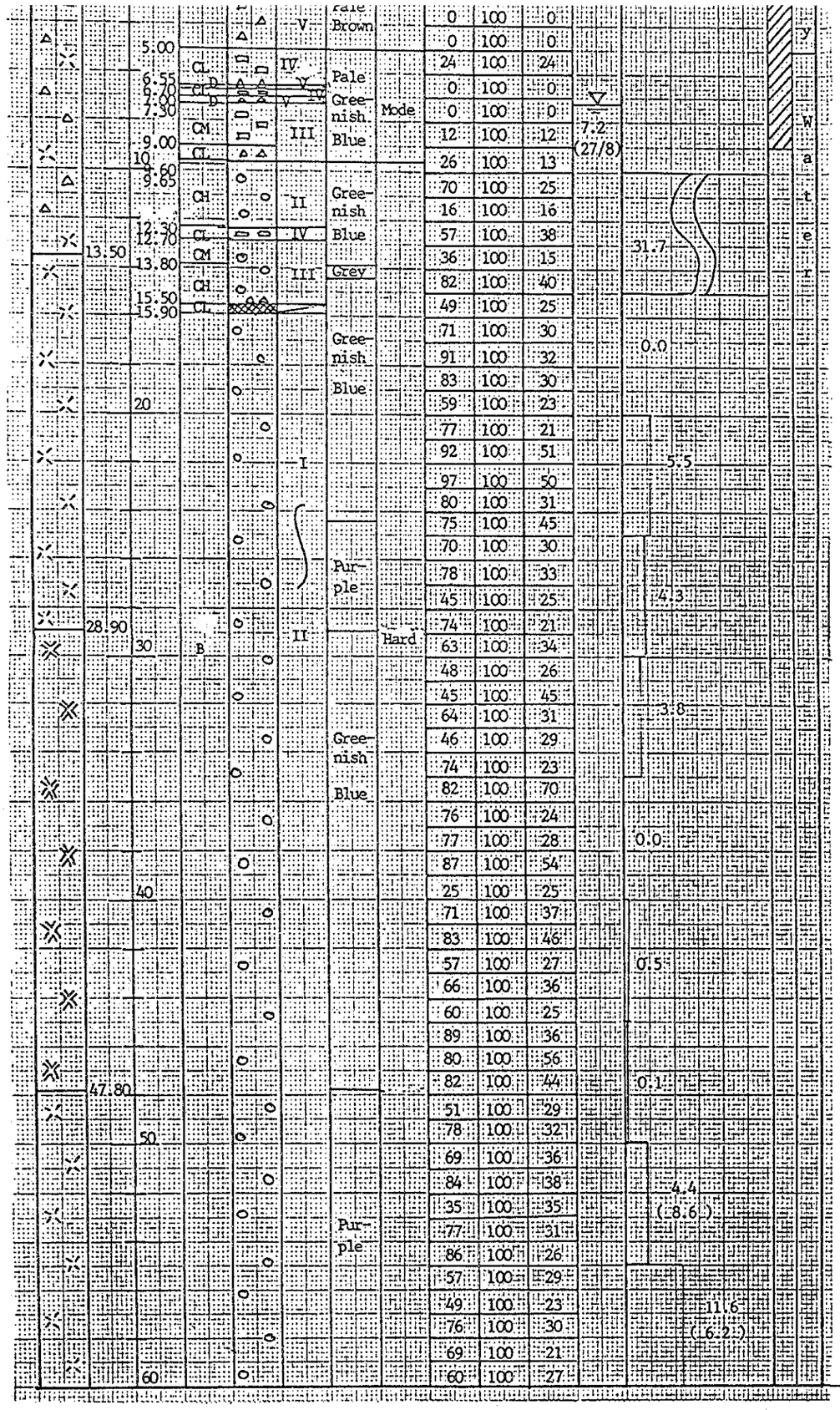


0.80～5.00m
Loose to dense,clayey silty sand.

5.00～9.60m
Weak to moderately weak,highly fractured. Cracks are filled with limonite and sand.

9.60～12.30m
Moderatly strong to strong,slightly fractured.

9.65m minor fault gouge 5cm thickness,20° inclination.

9.65～13.80m This section is undergone by metamorphism,brown～grayish yellowish green clay adheres to cracks which is apt to be opened.

12.30～15.90m
Moderately weak to moderately strong,partly fractured.

13.80～14.30m Undergone by metamorphism.

15.60～15.90m No corerecovery.

15.90～24.50m
Moderately strong to very strong,partly fractured. Cracks are filled with calcite veins.

24.50～60.00m
Very strong,slightly fractured. Cracks are filled with calcite veins.

52.00～52.40m,59.40～59.60m Steep angled cracks which are metamorphied heavily.

27.20m,26.90m Opened cracks are recognised along calcite veins.

Geological Log

- Top Soil
- Tuff Breccia – Tuff
- Tuff (Purple)
- Tuff (Greenish Blue)

Core Shape

- Clay – Sand
- Fragment – Rhomb.
- Rhomb. – Short Pole
- Pole
- Core recovery 0 portion

Hardness

Hard	A dull sound or a slightly dull sound is emitted when hammered.
Mode	Rock fragments cannot be broken by finger, but it's easy to be broken by hammer.
Soft	Rock fragments can be taken to pieces by finger.

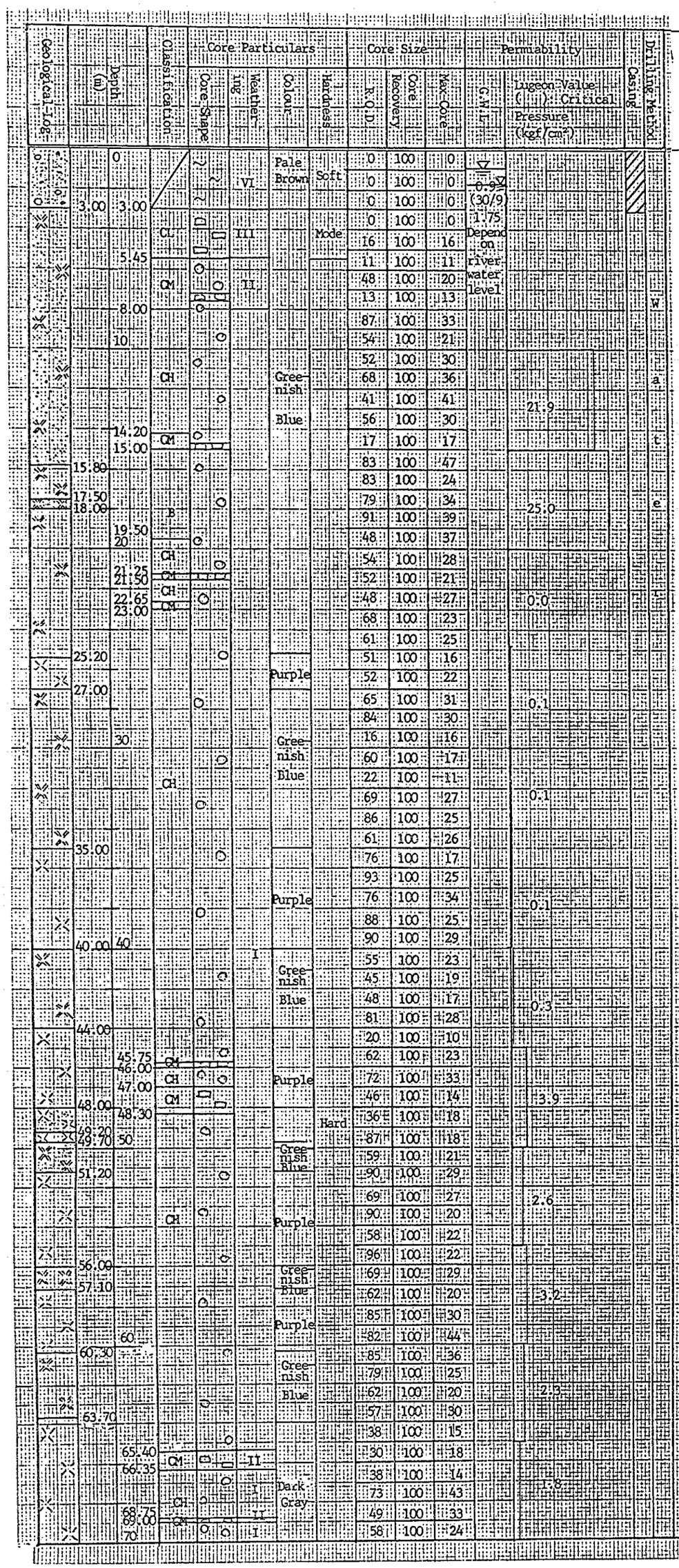
Weathering

I	No visible signs of weathering. Rock fresh, crystals bright. Few discontinuities may show slight staining.
II	Penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material. Discontinuities are discoloured and discolouration can extend into rock up to a few mm from discontinuity surface.
III	Slight discolouration extends through the greater part of the rock mass. The rock material is not friable(except in the case of poorly cemented sedimentary rocks). Discontinuities are stained and /or contain a filling comprising altered materials
IV	Weathering extends throughout rock mass and the rock material is partly friable Rock has no lustre. All material except quartz is discoloured. Rock can be excavated with geologist's pick.
V	Rock is totally discoloured and decomposed and in a friable condition with only fragments of the rock texture and structure preserved. The external appearance is that of a soil.
VI	Soil material with complete disintegration of texture, structure and mineralogy of the parent rock.

I Unweathered rock
II Slightly weathered rock
III Moderately weathered rock
IV Highly weathered rock
V Completely weathered rock
VI Residual soil

Fig. 4-6

Drilling Number	D-1
Location	Dam Site Left-Upper Bank
Length	L = 60 m
Level	EL. 107.889
Direction	Vertical



Description

0.00～3.00m
Very weak, pale brown and gray, sediment of sand, granule and pebble gravels. Gravels consist of chert, green rock and shale.

3.00～5.45m
Weak, partly fractured.
Cracks are filled with limonite partly.

5.45～8.00m
Moderately strong, partly fractured.
Cracks are filled with limonite slightly.

8.00～25.20m
Moderately strong to very strong, stightly fractured.

14.20～15.00m Cracks are colored with limonite.

25.20～27.00m
Moderately weak.

27.00～35.00m
Moderately strong.

35.00～40.00m
Strong.

40.00～44.00m
Moderately weak to very strong.

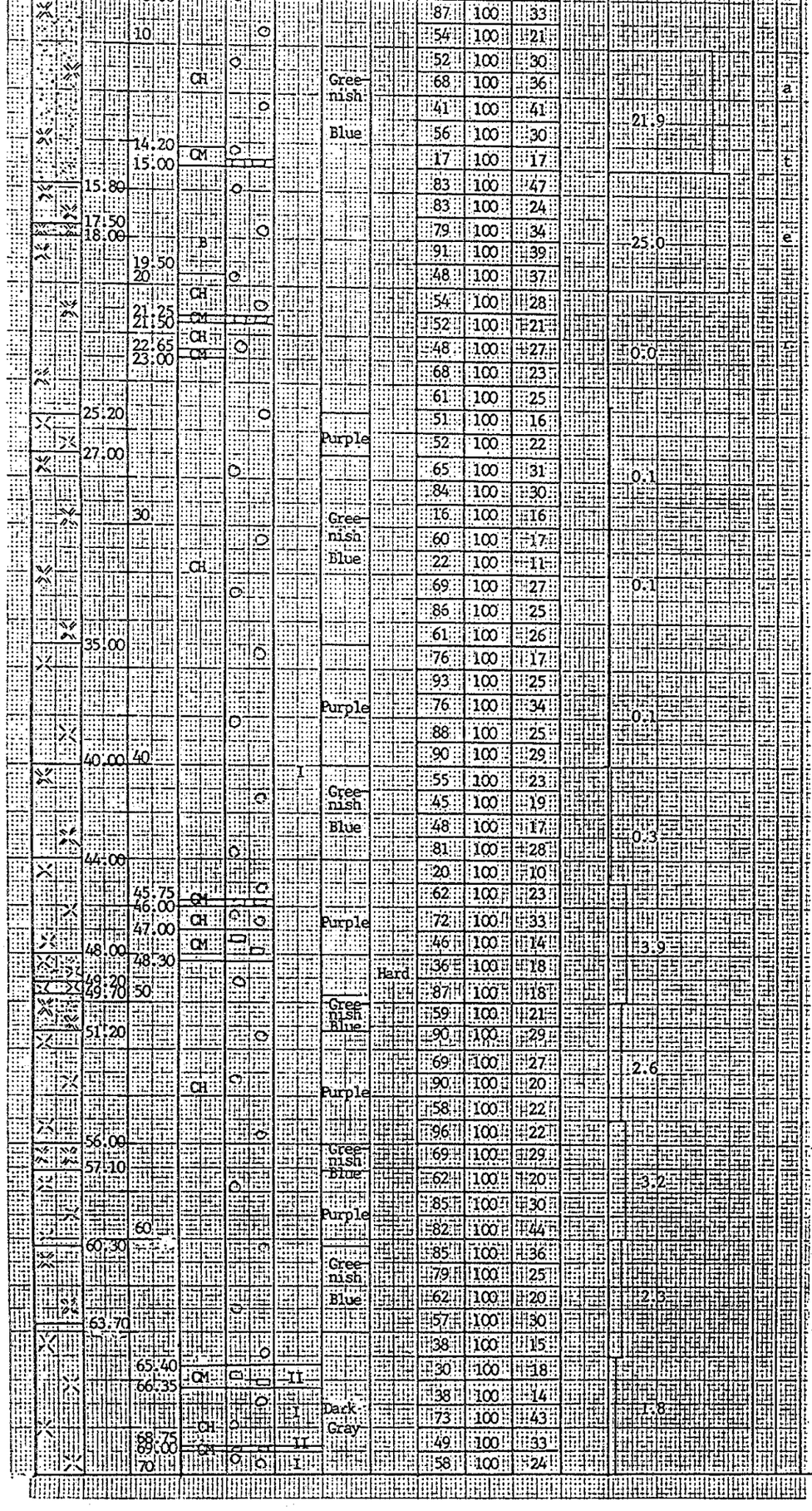
44.00～57.10m
Moderately strong to strong.

57.10～60.00m
Very strong, fractured slightly.

60.00～63.70m
Very strong to moderately strong, partly fractured.

63.70～66.35m
Moderately weak.

66.35～70.00m
Strong.



Cracks are filled with limonite partly.

5.45～8.00m
Moderately strong,partly fractured.
Cracks are filled with limonite slightly.

8.00～25.20m
Moderately strong to very strong,stightly fractured.

14.20～15.00m Cracks are colored with limonite.

25.20～27.00m
Moderately weak.

27.00～35.00m
Moderately strong.

35.00～40.00m
Strong.

40.00～44.00m
Moderately weak to very strong.

44.00～57.10m
Moderately strong to strong.

57.10～60.00m
Very strong,fractured slightly.

60.00～63.70m
Very strong to moderately strong,partly fractured.

63.70～66.35m
Moderately weak.

66.35～70.00m
Strong.

Geological Log

- River Accumulation
- Tuff (fine, purple- dark gray)
- Tuff (coarse, purple)
- Tuff (fine, greenish blue)
- Tuff (coarse, greenish blue)

Core Shape

- Clay - Sand
- Rhomb - Short Pole
- Pole

Hardness

Hard	A dull sound or a slightly dull sound is emitted when hammered.
Mode	Rock fragments cannot be broken by finger, but it's easy to be broken by hammer.
Soft	Rock fragments can be taken to pieces by finger.

Weathering

I	No visible signs of weathering. Rock fresh, crystals bright. Few discontinuities may show slight staining.
II	Penetrative weathering developed on open discontinuity surface but only slight weathering of rock material. Discontinuities are discoloured and discolouration can extend into rock up to a few mm from discontinuity surface.
III	Slight discolouration extends through the greater part of the rock mass. The rock material is not friable(except in the case of poorly cemented sedimentary rocks). Discontinuities are stained and/or contain a filling comprising altered materials.
IV	Weathering extends throughout rock mass and the rock material is partly friable. Rock has no lustre. All materials except quartz is discoloured. Rock can be excavated with geologist's pick.
V	Rock is totally discoloured and decomposed and in a friable condition with only fragments of the rock texture appearance is that of a soil.
VI	Soil material with complete disintegration of texture, structure and mineralogy of the parent rock.

I Unweathered rock
II Slightly weathered rock
III Moderately weathered rock
IV Highly weathered rock
V Completely weathered rock
VI Residual soil

Fig. 4-7

Drilling Number	D - 2	
Location	Main Dam	Bottom Of River
Length	L = 70 m	
Level	EL. 28.423	
Direction	Vertical	

Geological Log	Depth (m)	Classification	Core Particulars: Core Shape	Core Particulars: Weathering	Core Particulars: Colour	Core Particulars: Hardness	Core Size: R.Q.D	Core Size: Recovery	Core Size: Max.Core	G.W.L	Permiability: Lugeon Value ( ) : Critical Pressure (kgf/cm²)	Casing	Drilling Method	Description
	0.20			VI	Brown		0	100	0				Dry	0.00～0.20m Soft, brown, sandy silty clay.
	7.45	D		V	Pale Brown	Soft	0	100	0				Wat er	0.20～6.00m Loose to dense, pale brown, clayey silty fine sand.
	8.75 10			III			11	100	11					6.00～8.75m Very weak, pale brown, highly fractured and partly decomposed.
				IV	Pale Brown	Mode	0	100	0		27.4			8.75～19.53m Very weak to weak, pale brown to gray, highly fractured and slightly decomposed, tuffaceous sandstone.
		CL					0	100	0					19.53～20.50m Weak, black, shale.
	19.53 20				Gray		12	100	12		14.3			20.50～22.00m Weak, pale greenish blue, tuffaceous sandstone.
	20.50 21.00 22.00				Black Pale Greenish Blue		14	100	14		21.7			22.00～25.50m Weak to moderately weak, black, partly fractured, shale. 22.20～22.35m quartz vein(70° inclination).
	25.50 26.20 26.70 27.25	CM CL CM		II	Black Pale Greenish Blue Black		26 33 11 10 48	100 100 100 100 100	15 11 11 10 17					25.50～30.00m Moderately weak to strong, pale greenish blue, partly fractured, tuffaceous sandstone.
	30.00 29.90	CH		III	Pale Greenish Blue		59 64 14	100 100 100	33 22 14	28.50	5.3 (8.3) (13/10)			30.00～33.60m Weak, black, partly fractured, shale.
	32.65 32.80 33.60	CM		II	Black Pale Greenish Blue	Hard	27 0 24	100 100 100	14 0 13		7.8			33.60～37.85m Weak, pale greenish blue, partly fractured, tuffaceous sandstone.
	36.90 37.85 39.00 40	CH		I	Black		43 0 0 28 0 15	100 100 100 100 100 100	17 0 0 18 0 15		3.8			37.85～39.00m Weak, black, shale. 39.00～48.00m Weak, pale greenish blue, gravelly fractured, tuffaceous sandstone.
	43.00 43.80	CM CL		II III	Pale Greenish Blue		31 15 0 0 0	100 100 100 100 100	17 15 0 0 0		3.2			48.00～56.30m Weak to moderately weak, pale greenish blue, partly fractured, tuffaceous sandstone.
	46.15 48.00 50	CM CL		II III			36 0 0 24 12	100 100 100 100 100	13 0 0 13 12		3.4			56.30～60.00m Moderately weak to moderately strong, pale greenish blue, partly fractured, tuffaceous sandstone.
	56.30	CM CH		II I			0 24 56 43 56 24 41 69	100 100 100 100 100 100 100 100	0 13 18 16 20 13 18 33		3.2 3.3 (10.8)			
	58.60 58.00 60	CM CH					26 50	100 100	16 19					

Geological Log

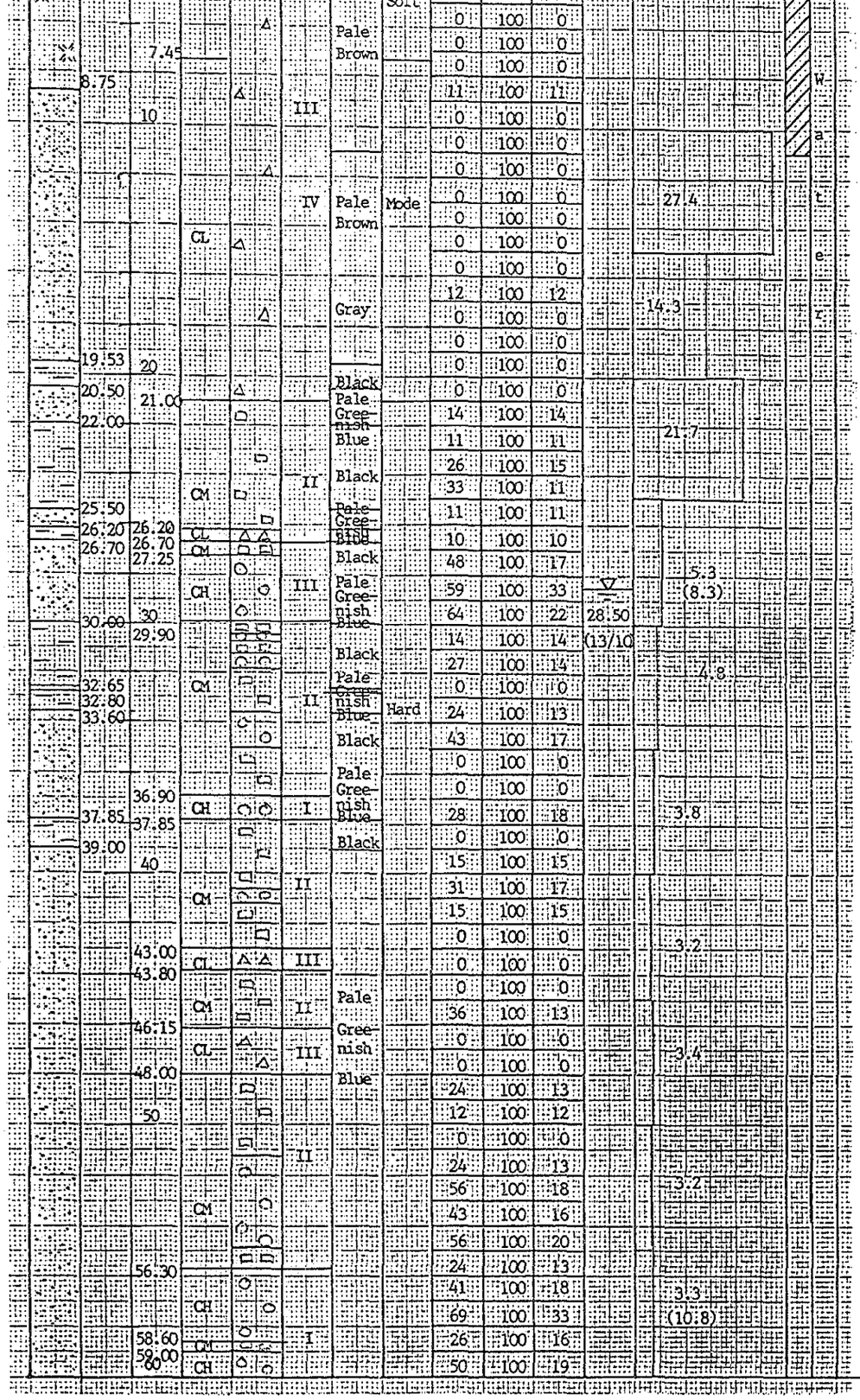
Top Soil

Tuff (fine, Green Blue)

Weathering

I No visible signs of weathering. Rock fresh, crystals bright. Few discontinuities may show slight staining.

I Unweathered rock
II Slightly weathered rock
III Moderately weathered rock
IV Highly weathered rock



Loose to dense, pale brown, clayey silty fine sand.

6.00～8.75m
Very weak, pale brown, highly fractured and partly decomposed.

8.75～19.53m
Very weak to weak, pale brown to gray, highly fractured and slightly decomposed, tuffaceous sandstone.

19.53～20.50m
Weak, black, shale.

20.50～22.00m
Weak, pale greenish blue, tuffaceous sandstone.

22.00～25.50m
Weak to moderately weak, black, partly fractured, shale.

22.20～22.35m quartz vein(70° inclination).

25.50～30.00m
Moderately weak to strong, pale greenish blue, partly fractured, tuffaceous sandstone.

30.00～33.60m
Weak, black, partly fractured, shale.

33.60～37.85m
Weak, pale greenish blue, partly fractured, tuffaceous sandstone.

37.85～39.00m
Weak, black, shale.

39.00～48.00m
Weak, pale greenish blue, gravelly fractured, tuffaceous sandstone.

48.00～56.30m
Weak to moderately weak, pale greenish blue, partly fractured, tuffaceous sandstone.

56.30～60.00m
Moderately weak to moderately strong, pale greenish blue, partly fractured, tuffaceous sandstone.

Geological Log

- Top Soil
- Tuff (fine, Greenish Blue)
- Tuffaceous Sandstone (Pale Greenish Blue
- Shale (Black)

Core Shape

- Clay – Sand
- Fragment – Rhomb
- Rhomb – Short Pole
- Pole

Hardness

Hard	A dull sound or a slightly dull sound is emitted when hammered.
Mode	Rock fragments cannot be broken by finger, but it's easy to be broken by hammer.
Soft	Rock fragments can be taken to pieces by finger.

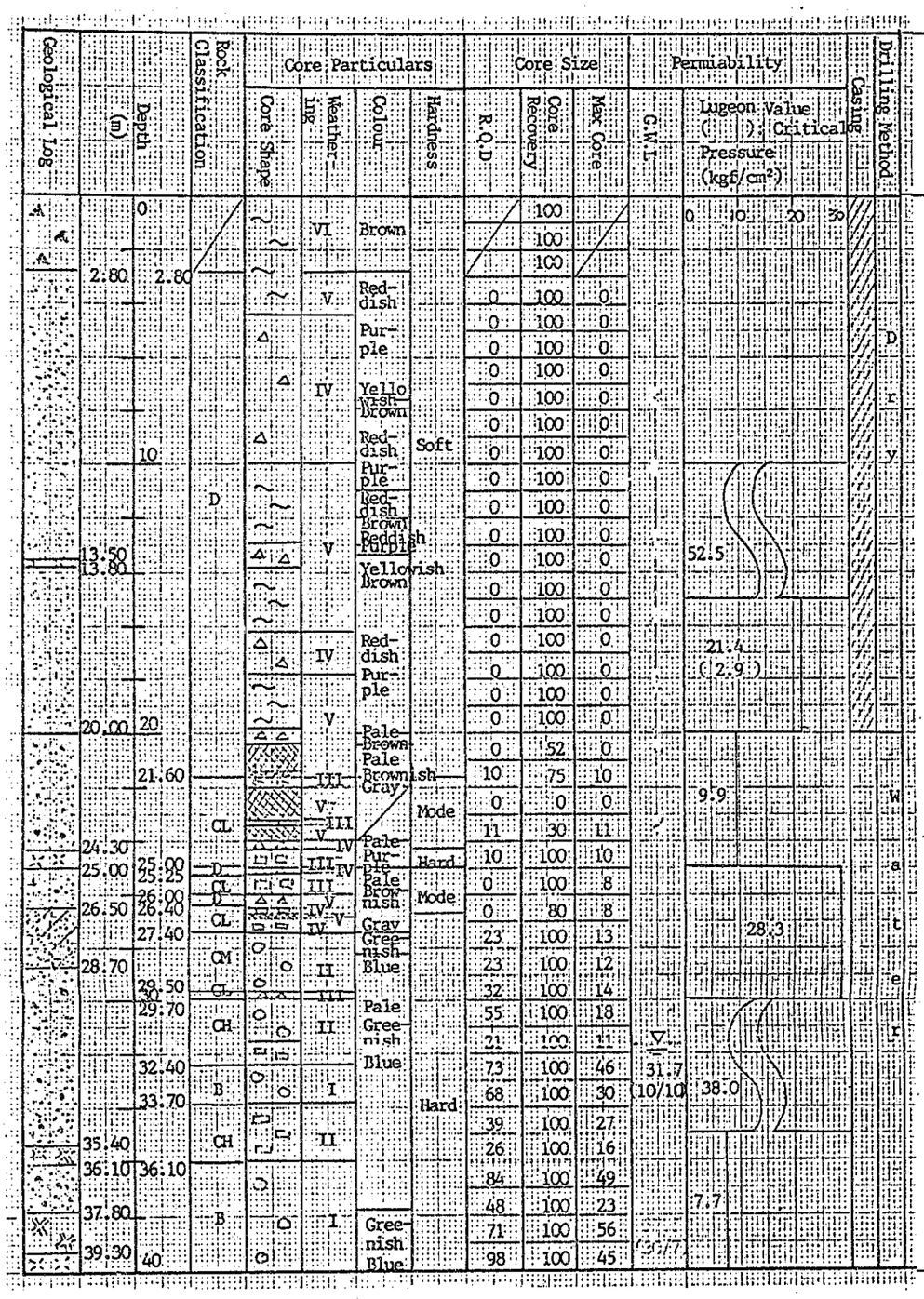
Weathering

I	No visible signs of weathering. Rock fresh, crystals bright. Few discontinuities may show slight staining.
II	Penetrative weathering developed on open discontinuity surface but only slight weathering of rock material. Discontinuities are discoloured and discolouration can extend into rock up to a few mm from discontinuity surface.
III	Slight discolouration extends through the greater part of the rock mass. The rock material is not friable (except in the case of poorly cemented sedimentary rocks). Discontinuities are stained and/or contain a filling comprising altered materials.
IV	Weathering extends throughout rock mass and the rock material is partly friable. Rock has no lustre. All material except quartz is discoloured. Rock can be excavated with geologist's pick.
V	Rock is totally discoloured and decomposed and in a friable condition with structure preserved. The external appearance is that of a soil.
VI	Soil material with complete disintegration of texture, structure and mineralogy of the parent rock.

I Unweathered rock
II Slightly weathered rock
III Moderately weathered rock
IV Highly weathered rock
V Completely weathered rock
VI Residual soil

Fig. 4-8

Drilling Number	D - 3
Location	Dam Site Right-Upper Bank
Length	L = 60 m
Level	EL. 115.109
Direction	Vertical



Description

0.00～2.80m
Firm, light to dark brown silty clay with a little sand and rootlets.

2.80～21.60m
Dense-Very dense clayey silty fine sand with a little gravels.

7.75～7.95m reddish brown
10.50～11.00m reddish brown
13.10～13.40m yellowish brown
Another section reddish purple (pink)

21.60～27.40m
Weak, tuffaceous conglomerate. fragment cores recovered 20.55～21.25m, 22.00～23.20m, 23.45～24.00m no core recovery. 24.30～25.00m purple tuff.

27.40～29.70m
Weak to moderately strong, highly fractured, tuffaceous conglomerate. Cracks are narrow with thin material.

29.70～32.40m
Maderately strong, highly fractured, tuffaceous conglomerate. Vertical crack from 30.90～31.40m.

Bellow 32.40m
Moderalely strong to very strong, partly fractured, tuffaceous conglomerate. Cracks are filled with calcite material which is dissolved partly(32.30m, 34.60m). 35.40～36.10m, 37.80～39.30m Greenish blue tuff.

Geological Log

- Top Soil and Talus Deposit
- Tuff (Purple)
- Tuff (Greenish Blue)
- Tuffaceous Sandstone
- Tuffaceous Conglomerate

Core Shape

- Clay – Sand.
- Fragment – Rhomb.
- Rhomb. – Short Cylindric
- Cylindric
- Core recovery 0 portion

Hardness

- Hard — A dull sound or a slightly dull sound is emitted when hammered.
- Mode — Rock fragments cannot be broken by finger, but it's easy to be broken by hammer.
- Soft — Rock fragments can be taken to pieces by finger.

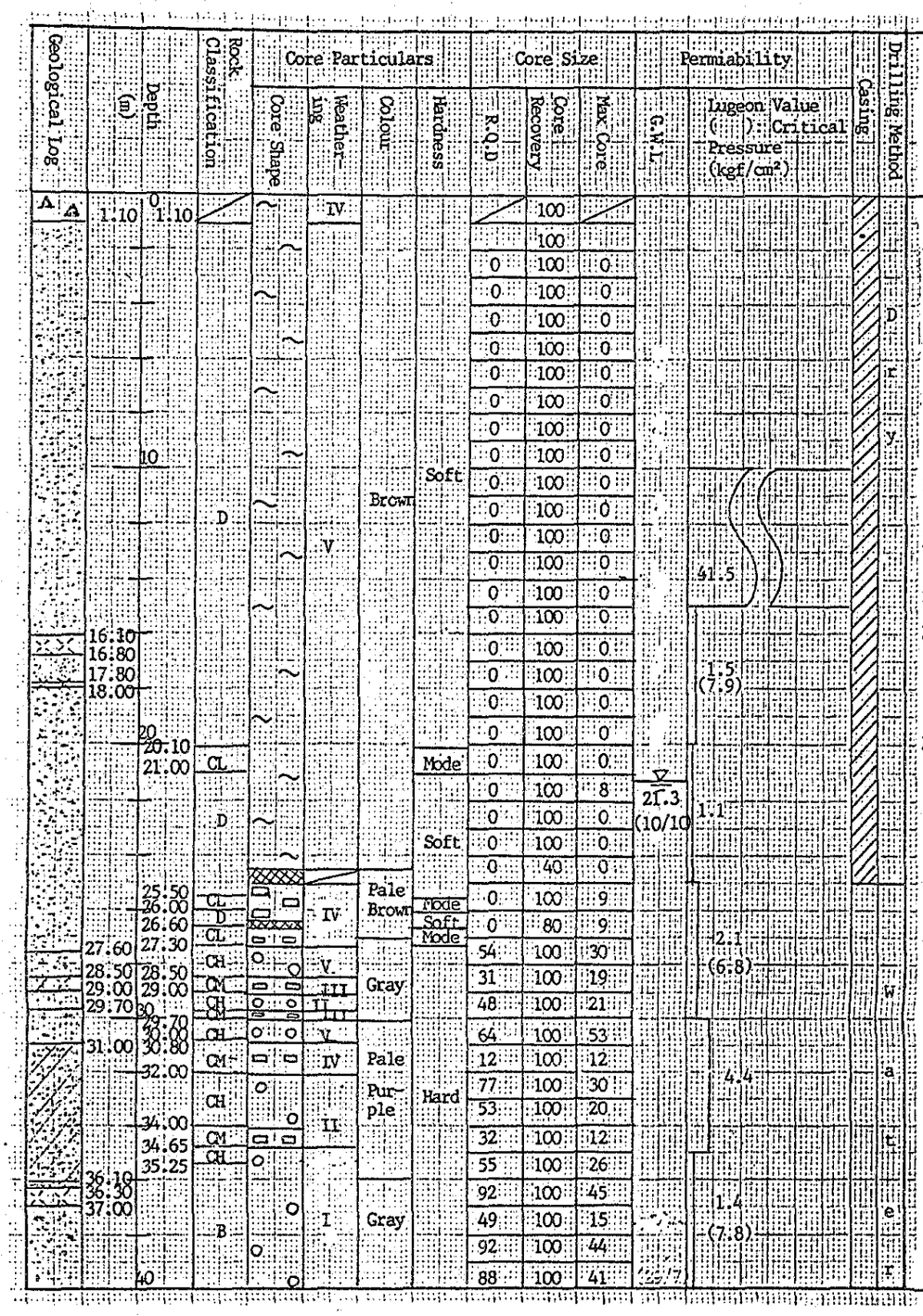
Weathering

- I — No visible signs of weathering. Rock fresh, crystals bright. Few discontinuities may show slight staining.
- II — Penetrative weathering developed on open discontinuity surface but only slight weathering of rock material. Discontinuities are discoloured and discolouration can extend into rock up to a few mm from discontinuity surface
- III — Slight discolouration extends through the greater part of the rock mass. The rock material is not friable (except in the case of poorly cemented sedimentary rocks). Discontinuities are stained and/or contain a filling comprising altered materials.
- IV — Weathering extends throughout rock mass and the rock material is partly friable. Rock has no lustre. All materials except quartz is discoloured. Rock can be excavated with geologist's pick.
- V — Rock is totally discoloured and decomposed and in a friable condition with only fragments of the rock texture and structure preserved. The external appearance is that of a soil.
- VI — Soil material with complete disintegration of texture, structure and mineralogy of the parent rock.

I Unweathered rock
II Slightly weathered rock
III Moderately weathered rock
IV Highly weathered rock
V Completely weathered rock
VI Residual soil

Fig. 4-9

Drilling Number	S-1
Location	Saddle Dam I Left-Upper Bank
Length	L = 40 m
Level	EL. 103.306
Direction	Vertical



Geological Log

- Top Soiland Talus Deposit
- Tuff (purple)
- Tuffaceous Sandstone
- Tuffaceous Conglomerate

Core Shape

- Clay - Sand
- Rhomb. - Short Pole
- Pole
- Core recovery 0 portion

Hardness

Hard	- A dull sound or a slightly dull sound is emitted when hammered.
Mode	- Rock fragments cannot be broken by finger, but it's easy to be broken by hammer.
Soft	- Rock fragments can be taken to pieces by finger.

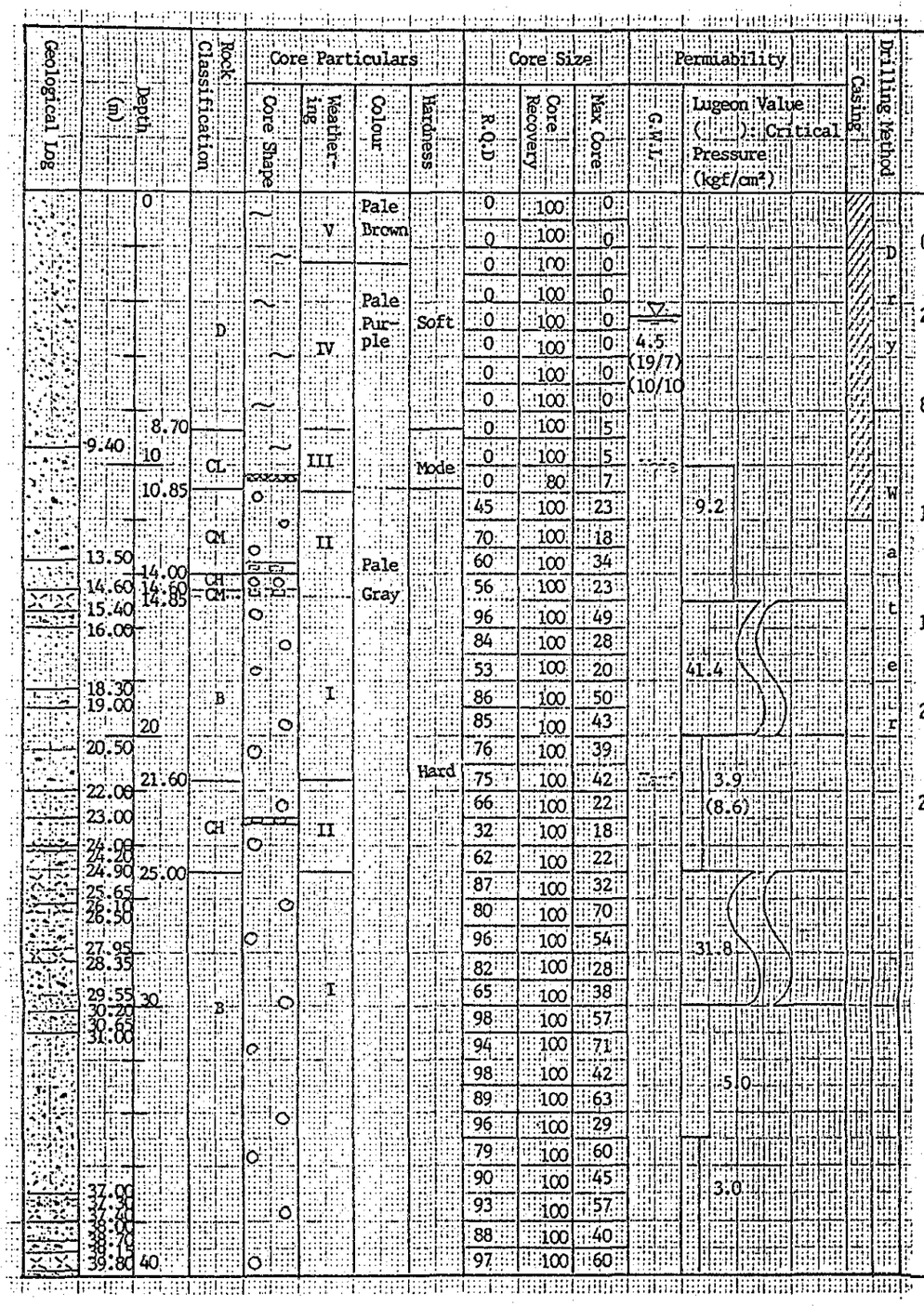
Weathering

I	No visible signs of weathering. Rock fresh, crystals bright. Few discontinuities may show slight staining.
II	Open discontinuity surface but only slight weathering of rock material. Discontinuities are discoloured and discolouration can extend into rock up to a few mm from discontinuity surface.
III	Slight discolouration extends through the greater part of the rock mass. The rock material is not friable(except in the case of poorly cemented sedimentary rocks). Discontinuities are stained and/or contain a filling comprising altered materials.
IV	Weathering extends throughout rock mass and the rock material is partly friable. Rock has no lustre. All material except quartz is discoloured. Rock can be excavated with geologist's pick.
V	Rock is totally discoloured and decomposed and in a friable condition with only fragment of the rock texture and structure preserved. The external appearance is that of a soil.
VI	Soil material with complete disintegration of texture, structure and mineralogy of the parent rock.

I Unweathered rock
II Slightly weathered rock
III Moderately weathered rock
IV Highly weathered rock
V Completely weathered rock
VI Residual soil

Fig. 4-10

Drilling Number	S - 2
Location	Saddle Dam I Left -Lower Bank
Length	L = 40 m
Level	EL. 73 . 026
Direction	Vertical



Description

0.00～2.50m
Loose, pale brown, clayey silty sand.

2.50～8.70m
Medium dense, pale purple, clayey silt sand with a little rock fragments.

8.70～10.85m
Very weak, gravelly and highly decomposed tuffaceous sandstone-conglomerate, cracks are narrow with fine grained material.

10.85～14.00m
Moderately weak to moderately strong, tuffaceous conglomerate.
Lamina is remarkable(50° ～60° inclination).

14.00～21.60m
Moderately strong to very strong, tuffaceous sandstone-conglomerate.

21.60～25.00m
Moderately strong, tuffaceous sandstone-conglomerate.

25.00～40.00m
Very strong, alternation which consists of tuffaceous sandstone, tuffaceous conglomerate and tuff.

Geological Log

- Tuff (purple)
- Tuffaceous Sandstone
- Tuffaceous Conglomerate

Core Shape

- Clay - Sand
- Pole
- Rhomb. - Short Pole
- Core recovery 0 portion

Hardness

Hard - A dull sound or a slightly dull sound is emitted when hammered.

Mode - Rock fragments cannot be broken by finger, but it's easy to be broken by hammer.

Soft - Rock fragments can be taken to pieces by finger.

Weathering

I No visible signs of weathering. Rock fresh, crystals bright. Few discontinuities may show slight staining.

II Penetrative weathering developed on open discontinuity surface but only slight weathering of rock material. Discontinuities are discoloured and discolouration can extend into rock up to a few mm from discontinuity surface.

III Slight discolouration extends through the greater part of the rock mass. The rock material is not friable(except in the case of poorly cemented sedimentary rocks). Discontinuities are stained and/or contain a filling comprising altered materials.

IV Weathering extends throughout rock mass and the rock material is partly friable. Rock has no lustre. All material except quartz is discoloured. Rock can be excavated with geologist's pick.

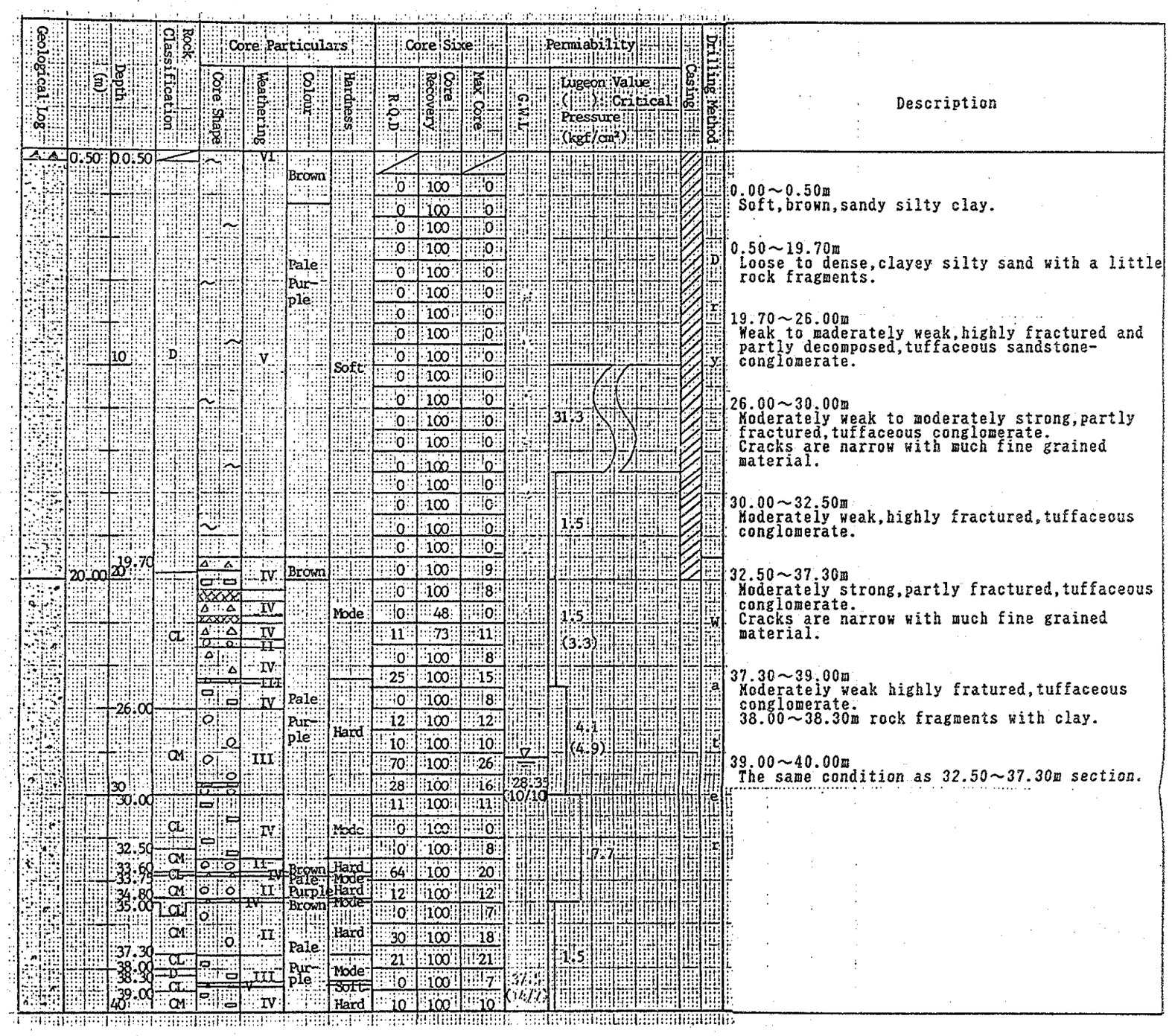
V Rock is totally discoloured and decomposed and in a friable condition with only fragment of the rock texture and structure preserved. The external appearance is that of a soil.

VI Soil material with complete disintegration of texture, structure and mineralogy of the parent rock.

I Unweathered rock
II Slightly weathered rock
III Moderately weathered rock
IV Highly weathered rock
V Completely weathered rock
VI Residual soil

Fig. 4-11

Drilling Number	S - 3
Location	Saddle Dam I Bottom Of River
Length	L = 40 m
Level	EL. 43 . 108
Direction	Vertical



Geological Log

- Top Soil
- Tuffaceous Sandstone
- Tuffaceous Conglomerate

Core Shape

- Clay - Sand
- Fragment - Rhomb.
- Rhomb. - Short Pole
- Pole
- Core recovery 0 portion

Hardness

- Hard - A dull sound or a slightly dull sound is emitted when hammered.
- Mode - Rock fragments cannot be broken by finger, but it's easy to be broken by hammer.
- Soft - Rock fragments can be taken to pieces by finger.

Weathering

- I — No visible signs of weathering. Rock fresh, crystals bright. Few discontinuities may show slight staining.
- II — Open discontinuity surface but only slight weathering of rock material. Discontinuities are discoloured and discolouration can extend into rock up to a few mm from discontinuity surface.
- III — Slight discolouration extends through the greater part of the rock mass. The rock material is not friable(except in the case of poorly cemented sedimentary rocks). Discontinuities are stained and/or contain a filling comprising altered materials.
- IV — Weathering extends throughout rock mass and the rock material is partly friable. Rock has no lustre. All material except quartz is discoloured. Rock can be excavated with geologist's pick.
- V — Rock is totally discoloured and decomposed and in a friable condition with only fragment of the rock texture and structure preserved. The external appearance is that of a soil.
- VI — Soil material with complete disintegration of texture, structure and mineralogy of the patent rock.

I Unweathered rock
II Slightly weathered rock
III Moderately weathered rock
IV Highly weathered rock
V Completely weathered rock
VI Residual soil

Fig. 4-12

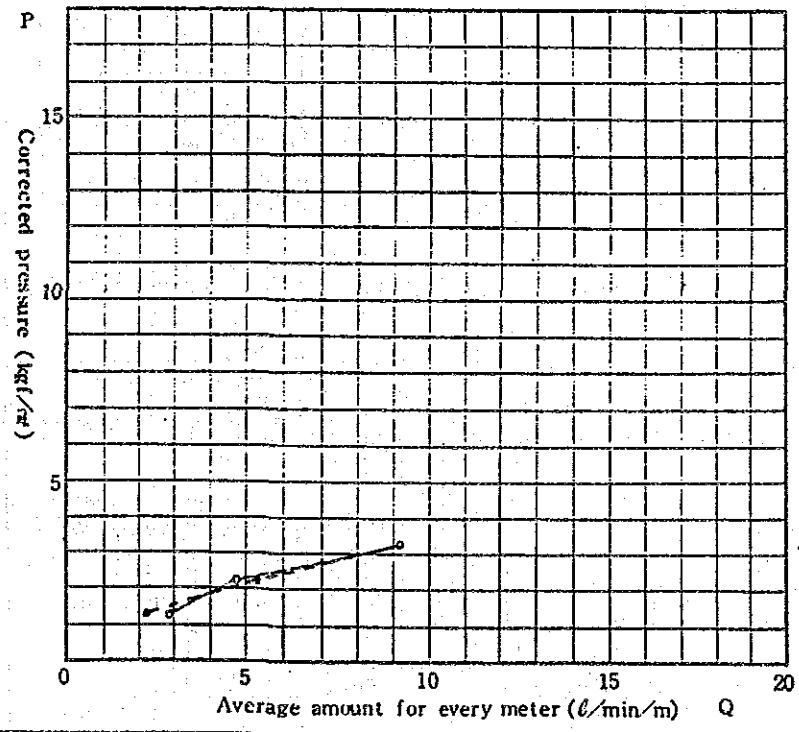
Drilling Number	S - 4
Location	Saddle Dam I Right Upper Bank
Length	L = 40 m
Level	EL. 108 . 789
Direction	Vertical

Lugeon Test Data Sheet

Stage No. 1

Location	Main Dam	Name of hole	D - 1	Depth (m)	10.0~15.0	Length of test section (m)	5.0
Water Level (m)	Nothing	Hight of gauge (m)	1.0	Length of rod (m)	11.0	Direction, Dip	Vertical
Diamiter of pipe (mm)	35	Type of packer	Expansion			Date	15/8

Reading of gauge Po (kgf/cm²)	Head loss h_3 (m)	Corrected pressure P (kgf/cm²)	Amount of injection per minutes (ℓ) 1	2	3	4	5	Average amount Q_0 (ℓ/min)	Average amount for every meter Q (ℓ/min/m)
			6	7	8	9	10		
0.0	0.2	1.3	14	15	6	22	15	14.3	2.9
			14	15	14	14	14		
1.0	0.5	2.3	23	25	22	26	23	24.2	4.8
			28	21	25	23	26		
2.0	1.6	3.2	42	49	51	46	46	45.9	9.2
			41	46	45	45	48		
1.0	0.5	2.3	25	23	29	28	26	26.6	5.3
			28	27	26	28	26		
0.0	0.1	1.3	12	12	12	11	12	11.0	2.2
			11	11	10	9	10		



Lugeon value (Lu)	-
Calculated Lugeon Value (Lu')	31.7
Maximum pressure (kgf/cm²)	3.2
Critical pressure (kgf/cm²)	-

$P = P_0 + \gamma_w (h_1 - h_2 - h_3)$ (kgf/cm²)

P : Corrected pressure (kgf/cm²)

P_0 : Reading of gauge (kgf/cm²)

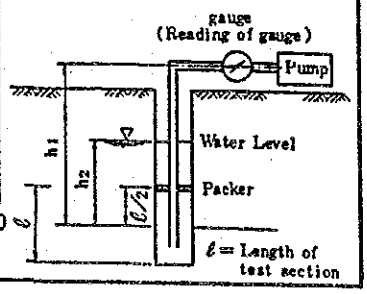
γ_w : Unitweight of water

$h_3 = \alpha Q_0^2 L$

Q_0 : Average amount (ℓ/min)

L : Length of Rod (m)

α : A coefficient (7×10^{-5} min²/ℓ²)



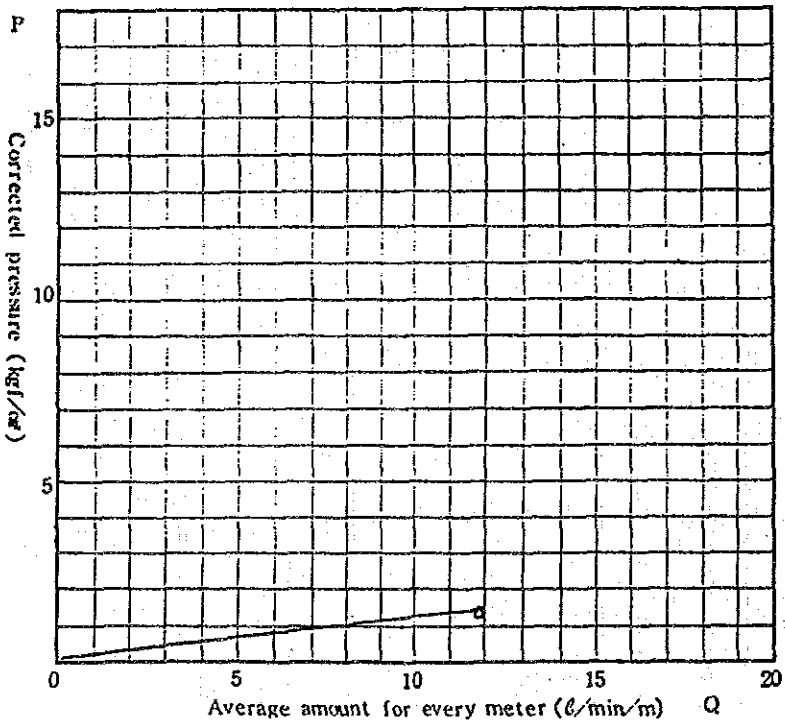
Lugeon Test Data Sheet

Stage No. 2

Location	Main Dam	Name of hole	D - 1	Depth (m)	15.0~20.0	Length of test section (m)	5.0
Water Level (m)	Nothing	Hight of gauge (m)	0.5	Length of rod (m)	15.5	Direction, Dip	Vertical
Diamiter of pipe (mm)	35	Type of packer	Expansion			Date	16/8

Reading of gauge Po (kgf/cm²)	Head loss h_3 (m)	Corrected pressure P (kgf/cm²)	Amount of injection per minutes (ℓ) 1	2	3	4	5	Average amount Q_0 (ℓ/min)	Average amount for every meter Q (ℓ/min/m)
			6	7	8	9	10		
			61	60	59	57	65		
0.0	3.8	1.4	61	60	59	57	55	59.4	11.9

Open crack exist in 15.50 - 16.00m in depth. The water injected leak through these cracks.
There was not water return from the mouth of the hole.



Lugeon value (Lu)	—
Calculated Lugeon Value (Lu')	—
Maximum pressure (kgf/cm²)	—
Critical pressure (kgf/cm²)	—

$P = P_0 + \gamma_w (h_1 - h_2 - h_3)$ (kgf/cm²)

P : Corrected pressure (kgf/cm²)

P_0 : Reading of gauge (kgf/cm²)

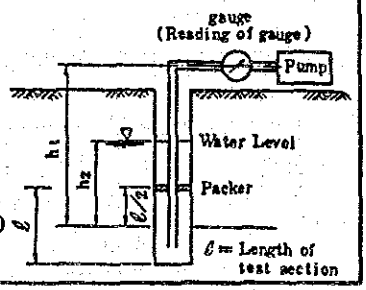
γ_w : Unitweight of water

$h_3 = \alpha Q_0^2 L$

Q_0 : Average amount (ℓ/min)

L : Length of Rod (m)

α : A coefficient (7×10^{-5} min²/ℓ²)

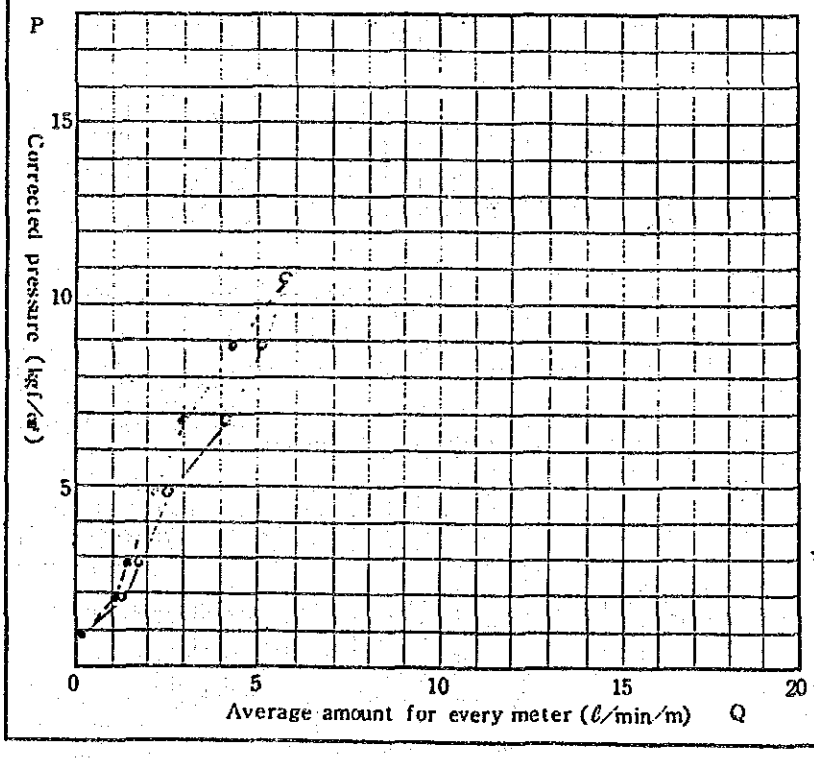


Lugeon Test Data Sheet

Stage No. 3

Location	Main Dam	Name of hole	D - 1	Depth (m)	20.0~ 25.0	Length of test section (m)	5.0
Water Level (m)	8.0	Hight of gauge (m)	1.5	Length of rod (m)	21.5	Direction, Dip	Vertical
Diamiter of pipe (mm)	35	Type of packer	Expansion			Date	17/8

Reading of gauge P_0 (kgf/cm²)	Head loss h_3 (m)	Corrected pressure P (kgf/cm²)	Amount of injection per minutes (ℓ) 1	2	3	4	5	Average amount Q_0 (ℓ/min)	Average amount for every meter Q (ℓ/min/m)
			6	7	8	9	10		
0.0	0.0	0.9	0	1	0	1	0	0.4	0.1
			0	1	0	1	0		
1.0	0.1	1.9	6	7	5	6	6	6.1	1.2
			5	7	7	6	6		
2.0	0.1	2.9	9	10	11	8	9	9.2	1.8
			10	9	8	9	9		
4.0	0.2	4.9	12	13	13	12	11	12.8	2.6
			11	11	12	11	22		
6.0	0.6	6.9	18	20	19	37	18	20.7	4.1
			18	18	20	20	19		
8.0	1.0	8.9	25	24	25	26	27	25.3	5.1
			25	25	26	26	24		
10.0	1.2	10.8	30	28	29	29	29	28.8	5.8
			30	28	29	28	28		
8.0	0.7	8.9	22	21	23	22	23	22.1	4.4
			22	21	22	22	23		
6.0	0.3	6.9	16	15	15	15	15	15.2	3.0
			14	15	15	16	16		
4.0	0.2	4.9	10	11	12	11	11	10.8	2.2
			11	10	10	11	11		
2.0	0.1	2.9	9	8	8	8	9	7.9	1.6
			8	9	8	7	5		
1.0	0.0	1.9	6	5	5	4	4	5.3	1.1
			6	6	6	6	5		
0.0	0.0	0.9	1	0	1	0	1	0.5	0.1
			0	0	1	0	1		



Lugeon value (Lu)	5.5
Calculated Lugeon Value (Lu')	–
Maximum pressure (kgf/cm²)	10.8
Critical pressure (kgf/cm²)	–

$P = P_0 + \gamma_w (h_1 - h_2 - h_3)$ (kgf/cm²)

P : Corrected pressure (kgf/cm²)

P_0 : Reading of gauge (kgf/cm²)

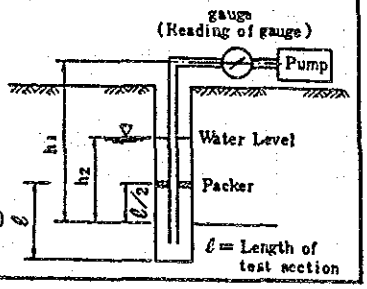
γ_w : Unitweight of water

$h_3 = \alpha Q_0^2 L$

Q_0 : Average amount (ℓ/min)

L : Length of Rod (m)

α : A coefficient (7×10^{-5} min²/ℓ²)

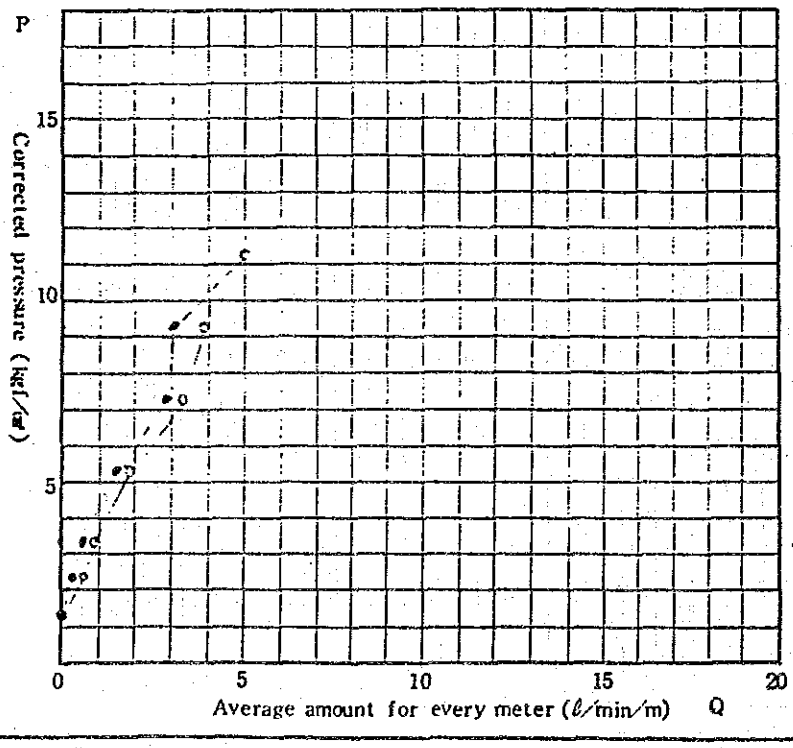


Lugeon Test Data Sheet

Stage No. 4

Location	Main Dam	Name of hole	D - 1	Depth (m)	25.0 ~ 30.0	Length of test section (m)	5.0
Water Level (m)	8.0	Hight of gauge (m)	5.0	Length of rod (m)	25.5	Direction, Dip	Vertical
Diamiter of pipe (mm)	35	Type of packer	Expansion			Date	20/8

Reading of gauge Po (kgf/cm²)	Head loss h_3 (m)	Corrected pressure P (kgf/cm²)	Amount of injection per minutes (ℓ) 1	2	3	4	5	Average amount Q_0 (ℓ/min)	Average amount for every meter Q (ℓ/min/m)
			6	7	8	9	10		
0.0	0.0	1.3	0	1	0	0	1	0.3	0.1
			0	0	1	0	0		
1.0	0.0	2.3	4	4	4	2	2	2.8	0.6
			3	4	3	1	1		
2.0	0.0	3.3	5	6	6	5	4	4.5	0.9
			5	3	5	3	3		
4.0	0.2	5.3	4	11	11	11	11	9.7	1.9
			10	11	9	9	10		
6.0	0.5	7.3	17	16	15	16	17	16.2	3.2
			17	16	16	16	16		
8.0	0.7	9.2	19	20	20	20	19	19.3	3.9
			20	19	18	19	19		
10.0	1.1	11.2	26	49	24	24	15	25.1	5.0
			24	25	25	14	25		
8.0	0.4	9.3	17	17	16	16	10	15.6	3.1
			14	17	16	16	17		
6.0	0.4	7.3	14	13	23	14	14	14.7	2.9
			13	14	14	14	14		
4.0	0.1	5.3	8	8	8	7	7	7.6	1.5
			6	8	8	8	8		
2.0	0.0	3.3	3	3	4	3	2	3.1	0.6
			4	3	3	3	3		
1.0	0.0	2.3	1	2	2	1	1	1.7	0.3
			1	3	2	2	2		
0.0	0.0	1.3	0	0	0	1	0	0.3	0.1
			0	1	0	0	1		



Lugeon value (Lu)	4.3
Calculated Lugeon Value (Lu')	-
Maximum pressure (kgf/cm²)	11.2
Critical pressure (kgf/cm²)	-

$P = P_0 + \gamma_w (h_1 - h_2 - h_3)$ (kgf/cm²)

P : Corrected pressure (kgf/cm²)

P_0 : Reading of gauge (kgf/cm²)

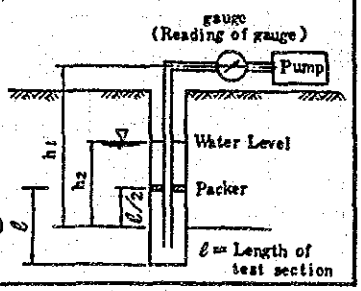
γ_w : Unitweight of water

$h_3 = \alpha Q_0^2 L$

Q_0 : Average amount (ℓ/min)

L : Length of Rod (m)

α : A coefficient (7×10^{-5} min²/ℓ²)

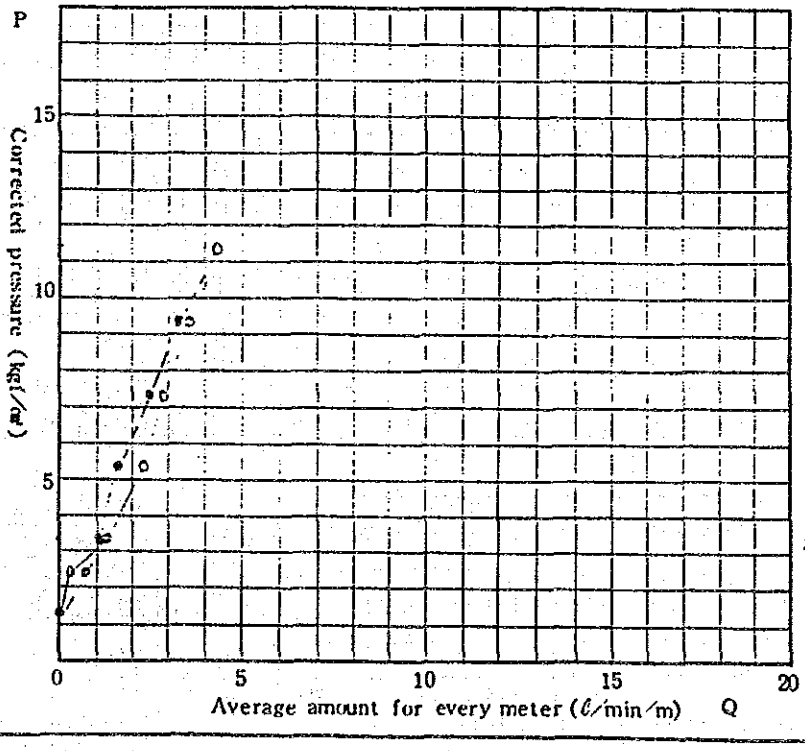


Lugeon Test Data Sheet

Stage No. 5

Location	Main Dam	Name of hole	D - 1	Depth (m)	30.0~35.0	Length of test section (m)	5.0
Water Level (m)	9.2	Hight of gauge (m)	5.0	Length of rod (m)	30.5	Direction, Dip	Vertical
Diamiter of pipe (mm)	35	Type of packer	Expansion			Date	22/8

Reading of gauge P_0 (kgf/cm²)	Head loss h_3 (m)	Corrected pressure P (kgf/cm²)	Amount of injection per minutes (ℓ) 1	2	3	4	5	Average amount Q_0 (ℓ/min)	Average amount for every meter Q (ℓ/min/m)
			6	7	8	9	10		
0.0	0.0	1.4	0 / 0	0 / 0	0 / 1	1 / 0	0 / 0	0.2	0.0
1.0	0.0	2.4	1 / 2	1 / 2	1 / 2	2 / 2	1 / 2	1.6	0.3
2.0	0.1	3.4	5 / 6	6 / 6	6 / 6	6 / 6	6 / 5	5.8	1.2
4.0	0.3	5.4	10 / 11	11 / 11	11 / 11	11 / 11	12 / 11	11.0	2.2
6.0	0.5	7.4	14 / 15	15 / 16	14 / 15	15 / 14	15 / 13	14.6	2.9
8.0	0.7	9.4	19 / 18	17 / 17	18 / 19	17 / 18	16 / 19	17.8	3.6
10.0	1.0	11.3	20 / 22	21 / 21	26 / 20	21 / 21	21 / 20	21.3	4.3
8.0	0.6	9.4	18 / 17	17 / 17	18 / 18	17 / 16	18 / 16	17.2	3.4
6.0	0.4	7.4	12 / 11	13 / 14	14 / 13	13 / 13	12 / 14	12.9	2.6
4.0	0.2	5.4	10 / 9	9 / 9	8 / 8	10 / 8	10 / 8	8.7	1.7
2.0	0.1	3.4	5 / 5	7 / 6	6 / 5	6 / 5	5 / 6	5.6	1.1
1.0	0.0	2.4	3 / 3	3 / 3	3 / 3	3 / 3	12 / 2	3.8	0.8
0.0	0.0	1.4	0 / 0	0 / 1	0 / 0	0 / 0	0 / 0	0.1	0.0



Lugeon value (Lu)	3.8
Calculated Lugeon Value (Lu')	-
Maximum pressure (kgf/cm²)	11.3
Critical pressure (kgf/cm²)	-

$P = P_0 + \gamma_w (h_1 - h_2 - h_3)$ (kgf/cm²)

P : Corrected pressure (kgf/cm²)

P_0 : Reading of gauge (kgf/cm²)

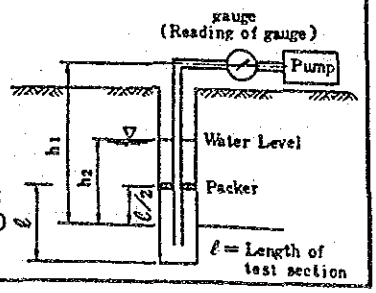
γ_w : Unitweight of water

$h_3 = \alpha Q_0^2 L$

Q_0 : Average amount (ℓ/min)

L : Length of Rod (m)

α : A coefficient (7×10^{-5} min²/ℓ²)

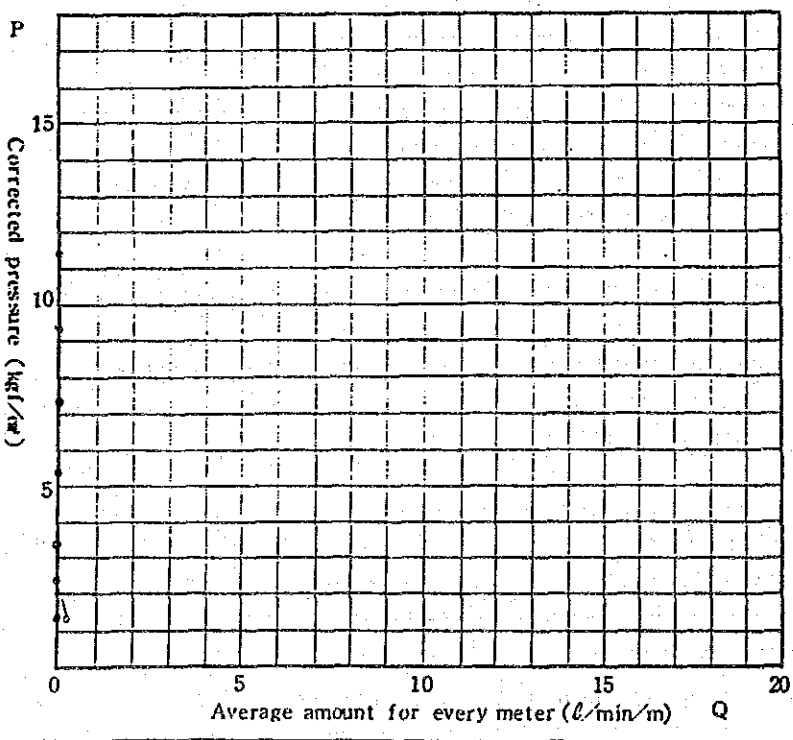


Lugeon Test Data Sheet

Stage No. 6

Location	Main Dam	Name of hole	D - 1	Depth (m)	35.0~40.0	Length of test section (m)	5.0
Water Level (m)	8.7	Hight of gauge (m)	5.0	Length of rod (m)	36.5	Direction, Dip	Vertical
Diamiter of pipe (mm)	35	Type of packer	Expansion			Date	23/8

Reading of gauge Po (kgf/cm²)	Head loss h_3 (m)	Corrected pressure P (kgf/cm²)	Amount of injection per minutes (ℓ) 1	2	3	4	5	Average amount Q_0 (ℓ/min)	Average amount for every meter Q (ℓ/min/m)
			6	7	8	9	10		
0.0	0.0	1.4	0	1	2	1	1	1.1	0.2
			1	1	2	1	1		
1.0	0.0	2.4	1	0	1	0	0	0.2	0.0
			0	0	0	0	0		
2.0	0.0	3.4	0	0	0	0	0	0.1	0.0
			1	0	0	0	0		
4.0	0.0	5.4	0	0	0	0	0	0.1	0.0
			0	1	0	0	0		
6.0	0.0	7.4	0	0	0	0	0	0.1	0.0
			0	1	0	0	0		
8.0	0.0	9.4	0	0	0	0	0	0.0	0.0
			0	0	0	0	0		
10.0	0.0	11.4	0	0	0	0	0	0.0	0.0
			0	0	0	0	0		
8.0	0.0	9.4	0	0	0	0	0	0.0	0.0
			0	0	0	0	0		
6.0	0.0	7.4	0	0	0	0	0	0.0	0.0
			0	0	0	0	0		
4.0	0.0	5.4	0	0	0	0	0	0.0	0.0
			0	0	0	0	0		
2.0	0.0	3.4	0	0	1	0	0	0.1	0.0
			0	0	0	0	0		
1.0	0.0	2.4	0	0	0	0	0	0.0	0.0
			0	0	0	0	0		
0.0	0.0	1.4	0	0	0	0	0	0.0	0.0
			0	0	0	0	0		



Lugeon value (Lu)	0.0
Calculated Lugeon Value (Lu')	-
Maximum pressure (kgf/cm²)	11.4
Critical pressure (kgf/cm²)	-

$P = P_0 + \gamma_w (h_1 - h_2 - h_3)$ (kgf/cm²)

P : Corrected pressure (kgf/cm²)

P_0 : Reading of gauge (kgf/cm²)

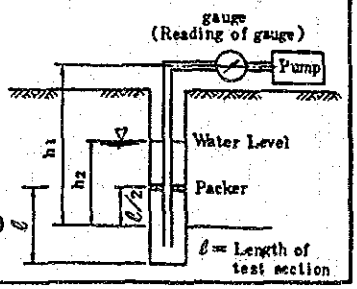
γ_w : Unitweight of water

$h_3 = \alpha Q_0^2 L$

Q_0 : Average amount (ℓ/min)

L : Length of Rod (m)

α : A coefficient (7×10^{-5} min²/ℓ²)

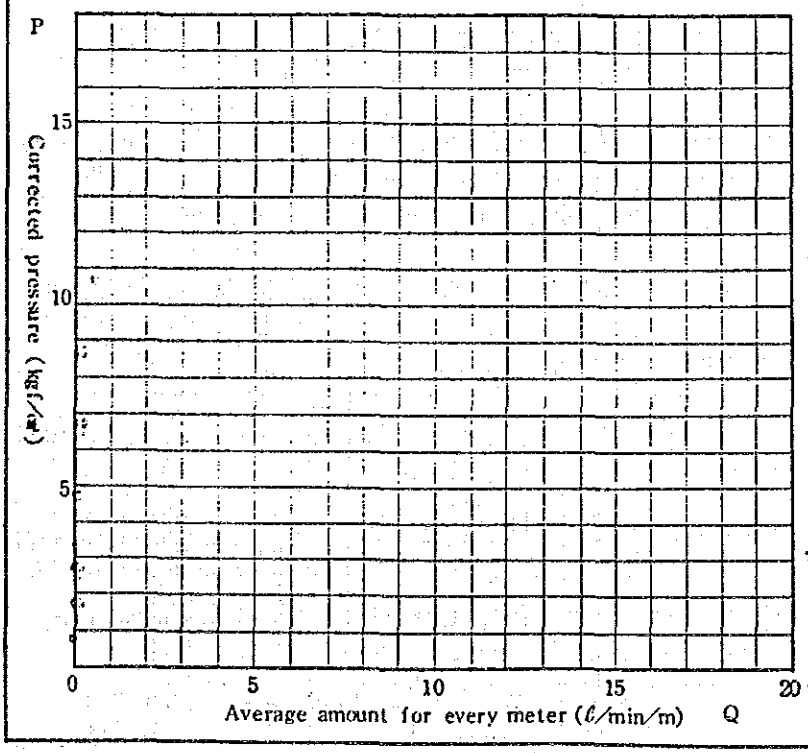


Lugeon Test Data Sheet

Stage No. 7

Location	Main Dam	Name of hole	D - 1	Depth (m)	40.0~45.0	Length of test section (m)	5.0
Water Level (m)	8.0	Hight of gauge (m)	0.5	Length of rod (m)	40.5	Direction, Dip	Vertical
Diamiter of pipe (mm)	35	Type of packer	Expansion			Date	24/8

Reading of gauge P_0 (kgf/cm²)	Head loss h_3 (m)	Corrected pressure P (kgf/cm²)	Amount of injection per minutes (ℓ) 1	2	3	4	5	Average amount Q_0 (ℓ/min)	Average amount for every meter Q (ℓ/min/m)
			6	7	8	9	10		
0.0	0.0	0.8	0	0	0	2	0	0.2	0.0
			0	0	0	0	0		
1.0	0.0	1.8	1	0	0	0	1	0.3	0.1
			0	0	0	0	1		
2.0	0.0	2.8	1	0	1	0	1	0.7	0.1
			1	1	0	1	1		
4.0	0.0	4.8	1	0	0	1	0	0.4	0.1
			0	0	1	1	0		
6.0	0.0	6.8	3	1	2	2	2	1.7	0.3
			2	1	1	2	1		
8.0	0.0	8.8	4	2	2	2	2	1.4	0.3
			0	1	1	0	0		
10.0	0.0	10.8	2	3	2	3	3	2.9	0.6
			3	3	3	4	3		
8.0	0.0	8.8	0	1	0	0	0	0.4	0.1
			0	2	0	1	0		
6.0	0.0	6.8	1	0	0	0	1	0.4	0.1
			1	0	1	0	0		
4.0	0.0	4.8	0	0	0	0	1	0.1	0.0
			0	0	0	0	0		
2.0	0.0	2.9	0	0	0	0	0	0.0	0.0
			0	0	0	0	0		
1.0	0.0	1.8	0	0	1	0	0	0.1	0.0
			0	0	0	0	0		
0.0	0.0	0.9	0	0	0	0	0	0.0	0.0
			0	0	0	0	0		



Lugeon value (Lu)	0.5
Calculated Lugeon Value (Lu')	-
Maximum pressure (kgf/cm²)	10.8
Critical pressure (kgf/cm²)	-

$P = P_0 + \gamma_w (h_1 - h_2 - h_3)$ (kgf/cm²)

P : Corrected pressure (kgf/cm²)

P_0 : Reading of gauge (kgf/cm²)

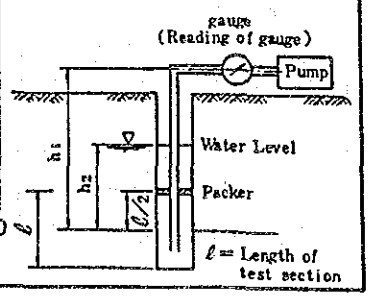
γ_w : Unitweight of water

$h_3 = \alpha Q_0^2 L$

Q_0 : Average amount (ℓ/min)

L : Length of Rod (m)

α : A coefficient (7×10^{-5} min²/ℓ²)

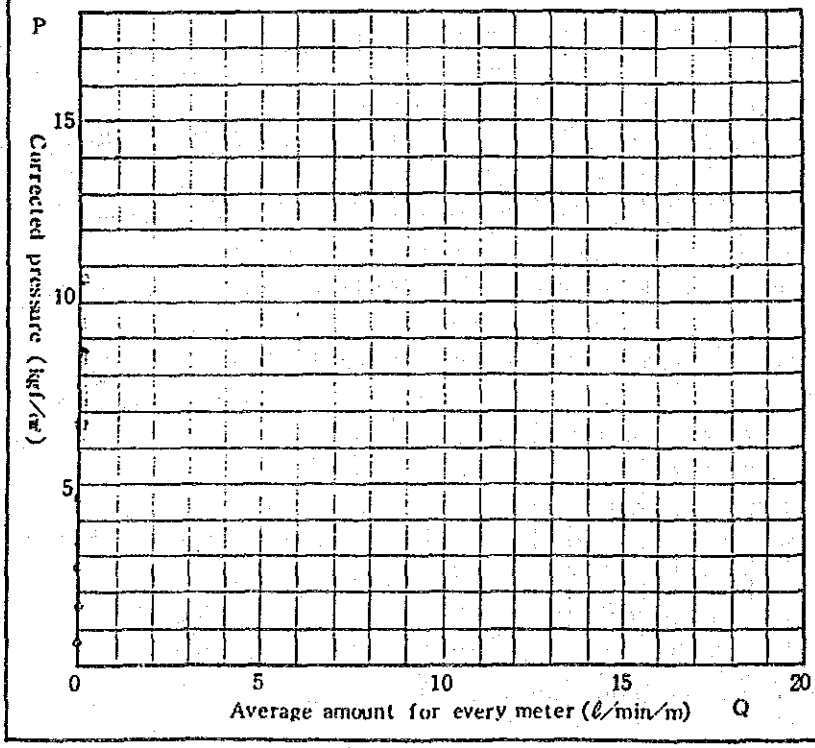


Lugeon Test Data Sheet

Stage No. 8

Location	Main Dam	Name of hole	D - 1	Depth (m)	45.0 ~ 50.0	Length of test section (m)	5.0
Water Level (m)	6.9	Hight of gauge (m)	0.5	Length of rod (m)	45.5	Direction, Dip	Vertical
Diamiter of pipe (mm)	35	Type of packer	Expansion			Date	25/8

Reading of gauge Po (kgf/cm²)	Head loss h_3 (m)	Corrected pressure P (kgf/cm²)	Amount of injection per minutes (ℓ) 1	2	3	4	5	Average amount Q_0 (ℓ/min)	Average amount for every meter Q (ℓ/min/m)
			6	7	8	9	10		
0.0	0.0	0.7	0	0	1	0	0	0.2	0.0
			0	0	1	0	0		
1.0	0.0	1.7	0	0	0	1	0	0.2	0.0
			0	0	1	0	0		
2.0	0.0	2.7	1	0	0	0	0	0.2	0.0
			0	1	0	0	0		
4.0	0.0	4.7	0	0	0	0	1	0.2	0.0
			0	0	1	0	0		
6.0	0.0	6.7	0	0	0	1	0	0.3	0.1
			1	0	0	1	0		
8.0	0.0	8.7	0	1	0	1	0	0.4	0.1
			1	0	0	1	0		
10.0	0.0	10.7	0	0	1	1	1	0.6	0.1
			1	1	0	1	0		
8.0	0.0	8.7	0	1	0	0	1	0.3	0.1
			0	0	1	0	0		
6.0	0.0	6.7	0	0	1	0	0	0.2	0.0
			0	1	0	0	0		
4.0	0.0	4.7	0	0	1	0	0	0.2	0.0
			0	0	0	0	1		
2.0	0.0	2.7	0	0	0	0	0	0.1	0.0
			1	0	0	0	0		
1.0	0.0	1.7	0	0	0	0	0	0.1	0.0
			0	0	0	1	0		
0.0	0.0	0.7	0	0	0	0	0	0.1	0.0
			0	0	0	1	0		



Lugeon value (Lu)	0.1
Calculated Lugeon Value (Lu')	-
Maximum pressure (kgf/cm²)	10.7
Critical pressure (kgf/cm²)	-

$P = P_0 + \gamma_w (h_1 - h_2 - h_3)$ (kgf/cm²)

P : Corrected pressure (kgf/cm²)

P_0 : Reading of gauge (kgf/cm²)

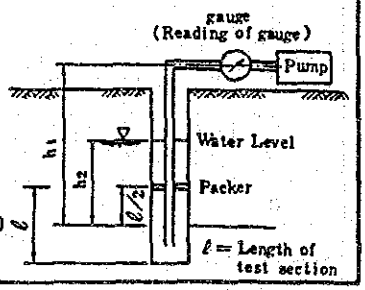
γ_w : Unitweight of water

$h_3 = \alpha Q_0^2 L$

Q_0 : Average amount (ℓ/min)

L : Length of Rod (m)

α : A coefficient (7×10^{-5} min²/ℓ²)

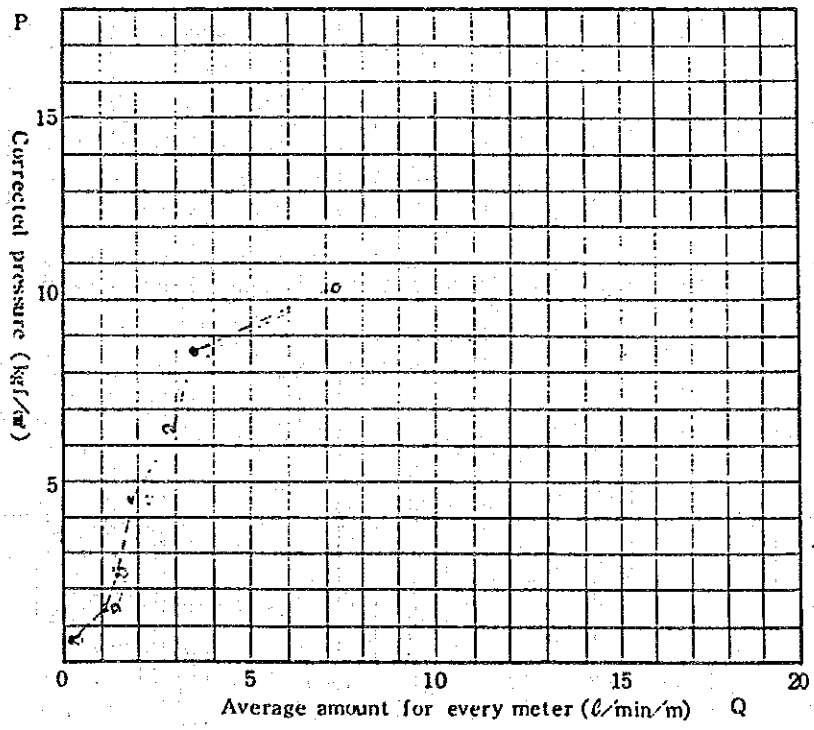


Lugeon Test Data Sheet

Stage No. 9

Location	Main Dam	Name of hole	D - 1	Depth (m)	50.0~55.0	Length of test section (m)	5.0
Water Level (m)	7.1	Hight of gauge (m)	0.5	Length of rod (m)	50.5	Direction, Dip	Vertical
Diamiter of pipe (mm)	35	Type of packer	Expansion			Date	26/8

Reading of gauge P_0 (kgf/cm²)	Head loss h_3 (m)	Corrected pressure P (kgf/cm²)	Amount of injection per minutes (ℓ) 1	2	3	4	5	Average amount Q_0 (ℓ/min)	Average amount for every meter Q (ℓ/min/m)
			6	7	8	9	10		
0.0	0.0	0.8	2	2	1	1	1	2.0	0.4
			2	2	4	3	2		
1.0	0.2	1.7	1	6	8	6	7	6.8	1.4
			8	8	9	7	8		
2.0	0.2	2.7	9	9	8	9	8	8.2	1.6
			8	7	9	8	7		
4.0	0.5	4.7	12	12	12	11	11	11.3	2.3
			11	12	11	11	10		
6.0	0.7	6.7	16	15	14	14	14	14.2	2.8
			14	13	14	15	13		
8.0	1.4	8.6	16	20	20	20	20	19.7	3.9
			20	21	20	21	19		
10.0	4.5	10.3	38	37	36	37	36	35.8	7.2
			37	38	27	36	36		
8.0	1.2	8.6	16	21	18	17	17	18.2	3.6
			19	19	19	19	17		
6.0	0.8	6.7	14	15	15	15	14	14.7	2.9
			14	15	15	15	15		
4.0	0.3	4.7	10	10	11	11	10	9.6	1.9
			9	9	9	9	8		
2.0	0.2	2.7	8	8	8	8	8	7.3	1.5
			7	7	7	6	6		
1.0	0.1	1.7	6	6	6	5	5	5.4	1.1
			6	5	5	5	5		
0.0	0.0	0.8	1	1	2	2	1	1.0	0.2
			1	0	1	1	0		



Lugeon value (Lu)	-
Calculated Lugeon Value (Lu')	4.4
Maximum pressure (kgf/cm²)	10.3
Critical pressure (kgf/cm²)	8.6

$P = P_0 + \gamma_w (h_1 - h_2 - h_3)$ (kgf/cm²)

P : Corrected pressure (kgf/cm²)

P_0 : Reading of gauge (kgf/cm²)

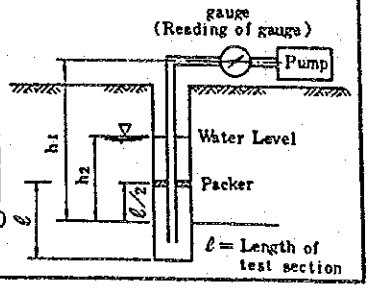
γ_w : Unitweight of water

$h_3 = \alpha Q_0^2 L$

Q_0 : Average amount (ℓ/min)

L : Length of Rod (m)

α : A coefficient (7×10^{-5} min²/ℓ²)

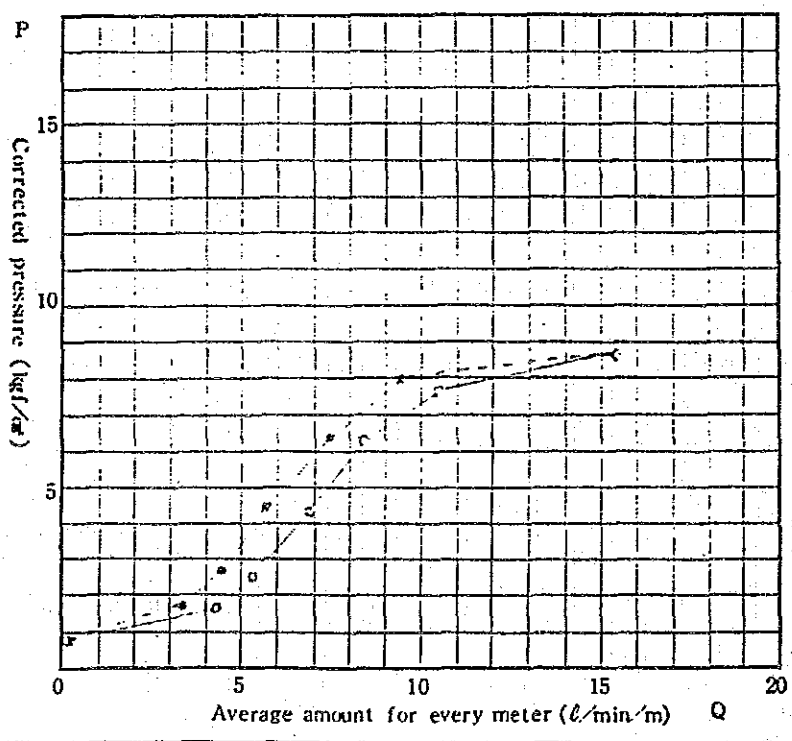


Lugeon Test Data Sheet

Stage NO. 10

Location	Main Dam	Name of hole	D - 1	Depth (m)	55.0~60.0	Length of test section (m)	5.0
Water Level (m)	8.2	Hight of gauge (m)	0.5	Length of rod (m)	55.5	Direction, Dip	Vertical
Diamiter of pipe (mm)	35	Type of packer	Expansion			Date	27/8

Reading of gauge Po (kgf/cm²)	Head loss h_3 (m)	Corrected pressure P (kgf/cm²)	Amount of injection per minutes (ℓ) 1	2	3	4	5	Average amount Q_0 (ℓ/min)	Average amount for every meter Q (ℓ/min/m)
			6	7	8	9	10		
0.0	0.0	0.9	1	0	1	0	1	0.6	0.1
			1	0	1	1	0		
1.0	1.8	1.7	20	26	22	23	23	21.8	4.4
			22	21	20	22	19		
2.0	2.9	2.6	28	29	26	27	29	27.2	5.4
			28	26	27	26	26		
4.0	4.6	4.4	35	35	33	36	34	34.3	6.9
			26	44	35	34	31		
6.0	6.6	6.2	45	43	44	43	40	41.3	8.3
			40	40	41	38	39		
8.0	10.4	7.8	52	52	49	52	52	51.7	10.3
			51	53	52	52	52		
10.0	23.0	8.6	67	76	66	164	66	77.0	15.4
			65	67	66	67	66		
8.0	8.8	8.0	50	48	48	48	48	47.7	9.5
			47	47	47	47	47		
6.0	5.3	6.3	39	38	38	37	37	36.9	7.4
			36	36	36	36	36		
4.0	3.3	4.5	30	30	30	29	29	29.0	5.8
			29	29	28	28	28		
2.0	2.1	2.7	25	25	23	23	23	23.0	4.6
			23	22	22	22	22		
1.0	1.1	1.8	19	18	17	17	17	16.9	3.4
			17	16	16	16	16		
0.0	0.0	0.9	2	2	0	1	1	0.9	0.2
			0	1	1	0	1		



Lugeon value (Lu)	–
Calculated Lugeon Value (Lu')	11.6
Maximum pressure (kgf/cm²)	8.6
Critical pressure (kgf/cm²)	6.2

$P = P_0 + \gamma_w (h_1 - h_2 - h_3)$ (kgf/cm²)

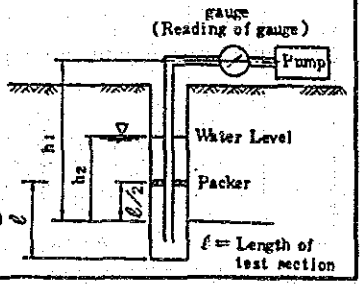
P : Corrected pressure (kgf/cm²)

P_0 : Reading of gauge (kgf/cm²)

γ_w : Unitweight of water

$h_3 = \alpha Q_0^2 L$

Q_0 : Average amount (ℓ/min)

L : Length of Rod (m)

α : A coefficient (7×10^{-5} min²/ℓ²)