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Oskarshamn site investigation

Drill hole KSH01A

Indirect tensile strength test

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March 2004

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Keywords: Rock mechanics, Indirect tensile strength, Tension test.

Abstract

The density and the indirect tensile strength of 40 wet specimens of intact rock stored in water during 9–17 days from borehole KSH01A in Simpevarp have been determined. The samples were taken at four levels ranging between 303–321 m, 401–414 m, 481–499 m and 699–714 m. Moreover, the rock types were Quartz monzodiorite and Fine-grained dioritoid. The specimens were photographed before and after the mechanical test.

The measured densities for the water saturated specimens were in the range 2763–2891 kg/m^3, which yield a mean value of 2806 kg/m^3 and the obtained values for the indirect tensile strength were in the range 8.7–23.8 MPa with a mean value of 17.2 MPa. Several specimens had pre-existing weakness planes and displayed a lower tensile strength. The indirect tensile strength, when the specimens with defects are excluded from the series, was in the range 12.0–23.8 MPa with a mean value of 18.5 MPa.

Contents

1 Introduction

The indirect tensile strength and the density for intact rock have been determined for water-saturated specimens sampled from borehole KSH01A in Simpevarp, see map in Figure 1-1. The specimens, in form of circular discs, were cut from rock cores and selected based on the preliminary core logging with the strategy to primarily investigate the properties of the dominant rock type. The test programme follows the activity plan AP PS 400-03-066 (SKB internal controlling document) and is controlled by SP-QD 13.1 (SP quality document).

According to the used test method, the samples were put in water and stored in water for minimum 7 days. This yields a water saturation, which is intended to resemble the in-situ moisture conditions. The density and the indirect tensile strength were then determined at this moisture condition. The rock material had a homogenous structure, which implies that the mechanical response of is expected to be approximately isotropic. The direction of loading is displayed on the specimens by a drawn line on each specimen. The samples were photographed before and after the mechanical testing.

The Swedish Nuclear Fuel and Waste Management Co (SKB) supplied Swedish National Testing and Research Institute (SP) with rock cores. The rock cores arrived at SP in May 2003 and were tested during January and February 2004. The method description, SKB MD 190.004, ver 1.9, (SKB internal controlling document), was followed for sampling and for the indirect tensile strength tests and SKB MD 160.002, ver 1.9, (SKB internal controlling document) was followed when the density was determined. All work described in this report was carried out by the department of Building Technology and Mechanics at SP.

Figure 1-1. *Map of Oskarshamn site.*

2 Objective and scope

The purpose of the testing is to determine the density and the tensile strength of a cylindrical intact rock core. The results from the tests are going to be used in the rock mechanical model, which will be established for the candidate area selected for site investigations at Simpevarp.

3 Equipment

A circular saw with a diamond blade was used to cut the specimens to their final lengths. Samples with a rough cutting surface were levelled in a grinding machine. The measurements of the dimensions were made with a sliding calliper. Furthermore, the tolerances were made checked by means of a dial indicator and a stone face plate.

The specimens and the water were weighted using a scale for weight measurement. A thermometer was used for the water temperature measurement. The calculated wet density was determined with an uncertainty of ± 4 kg/m^3.

The mechanical testing was carried out in a load frame where the crossbar is mechanically driven by screws and has maximum load capacity is 100 kN in compression. The axial compressive load was measured by an external 100 kN load cell. The uncertainty of the load measurement is less than 1%.

The frame was equipped with a pair of curved bearing blocks, radius 39 mm and width 29 mm, with pins for guiding the vertical deformation. The top platen includes a spherical seating in order to have a fully centred loading position. The samples were photographed with a 4.0 Mega pixel digital camera at highest resolution and the photographs were stored in a jpeg-format.

4 Execution

The water saturation and determination of the density of the wet specimens were made in accordance with the method description SKB MD 160.002, ver 1.9, (SKB internal controlling document). This includes determination of density in accordance to ISRM /1/ and water saturation by SS EN 13755 /2/. The determination of the indirect tensile strength was carried out according to the method description SKB 190.004, ver 1.9, (SKB internal controlling document). The test method follows ASTM D3967-95a /3/.

4.1 Description of the samples

The rock type characterisation was made according to Stråhle /4/ using the SKB mapping (Boremap). The identification marks, upper and lower sampling depth (Secup and Seclow) and the rock type are shown in Table 4-1.

Table 4-1. Specimen identification, sampling depth and rock type for all specimens.

Identification	Secup	Seclow	Rock type
KSH01A-110-1	302.80	302.85	Quartz monzodiorite
KSH01A-110-3	303.51	303.56	Quartz monzodiorite
KSH01A-110-5	306.01	306.06	Quartz monzodiorite
KSH01A-110-7	310.18	310.23	Quartz monzodiorite
KSH01A-110-9	310.57	310.62	Quartz monzodiorite
KSH01A-110-11	313.22	313.27	Quartz monzodiorite
KSH01A-110-13	318.67	318.72	Quartz monzodiorite
KSH01A-110-15	319.16	319.20	Quartz monzodiorite
KSH01A-110-17	319.25	319.30	Quartz monzodiorite
KSH01A-110-19	320.09	320.13	Quartz monzodiorite
KSH01A-110-24	401.88	401.93	Fine-grained dioritoid
KSH01A-110-25	401.93	401.98	Fine-grained dioritoid
KSH01A-110-26	402.16	402.21	Fine-grained dioritoid
KSH01A-110-27	402.41	402.46	Fine-grained dioritoid
KSH01A-110-28	402.46	402.51	Fine-grained dioritoid
KSH01A-110-29	402.51	402.56	Fine-grained dioritoid
KSH01A-110-30	402.86	402.91	Fine-grained dioritoid
KSH01A-110-31	402.91	402.96	Fine-grained dioritoid
KSH01A-110-32	413.77	413.82	Fine-grained dioritoid
KSH01A-110-33	414.59	414.63	Fine-grained dioritoid
KSH01A-110-36	481.12	481.17	Fine-grained dioritoid
KSH01A-110-37	481.17	481.22	Fine-grained dioritoid
KSH01A-110-38	485.26	485.31	Fine-grained dioritoid

KSH01A-110-39	491.62	491.67	Fine-grained dioritoid
KSH01A-110-40	494.63	494.68	Fine-grained dioritoid
KSH01A-110-41	495.40	495.45	Fine-grained dioritoid
KSH01A-110-42	497.20	497.25	Fine-grained dioritoid
KSH01A-110-43	497.25	497.30	Fine-grained dioritoid
KSH01A-110-44	497.30	497.35	Fine-grained dioritoid)
KSH01A-110-45	499.55	499.60	Fine-grained dioritoid
KSH01A-110-48	699.54	699.59	Quartz monzodiorite
KSH01A-110-49	699.59	699.63	Quartz monzodiorite
KSH01A-110-50	699.82	699.86	Quartz monzodiorite
KSH01A-110-51	699.86	699.91	Quartz monzodiorite
KSH01A-110-52	702.28	702.33	Quartz monzodiorite
KSH01A-110-53	702.33	702.38	Quartz monzodiorite
KSH01A-110-54	707.42	707.47	Quartz monzodiorite
KSH01A-110-55	708.68	708.73	Quartz monzodiorite
KSH01A-110-56	708.73	708.78	Quartz monzodiorite
KSH01A-110-57	713.17	713.22	Quartz monzodiorite

4.2 Testing

A step-by step description of the full test procedure is as follows:

Step	Activity
1	The drill cores were marked where the samples are to be taken.
2	The samples were cut to the specified length according to markings. If the cutting surfaces were rough, they were slightly grinded.
3	The tolerances were checked: parallel and perpendicular surfaces, smooth and straight circumferential surface.
4	The diameter and thickness were measured three times each. The respectively mean value determines the dimensions that are reported.
5	The direction of compressive loading was marked as a line on one of the plane surfaces with a marker pen.
6	The samples were then put in water and stored in water for minimum 7 days. The weight of water and one specimen together was determined. The specimen was taken out from the water and the weight of the water and rock specimen was determined separately and by knowing the density of the water the wet density could be computed. This was repeated for each specimen.
7	Digital photos were then taken on each sample.
8	The wet samples were inserted in the loading device one by one, with the correct orientation given by the marked line, and then loaded up to failure in deformation control. The load frame crossbar speed was set to 0.3 mm/min, which yielded a loading rate of approximately 9.5 MPa/min. The maximum compressive load, which also defines the failure load, was registered.
9	Digital photos were then taken on each sample after the mechanical testing.

The temperature of the water was 20.5°C, which equals to a water density of 998.1 kg/m^3, when the density determinations of the rock specimens were carried out. Further, the specimens 1–19 had been stored 17 days in water and specimens 24–57 had been stored 9 days in water when the density and the indirect tensile strength were determined.

An auto-calibration of the load frame was run before the mechanical test in order to check the system. Further, an individual check-list was filled in and checked for every sample during all the steps in the execution. Moreover, comments were made upon observed things during the mechanical testing that are relevant for the interpretation of the results. The check-list form is a SP internal quality document.

The diameter and thickness were entered into the test software whereby the test software computed the indirect tensile strength together with the mean value and standard deviation for the whole test series. The results were then exported as text-files and stored in a file server on the SP computer network. The results were imported to program MS Excel and rearranged to the SICADA data base format. Moreover, the diagram was produced using MS Excel.

5 Results

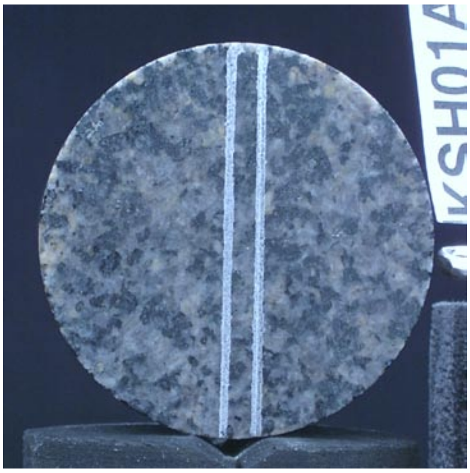
The results of the individual specimens are presented in Section 5.1 and a summary of the results is given in Section 5.2. The original results, unprocessed raw data obtained from the testing, were reported to the SICADA database, FN 96. These data together with the digital photographs of the individual specimens were stored on a CD and handed over to SKB. The handling of the results follows SDP-508 (SKB internal controlling document) in general.

5.1 Description and presentation of the specimen

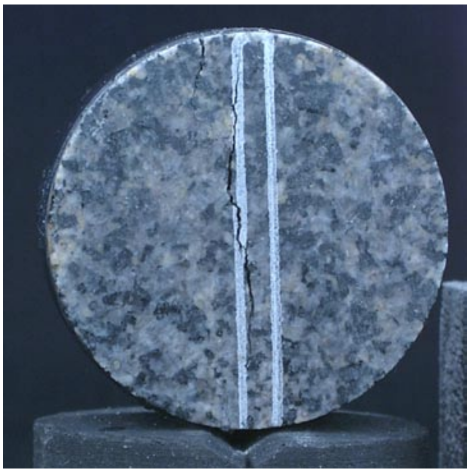
The results for the individual specimens are as follows:

Specimen ID: KSH01A-110-1

Before mechanical test



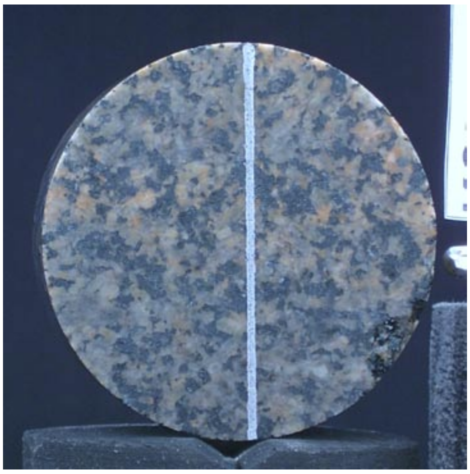
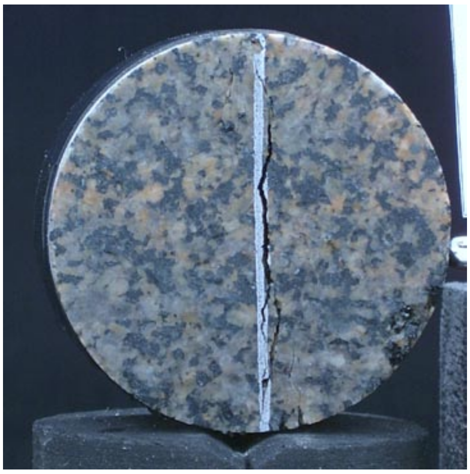
After mechanical test



Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.2	2779	12.0	

Comments: None

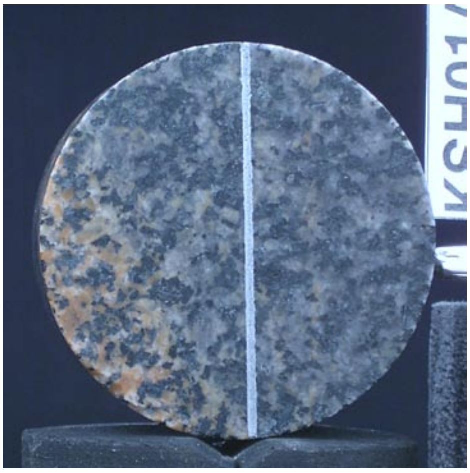
Specimen ID: KSH01A-110-3

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.2	25.5	2773	12.4	

Comments: None

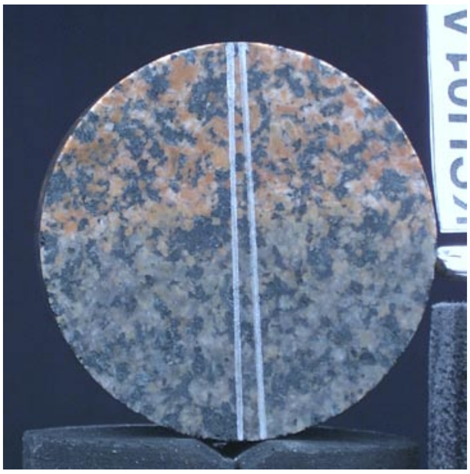
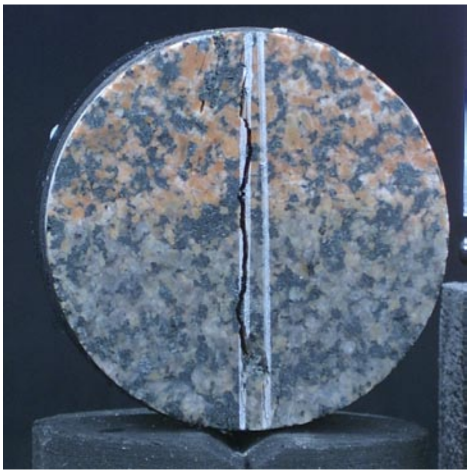
Specimen ID: KSH01A-110-5

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.3	2777	15.1	

Comments: None

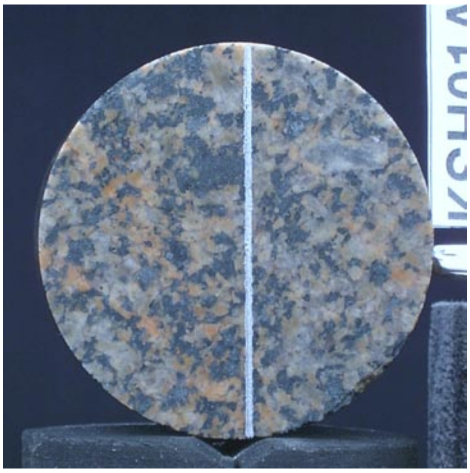
Specimen ID: KSH01A-110-7

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m³]	Tensile strength [MPa]	Loading direction
50.2	26.1	2769	15.0	

Comments: None

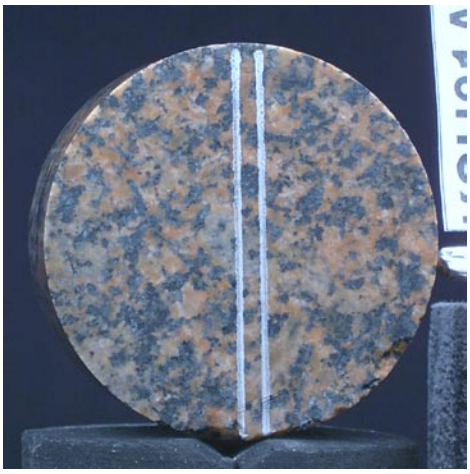
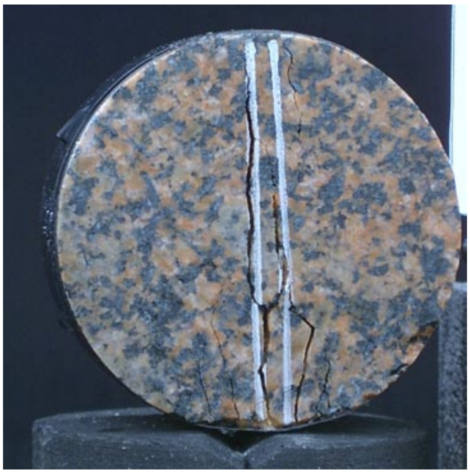
Specimen ID: KSH01A-110-9

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m³]	Tensile strength [MPa]	Loading direction
50.1	26.2	2775	15.9	

Comments: None

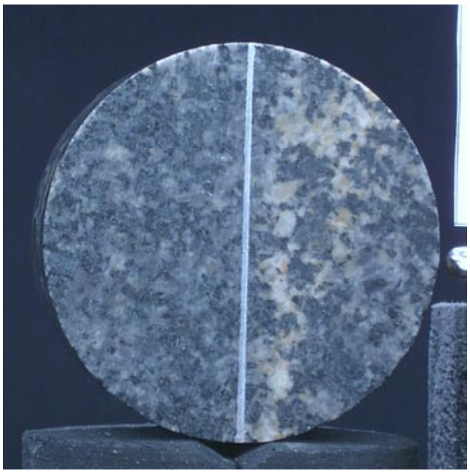
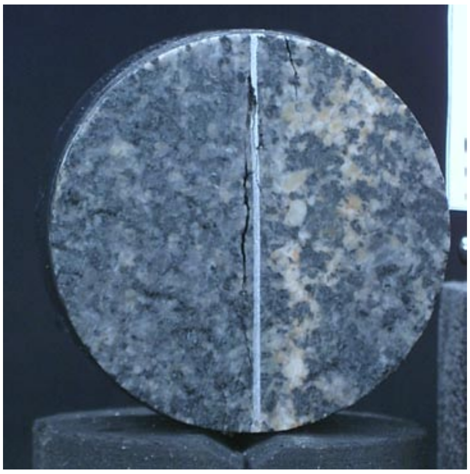
Specimen ID: KSH01A-110-11

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	25.7	2781	17.6	

Comments: A small piece on the edge of the specimen close to the loading place is missing

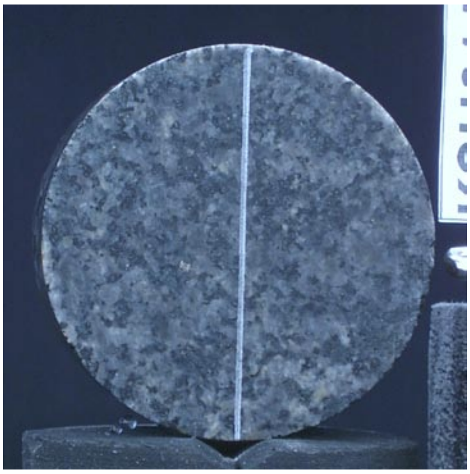
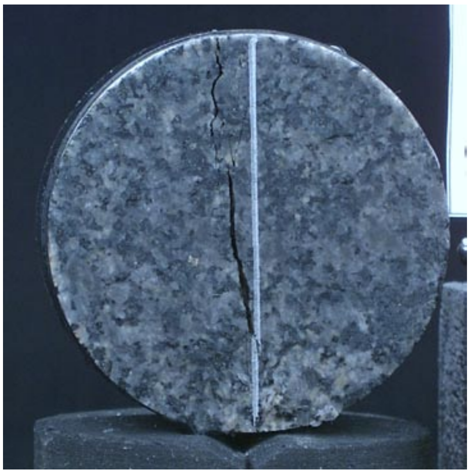
Specimen ID: KSH01A-110-13

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.0	26.3	2800	15.9	

Comments: None

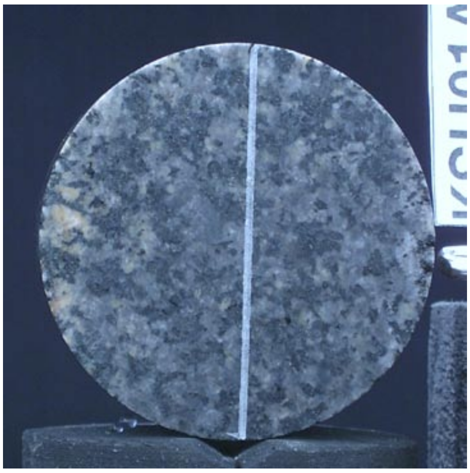
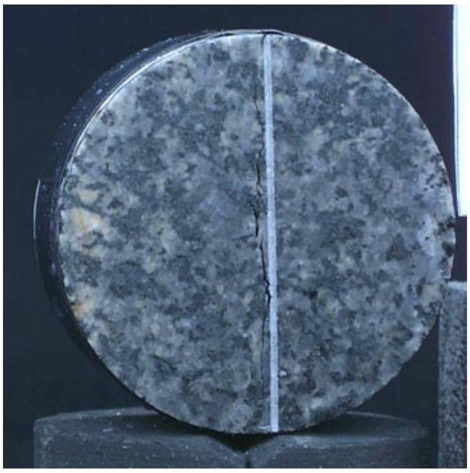
Specimen ID: KSH01A-110-15

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.0	26.2	2803	15.2	

Comments: None

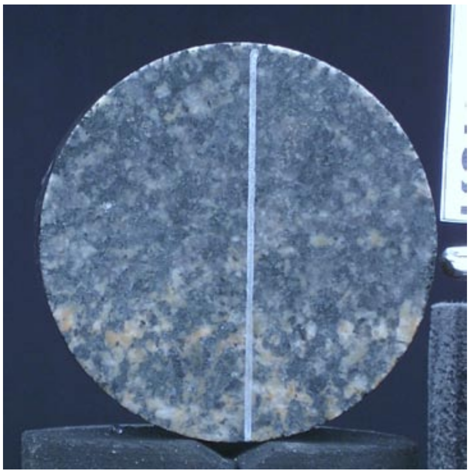
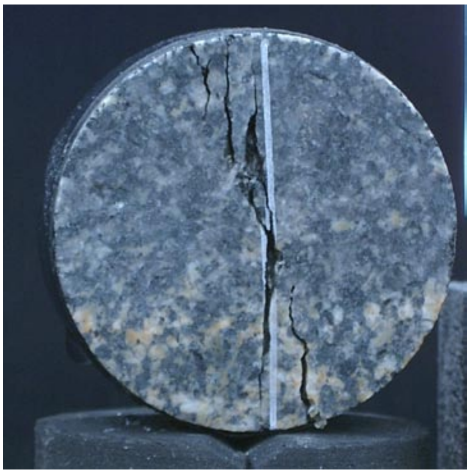
Specimen ID: KSH01A-110-17

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.0	26.3	2792	15.9	

Comments: None

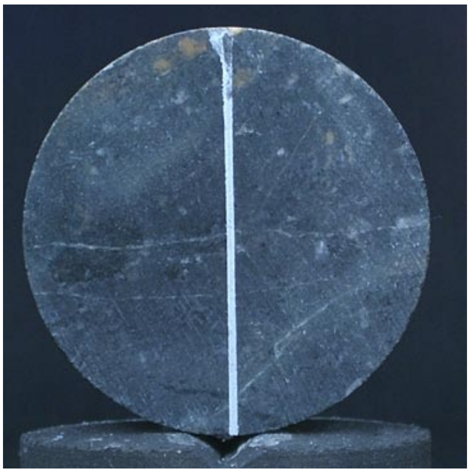
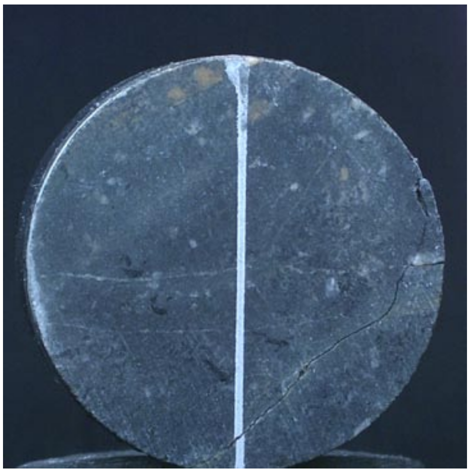
Specimen ID: KSH01A-110-19

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.1	2802	15.9	

Comments: None

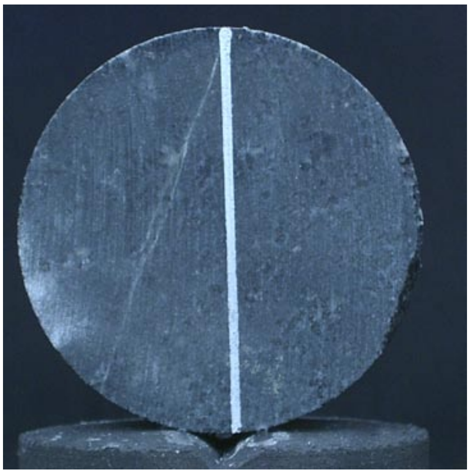
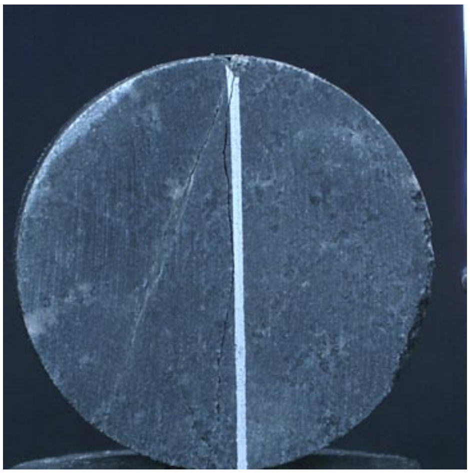
Specimen ID: KSH01A-110-24

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.1	2763	8.7	

Comments: The crack direction is not vertical

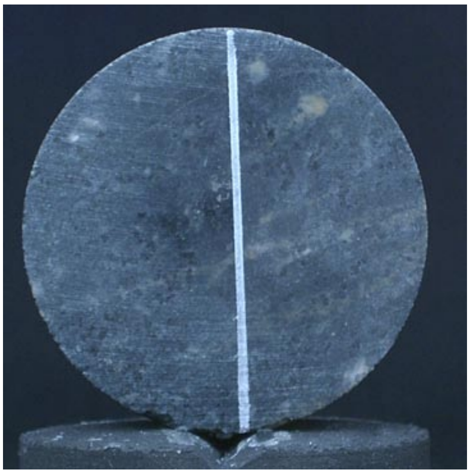
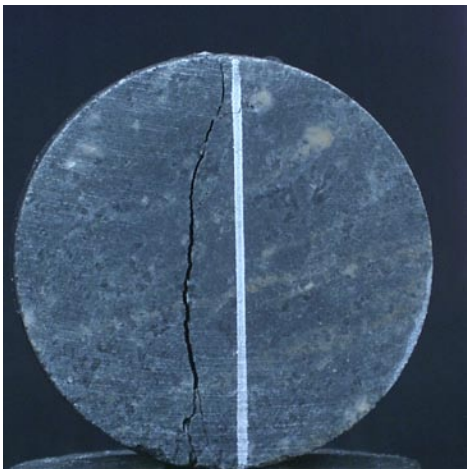
Specimen ID: KSH01A-110-25

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.2	26.2	2797	9.0	

Comments: A secondary crack was developed in a pre-existent weakness plane in addition to the primary vertical crack

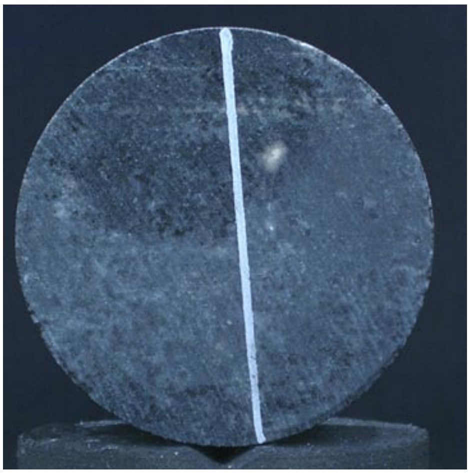
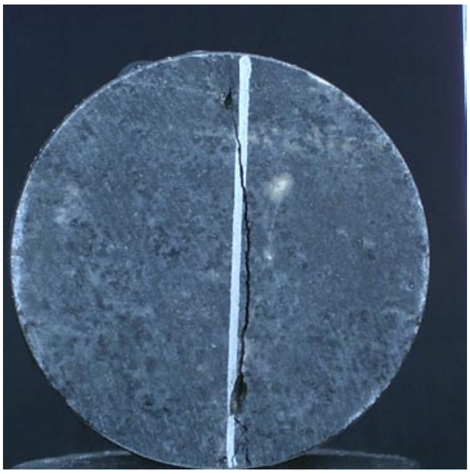
Specimen ID: KSH01A-110-26

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.1	2803	16.8	

Comments: None

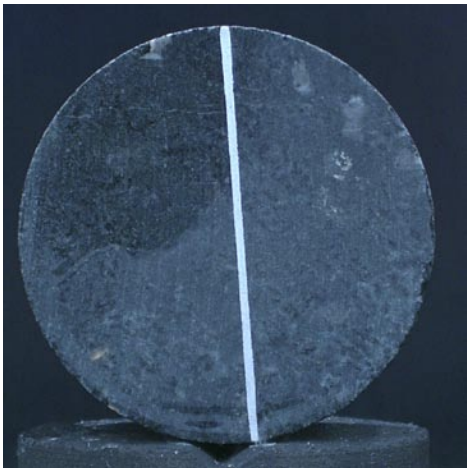
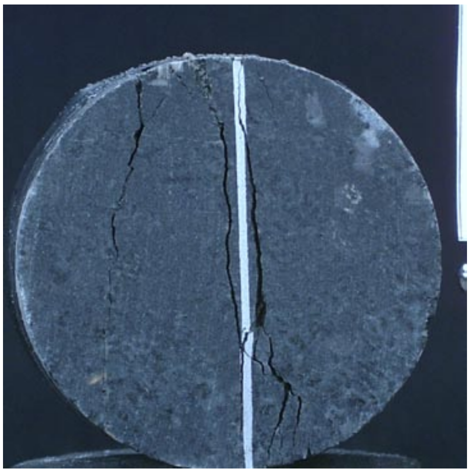
Specimen ID: KSH01A-110-27

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.5	2784	16.6	

Comments: None

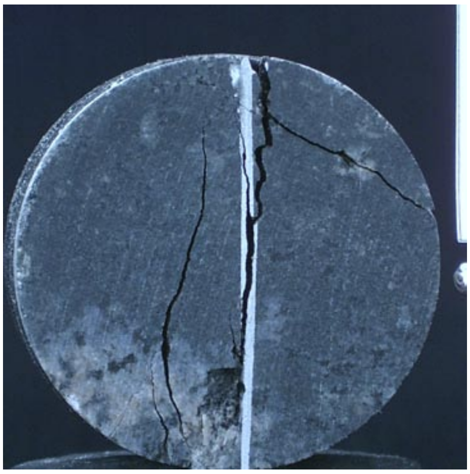
Specimen ID: KSH01A-110-28

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.3	26.3	2805	16.8	

Comments: A secondary crack was developed away from the loading line

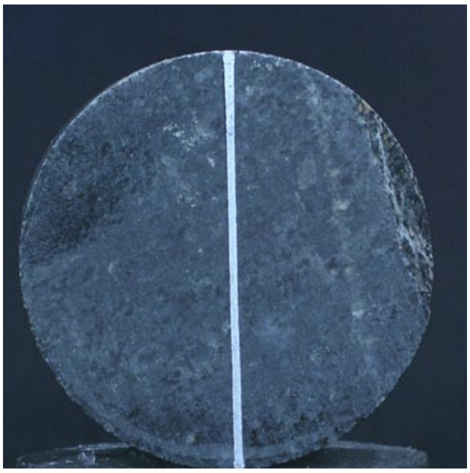
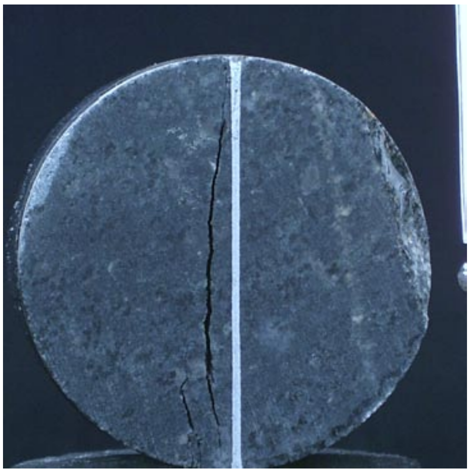
Specimen ID: KSH01A-110-29

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.3	2802	21.2	

Comments: A secondary crack was developed

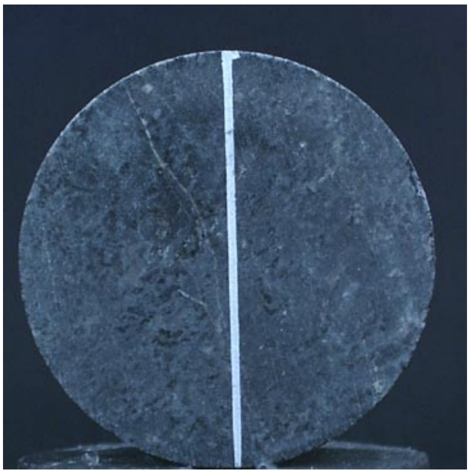
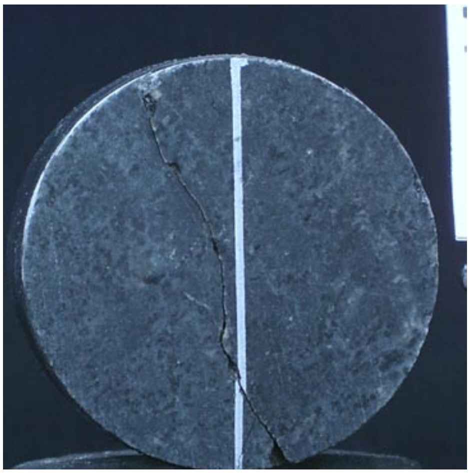
Specimen ID: KSH01A-110-30

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.2	2797	17.1	

Comments: None

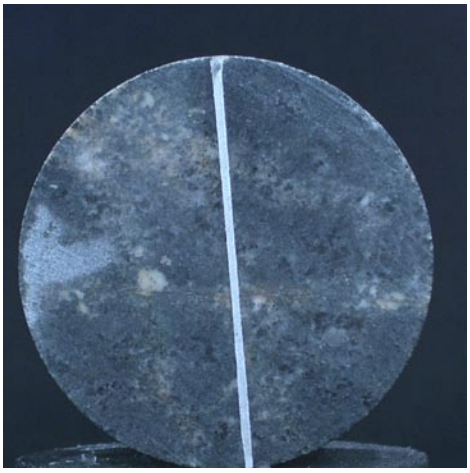
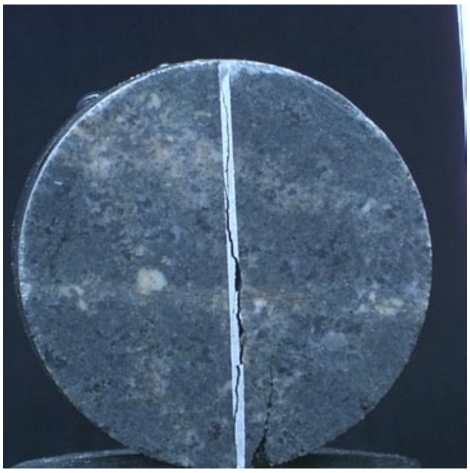
Specimen ID: KSH01A-110-31

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.0	2805	12.9	

Comments: A crack was developed in a pre-existing weakness plane at 7 MPa. The crack through the thickness is not perpendicular to the end surfaces

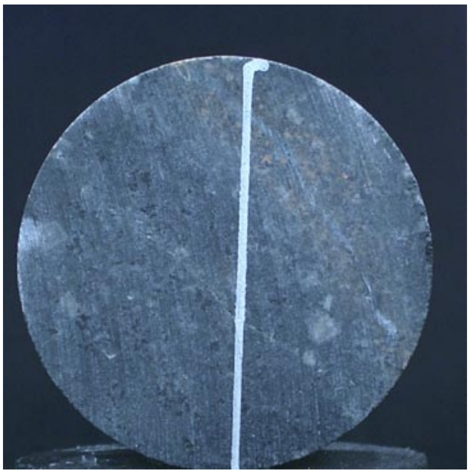
Specimen ID: KSH01A-110-32

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
49.5	26.3	2783	13.8	

Comments: None

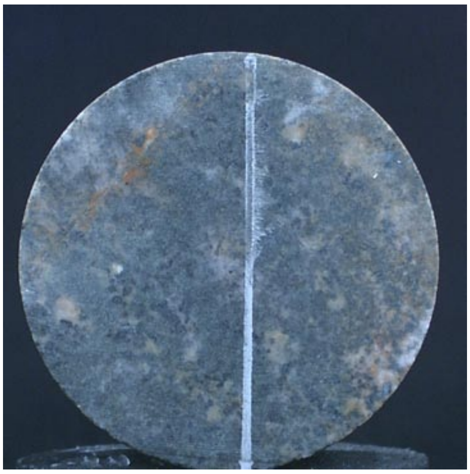
Specimen ID: KSH01A-110-33

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
49.6	26.7	2806	10.9	

Comments: A crack was developed in a pre-existent weakness. The crack has a kink. A drop of load force was observed at 8 and 10 MPa

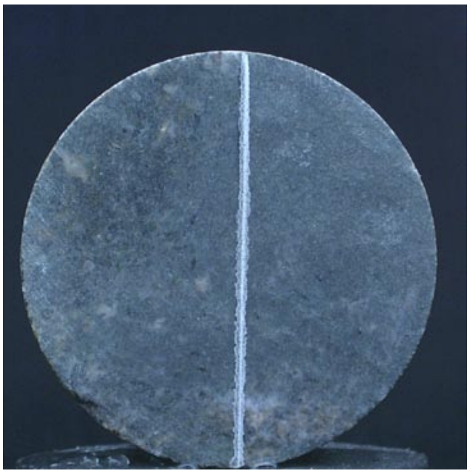
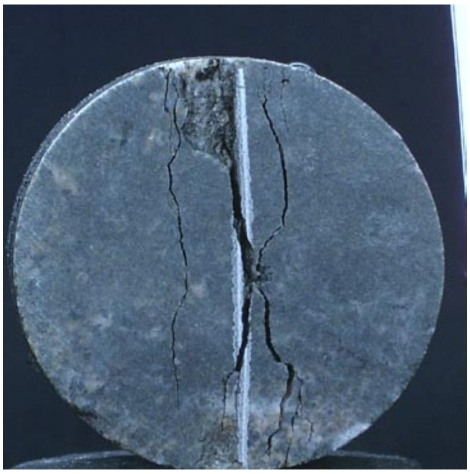
Specimen ID: KSH01A-110-36

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	25.9	2777	19.0	

Comments: A crack was developed in a pre-existent weakness plane

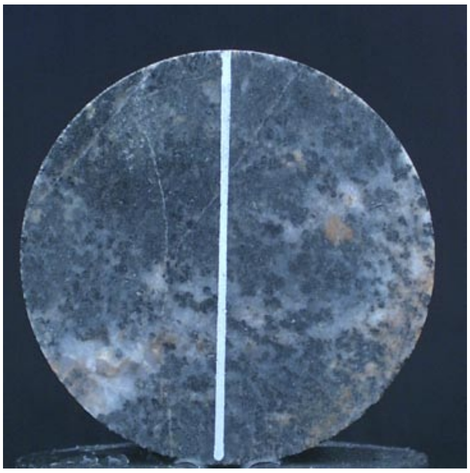
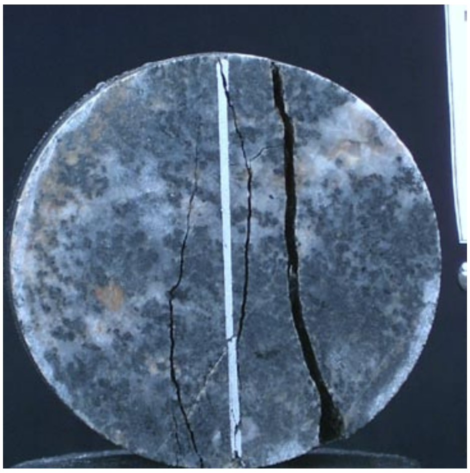
Specimen ID: KSH01A-110-37

Before mechanical test	After mechanical test
	

Diameter [mm]	**Height [mm]**	**Density [kg/m³]**	**Tensile strength [MPa]**	**Loading direction**
50.1	26.6	2797	21.5	

Comments: None

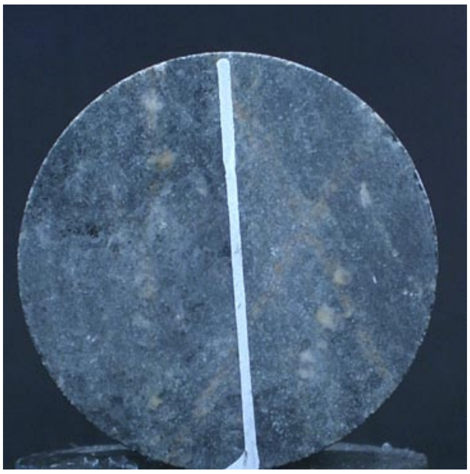
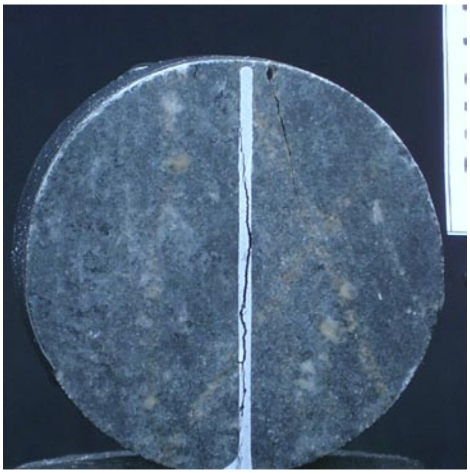
Specimen ID: KSH01A-110-38

Before mechanical test	After mechanical test
	

Diameter [mm]	**Height [mm]**	**Density [kg/m³]**	**Tensile strength [MPa]**	**Loading direction**
50.1	26.1	2763	14.1	

Comments: A crack was developed in a pre-existent weakness plane

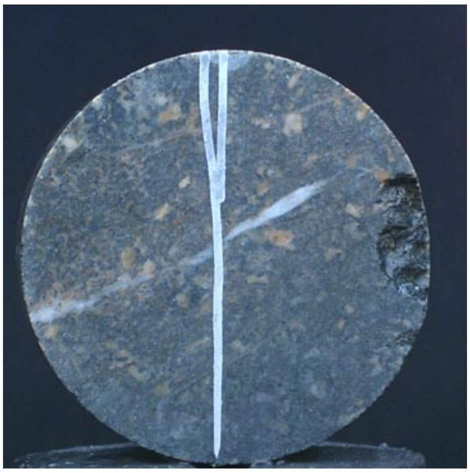
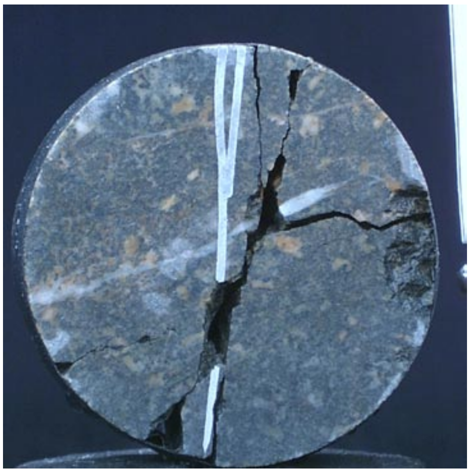
Specimen ID: KSH01A-110-39

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.2	2812	19.9	

Comments: None

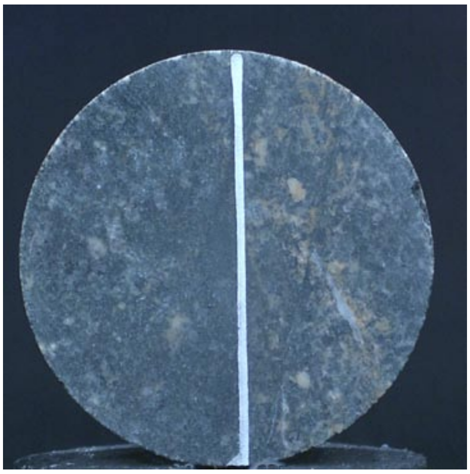
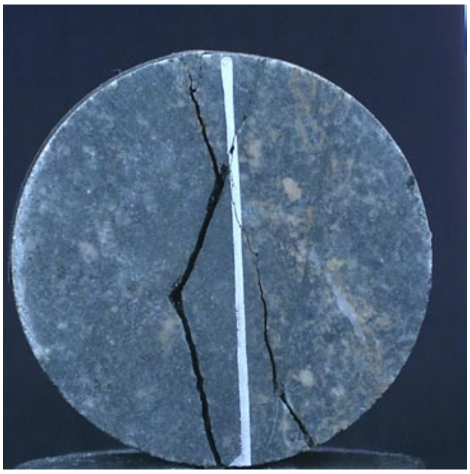
Specimen ID: KSH01A-110-40

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.1	2803	19.6	

Comments: A secondary crack was formed in addition to the primary vertical crack

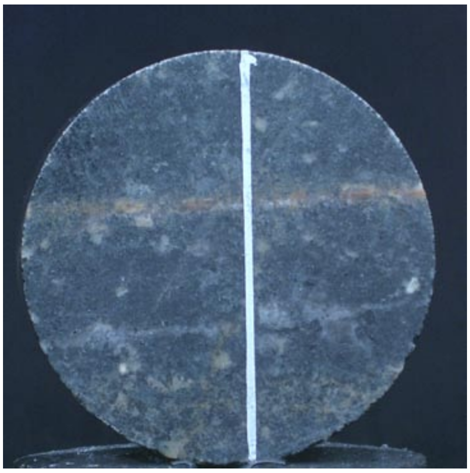
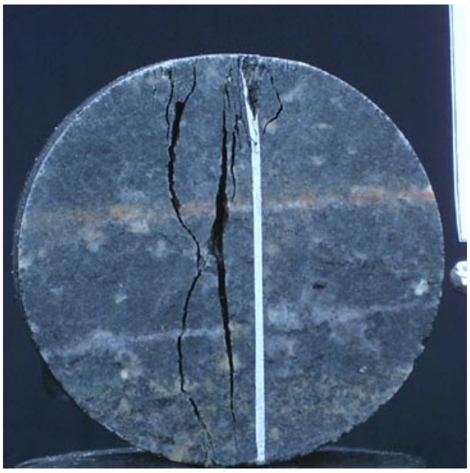
Specimen ID: KSH01A-110-41

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.2	2777	8.8	

Comments: The crack has a kink due to a pre-existent weakness plane

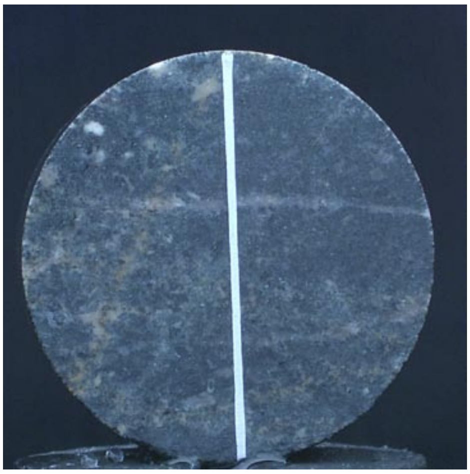
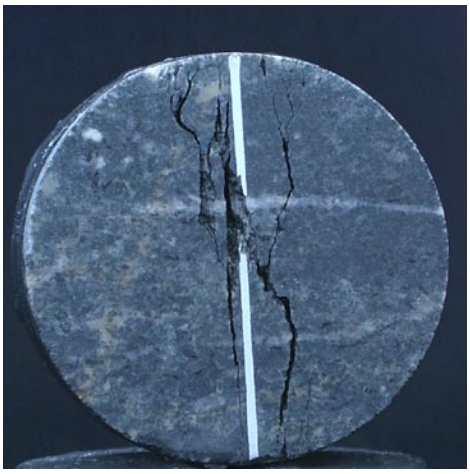
Specimen ID: KSH01A-110-42

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	25.9	2796	20.8	

Comments: None

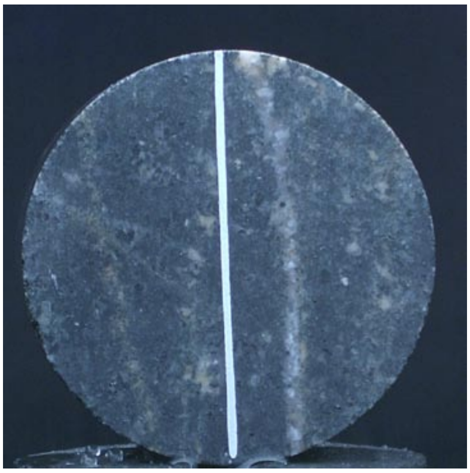
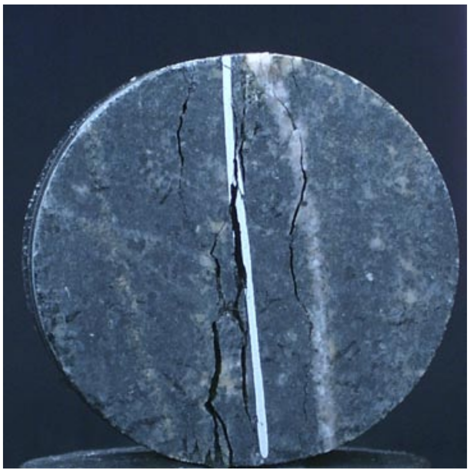
Specimen ID: KSH01A-110-43

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.2	26.1	2792	20.4	

Comments: None

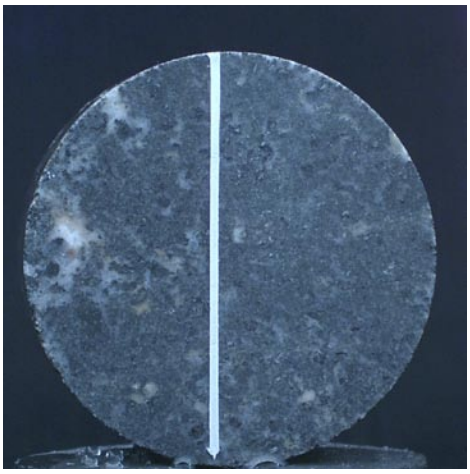
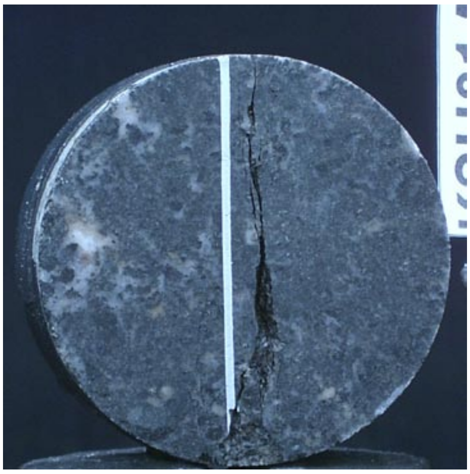
Specimen ID: KSH01A-110-44

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.1	26.1	2797	21.9	

Comments: None

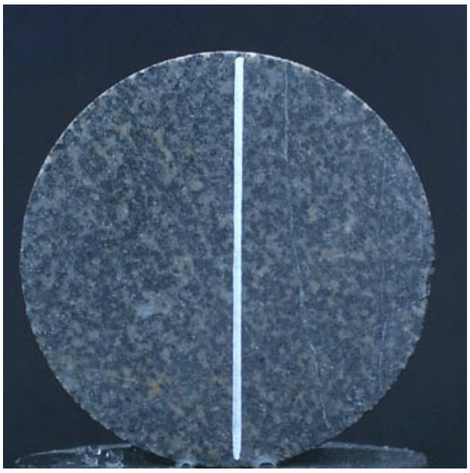
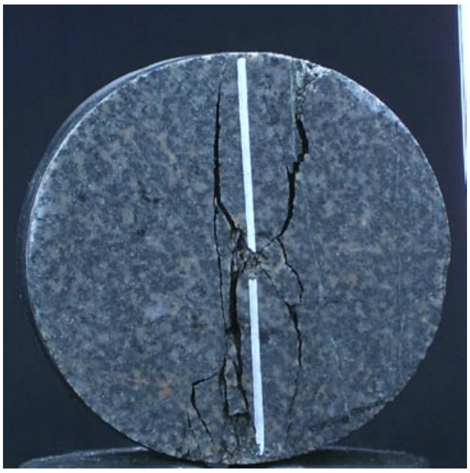
Specimen ID: KSH01A-110-45

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.0	26.3	2794	19.8	

Comments: None

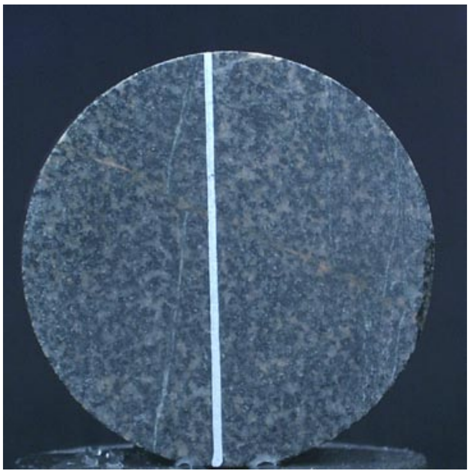
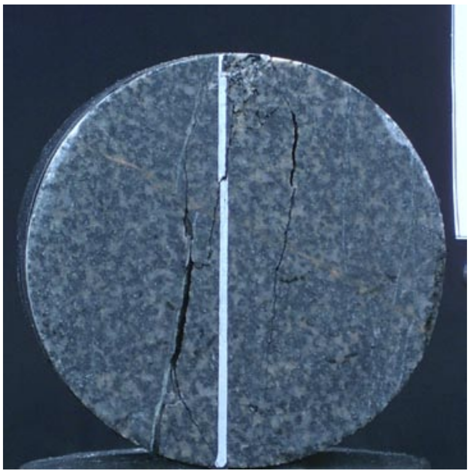
Specimen ID: KSH01A-110-48

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.0	26.1	2842	19.9	

Comments: None

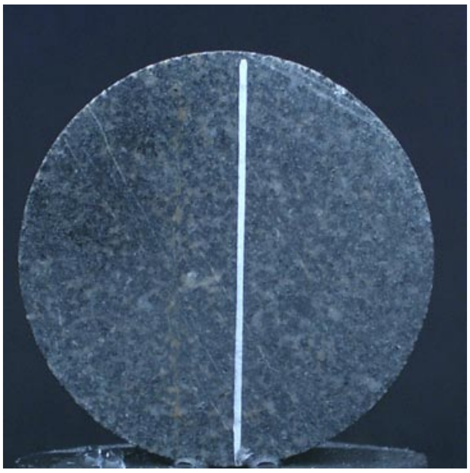
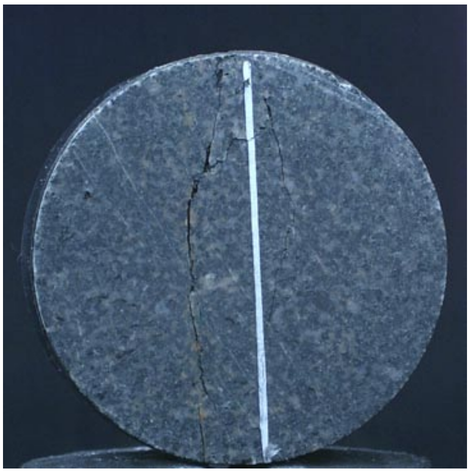
Specimen ID: KSH01A-110-49

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m³]	Tensile strength [MPa]	Loading direction
50.0	26.1	2847	16.7	

Comments: Cracking occurred in a pre-existent weakness plane

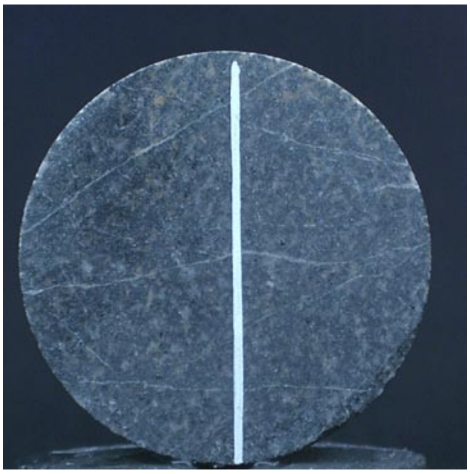
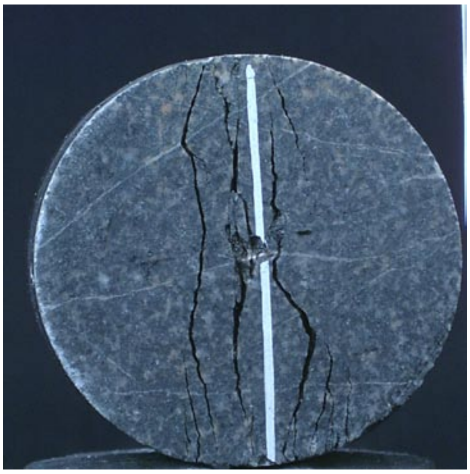
Specimen ID: KSH01A-110-50

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m³]	Tensile strength [MPa]	Loading direction
50.0	26.2	2833	19.6	

Comments: None

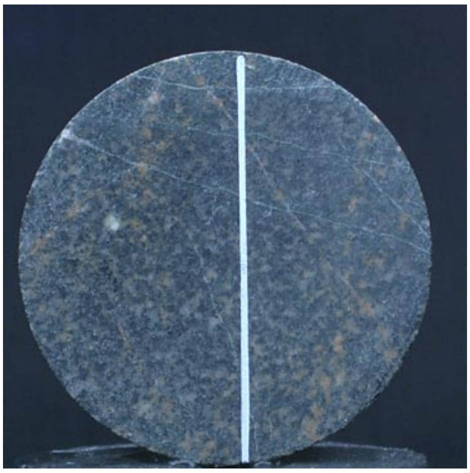
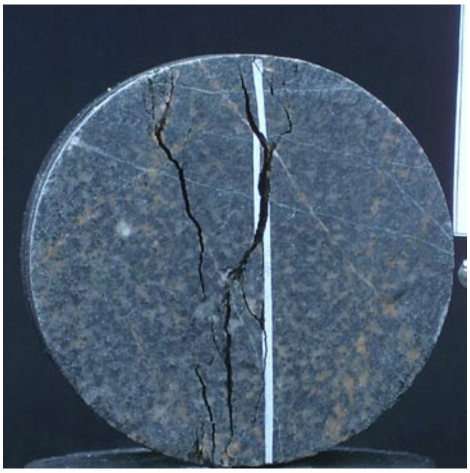
Specimen ID: KSH01A-110-51

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.0	26.1	2826	23.8	

Comments: None

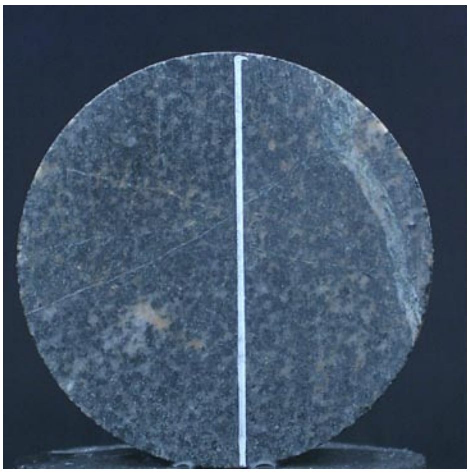
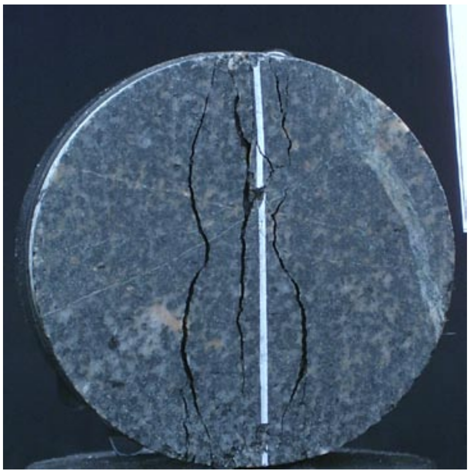
Specimen ID: KSH01A-110-52

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m^3]	Tensile strength [MPa]	Loading direction
50.2	26.2	2838	16.7	

Comments: The cracking may have been effected of pre-existing weakness planes

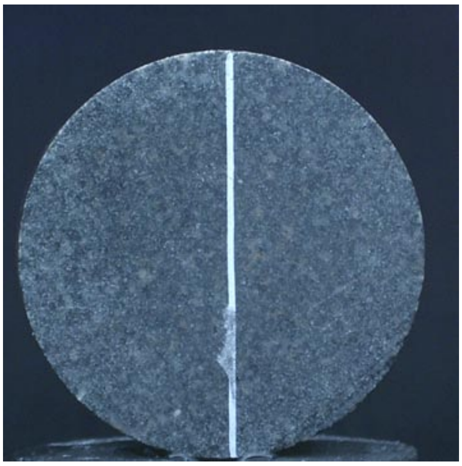
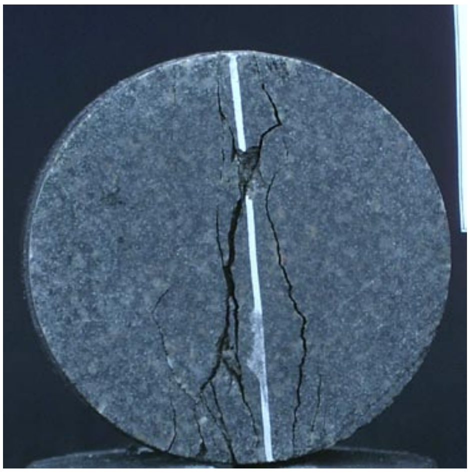
Specimen ID: KSH01A-110-53

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m³]	Tensile strength [MPa]	Loading direction
50.0	26.3	2825	21.3	

Comments: None

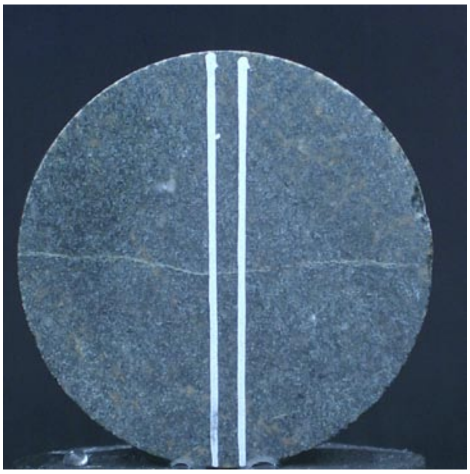
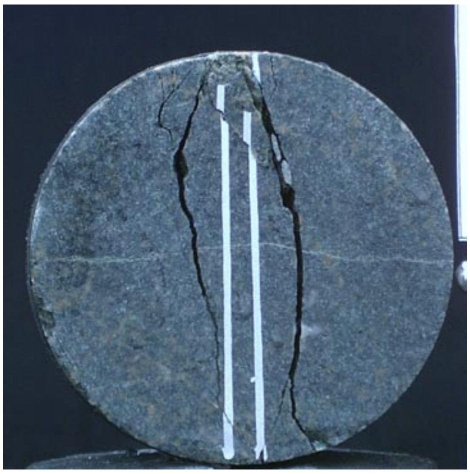
Specimen ID: KSH01A-110-54

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m³]	Tensile strength [MPa]	Loading direction
50.0	26.0	2891	22.7	

Comments: None

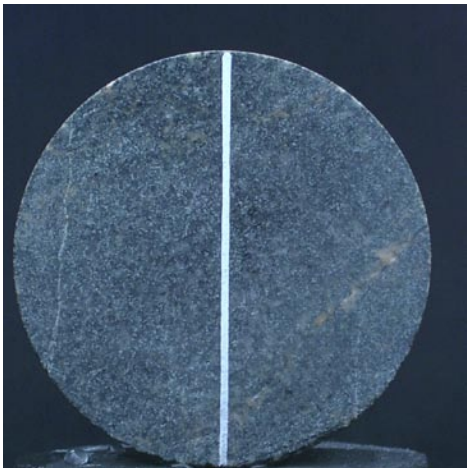
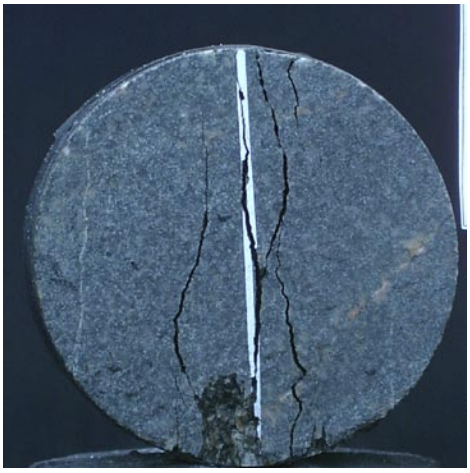
Specimen ID: KSH01A-110-55

Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m³]	Tensile strength [MPa]	Loading direction
50.1	26.1	2865	23.8	

Comments: None

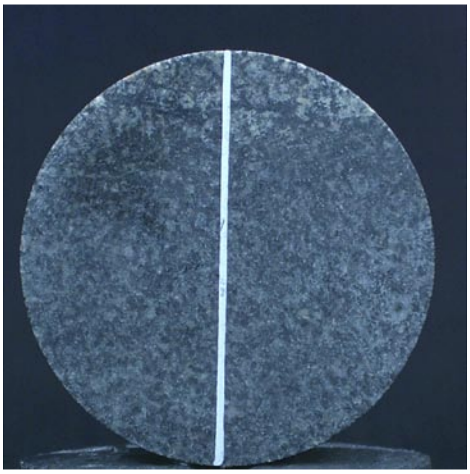
Specimen ID: KSH01A-110-56

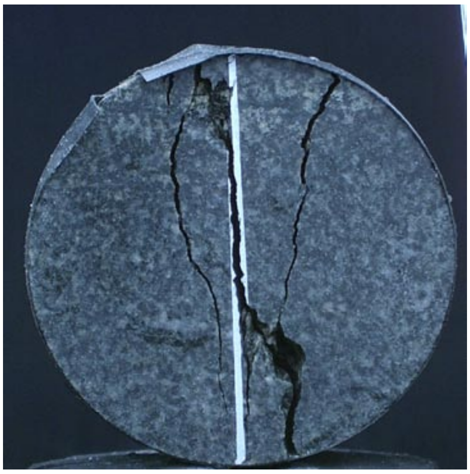
Before mechanical test	After mechanical test
	

Diameter [mm]	Height [mm]	Density [kg/m³]	Tensile strength [MPa]	Loading direction
50.1	26.3	2872	22.6	

Comments: None

Specimen ID: KSH01A-110-57				
Before mechanical test			After mechanical test	





Diameter [mm]	Height [mm]	Density [kg/m³]	Tensile strength [MPa]	Loading direction
50.1	26.2	2880	22.4	

Comments: None

5.2 Results for the entire test series

A summary of the test results is shown in Tables 5-1 to 5-3. It is seen that specimen number 24, 25, 31, 33, 38, 41, 49 and 52 had pre-existing failure planes and displayed lower values on the tensile strength. The densities and tensile strength versus the depth, at which the samples are taken, are shown in Figures 5-1 and 5-2.

Table 5-1. Summary of results.

Identification	Density [kg/m3]	Tensile strength [MPa]	Comments
KSH01A-110-1	2779	12.0	
KSH01A-110-3	2773	12.4	
KSH01A-110-5	2777	15.1	
KSH01A-110-7	2769	15.0	
KSH01A-110-9	2775	15.9	
KSH01A-110-11	2781	17.6	A small piece on the edge of the specimen close to the loading place is missing
KSH01A-110-13	2800	15.9	
KSH01A-110-15	2803	15.2	
KSH01A-110-17	2792	15.9	
KSH01A-110-19	2802	15.9	

KSH01A-110-24	2763	8.7	The crack direction is not vertical
KSH01A-110-25	2797	9.0	A secondary crack was developed in a pre-existent weakness plane in addition to the primary vertical crack
KSH01A-110-26	2803	16.8	
KSH01A-110-27	2784	16.6	
KSH01A-110-28	2805	16.8	A secondary crack was developed away from the loading line
KSH01A-110-29	2802	21.2	A secondary crack was developed
KSH01A-110-30	2797	17.1	
KSH01A-110-31	2805	12.9	A crack was developed in a pre-existing weakness plane at 7 MPa. The crack through the thickness is not perpendicular to the end surfaces
KSH01A-110-32	2783	13.8	
KSH01A-110-33	2806	10.9	A crack was developed in a pre-existent weakness. The crack has a kink. A drop of load force was observed at 8 and 10 MPa
KSH01A-110-36	2777	19.0	A crack was developed in a pre-existent weakness plane
KSH01A-110-37	2797	21.5	
KSH01A-110-38	2763	14.1	A crack was developed in a pre-existent weakness plane
KSH01A-110-39	2812	19.9	
KSH01A-110-40	2803	19.6	A secondary crack was formed in addition to the primary vertical crack
KSH01A-110-41	2777	8.8	The crack has a kink due to a pre-existent weakness plane
KSH01A-110-42	2796	20.8	
KSH01A-110-43	2792	20.4	
KSH01A-110-44	2797	21.9	
KSH01A-110-45	2794	19.8	
KSH01A-110-48	2842	19.9	
KSH01A-110-49	2847	16.7	Cracking occurred in a pre-existent weakness plane
KSH01A-110-50	2833	19.6	
KSH01A-110-51	2826	23.8	
KSH01A-110-52	2838	16.7	The cracking may have been effected of pre-existing weakness planes
KSH01A-110-53	2825	21.3	
KSH01A-110-54	2891	22.7	
KSH01A-110-55	2865	23.8	
KSH01A-110-56	2872	22.6	
KSH01A-110-57	2880	22.4	

Table 5-2. Calculated mean values (Mean val) and standard deviation (Std dev) of wet density and tensile strength at the different sampling levels and for the whole series.

	Density [kg/m3]	Tensile strength [MPa]
Mean val (303–321 m)	2785	15.1
Mean val (401–414 m)	2795	14.4
Mean val (481–499 m)	2791	18.6
Mean val (699–717 m)	2852	21.0
Mean val (Whole series)	2806	17.2
Std dev (303–321 m)	12.9	1.7
Std dev (401–414 m)	13.9	4.0
Std dev (481–499 m)	14.4	4.1
Std dev (481–717 m)	23.5	2.7
Std dev (Whole series)	31.7	4.1

Table 5-3. Calculated mean values (Mean val) and standard deviation (Std dev) of wet density and tensile strength at the different sampling levels and for the whole series with the results from specimen number 24, 25, 31, 33, 41, 49 and 52 excluded in the summary due to pre-existing defects.

	Density [kg/m3]	Tensile strength [MPa]
Mean val (303–321 m)	2785	15.1
Mean val (401–414 m)	2796	17.1
Mean val (481–499 m)	2792	19.7
Mean val (699–717 m)	2854	22.0
Mean val (Whole series)	2807	18.5
Std dev (303–321 m)	12.9	1.7
Std dev (401–414 m)	9.8	2.4
Std dev (481–499 m)	15.2	2.3
Std dev (481–717 m)	25.9	1.6
Std dev (Whole series)	32.0	3.3

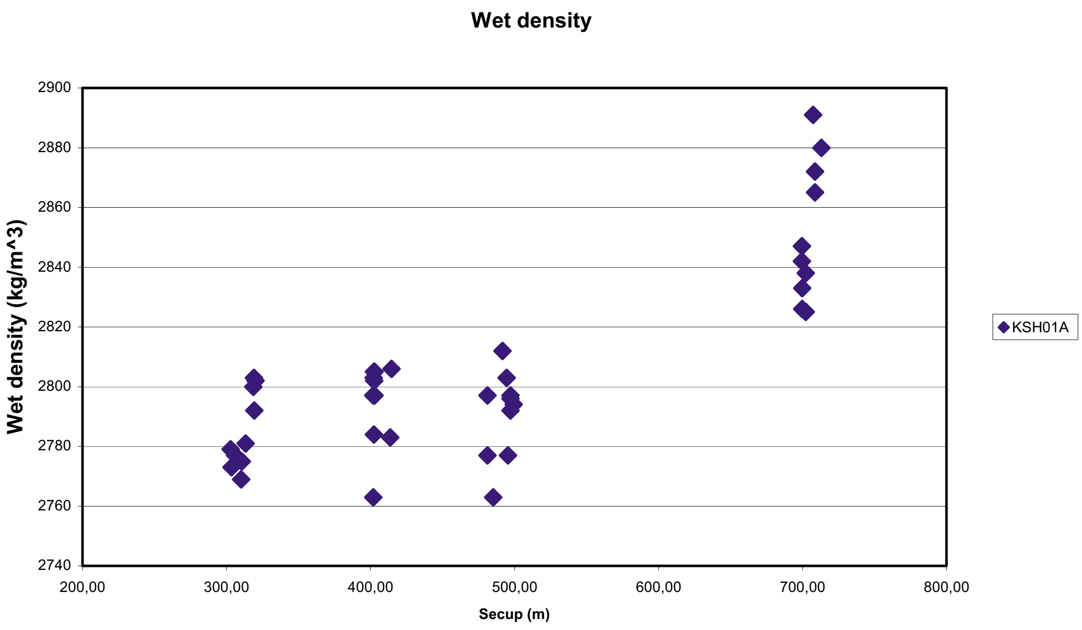


Figure 5-1. *Density versus depth at which the samples are taken in the borehole.*

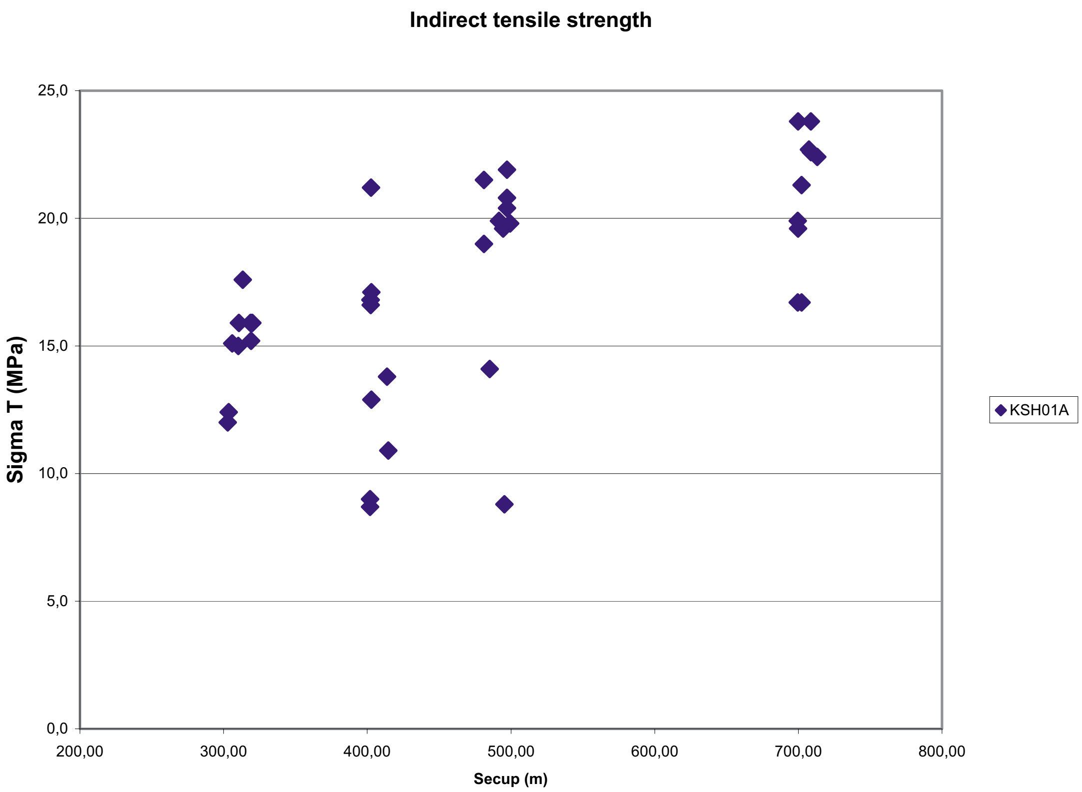


Figure 5-2. *Tensile strength versus depth at which the samples are taken in the borehole.*

5.3 Discussion

The testing was conducted according to the method description and the activity plan with no departures.

References

/1/ ISRM. Suggested Method for Determining Water Content, Porosity, Density, Absorption and Related Properties and Swelling and Slake-durability Index Properties. Int. J. Rock. Mech. Min. Sci. & Geomech. Abstr. 16(2), pp. 141–156, 1979.

/2/ SS-EN 13755. Natural stone test methods – Determination of water absorption at atmospheric pressure.

/3/ ASTM 4543-01. Standard practice for preparing rock core specimens and determining dimensional and shape tolerance, 2001.

/4/ Stråhle A. Definition och beskrivning av parametrar för geologisk, geofysisk och bergmekanisk kartering av berg, SKB R-01-19. In Swedish.