

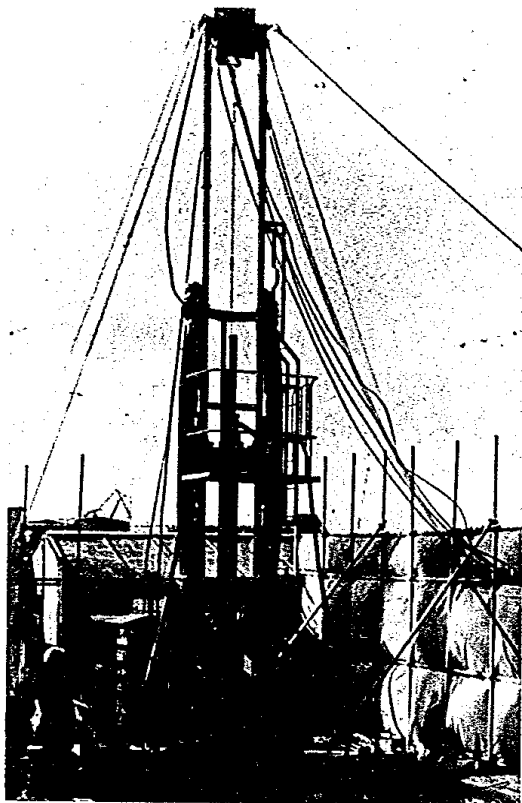


Public Works Research
Institute No. 901

Special Foil Sampler with Rotary Drilling Rig and Its Performance

July 1974

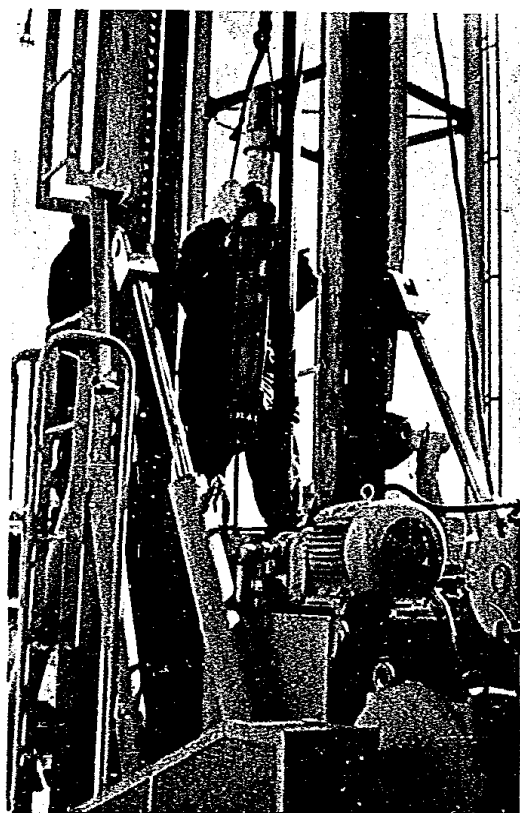
Public Works Research Institute
Ministry of Construction



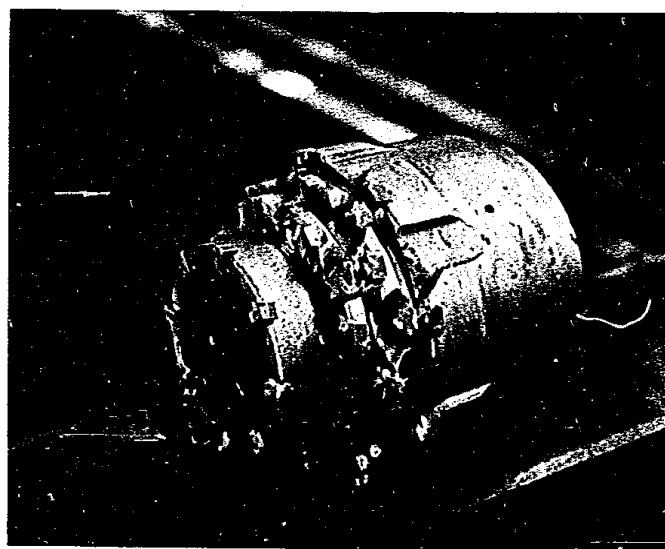
Sampling by use of Special Foil Sampler



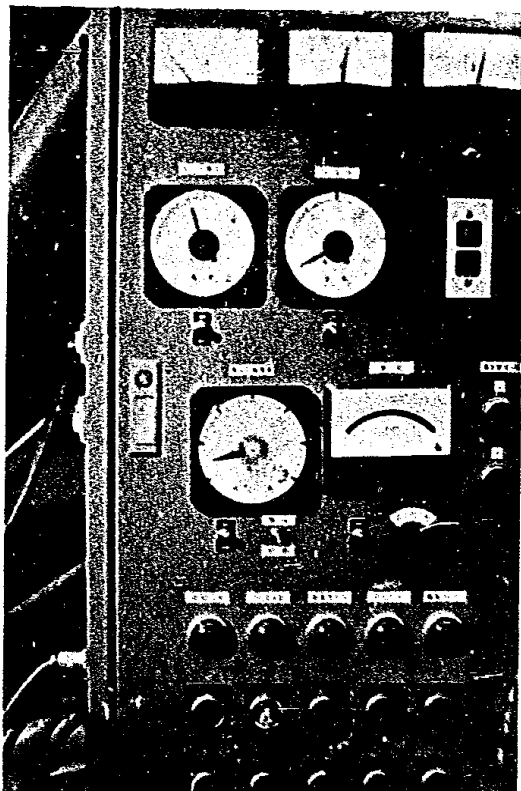
Setting Water Swivel



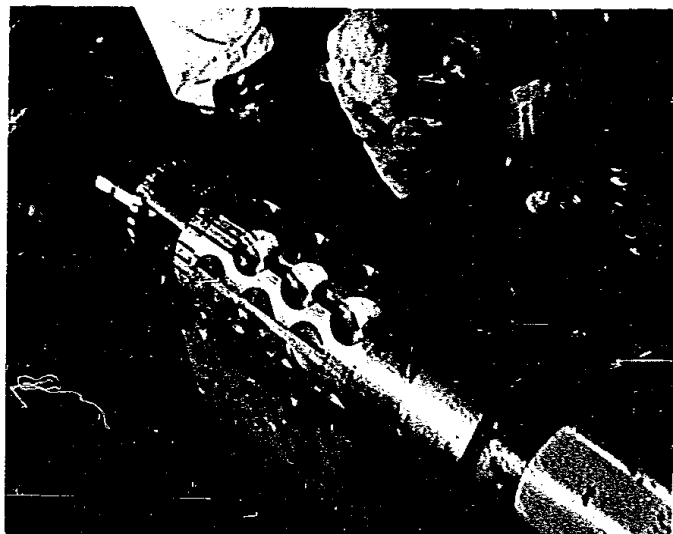
Sampler Head



Rotary Bit



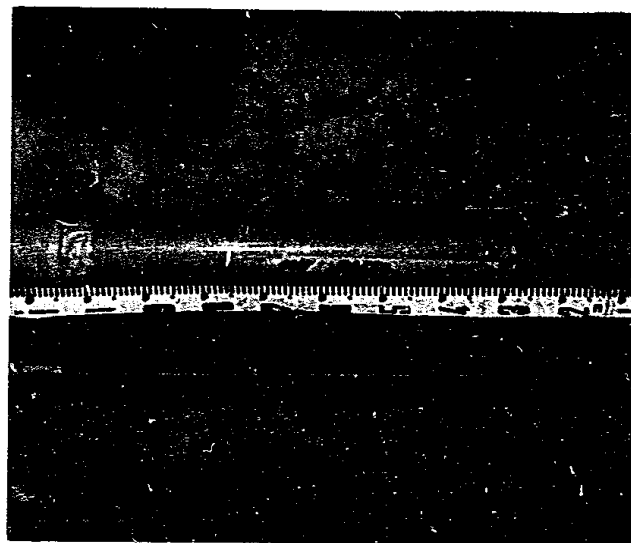
Indicator Board



Fixing Foil Jape



Sampler tube



Sampled Clay

**Special Foil Sampler with Rotary Drilling Rig
and
Its Performance**

Foundation Engineering Section

Keiichi Komada, Chief

Yoshio Adachi, Senior Researcher

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1. Introduction

The sampling work must be performed at first in the soil survey of the construction site for bridge, gate, weir, harbor and also buildings to collect the data of soil.

It has made a progress with improvement and development of sampling machines such as thin-walled sampler, stationary piston sampler and denison sampler etc. As the result, we can use the suitable sampler for the characteristics of soil and the purpose of survey. However, it is quite difficult to obtain the continuous and undisturbed sample from the poor ground to the fairly hard ground such as the diluvial deposit including sandy soil or soft rock. Such work is deemed difficult to perform with the conventional sampling machines.

With a view to being possible to obtain the continuous and undisturbed sample of all kinds of soil stratum, Foundation Engineering Section of the Public Works Research Institute began to develop a new sampling method and completed a Special Foil Sampler with rotary drilling rig in 1966.

This sampler was used in various kinds of soil and as a result of examining its applicability, improvement was made repeatedly in its sampling method.

In September 1973, the remodelled type of Special Foil Sampler was produced, taking into consideration all the results of practical use. It is capable of obtaining sample, larger in its diameter than that of No. 1 machine.

Shown hereunder are the outlines of the Special Foil Sampler and the records of its practical applications.

2. Importance of Sampling

It is a well-known fact that in designing structures, the soil must first be surveyed to make clear the properties of the soil at the construction site.

Sampling is a basic work of soil survey, and the accuracy and reliability of the soil survey are dependent greatly on quality of the sampling method. The samples are subjected to various tests to ascertain strength characteristics, physical properties and deformable characteristics of soil. The disturbance in samples has a great effects on these characteristics.

Accordingly, in order to grasp the correct properties of soil and soil layers, samples must be taken in a manner to represent the true formation of soil. This makes it possible to observe the true conditions of soil.

As mentioned above, to obtain the continuous and undisturbed sample is the most significant and important matter in sampling.

3. Principles of Special Foil Sampler

With the conventional foil sampler, it is possible to take clay sample continuously for 10 - 20 m by one stroke of pushing. However, as the foil sampler has about 20 pieces of foil tape, the external diameter of the sampler is required to be larger than that of the other samplers. This means a difficulty in pushing process where the soil is comparatively hard, for instance clay having N value higher than 5. Therefore, a rotary type boring method must be used in order to make easier the pushing process to soil.

Thus, Special Foil Sampler is a combination of a foil sampler and a rotary-type boring system.

Fig. 1 shows a diagram on the head of sampler. It consists of two parts: outer system of the rotary tube and inner system of the sampler tube. The bearing makes the outer tube not to transmit its rotation to the inner tube. The point of the outer tube is fitted with the drilling bit and the point of the inner tube is fitted with a cutting edge. The tip of the cutting edge is protruded downward from that of the drilling bit. The length of protrusion is changeable according to the hardness of soil. A foil magazine containing foil tapes, 12 mm wide, 0.1 mm thick, is housed in the sampler head. Another end of the foil tape is fitted to the piston which is fixed on the ground by a link rod.

When the outer tube is rotated with water fed, the soil facing the drilling bit is drilled. The sampler tube is pushed into the soil, then, the sample of soil are wrapped successively in the foil tape.

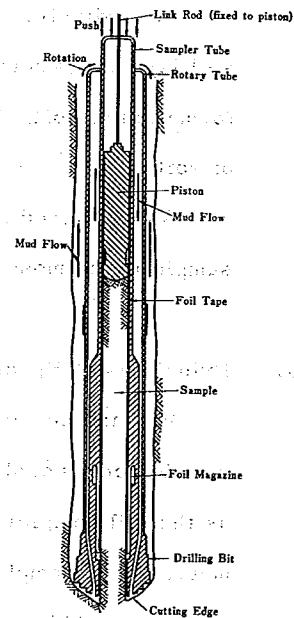


Fig. 1 Diagram of the Head of Special Foil Sampler

The foil tape works to avoid the resistance between the sample and the inside of the sampler tube, and also to prevent deformation of sample caused by its own weight. This makes possible the continuous and undisturbed sampling that represent the true soil formation.

4. Mechanism of Special Foil Sampler

Table 1 shows the comparison of two Special Foil Samplers.

The diameter of the sample taken by remodelled type of Special Foil Sampler is as large as 93.2 mm, and this sampler serves the pushing and pulling force more than the original type.

Given hereunder is a brief description of the construction of the remodelled-type Special Foil Sampler. No. 1 sampler is of the same construction.

(1) Sampler Head

It consists of the following parts:

- (a) Portion of foil tape which works to remove the friction between the sample and the sampler tube and makes it possible to obtain the continuous and undisturbed sample of clay, sand or soft rock (Fig. 2).
- (b) Rotary bit which consists of multistage bit using metal tips and makes the pushing of the sampler tube easy by drilling the soil at its point (Fig. 3).
- (c) The cutting edge is fitted at the point of the sampler tube and pressed into the soil when the sampler tube is pushed (Fig. 4).

Table 1 Comparison of Two Special Foil Samplers

Items	Specifications	No.1 Special Foil Sampler	No.2 Special Foil Sampler
Sampler Head	Diameter of sample	64 mm	93.2 mm
	Applicable depth of sampling	80 m	80 m
	Length of sample	10 m for one stroke	10 m for one stroke
	Number of foil tape	12 pcs.	24 pcs.
	Internal diameter of sampler tube	64 mm	93.2 mm
	External diameter of sampler tube	68 mm	101.6 mm
	Unit length of sampler tube	2.5 m	2.5 m
	Internal diameter of rotary tube	127 mm	160 mm
	External diameter of rotary tube	140 mm	175 mm
	Unit length of rotary tube	2.5 m	2.5 m
Driving Section	Motor	3-phase 200 V	3-phase 200 V
	Number of revolution	From 27 rpm to 200 rpm, 8-step variable speed	From 16 rpm to 126 rpm, 9-step variable speed
	Revolution torque	75 kg.m	150 kg.m
Pushing and Pulling Section	Max. pushing force	2 t	5 t
	Pushing speed	0 ~ 0.3 m/min	0 ~ 0.3 m/min
	Max. pulling force	5 t	15 t
	Pulling speed	0 ~ 1.0 m/min	0 ~ 1.0 m/min
Muddy Water Pump	Max. pressure	25 kg/cm ²	25 kg/cm ²
	volume	16 ~ 70 l/min	41 ~ 104 l/min
Winch	Force	400 kg	1,350 kg
	Speed	30 m/min	30 m/min

The cutting edge is protruded from the point of the rotary bit to prevent the occurrence of disturbance in sample by the washing away or loosening of soil at the sampler edge caused by the muddy water gushing out from the bit.

The protruding length of the cutting edge differs according to the properties of soil. The adequate length for each sort of soil has been obtained through experiences in actual sampling, and its length is larger for the soft clayey or sandy soil and smaller for hard soil like soft rock. For the intermixed thin layers in which hardness is varied, the protruding length should accordingly be changed. For such requirement, the springs are inserted between the outer and inner systems to make the protruding length changeable.

(2) Driving Section

This is a device to rotate the rotary tube which constitutes the outer system.

The number of rotation that suits the soil formation can be chosen from the 9-step variable speed of 16 - 126 r.p.m.

The records of sampling by No. 1 Sampler indicate the adequate number of rotation for each kind of soil as shown in Table 2.

Table 2. Soil Conditions and Number of Rotation

Soil Conditions		Rotation (r.p.m.)
N value of sandy soil	N value of clayey soil	
0 - 15	0 - 4	27 - 60
15 - 49	5 - 24	27 - 100
Over 50	Over 25	67 - 133
Soft rock		67 - 200

(3) Pushing and Pulling Section

This section provides the sampler tube with a pushing force and let the cutting edge protruding from the point of the bit to be pressed into soil, and also provides a force to pull up the inner and outer tubes -- so constructed that it bites perfectly into the ground and a powerful pulling force is provided taking into consideration the friction between the outer tube and soil.

(4) Mast (Fig. 5)

This is necessary to connect and to disconnect each sampler tube or each rotary tube and to give tension to the link rod which fixes the piston. It is so constructed as to lay it down horizontally for the convenience of carrying.

(5) Muddy Water Circulation Device

This is a device to circulate muddy water for the discharge of slime out from the rotary bit, cooling of the bit and for prevention breaking of the bore hole wall. Fig. 6 shows the swivel

fitted to the upper end of the outer tube. As for the circulating route of the muddy water, refer to Fig. 1 in which it is indicated by arrows.

(6) Electric Section

Rotary foil sampler uses a motor as its moving power for the simplification of mechanism and for the ease of operation.

Power source is AC 200 - 220 V, 50 cycles, Max. 147.3 A.

And when the generator is used, the quantity of power is 40 KW.

(7) Truck (Fig. 5)

All the equipments are mounted

on the truck,

2.45 m wide and

3.9 m long. The

truck is equipped with tires and can

be moved within a

short distance.

For a long distance

transport a trailer

is used.

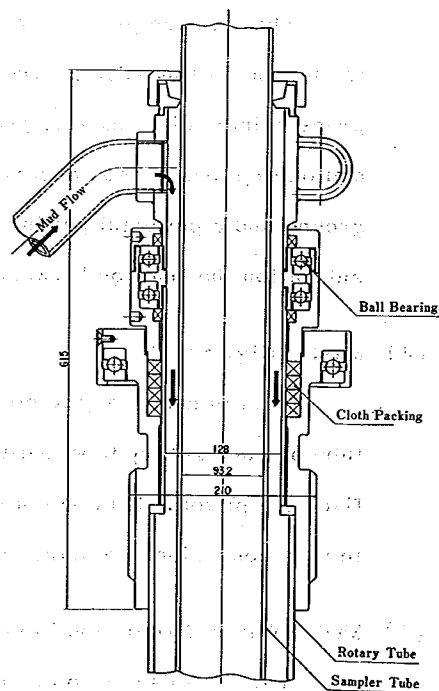


Fig. 6 Water Swivel

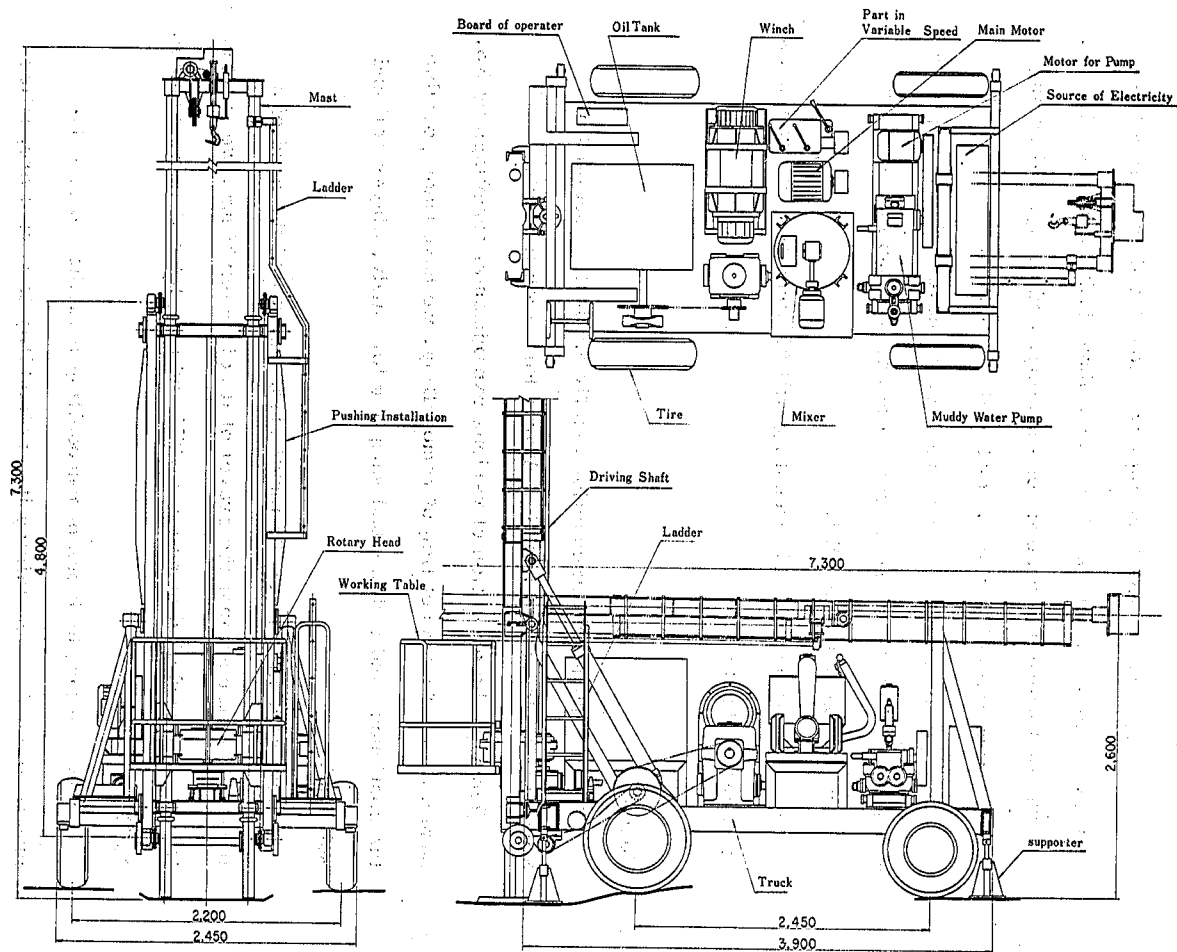


Fig. 5 Truck and Mast

5. Sampling Records

Since 1966 when No. 1 sampler was completed, sampling has been executed at various kinds of soil, about 1,200 m of total length.

Table 3 shows the records of sampling, and the typical boring log is shown collectively at the end of the pamphlet.

As regards the remodelled sampler, we have a plan to apply the actual soil. But there are no record of actual sampling as all the parts were completed in 1973.

In the present schedule sampling will be conducted at two places as shown in Table 4.

6. Postscript

We have made an introduction briefly about the Special Foil Sampler developed by the Public Works Research Institute.

Through the execution of various experimental samplings by No. 1 sampler and after repetition of remodelling, we have made possible the continuous and undisturbed sampling for sandy, clayey soil and soft rock.

However, in view of the insufficient thrust and the need of a larger diameter against the gravel of its diameter 50mm, we started to make a remodelled sampler in 1972 and completed it in September, 1973.

Now, we are desirous of remodelling it further to suit the practical use by ascertaining its applicability to varied properties of soil through repetition of sampling by use of the remodelled machine.

Table 3. List of Sampling by Rotary Foil Machine No. 1

Place	Sampling Depth (m)	Soil Condition	N value	Core Sampling Ratio (%)	Remarks
Taisho-ku, Osaka City, Osaka-fu (No. 1) (Mouth of Kizu River)	45.6	Alternate layers of silt and clay	6-15	85-97	Umeda stratum, Tenma stratum
" (No. 2)	40.5	Intermixed layers of silty clay, clay containing fine sand, and clay		0-98	
Edogawa-ku, Tokyo-to (No. 1)	52.7	Intermixed layers of sandy silt, clayey silt, silt and sand	2-50	78-100	Shitamachi formation, Tokyo stratum in the upper part
" (No. 2)	55.0	Intermixed layers of sandy silt, silt and sand	2-50	66-100	"
Chiba City, Chiba Prefecture (Precincts of Public Works Research Institute) (No. 1)	50.0	Alternate layers of fine sand and medium sand	10-70	0-95	Narita stratum
" (No. 2)	15.0	"	"	"	"
" (No. 3)	50.0	"	"	55-100	"
Puttsu City, Chiba Prefecture	50.6	Alternate layers of medium sand and silt	20-50	75-100	"
Niigata City, Niigata Prefecture (No. 1)	30.7	Alternate layers of fine and coarse sand	5-50	38-93	Dune sand
" (No. 2)	32.6	"	"	90-96	"
Funabashi City, Chiba Prefecture	80.2	Intermixed layers of fine, medium sand, and silty loam	"	80-100	Narita stratum
Sakaide City, Kagawa Prefecture	80.3	Alternate layers of sand containing gravel and silty clay	15-50	77-100	Mitoyo stratum
Kitagami-cho, Mono-gun Miyagi Prefecture (No. 1)	80.1	Intermixed layers of clay, fine sand and silty clay	2-50	23-99	
" (No. 2)	80.3	"	2-45	41-100	
" (No. 2 redrilling)	30.0	"	2-12	77-97	
Kohoku-cho, Mono-gun, Miyagi Prefecture (No. 3)	77.5	"	2-12	43-100	
Nakamaru-cho, Itabashi-ku, Tokyo-to (Tokyo Expressway Public Corporation No. 5 line) (No. 2)	25.0	Intermixed layers of silt, sandy silt, sand and gravel		100	
" (No. 7)	26.5			100	
" (No. 10)	27.0	"		100	
" (No. 15)	35.0	"		100	
Fujioka-cho, Shimotsuga-gun, Tochigi Prefecture (Watarase Control Pond) (No. A)	18.15	Intermixed layers of fine, medium sand and silt	8-50	100	
" (No. B)	15.2	Alternate layers of sandy silt and silt	3-48	78-100	
" (No. C)	15.95	Alternate layers of fine sand and silt	3-44	79-100	
" (No. D)	19.25	Intermixed layers of fine, medium sand and silt	4-50	100	
" (No. E)	25.95		3-50	81-100	
" (No. F)	15.45	Alternate layers of fine sand and silt	1-50	40-100	
Yashio-cho, Minami-Saitama-gun, Saitama Prefecture (Tokyo Expressway Public Corporation No. 6 line) (No. 1)	42.0	Intermixed layers of silt containing sand, silt and fine sand containing silt			
Near Ohi Steam-power plant, Shinagawa-ku, Tokyo-to (No. 1)	45.0	Intermixed layers of silt, sand and gravel		0-100	
" (No. 2)	38.5	"		5-100	

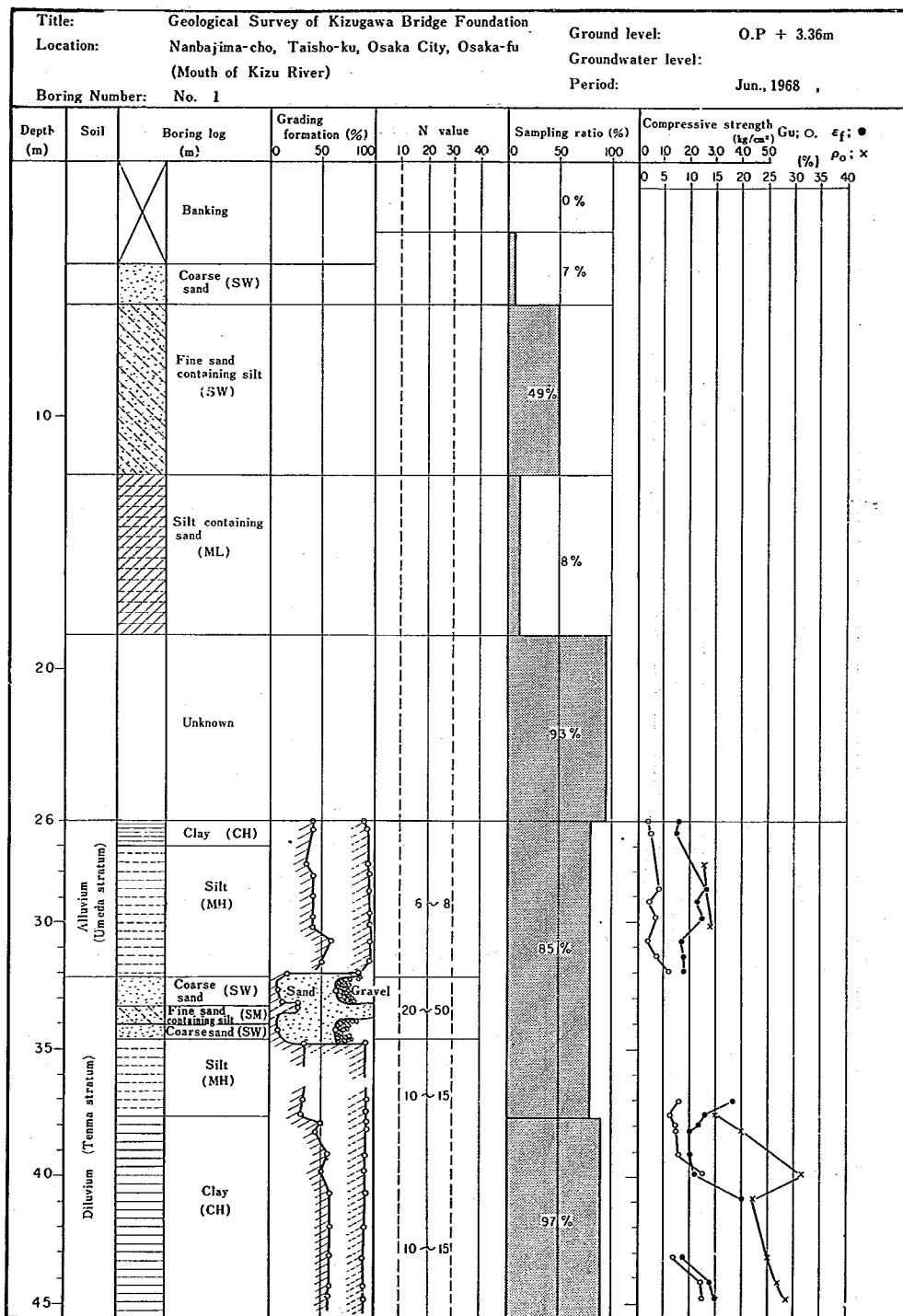
Table 4. List of Sampling by New Rotary Foil Machine

Place	Sampling Depth (m)	Soil Condition	N value	Core Sampling Ratio (%)	Remarks
Sorami-cho, Minato-ku, Nagoya City, Aichi Prefecture (Kinjo Pier in Nagoya Port)	80	Alternate layers of fine sand and clay	10-50	90-100	
Ukishima-cho, Kawasaki City, Kanagawa Prefecture	50	Alternate layers of fine sand and clay	2-9	82-100	

7. References

Shown hereunder are the references concerning the Special Foil Sampler.

- 1) Iwao Yoshida, Ryunos Shin Yoshinaka (1967): "Special Foil Sampler and an Example of Surveying Sandy Soil", The 2nd Conference of the Japanese Society of Soil Mechanics and Foundation Engineering (in Japanese).
- 2) Iwao Yoshida, Ryunos Shin Yoshinaka (1969): "Sampling by Special Foil Sampler (2nd Report)", The 4th Conference of the Japanese Society of Soil Mechanics and Foundation Engineering (in Japanese).
- 3) Iwao Yoshida, Ryunos Shin Yoshinaka, Hisahide Takamizu (1970): "A New Method for Continuous Sampling of Subsurface Materials and its Applicability", Public Works Research Institute Report, No. 137 (in Japanese).
- 4) Public Works Research Institute, Ministry of Construction (1970): "Report on Sampling of Deep Strata and the Investigation of Bearing Capacity" (in Japanese).
- 5) Yoshio Adachi, Takanori Izumi (1973): "Examples of Applying Special Foil Sampler to the Gravel", Civil Engineering Magazine Vol. 15, No. 6 (in Japanese).



Title: Geological survey at area of Komatsugawa, Tokyo					Ground level: A.P+0.107m							
Expressway Public Corporation					Groundwater level							
Location: Nishi-Komatsugawa, Edogawa-ku, Tokyo					Period: Feb. 19, 1969~Mar. 6, 1969							
Boring Number: No. 2												
Soil condition					Conditions of operation							
Scale (m)	Depth (m)	Boring log	Sampling ratio (%) 50	N value 10 20 30 40	Used cutting edge L (mm) Di (mm)	Excavating speed (min/m)	Mud sending volume (t/min)	Number of revolution (r.p.m)	Muddy water pressure (kg/cm ²)	Properties of muddy water		
										Specific gravity	Viscous speed (sec/100cc)	
5	0.75	Banking	Hand drilling									
	1.65	Medium sand										
	2.31	Silt										
10	4.50	Medium sand										
		Sandy silt	94.5%					48	27	0.5 1.0	1.060 1.065	43/946
15	14.61				L = 110 Di = 66	10 20						
			100%									
								35	40	1.0 1.5		38/946
20												
		Silt	100%									
								48	27	1.5 2.0	1.062 1.085	37/946
25												
			100%									
								48	27	1.5 2.0	1.084 1.102	40/946
30	30.30											
		Sandy silt	66.2%					48	27	2.0	1.088	39/946
35	38.07											
			100%									
								40	27	2.0	1.106	42/946
40			100%									
		Fine sand	100%					30 48	27 40	2.0	1.092	42/946
			100%					20	40	2.0	1.082	39/946
45	46.28		96.0%									
		Clayey silt										
	48.25		100%					25	40	2.0	1.090	39/946
50												
		Sandy silt						30	40	2.0	1.092	43/946
	50.75											
55		Fine sand	90.5%									
	55.00							30	40	2.0	1.082	43/946

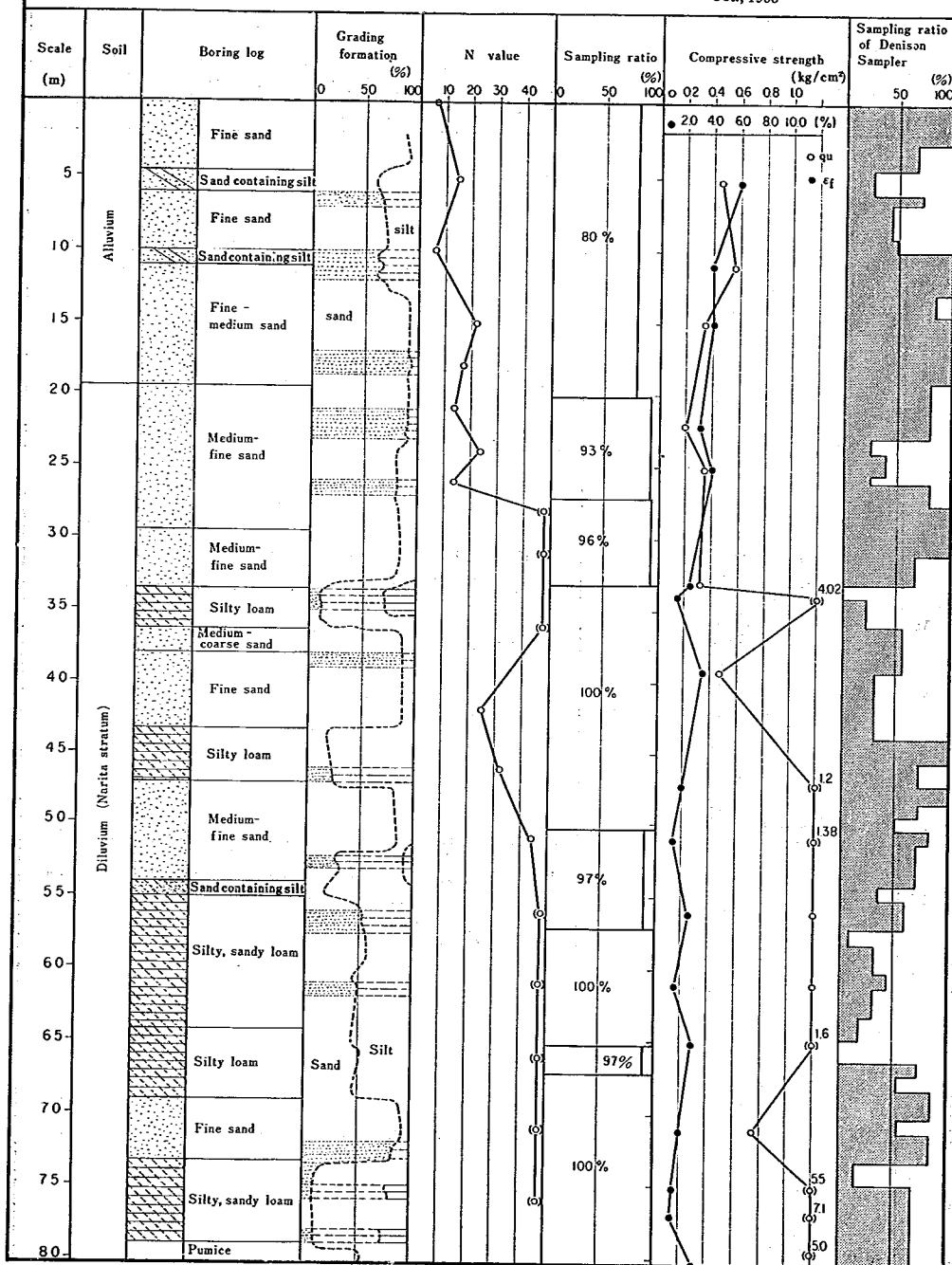
Title: Tokyo Bay geological survey
Location: Futtsu-cho, Futtsu City,
Chiba prefecture

Ground level T.P+1.06m
Groundwater level
Period: Feb. 1, 1966- Mar. 11, 1968

Soil condition					Conditions of operation											
Scale (m)	Depth (m)	Boring log		Sampling ratio (%) 50	N value				Used cutting edge L (mm) Di (mm)	Excavating speed (min/m)	Mud sending volume (t/min)	Number of revolution (r.p.m)	Pushing pressure (kg)	Muddy water pressure (kg/cm²)	Properties of muddy water	
					10	20	30	40							Specific gravity	Viscous speed (sec/500cc)
5	3.77	Fine sand	0%	N = 20				L = 70 Di = 64	5 10		100 133	600 800	2 5	1.10	35 40	
		Medium sand	100%													
10	12.45															
15	15.10															
20			92.0%						5 8	50 70	80	600 800	2 4	107	40	
25		Sand		N = 50												
30	30.79		91.0%						5 6	50	67	300 600	2 4	107	38 40	
35		Silt	98.0%						10 15	50	67 80	300	4 5	107	35	
45	43.30 44.54															
	48.46	Silt	75.0%						30	50	80	100	5	106	35	
50	49.77 50.64	Silt														

Title: Tokyo Bay Geological Survey No. 4
 Location: Hinode-cho, Funabashi City,
 Chiba prefecture

Ground level: T. P + 2.087m
 Groundwater level: G.L. - 1.55m
 Period: Oct., 1968



Title: Geological Survey for Honshu-Shikoku									Ground level: T.P+4.33m								
Location: Sakaide City, Kagawa prefecture									Groundwater level: G.L-2.5m								
									Period: Dec. 15, 1968~Feb. 27, 1968								
Soil condition									Conditions of operation								
Scale (m)	Depth (m)	Boring log (%)	Sampling ratio	N value					Used cutting edge L (mm) Di (mm)	Excava- ting speed (min/ m)	Mud sending volume (ℓ/min)	Number of rev- olution (r.p.m)	pushing pressure (kg)	Muddy water pressure (kg/cm ²)	Properties of muddy water		
				50	10	20	30	40							Specific gravity	Viscous speed (sec/500cc)	
5	5.05	Medium sand									75						
10		Sand	77%		N = 15~25				L = 125 Di = 66	9		67	200 3 400	1.5 3 2.5	1.07 3 1.08	28 3 32	
	12.80																
15	14.14	Clay															
20		Sand contain- ing gravel	100%							10 3 20	48						
25	25.00																
	27.00	Clay															
30		Sand contain- ing gravel	95%						L = 100 Di = 66	20 3 40	48	67 3 80	400 3 500	2	1.07 3 1.08	30 3 34	
35	37.00				N ≥ 50												
40																	
45											48						
50		Silty clay	100%						L = 100 Di = 64	30 3 60		80 3 133	600 3 900	2 3 3	1.06 3 1.11	31 3 34	
55											60						
60																	
65	65.05																
70		Sand contain- ing gravel							L = 70 Di = 64	20 3 40	60	67 3 80	700 3 900	2 3 3	1.06 3 1.08	31 3 35	
	72.00																
75		Sand contain- ing gravel with clay inter- posed															
80	80.28																

[illegible]

Title: Watarase Control Pond Geological Survey (No.1) Location: Fujioka-cho, Shimotsuga-gun, Tochigi Prefecture Boring Number: No. E Ground level: Y.P.+15.920m Groundwater level: G.L.-2.34m Period: Oct.15,1970-Oct.31, 1970							
Scale (m)	Elevation (m)	Depth (m)	Layer depth (m)	Boring log	Color tone	Soil condition	Observation
	Y.P. +						Sand loosely formed, homogeneous grain size, contains grass roots (roots of reed). Mixed with silty mica at 0.50-0.65m.
	13.880	2.04	2.04		Brownish-gray	Fine sand	
	13.580	2.34	0.30		Dark bluish gray	Fine sand	Contains humus
	12.980	2.94	0.60		Dark gray	Silt	Contains viscous humus
	12.630	3.29	0.35		Dark bluish gray	Medium sand	Contains pumice
	12.500	3.42	0.13		Brown	Silt	Humus
	12.310	3.61	0.19		Brown	Silt	Humus. Medium sand between 3.42-3.47m
	11.350	4.57	0.96		Dark bluish gray	Sand	Silt interposed between 3.95-4.00m Contains pumice
5					Dark bluish gray	Fine sand mixed with silt	Silty, contains grass roots Alternate layers of silt and fine sand
	10.470	5.45	0.88		Dark bluish gray	Sand	Silt layer between 5.55-5.65m
	9.980	5.94	0.49		Dark bluish gray	Sand	Contains carbonized wood pcs. around 15.85m
	9.820	6.10	0.16		Blackish gray	Fine Sand	Humus layer interposed
	8.970	6.95	0.85		Blackish gray	Sand	Bluish. Locally densified with pumice. Mostly fine sand in the lower part.
	8.890	7.03	0.08		Blackish gray	Coarse sand	Small-size gravel scattered.
	7.970	7.95	0.92		Blackish gray	Silt	Turns into fine sand in the lower part.
							Bluish. 8.03-8.10m : silt interposed, 8.17-8.20m: sandy silt.
10	6.020	9.90	1.95		Blackish gray	Sand	
	5.780	10.14	0.24		Dark brown	Silt	
	5.490	10.43	0.29		Dark brown	Humus	Pumice in large qt.
	4.920	11.00	0.57		Yellowish brown	Silt	Loamy. Contains pumice
	4.170	11.75	0.75		Dark brownish gray	Humus	Silt containing pumice
	3.270	12.65	0.90		Dark Brownish gray	Silt mixed with sand	Pumice has turned into clay Solidified.
					Milk-brown gray	Pumice	Sand interposed locally in small qt.
	1.970	13.95	1.30		Milk-gray	Pumice	Solidified like tuff. Greenish: 30cm in the lower part.
15	1.250	14.67	0.72		Blackish brown	Humus	Silt in the upper part. Gravel containing sand scattered around 15.40m, in the lower part.
	0.320	15.60	0.93		Dark brown	Fine sand mixed with silt	Mixed with pumice
	0.120	15.80	0.20				
							Gravel, max. size, 120m/m. Spherical or semi-spherical shaped gravel.
20	-4.580	20.50	4.70		Dark bluish gray	Sand gravel	
	-6.180	22.10	1.60		Dark bluish gray	Fine sand mixed with gravel	Spherical gravel, max. size 20m/m. Contains silt in very small qt.
	-6.880	22.72			Dark bluish gray	Sand gravel	
	-8.180	24.10	0.62		Dark bluish gray	Silt	Contains pumice to some extent. Sand interposed in lens-shape in the lower part. Hard silt.
25	-8.780	24.70	1.38		Dark bluish gray	Fine sand mixed with silt	Silty
	-10.030	25.95	1.25		Dark bluish gray	Silt	Gravel (15m/m) scattered in the upper part. Shell pcs. in large qt. between 20.35-20.60m. Some pumice throughout. Turns into sand in the lower part.

Title: Ability Test of Bit for Gravel						Ground level			
Location: Near Ohi steam-power plant, Shinagawa-ku, Tokyo						Groundwater level			
Boring number: No.1						Period: Feb. 7, 1972~Mar. 13, 1972			

Scale (m)	Boring log	Soil	Classification of bit	Classification of cutting edge	Sampling ratio (%)	Excavating time (min)	Excavating conditions			
							Number of revolution (r.p.m)	Water pressure (kg/cm ²)	Load (kg)	Water supply volume /drainage (ℓ/min/ (ℓ/min)
5		Banking	4-step bits	E-1 No.1			40		120	
			Single bit							
10		Silt	4-step bits	E-1 No.2			40	1.0	100	
15		Gravel	5-step bits	E-2 No.3 Magazine cutting for gravel			40	1.2	150	54/54 90/90
20		Silt					40	1.0~1.5	170	54/52.3
25		Gravel					40	1.3	150	54/54 90/72
30		Silt					40	0.8~1.0		60/60
35		Silt					40	1.0~1.3	100~120	60/58.9
40		Humus					40	1.0~1.4	100~110	60/60
45		Gravel	4-step bits	E-1 No.6			40	1.2~5.5	140	60/59.6
50		Silt					40	1.5	120	60/60
55		Silt					40	16~3.0	150~280	60/58
60		Gravel					40	280~320	160	60/59.6
65		Silt					40	1.5	140	60/58
70		Silt					40	2.5	160	60/60
75		Silt					40	2.6	80	60/59.6
80		Silt					40	3.0	90	60/58
85		Silt					40	2.5~3.0	110~140	60/59.6
90		Gravel	4-step bits	E-1 No.7			40	2.5	330	60/58
95		Gravel					40	1.6	130	60/60
100		Gravel					40	2.5	120	60/60
105		Gravel					40	2.0	140	60/60