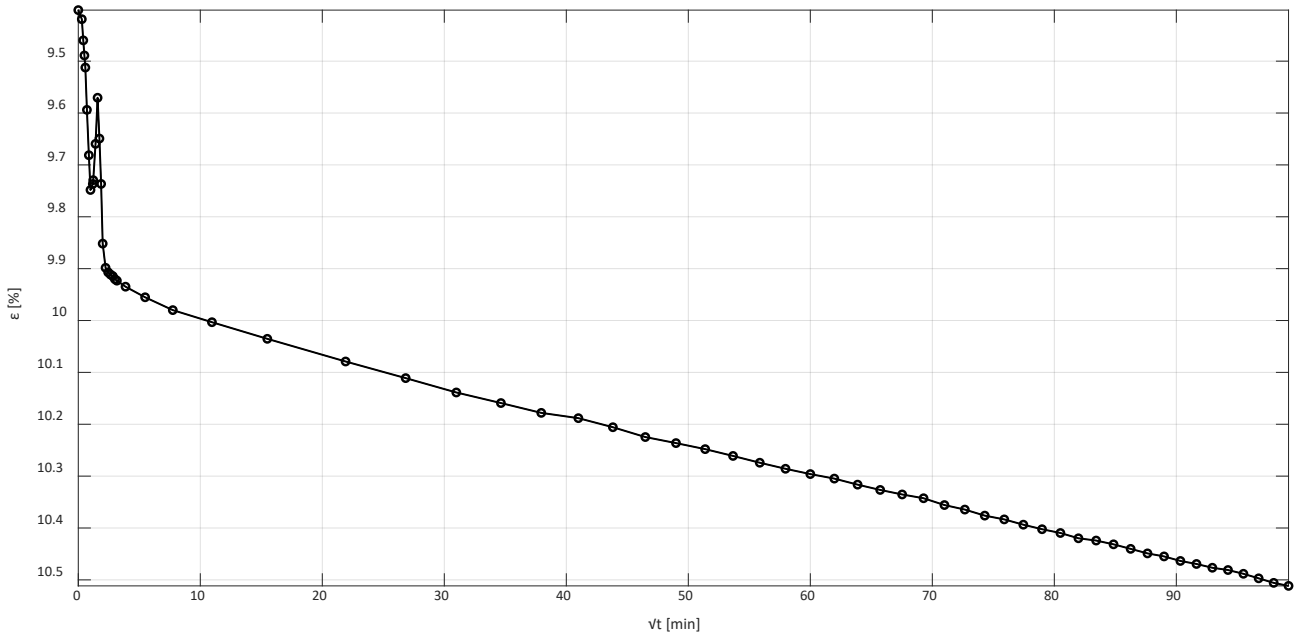
- Phase 17 – σ’ = 2039 kPa



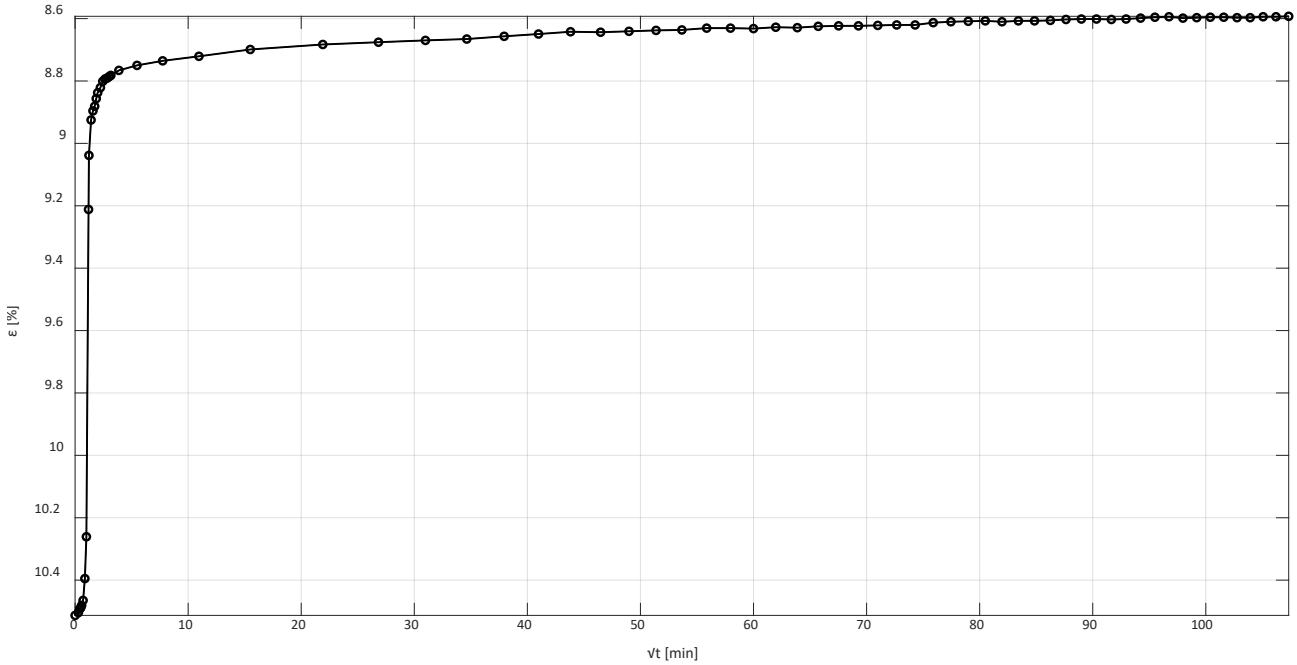
- Phase 18 – σ’ = 7135 kPa



- Phase 19 – σ’ = 28540 kPa



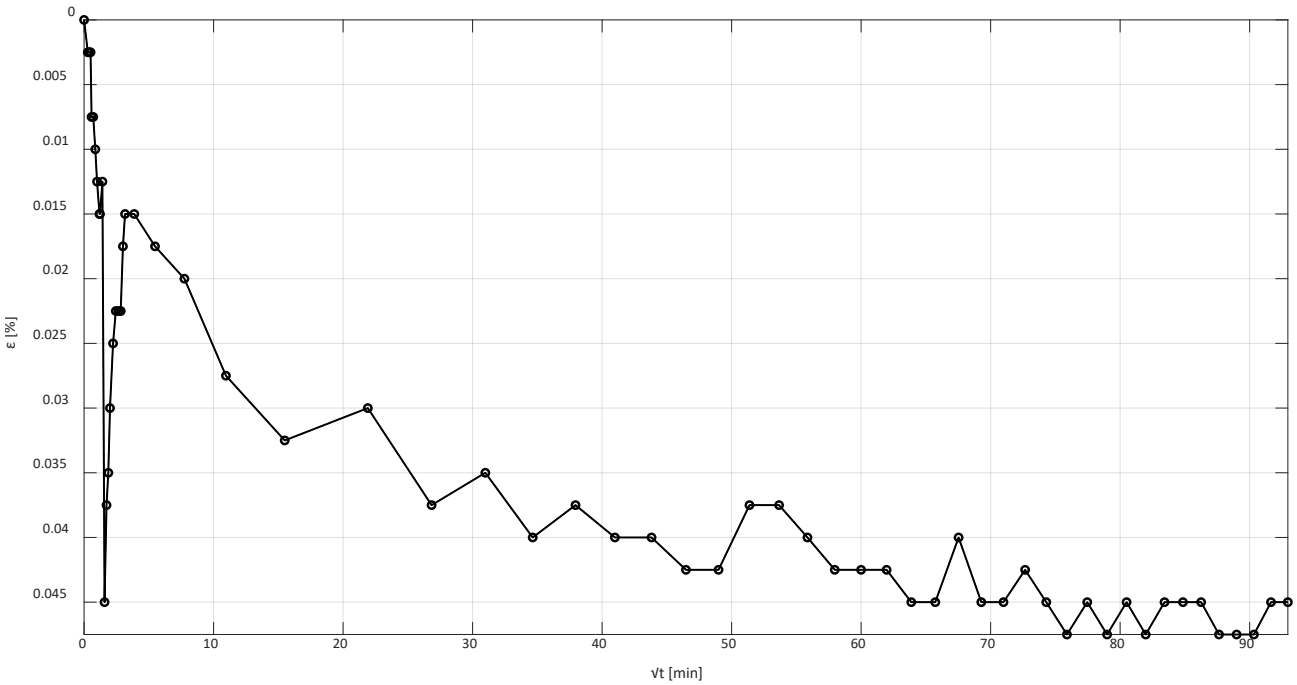
- Phase 20 – σ’ = 0 kPa



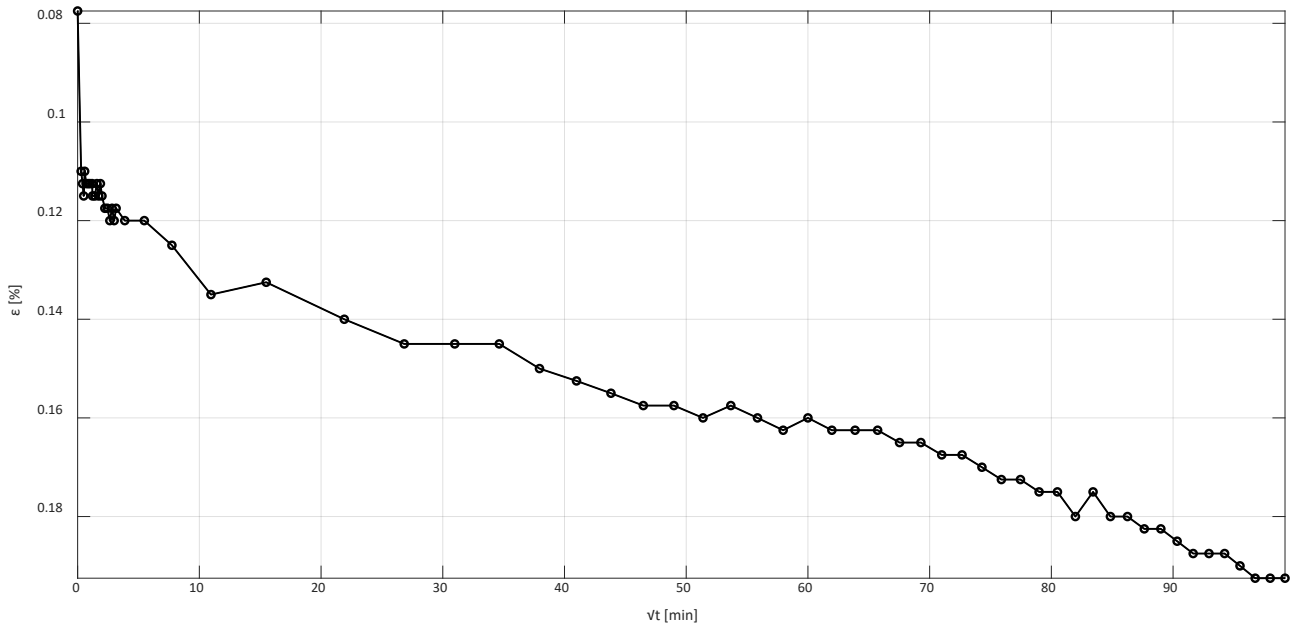
Test 1704CON1103 – Load steps

The results of each load step of Test 1704CON1103 is shown in a √t [min] - ε [%] graph.

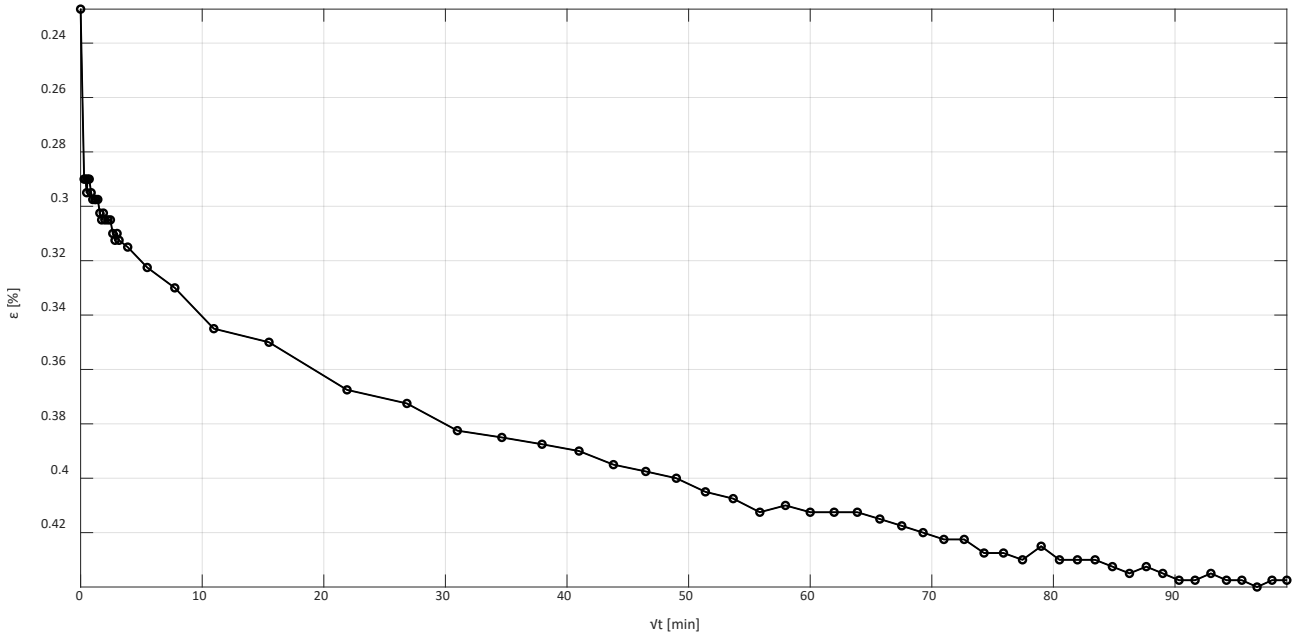
- Phase 1 – σ’ = 122 kPa



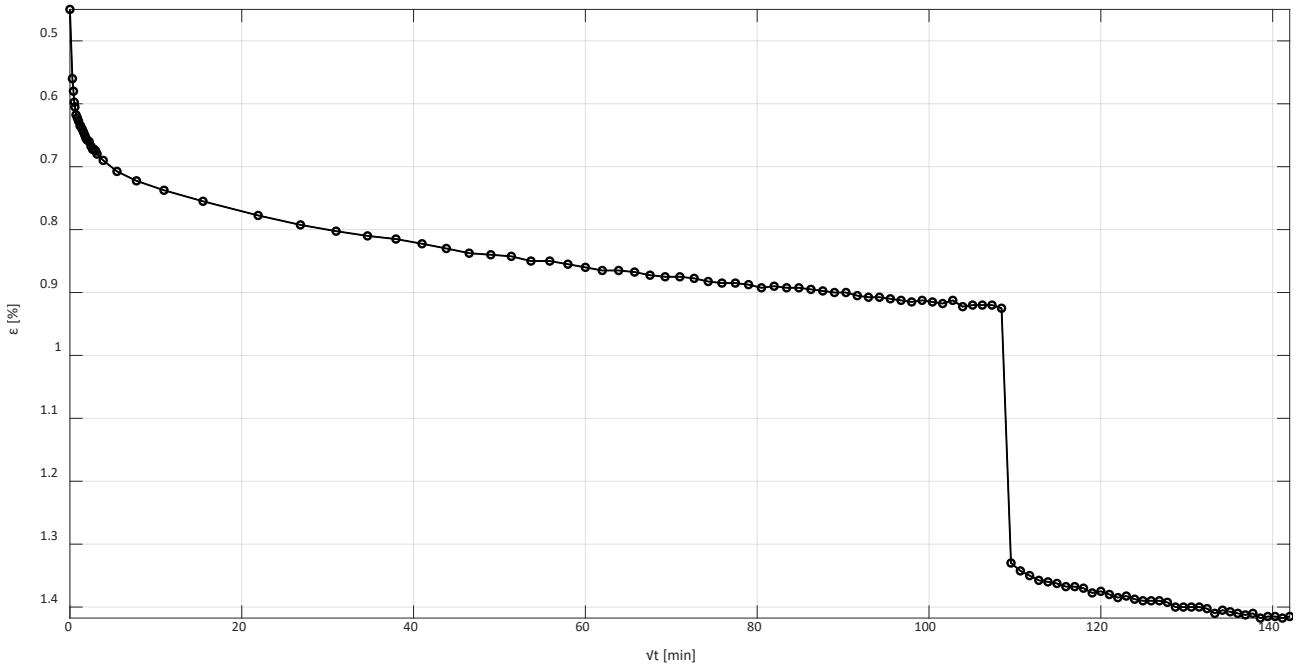
- Phase 2 – σ’ = 255 kPa



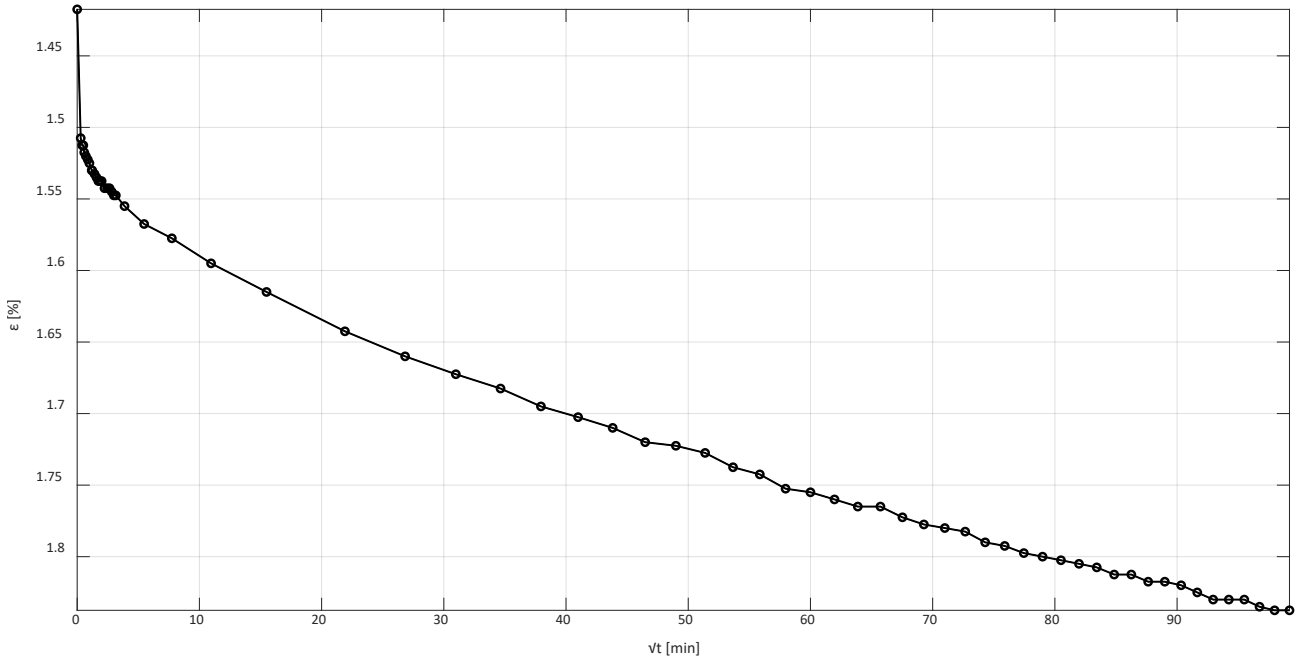
- Phase 3 – σ’ = 510 kPa



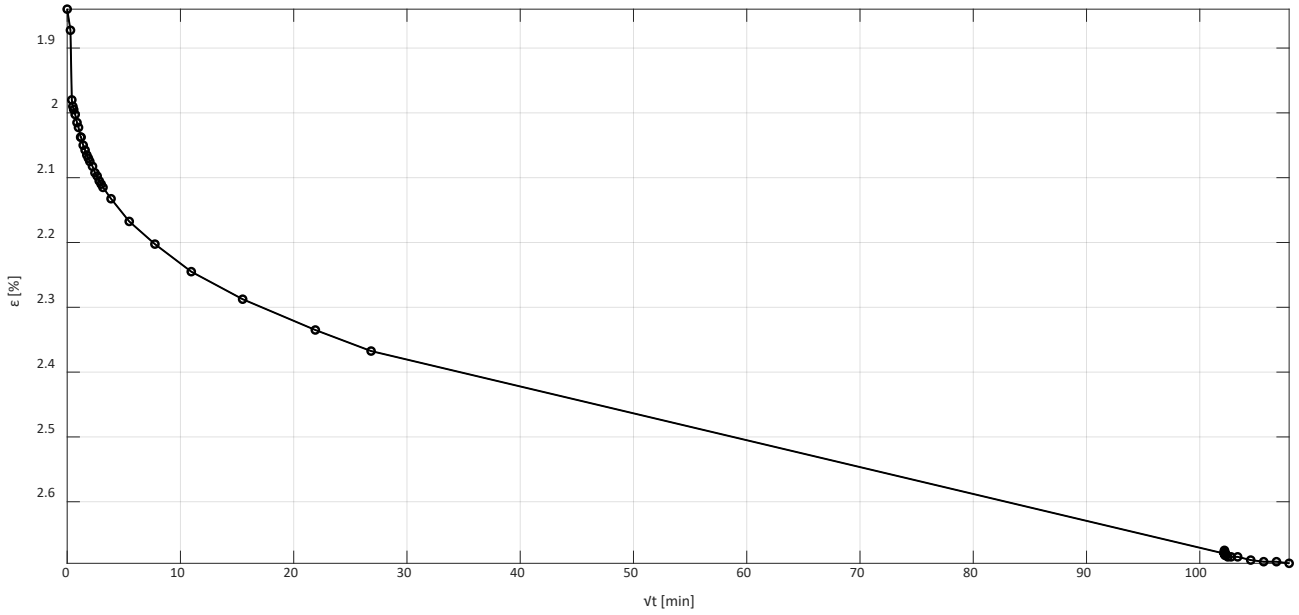
- Phase 4 – σ’ = 1019 kPa



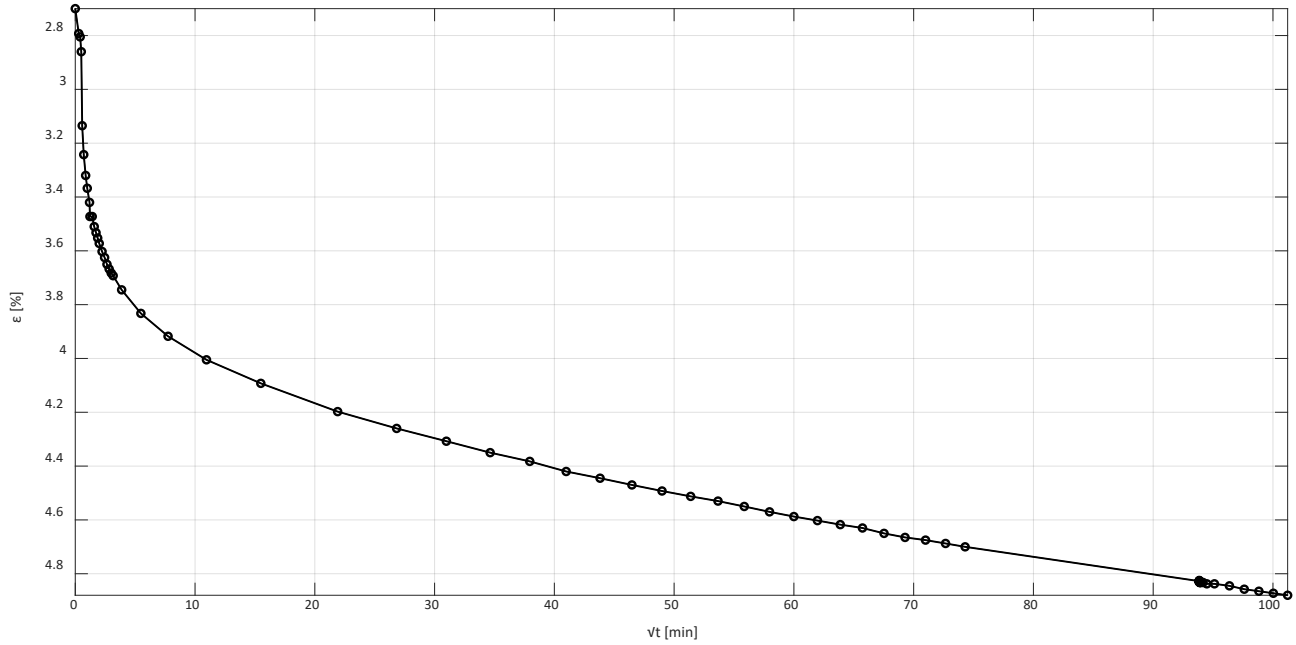
- Phase 5 – σ’ = 2039 kPa



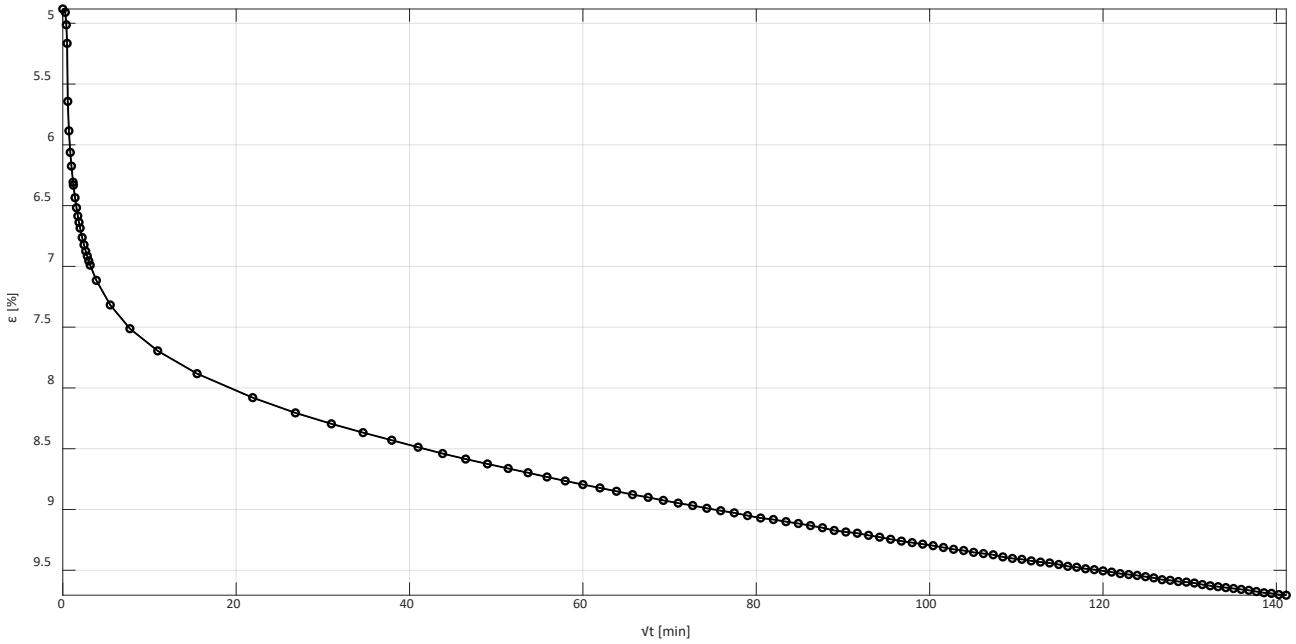
- Phase 6 – σ’ = 3567 kPa



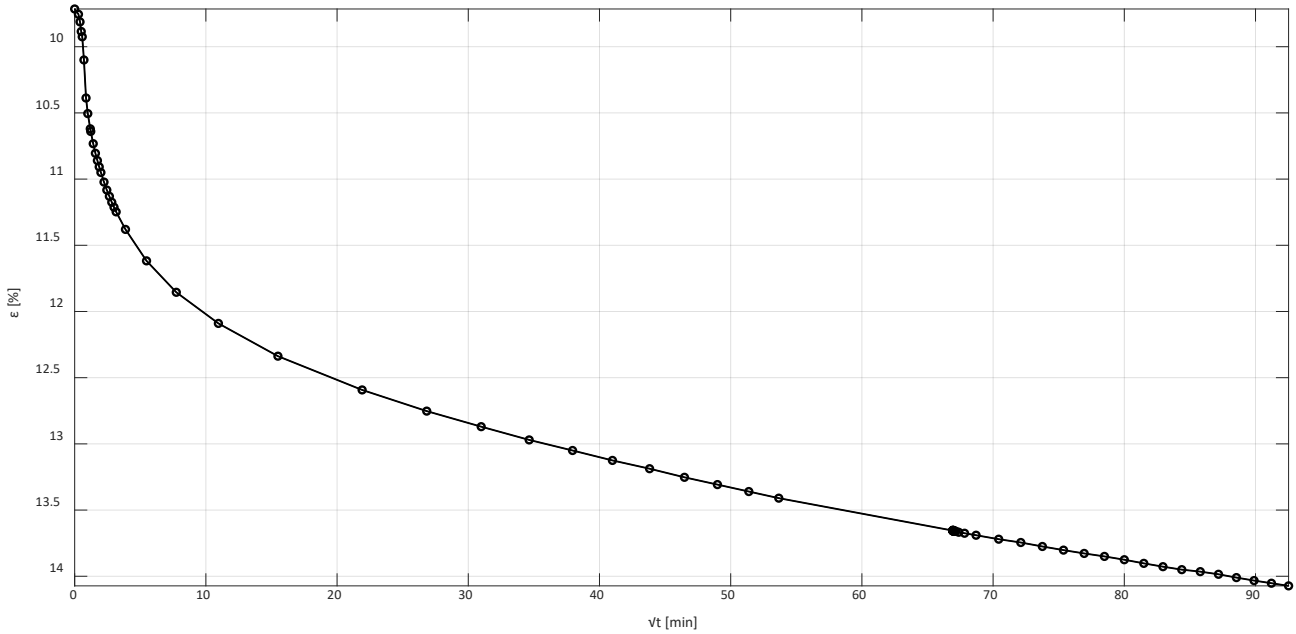
- Phase 7 – σ’ = 7135 kPa



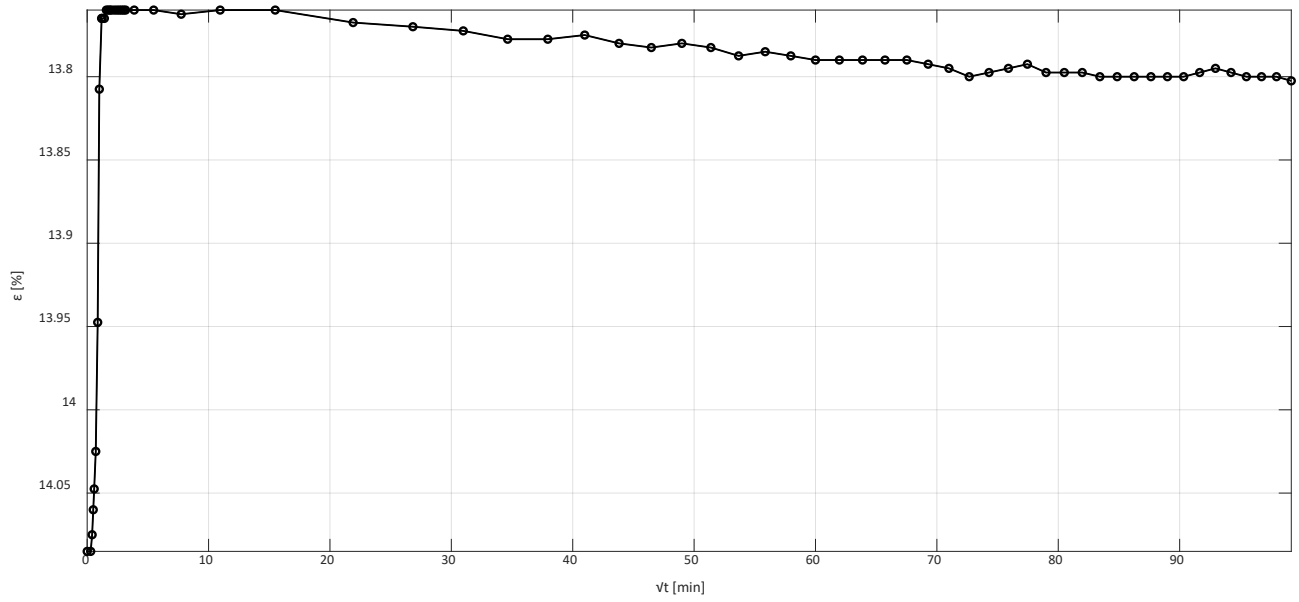
- Phase 8 – σ’ = 14270 kPa



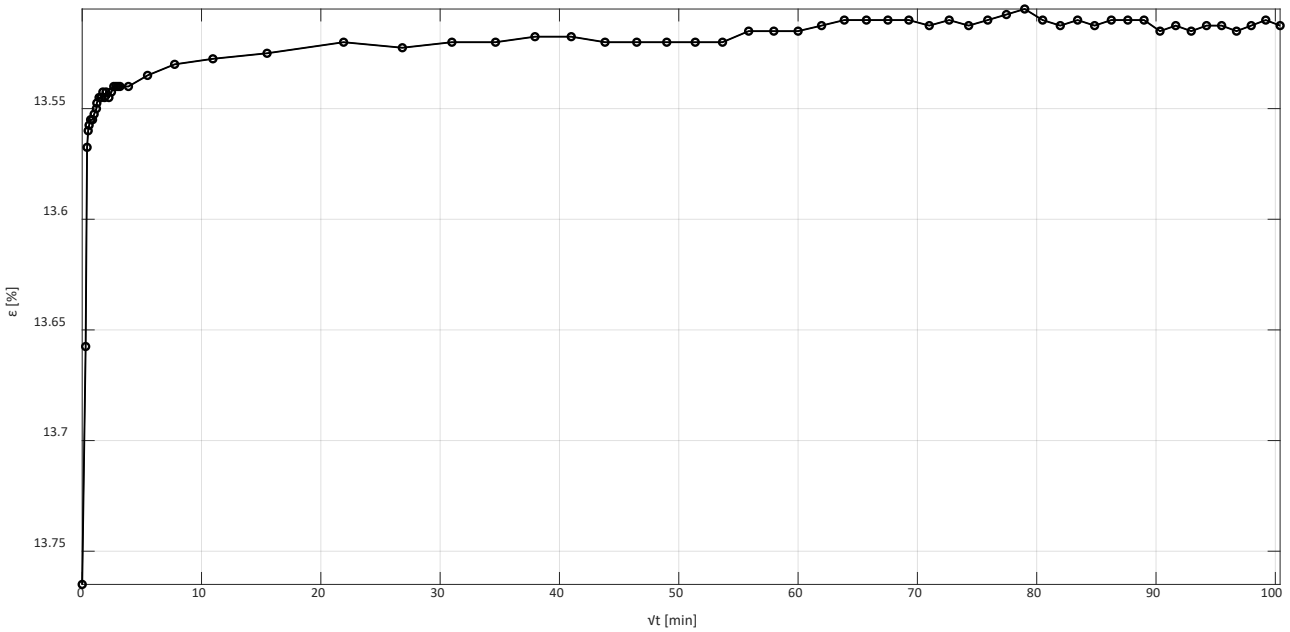
- Phase 9 – σ’ = 28540 kPa



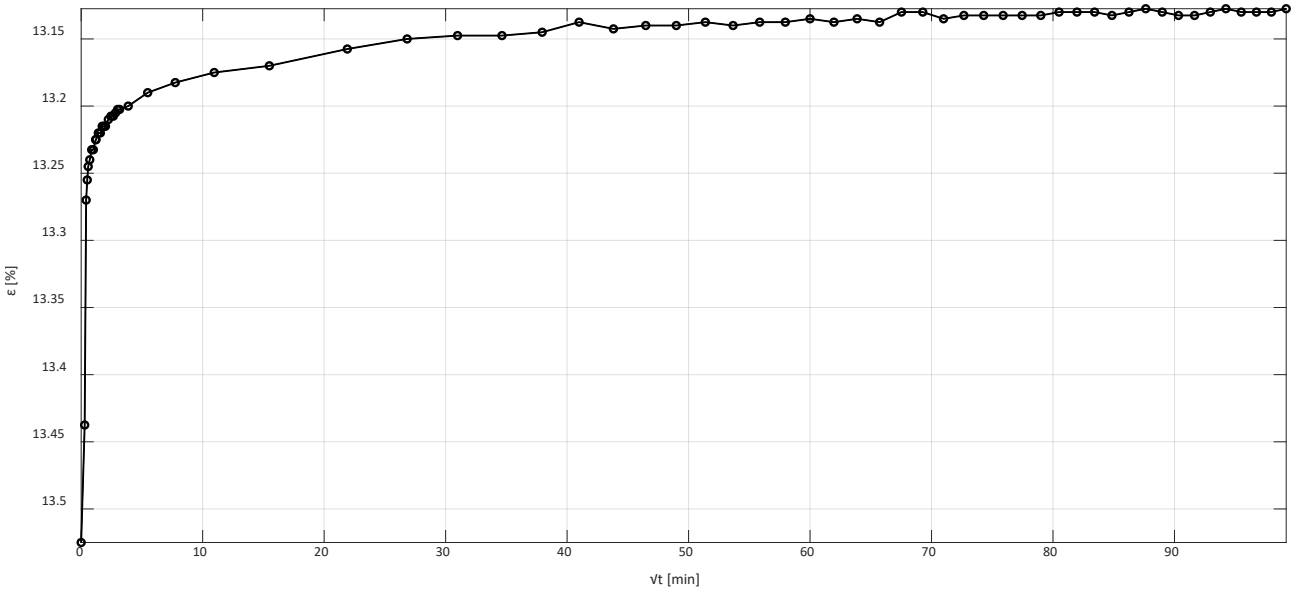
- Phase 10 – σ’ = 7135 kPa



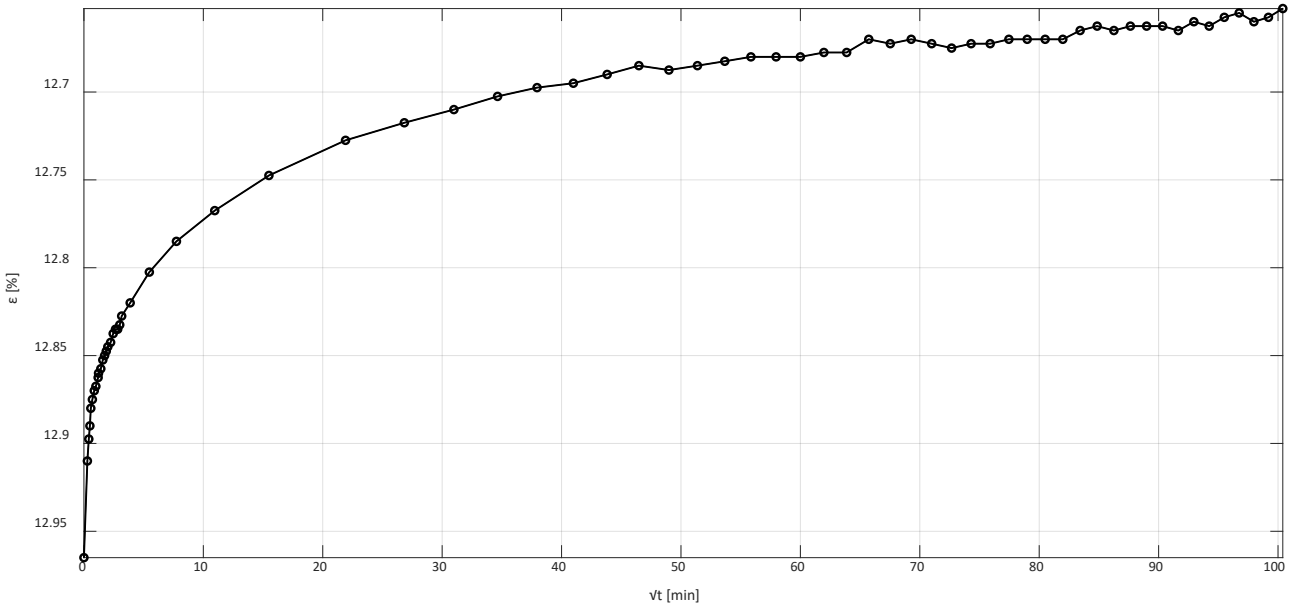
- Phase 11 – σ’ = 2039 kPa



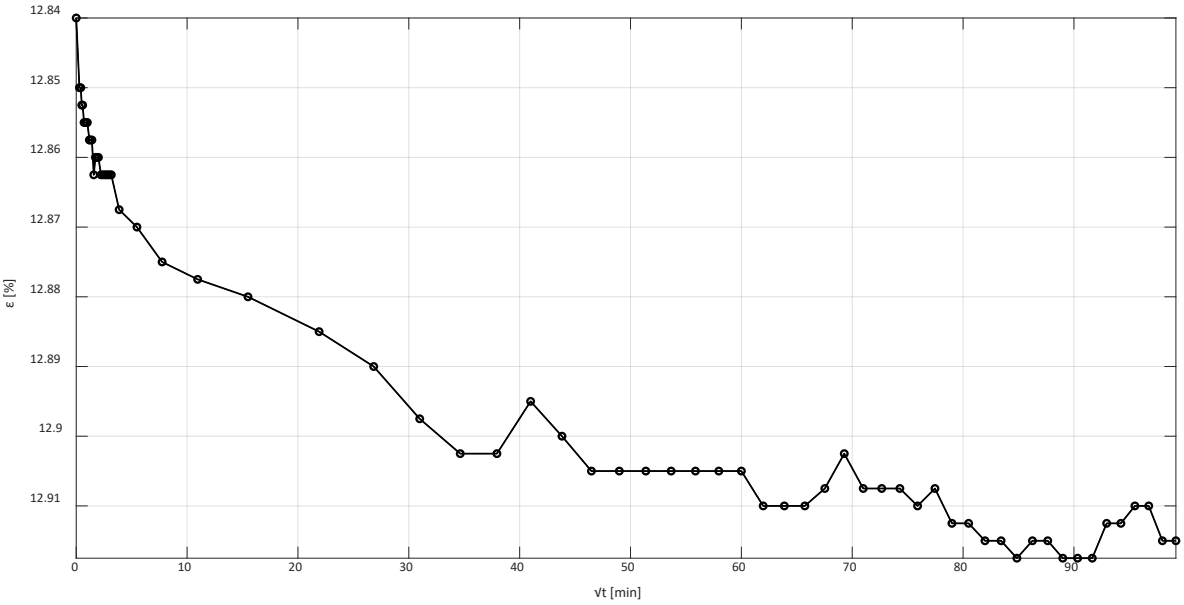
- Phase 12 – σ’ = 510 kPa



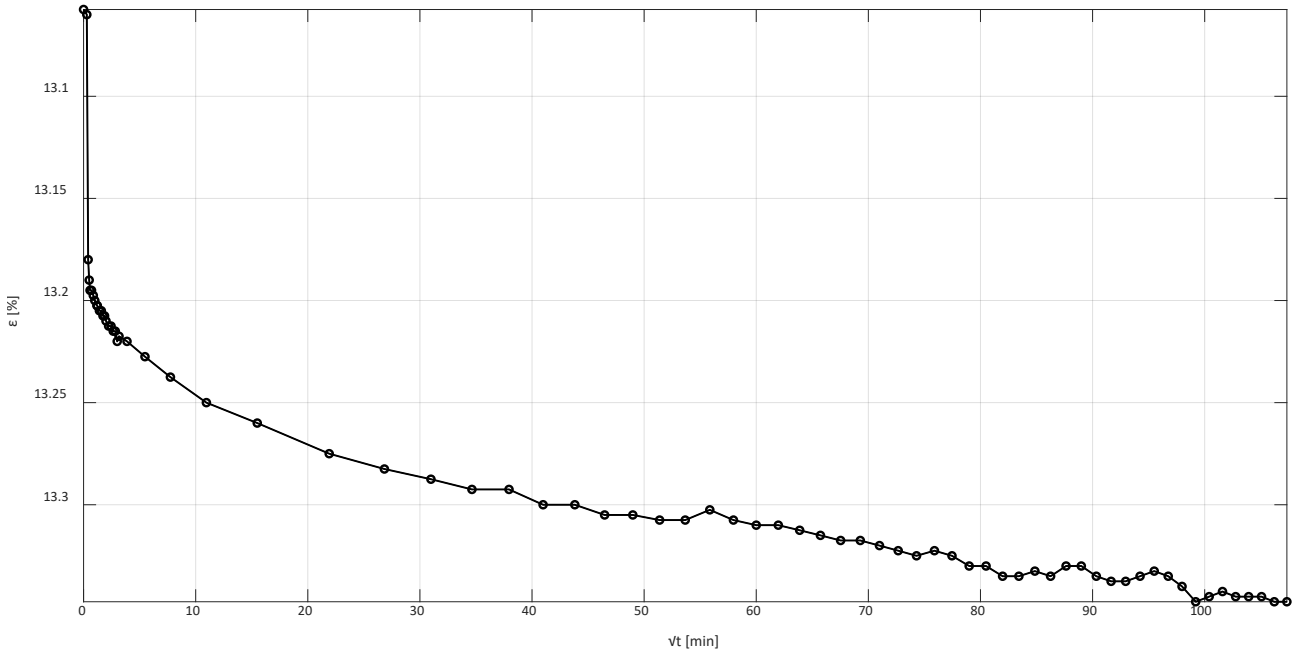
- Phase 13 – σ’ = 122 kPa



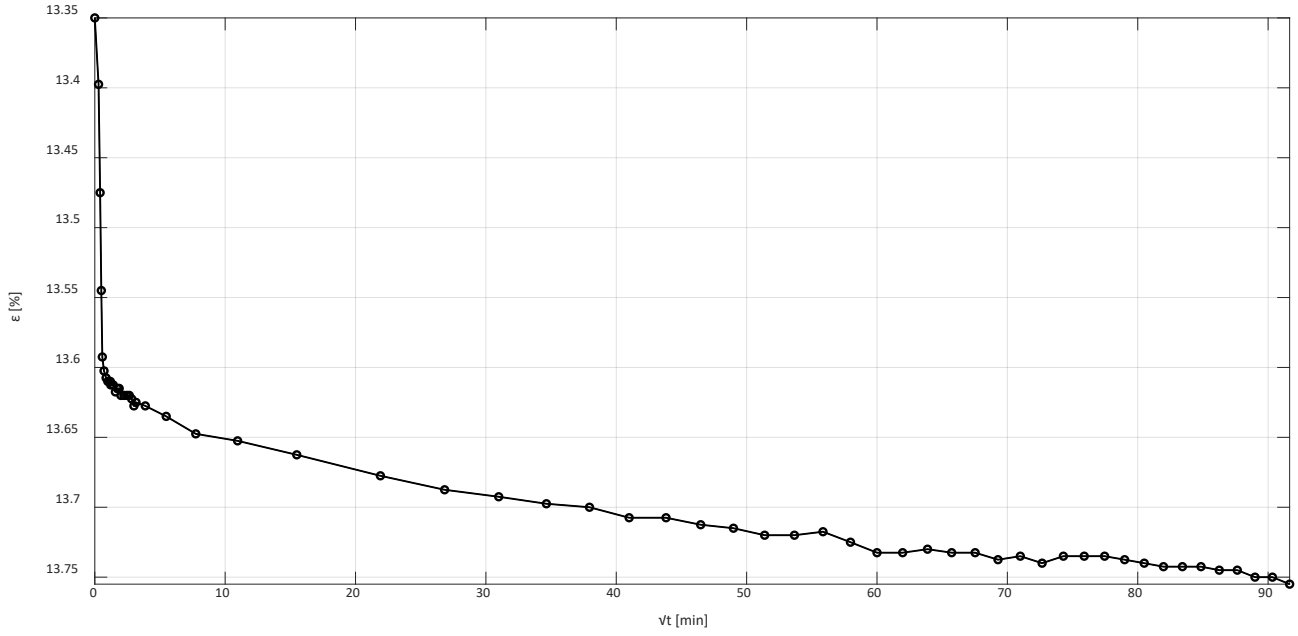
- Phase 14 – σ’ = 510 kPa



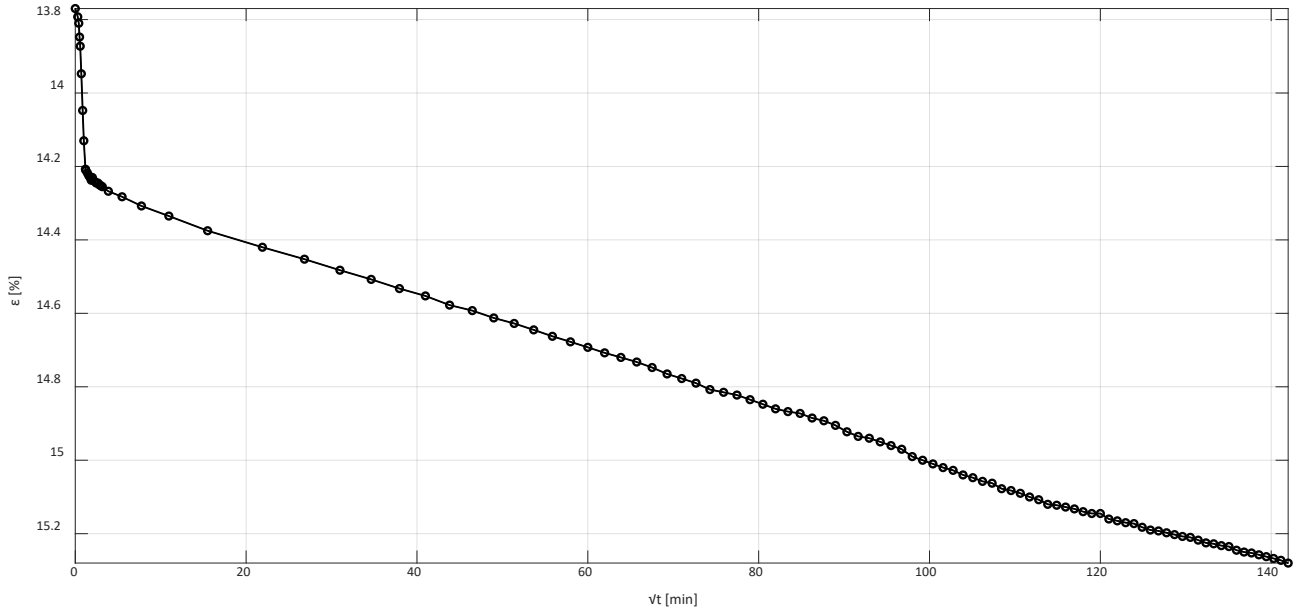
- Phase 15 – σ’ = 2039 kPa



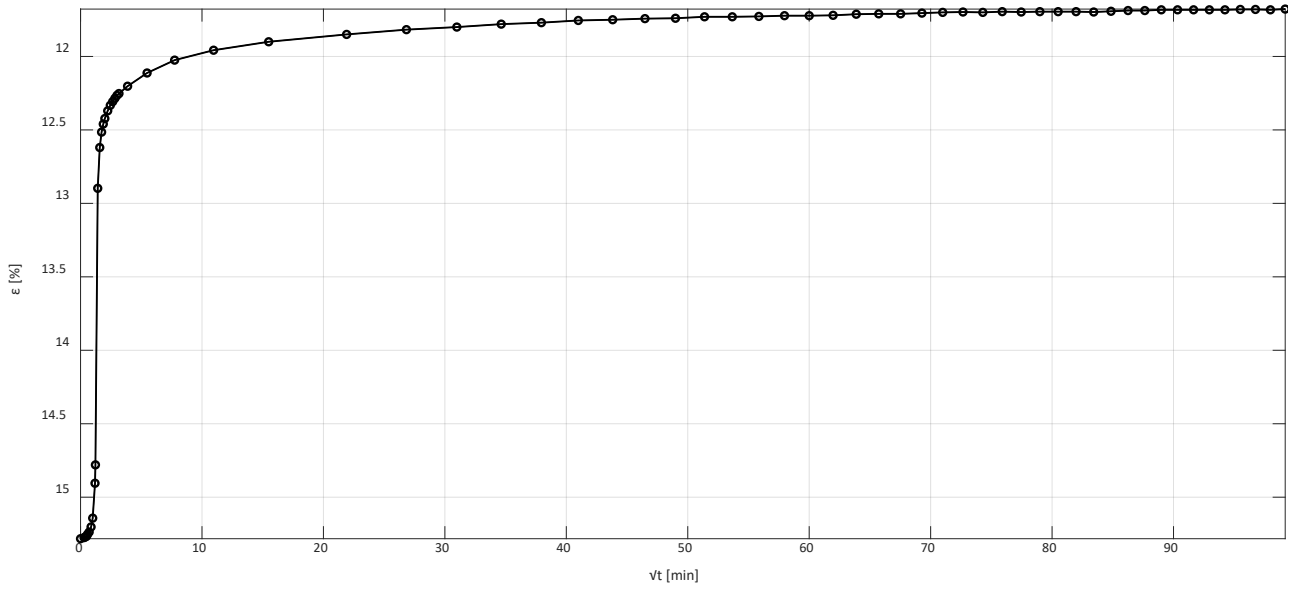
- Phase 16 – σ’ = 7135 kPa



- Phase 17 – σ’ = 28540 kPa



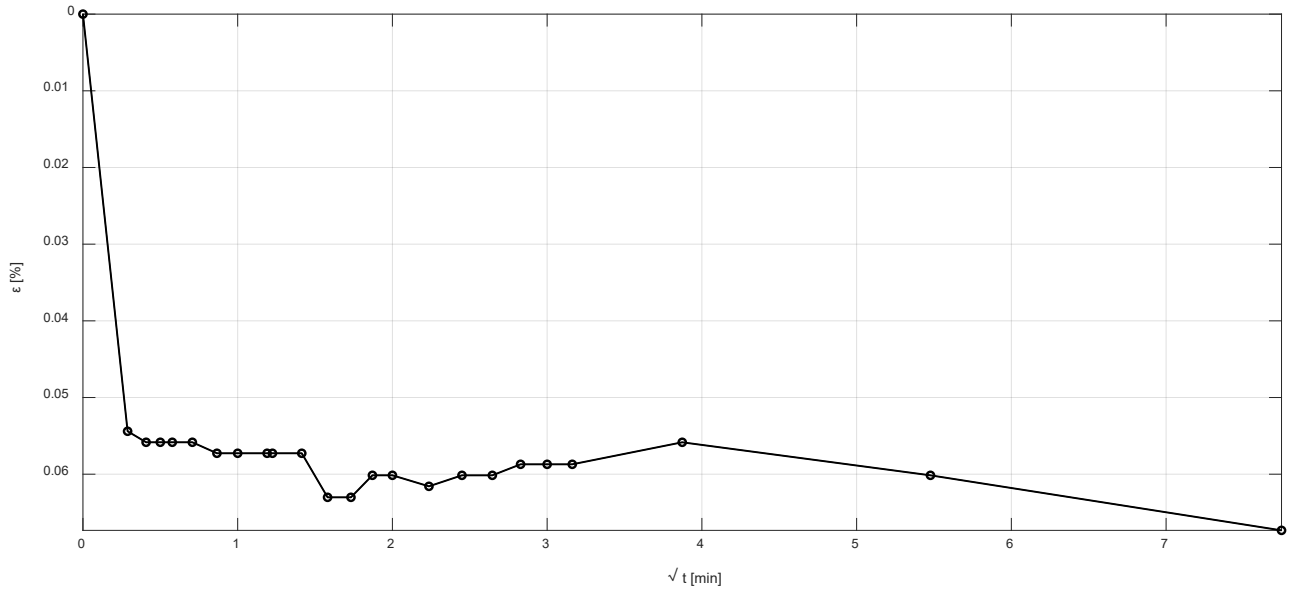
- Phase 18 – σ’ = 0 kPa



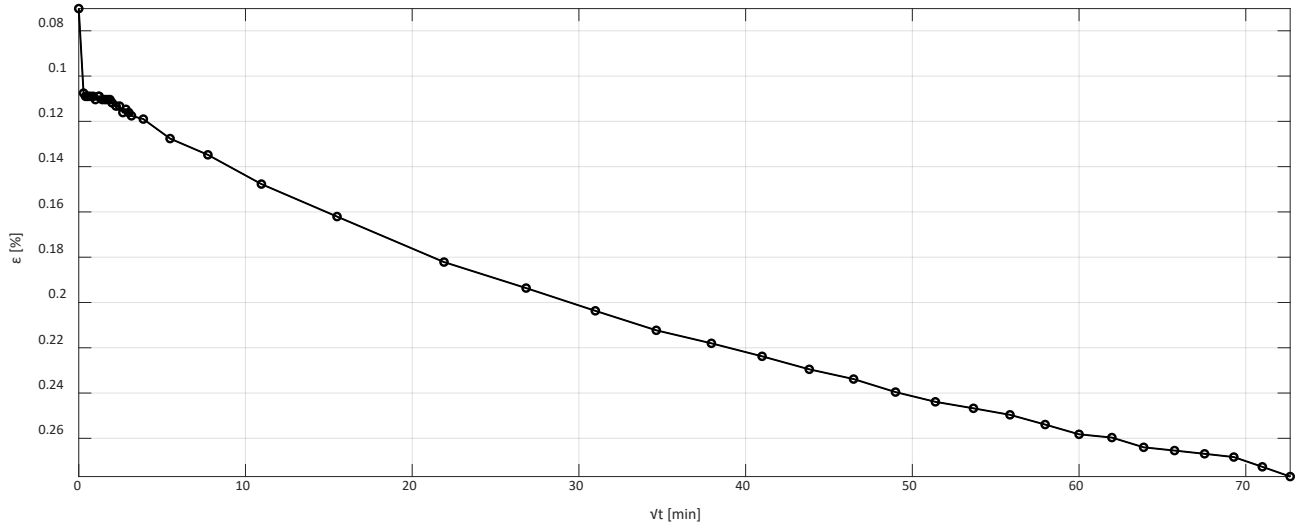
Test 1704CON1201 – Load steps

The results of each load step of Test 1704CON1201 is shown in a √t [min] - ε [%] graph.

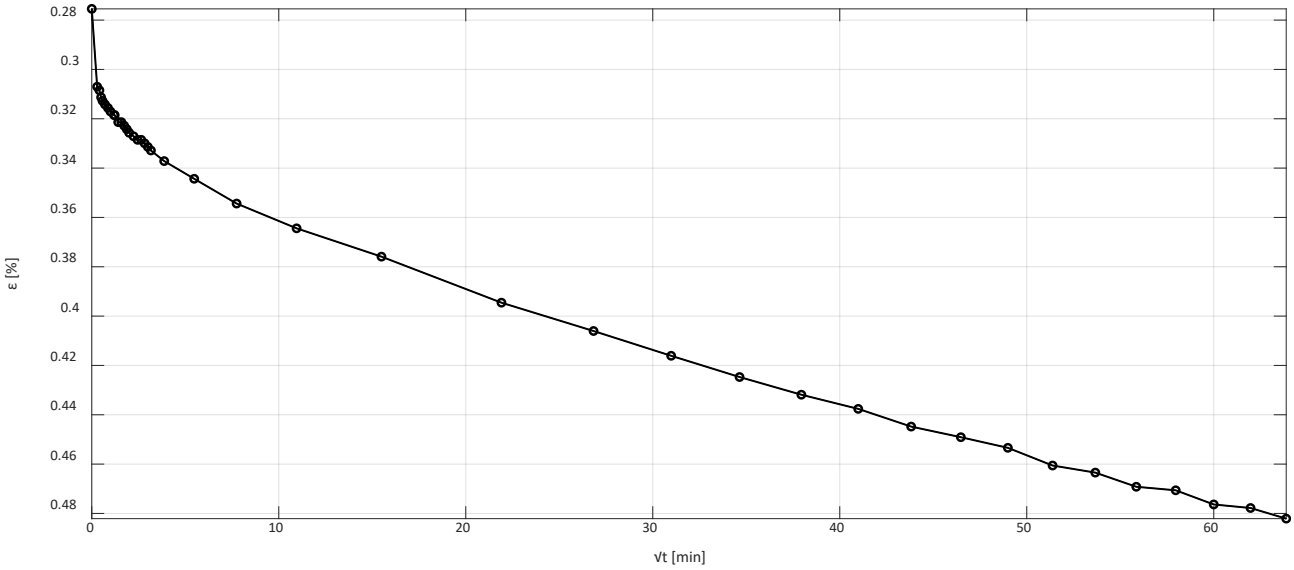
- Phase 1 – σ' = 31 kPa



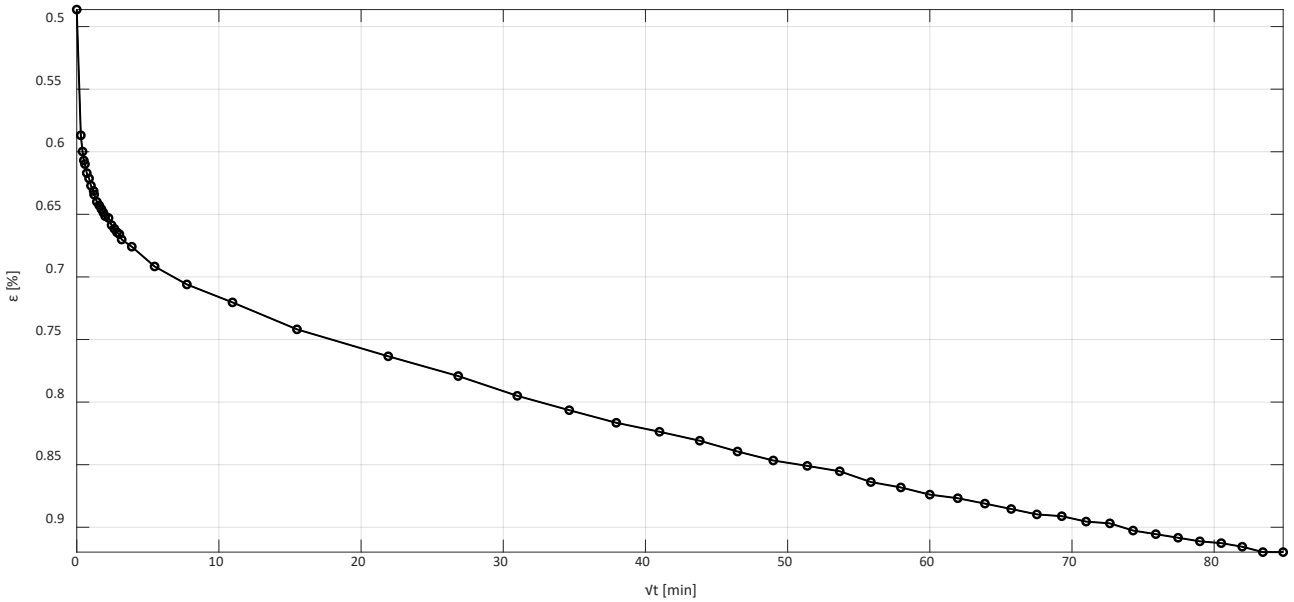
- Phase 2 – σ' = 61 kPa



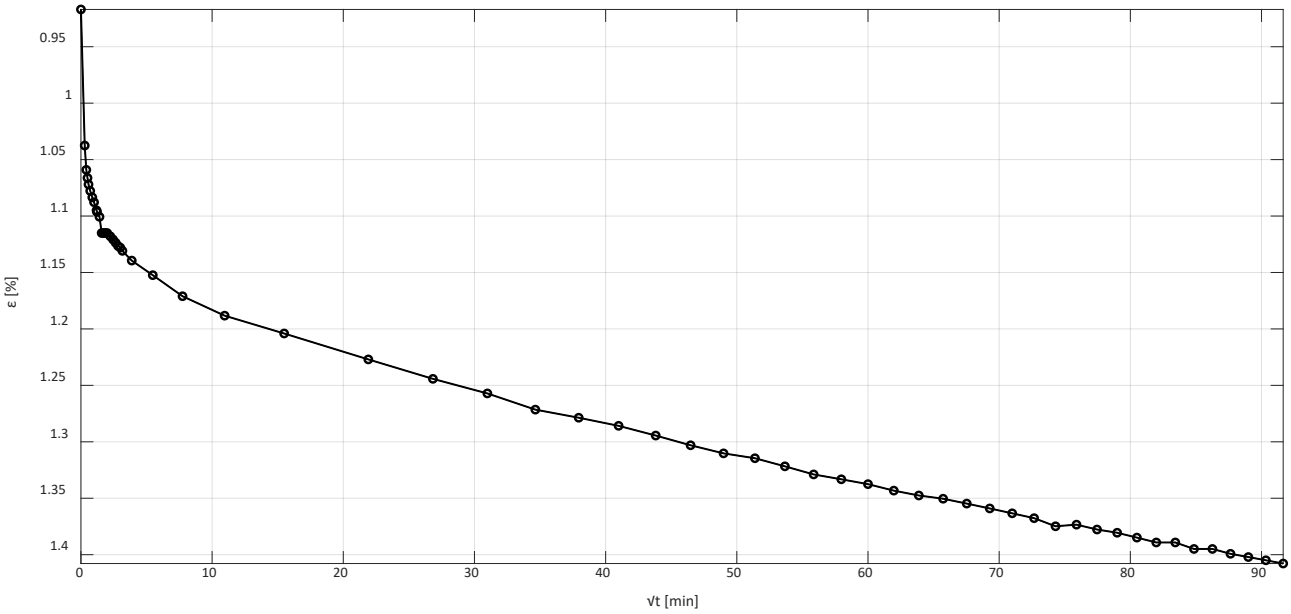
- Phase 3 – σ’ = 122 kPa



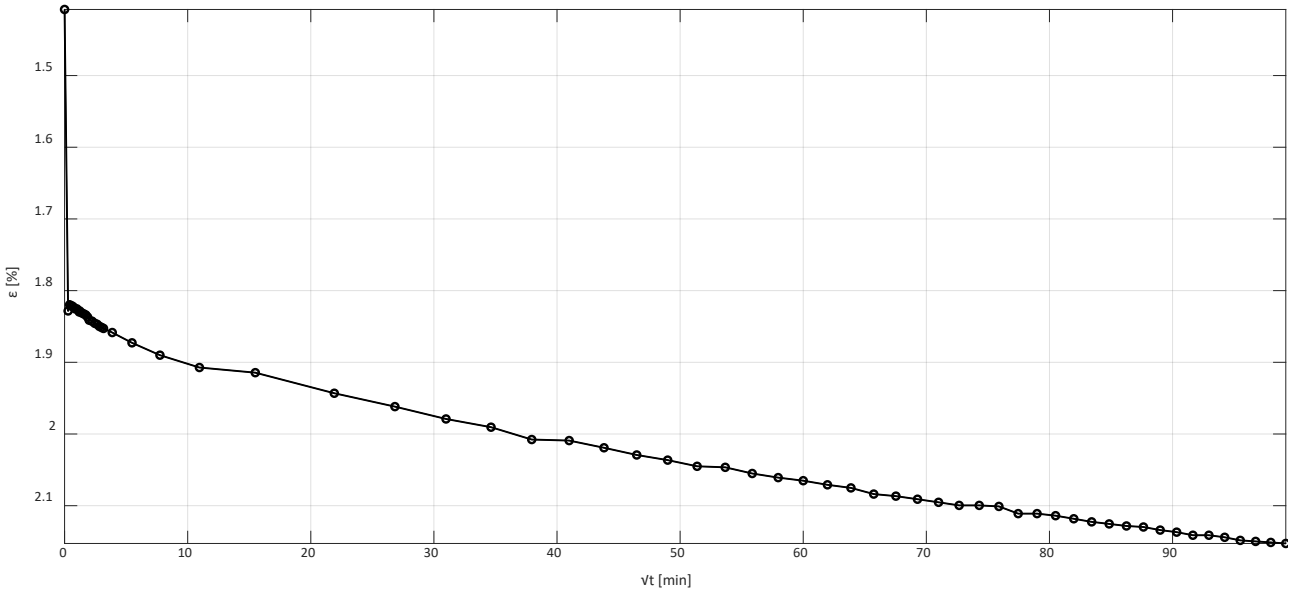
- Phase 4 – σ’ = 255 kPa



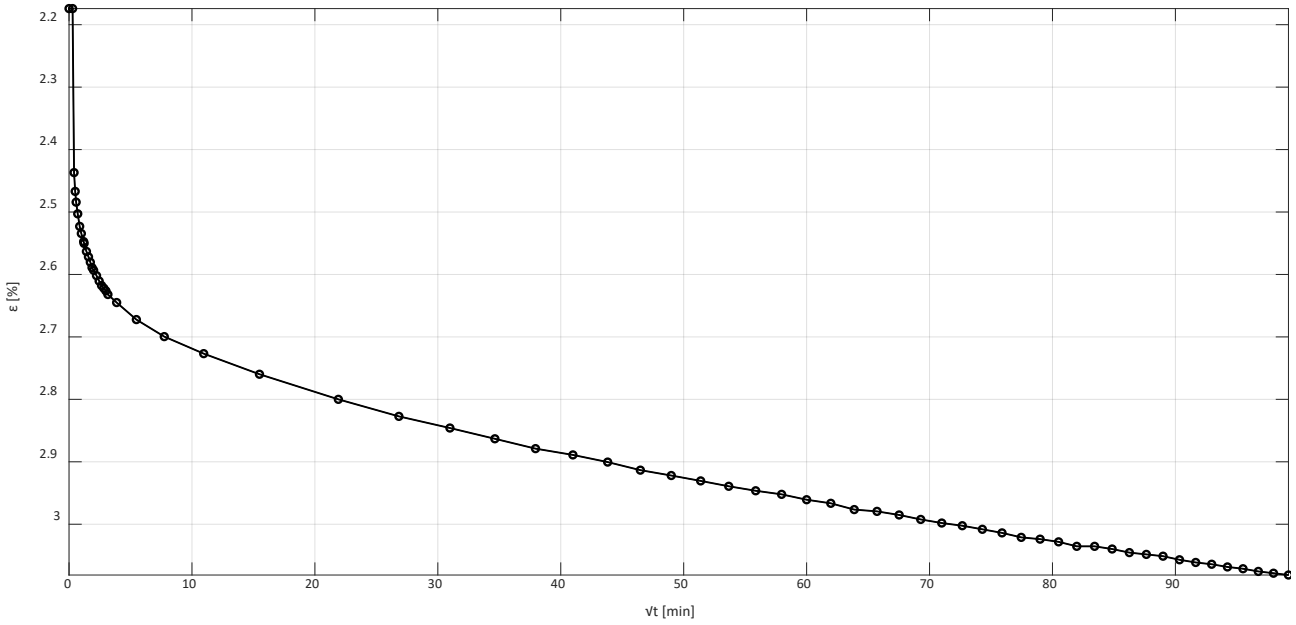
- Phase 5 – σ’ = 510 kPa



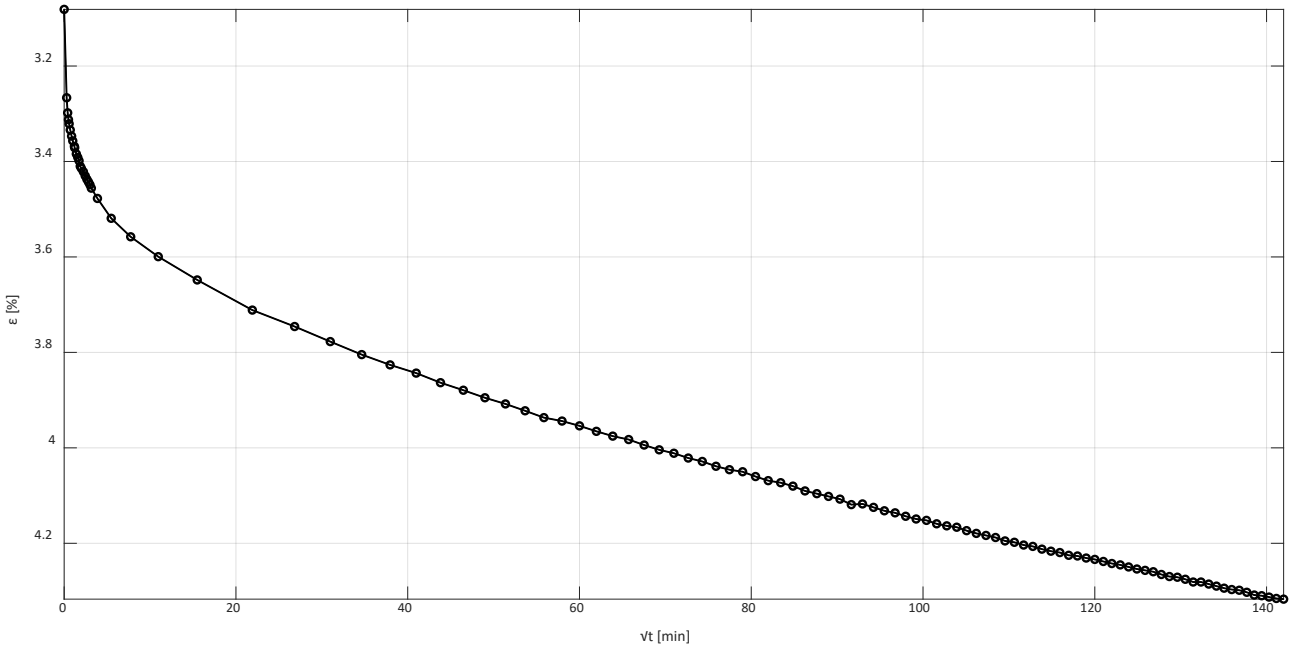
- Phase 6 – σ’ = 1019 kPa



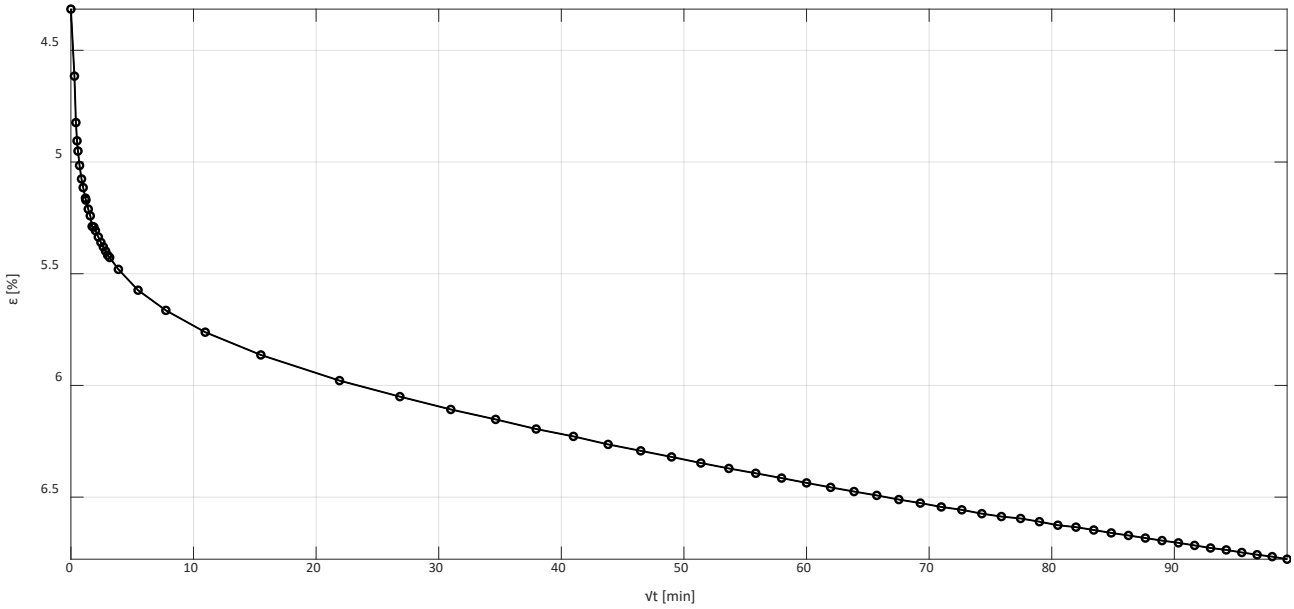
- Phase 7 – σ’ = 2039 kPa



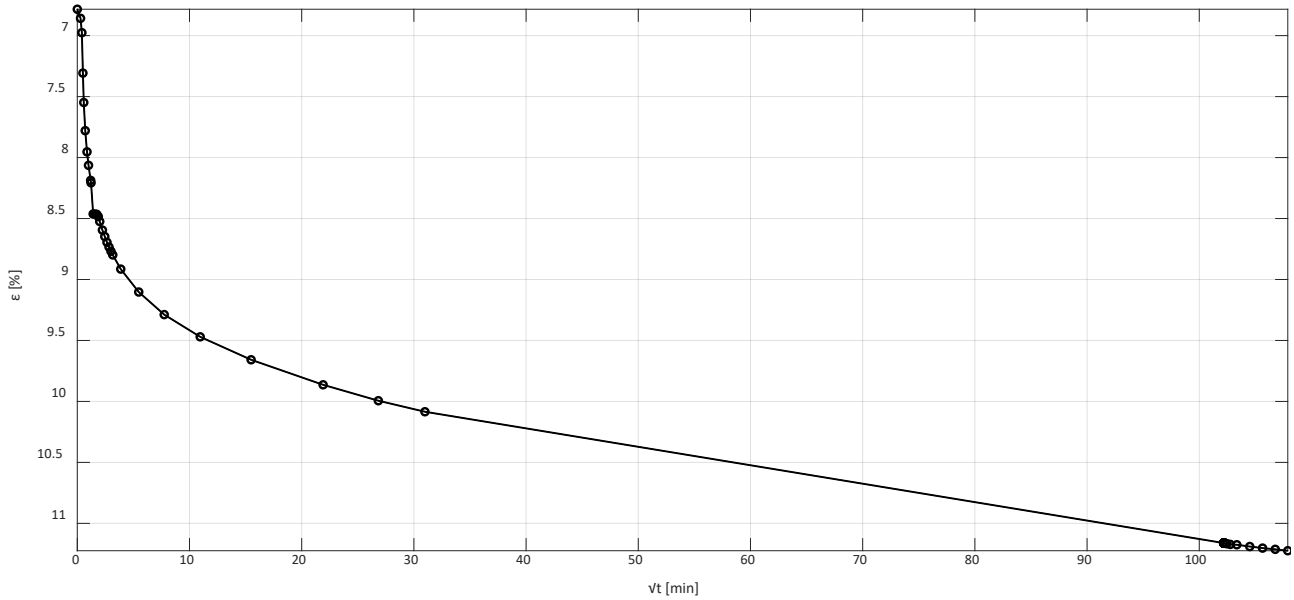
- Phase 8 – σ’ = 3567 kPa



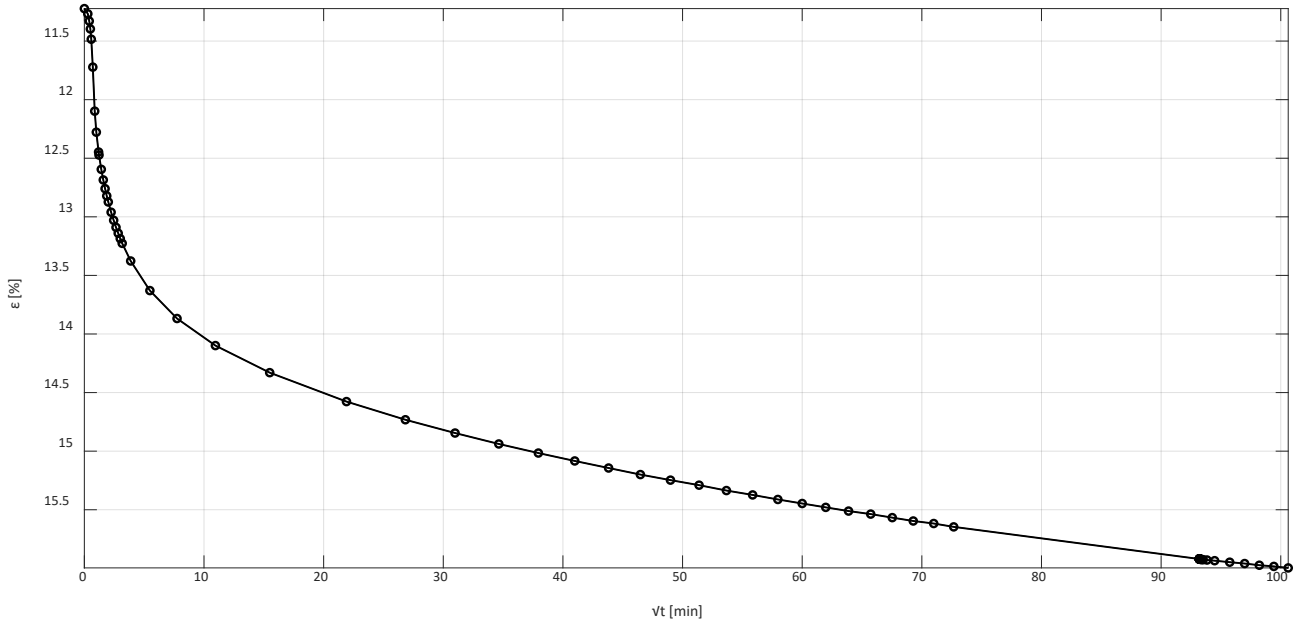
- Phase 9 – σ’ = 7135 kPa



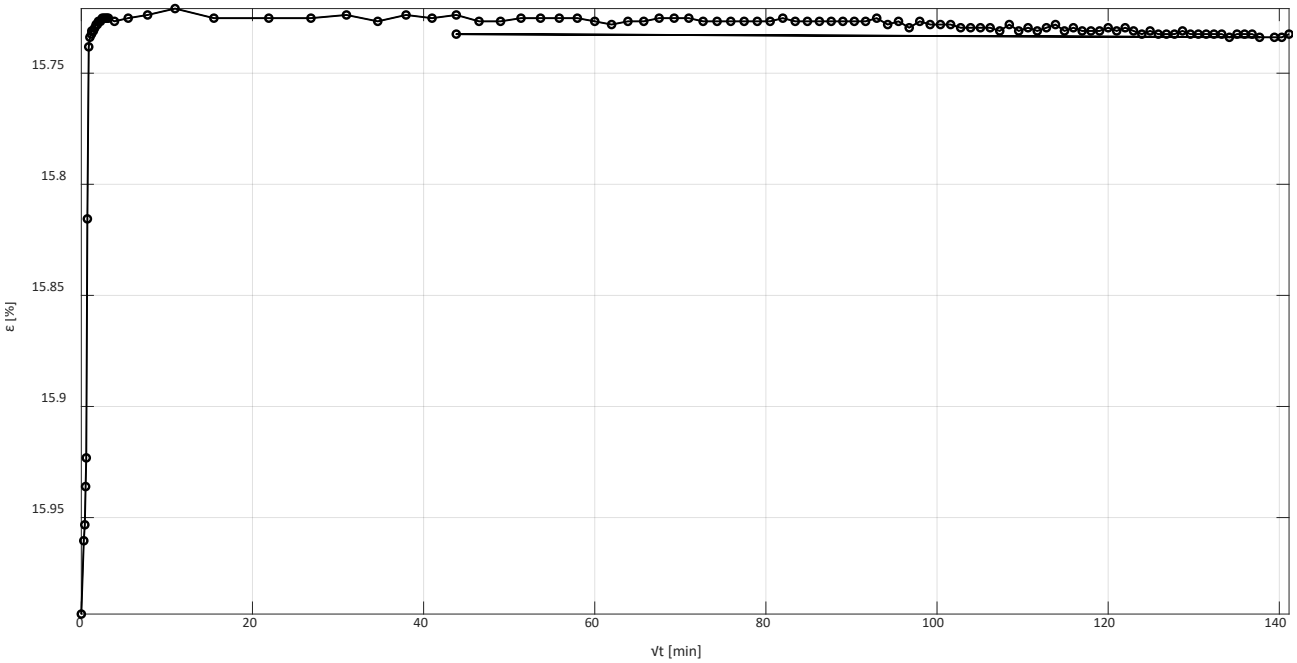
- Phase 10 – σ’ = 14270 kPa



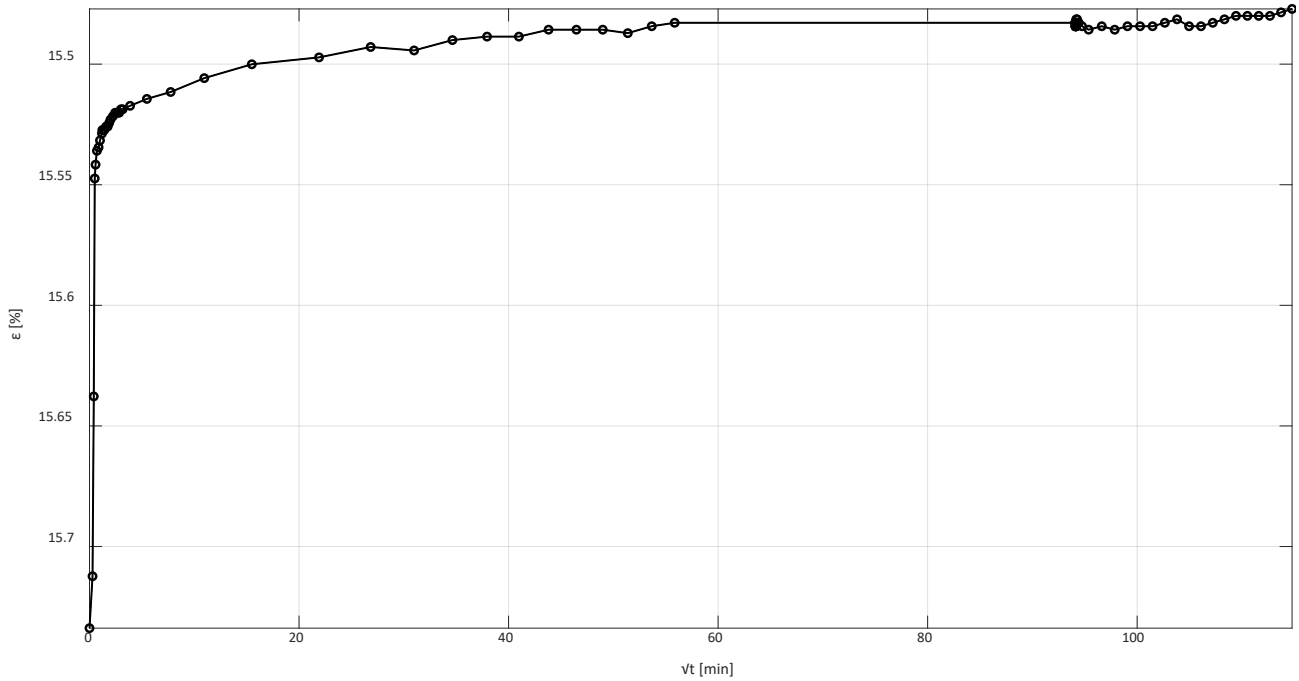
- Phase 11 – σ’ = 28540 kPa



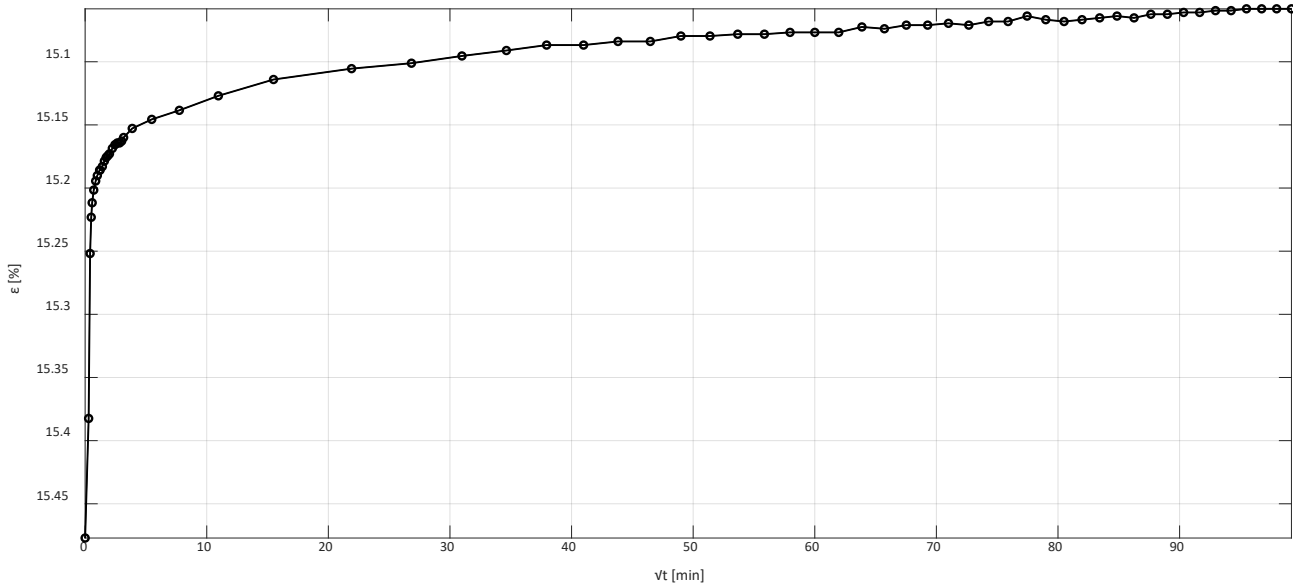
- Phase 12 – σ’ = 7135 kPa



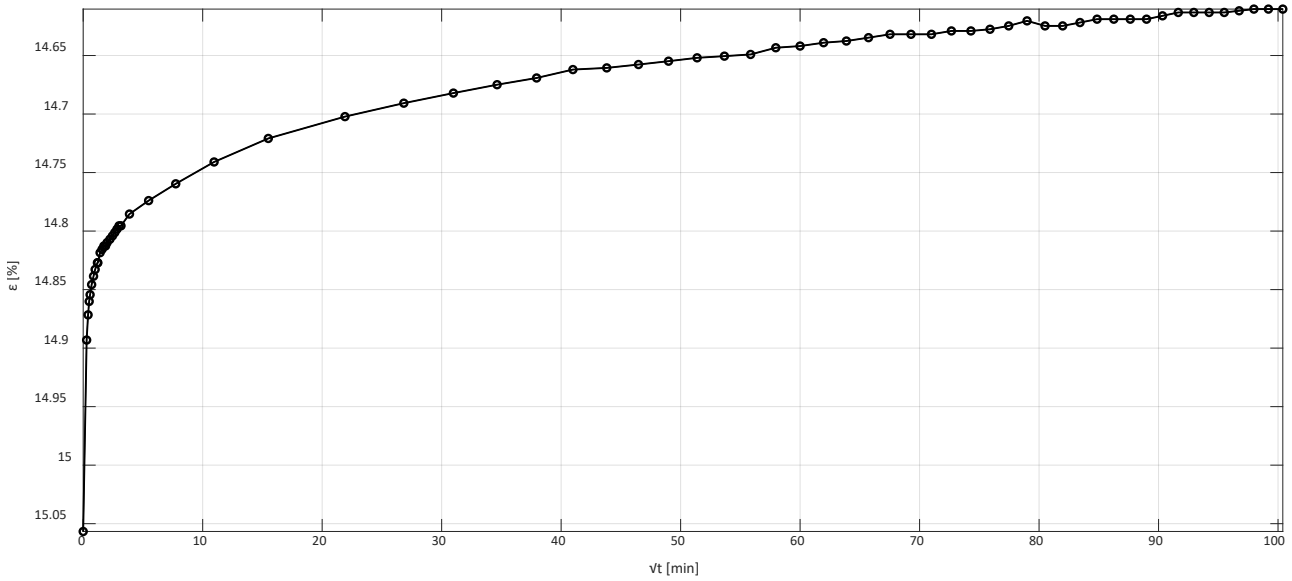
- Phase 13 – σ’ = 2039 kPa



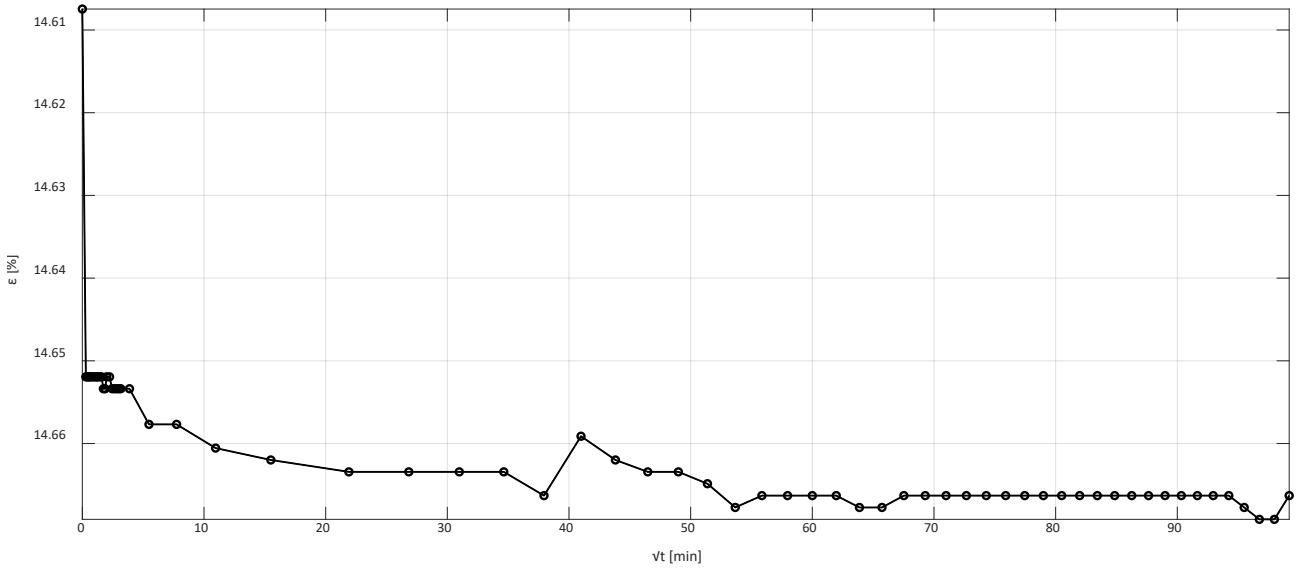
- Phase 14 – σ’ = 510 kPa



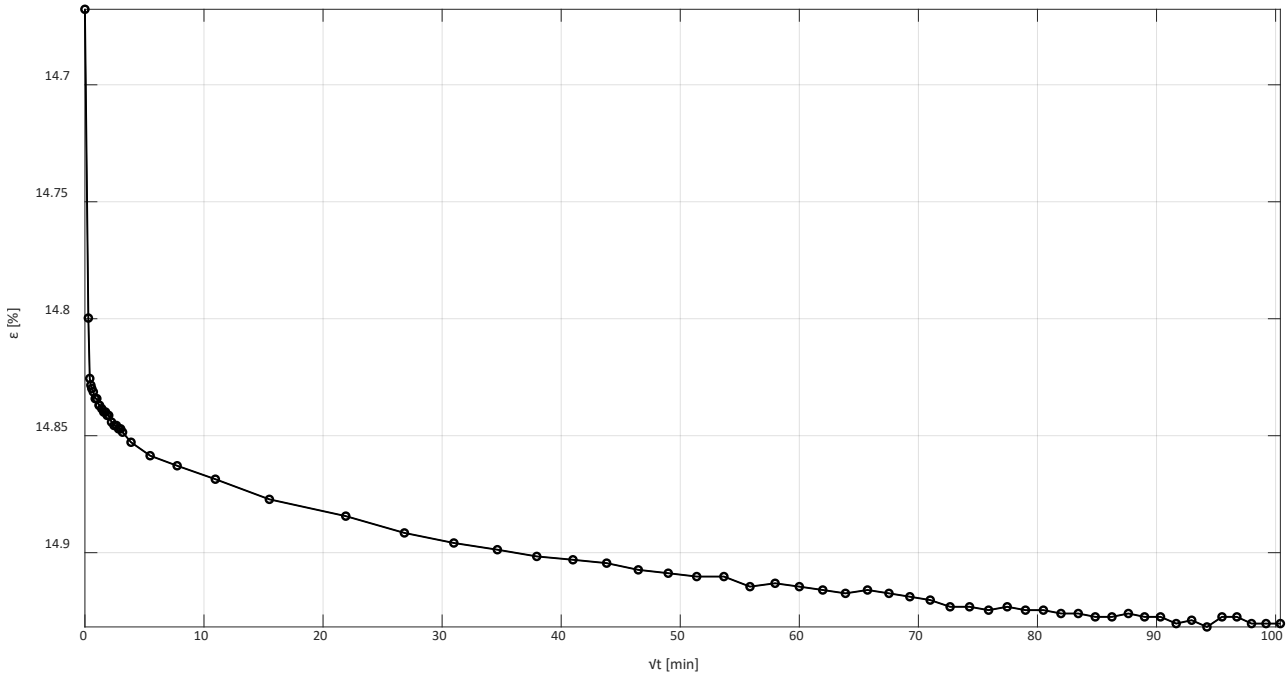
- Phase 15 – σ’ = 122 kPa



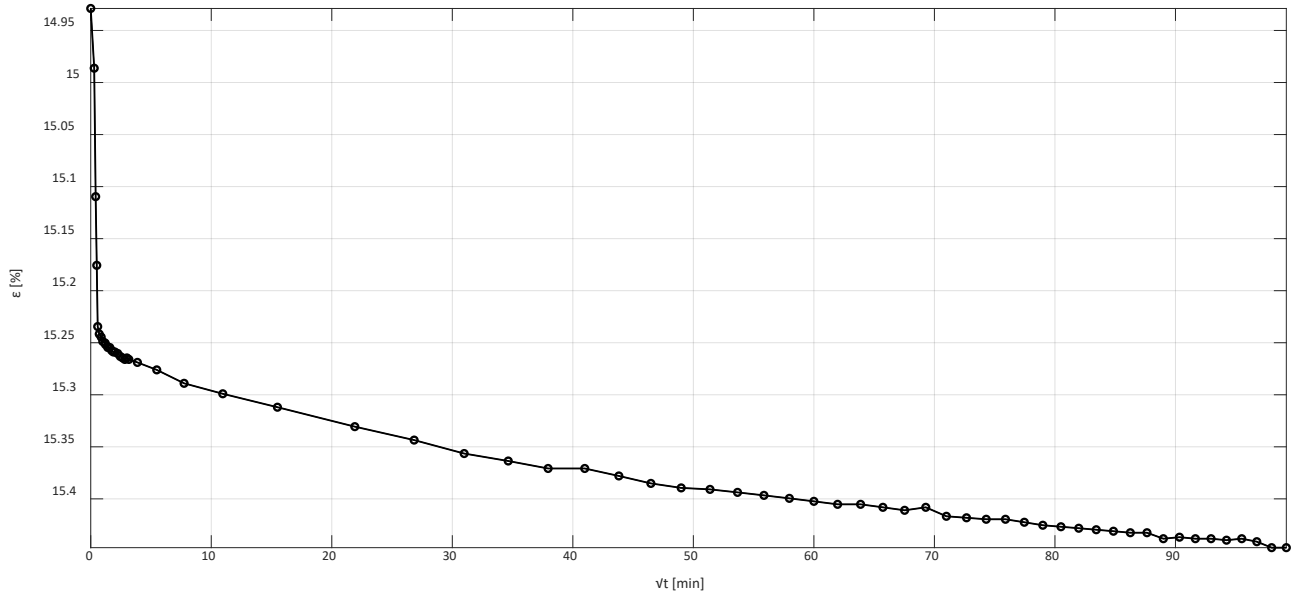
- Phase 16 – σ’ = 510 kPa



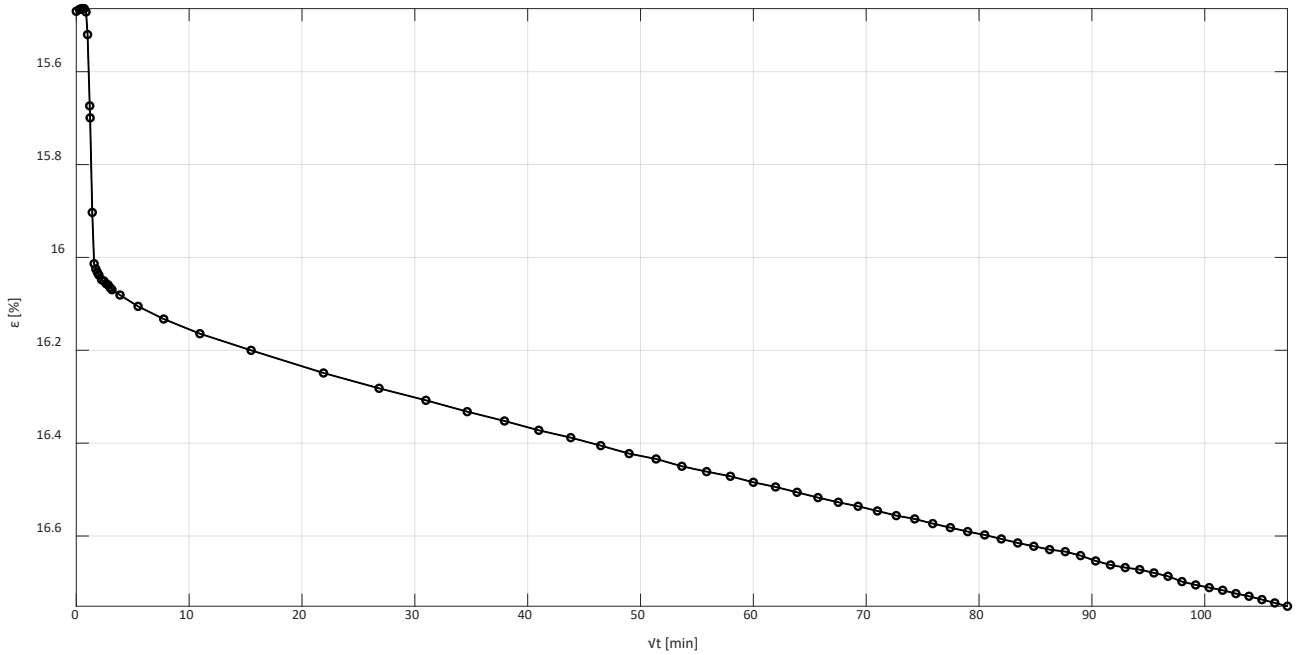
- Phase 17 – σ’ = 2039 kPa



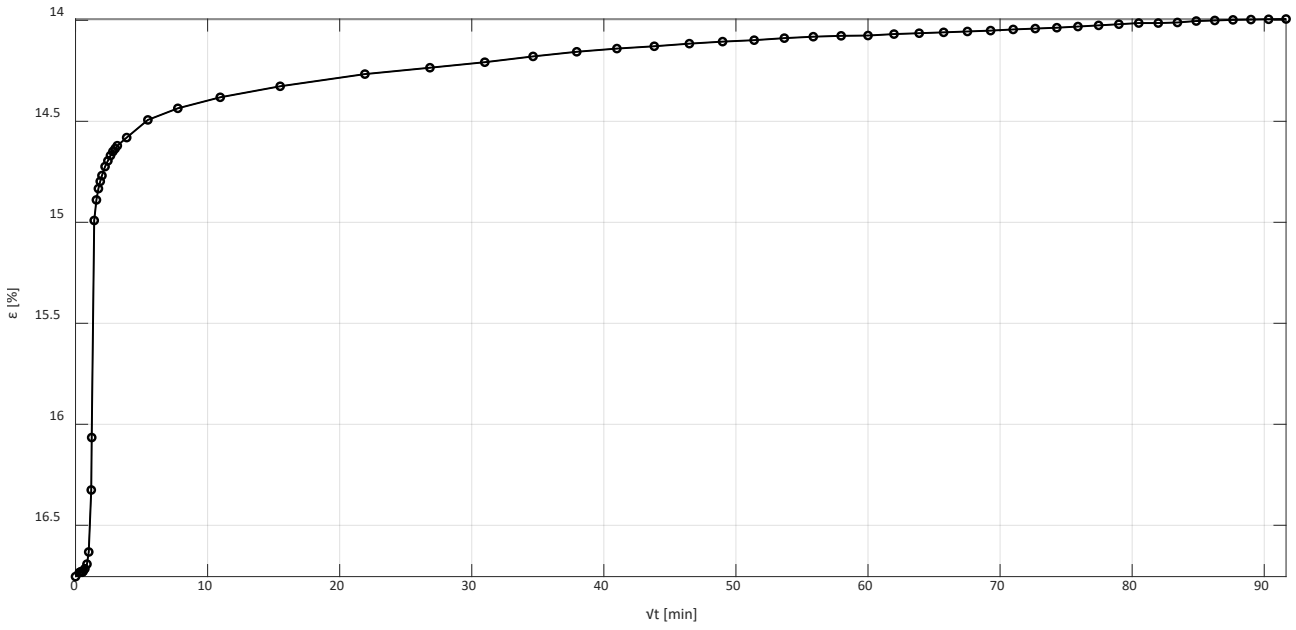
- Phase 18 – σ’ = 7135 kPa



- Phase 19 – σ’ = 28540 kPa



- Phase 20 – σ’ = 0 kPa



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