添付資料1 テーブルテスト、ベンチスケールテスト結果報告書

REPORT

Supported by:

東曹産業株式会社
TOSO SANGYO Co., Ltd.

NITTOC CONSTRUCTION CO., LTD

九州大学
KYUSHU UNIVERSITY

JICA PROJECT

VERIFICATION SURVEY WITH THE PRIVATE SECTOR

FOR DISSEMINATING JAPANESE TECHNOLOGIES

FOR GROUND IMPROVEMENT USING CHEMICAL GROUTING TECHNOLOGY

"TABLE TEST AND BENCH SCALE OBSERVATION REPORT"

Submitted to:

PU-net
KEMENTERIAN PEKERJAAN UMUM DAN PERUMAHAN RAKYAT
REPUBLIK INDONESIA

OUTLINE

I. Background

Indonesia has significant improvement in construction business especially in the recent years which reported growth from 7.07% in 2009 to 14.26% in 2015. In extend to support this good pattern, advanced technologies should be adopted to enhance the improvement of infrastructure in Indonesia.

Chemical grouting material is one of technologies that useful to support construction work. It is a method of flow-able material injection into the ground to alter and improve engineering characteristics and behavior of the underground sandy soil. Grouting material itself is a type of supporting material which usually used to seal soil and/or rock pores and crack. It consists of several materials which are mixed in liquid phase that within specified time will be changed to the solid phase.

The application of grouting material may be more cost effective; it can maximize another supported method or prevent cost lost that caused by damaging water. In the case of sodium silicate chemical grouting, it can be used as pioneer to improve the permeability of surrounding underground for giving time the other improvement such as cement grout to work.

Contrary, there is anxiety of environment pollution especially to groundwater when it is contacted with chemical grouting material. In Japan, there is special standard to regulate uses of chemical grouting material in construction field but in Indonesia there is no regulation yet. Because of this reason, the tests of effectiveness and safety of grouting material are conducted to ensure the compatibility of this technology in Indonesia and hope there will be regulation based on this tests.

II. Purpose

The purposes of these tests are:

1. To ensure the effectiveness of Sodium Silicate as Grouting Material.
2. To ensure the safety of Sodium Silicate as Grouting Material.

III. Introduction

1. Chemical Grouting (Sodium Silicate)

Chemical grouting is a method to solidify the state of the ground by filling the gap on the ground. Basically, it consists of two solutions that mix and flow into the ground. If these two solutions are mixed, the solutions will be solidified and alter the state of the ground in a specified time (See Figure 1).

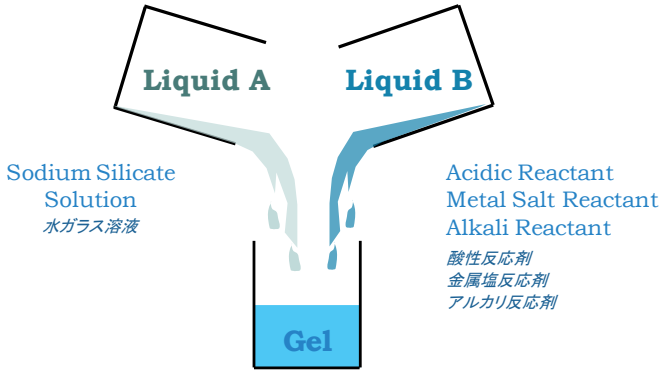


Figure 1　Chemical Grouting Method Mixing

There are two types mechanism of improvement, penetration grouting and fracture grouting (Figure 2). In case of penetration grouting, it works as the grout solution fills pores of soil and change the existing water void in soil. Furthermore, chemical agent is solidified and

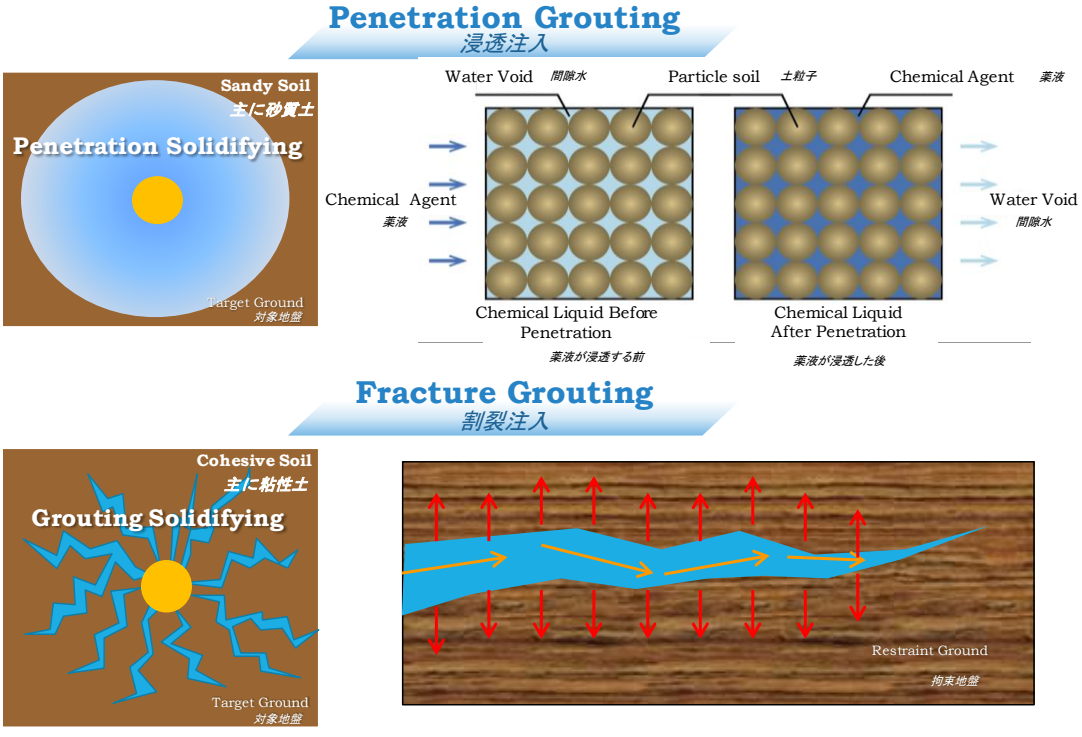


Figure 2　Improvement Mechanisms

improving the solid by bonding the soil particles. In the case of fracture grouting, chemical grouting flows to the fracture spaces and forms a solid gel. In addition, after fulfill the fracture space it swells to the surrounding soil.

Chemical grouting is used in wide application of construction field. An example of application is used in DAM repairing. As a part of grouting method, an advantage of this application in DAM repairing methods is not needed to decrease water level while working (Figure 3). The chemical grouting acts as barrier for cement grouting that need long time to work and prevent the change of cement grouting shape from designed shape (Figure 4).

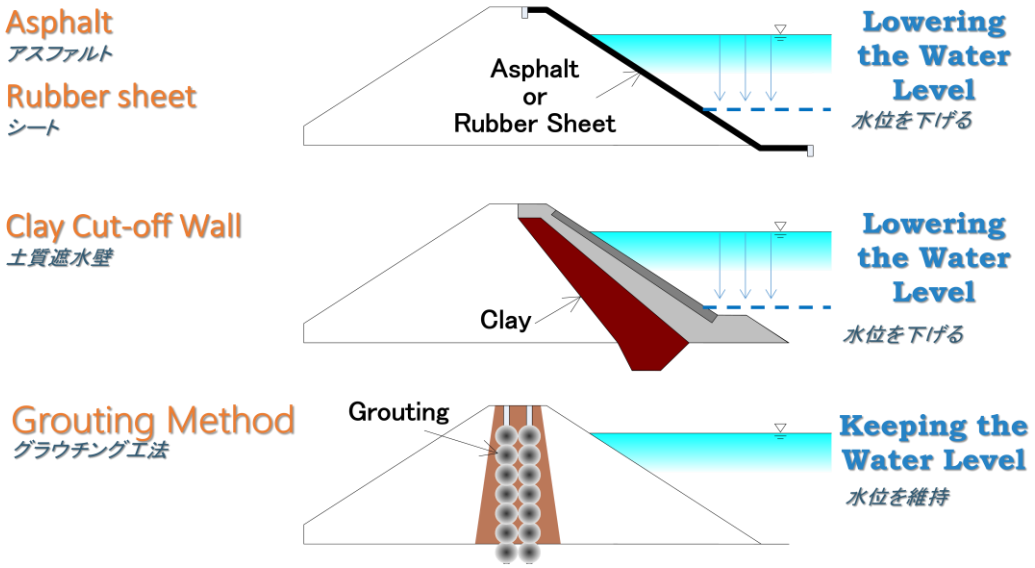


Figure 3　DAM Repairing Methods.

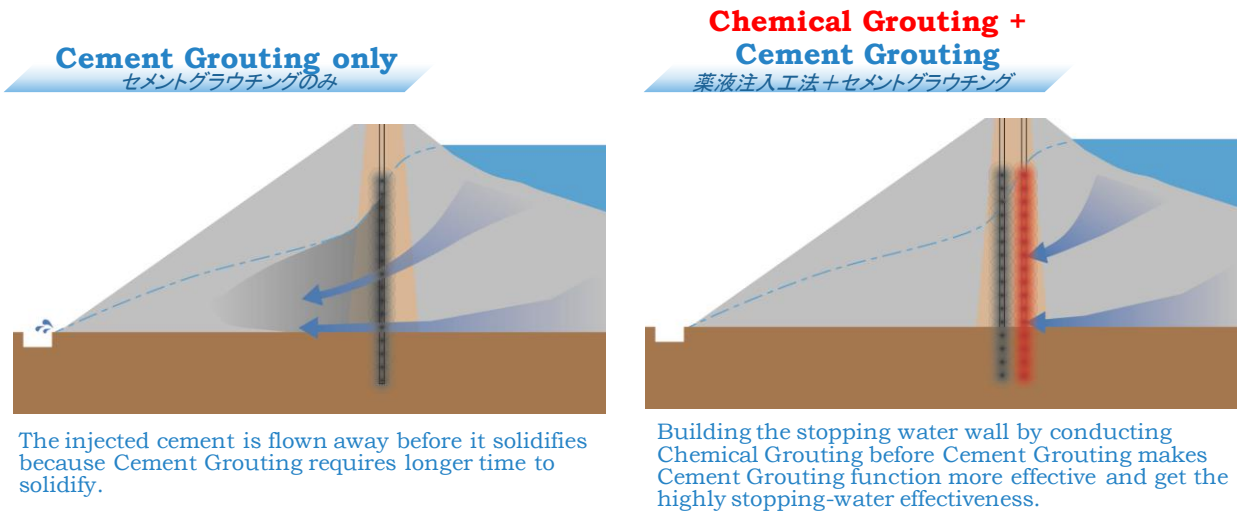
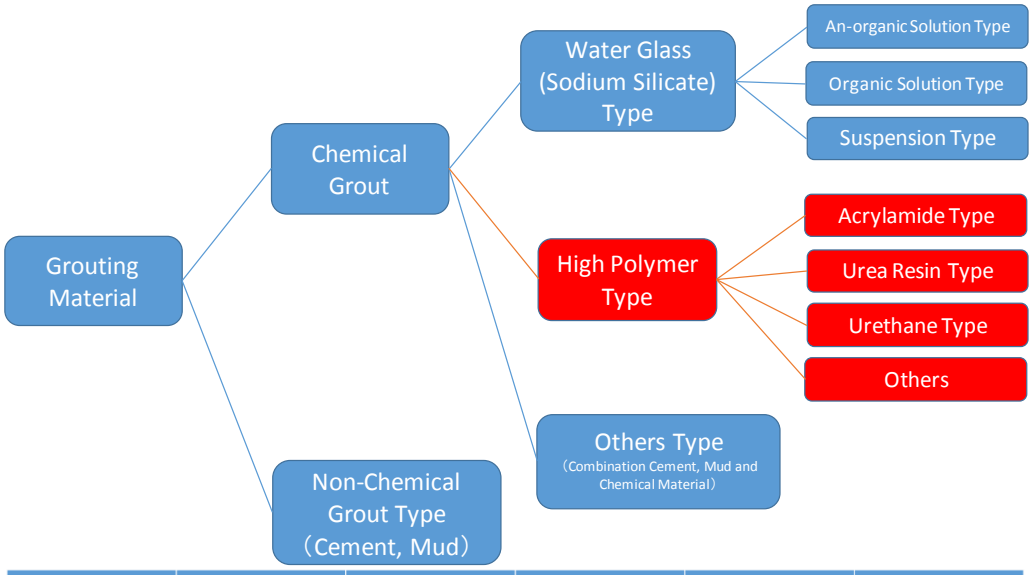


Figure 4　Application of Chemical Grouting in DAM Repairing

Regarding to the safety issues, the standard of procedure for chemical grouting was created in Japan since 1974 after the accident of chemical grouting (with acrylamide based) poisoned their citizen's water sources which injured some people. Started from that point uses of chemical grouting with high polymer based is forbidden. In addition, sodium silicate based, which is the most less poison and safe chemical grouting type, is recommended to use. Based on Japanese standard for grouting material, toxicity can be measured Median Lethal Dose or LD-50 (mg/kg) from experiments that use rats as an object. Lower numbers of LD-50 means higher numbers of toxic. If LD-50 > 5000 mg/kg, it means safe to consume (Figure 5). The fact is sodium silicate raw material is less poisoned than caffeine and ammonia which are commonly used for drink and food. It became safer after sodium silicate mixed with the reactants, even safer after it is solidified.



LD50 [mg/kg]	1～50	50～500	500～5,000	5,000～15,000	More than 15.000
Poison Level	Strong Poison	Middle Poison	Low Poison	Safe	
Sodium Silicate	–	–	sodium silicate material	After mixing	Solid Phase
Comparator Materials	Nicotine Potassium cyanide	Ammonia caffeine	Bittern boric acid	Salt Alcohol Soap	Ketchup Sugar

Figure 5 Toxicity Comparison

2. Safety Regulation Review

The regulation for chemical grouting in Indonesia has not established yet. Due to awareness of pollution to groundwater which may poison drinking source, the regulations that used for this test compare to regulations that role about drinking water (Table 1). Furthermore, international regulations that compared are WHO (World Health Organization) Drinking Water Quality, US EPA (United State Environment Protection Agency) Drinking Water Contaminants, EU (European Commission) Water Framework Directive and Japan Water Quality Standards. Regulations in Indonesia that compared are PP No. 82 Th. 2001 Class I (about Water Quality Management and Pollution Control) and PERMENKES No. 492 Th. 2010 (about Drinking Water Standards).

The tables are fitted to Indonesian regulation, PP No. 82 Th. 2001 Class I. It can be clearly seen that there are differences is significant in term of items limitation number, even more between Indonesian regulations. Generally, world regulations are more similar with PERMENKES No.492 Th. 2010. In international regulations, the reason of the value that supported by experiments results data are including on the report, it explains how many concentrate of chemical soluble on the water that might affect healthy issues. Meanwhile it is difficult to find the limit reason from Indonesian regulations. In addition, PERMENKES No.492 Th. 2010 is newer regulation than PP No. 82 Th. 2001. Regarding to this reason, PERMENKES No.492 Th. 2010 is preferably used as the main limitation.

IV. Table Test

Table test is conducted for the purpose of checking the grouting material safety and the effectiveness of chemical grouting on a laboratory scale. The grouting material safety is check by conducting leaching test and the effectiveness check was done by conducting performance test. The table test was conducted in Kyushu University, Japan and Institut Teknologi Bandung, Indonesia. In addition, the tests were conducted both in Japan and Indonesia using sands from each country and by applying the same test condition. It is conducted in order to confirm the effectiveness of chemical grouting in Indonesian ground by comparing the test result between Japan and Indonesia. The result of the table test is reported as follow.

Table 1　International comparison of water quality standards

Item Name	Water quality standard etc. (mg / L)					
Name	WHO	USEPA	EU	Japan	Indonesia	
	Guideline value	Drinking water standard	Directive	Water quality standard	PP No. 82 th.2001	PERMENKES No. 492
Ammonia	1.5(C)		0.5		0.5	1.5
Arsenic	0.01 (P)	0.05	0.01	0.01	0.05	0.01
Barium	0.7	2			1	0.7
Boron	0.5 (P)		1	1	1	0.5
Cadmium	0.003	0.005	0.005	0.01	0.01	0.003
Chloride	250(C)	250(C)	250	200	600	250
Chromium	0.05 (P)	0.1	0.05	0.05 (Hexavalent Chromium)	0.05 (Hexavalent Chromium)	0.05
Copper	2 (P)、1(C)	1.3(AL), 1.0 C	2	1	0.02	2
Cyanide	0.07	0.2 (free cyan)	0.05	0.01	0.02	0.07
Fluoride	1.5	4.0、2.0(C)	1.5	0.8	0.5	1.5
Hydrogen sulfide	0.05(C)				0.002	
Iron	0.3(C)	0.3(C)	0.2	0.3	0.3	0.3
Lead	0.01	0.015（AL)	0.01	0.05, 0.01 from H150401	0.03	0.01
Manganese	0.5 (P)、0.1(C)	0.05(C)	0.05	0.05, 0.01	0.1	0.4
Mercury	0.001	0.002 (as inorganic)	0.001	0.0005	1	0.001
Nitrate	50	10 as N	50	10 (as N)	10	50
Nitrite	3, 0.2 (P)	Nitrite nitrous oxide		0.05 (as N)	0.06	3
pH	-（C）	6.5～8.5(C)	6.5～9.5	5.8～8.6, 7.5 degree	6-9	6.5-8.5
Selenium	0.01	0.05	0.01	0.01	0.01	0.01
Sulfate	250(C)	250(C)	250		400	250
Total dissolved solids	1000(C)	500(C)		500, 30～200	1000	
Total Suspended Solid					50	
Zinc	3(C)	5(C)		1	0.05	3
Cobalt		0.002			0.2	
Chlorine	5 [1)]	MRDL=4.0		0.1 or more free [2)]	0.03	5
BOD					2	
COD					10	

1) For effective disinfection, there should be a residual concentration of free chlorine of ≥ 0.5 mg/litre after at least 30 min contact time at pH <8.0

2) 0.1 or more free (ministerial ordinance)　1 degree (comfortable)

1. Grouting Materials

Grouting materials used in the test were the products of TOSO SANGYO. CO. LTD, a chemical grouting material with sodium silicate as its main component. The composition of the grouting materials is shown in table 2 below.

Table 2 Chemical Grouting Composition

		A 液 200L Solution A 200 L		B 液 200L Solution B 200 L	
		主剤#12 Sodium Silicate	水 Water	硬化剤 #320 Middle	水 Water
		L	L	Kg	L
標準配合 Mixture		80	120	13	197
200mL	mL	40	60	-	98.5
	G	55.9	60.0	6.5	98.5

Chemical grouting material is gelled in approximately three minutes after mixing diluted solution of sodium silicate (Solution A) with diluted solution of #320 middle (Solution B), that contains potassium carbonate and sodium carbonate as its main ingredient.

2. Leaching Test

2.1. Purpose

Leaching test was conducted to confirm the effect of grouting material on the water environment as well as to confirm its safety.

2.2. Test Method

Leaching test was adopted based on the Dutch Leaching Test Standard (EA NEN 7375:2004). The test procedure is described below.

i. Specimen Fabrication

To create a specimen, 160g of sands and 100ml of grouting material was poured into a mold (ϕ 50mm, h100mm).

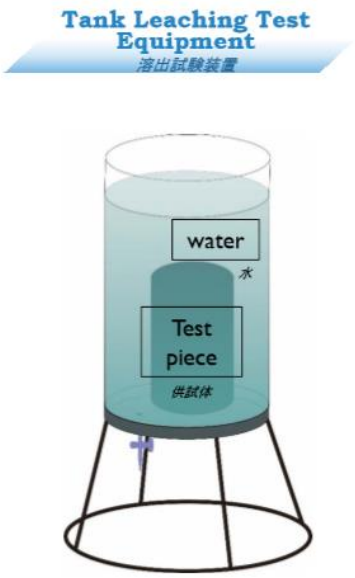


Figure 6 Dutch Leaching Test Apparatus

ii. Immersion of Specimen

Specimen is immersed in pure water with 5 times volume ratio (see Figure 6).

iii. Leaching Test

The immersion water is replaced on 1, 9, 16 and 36 days after the leaching test was started. The immersion water extracted from each materials (day 1, 9, 16 and 36) is subjected to component analysis after filtration and acidification.

2.3. Test Cases

The test was conducted by carrying out two cases; the first case in which Indonesian sand (river sand from Cililin in West Java) was used (test was conducted in Indonesia); and the second case in which Japanese sand (beach sand) was used (test was conducted in Japan). Moreover, in order to confirm that the components eluted from the sand itself are not derived from chemical grouting material, a specimen made only of sand without containing chemical grouting material was also created to carry out the leaching test. The composition of sand used in the test is shown in Table 3.

Table 3 Sand Compositions.

Soil Sample	Grain Size	%Mass	Soil Type	Soil Sample	Grain Size	%Mass	Soil Type
Indonesia Sand Sample	Coarse Sand	6.3%	Well Graded Sand (SW)	Japan Sand Sample	Coarse Sand	0.2%	Well Graded Sand (SW)
	Medium Sand	42.65%			Medium Sand	78.5%	
	Fine Sand	50.65%			Fine Sand	17%	
	Clay	0.38%			Clay	3.8%	

Japan Sand Chemical Component Analysis								
Elements	Amount	Unit	Elements	Amount	Unit	Elements	Amount	Unit
SiO_2	82.719	mass %	V	21	ppm	Sb	15	ppm
TiO_2	0.152	mass %	Cr	54	ppm	Sn	17	ppm
Al_2O_3	6.284	mass %	Co	21	ppm	Bi	0	mass %
FeO	0.779	mass %	Ni	26	ppm	Mo	12	ppm
MnO	0.02	mass %	Cu	0.0011	mass %	W	14	ppm
MgO	0.497	mass %	Zn	0.0018	mass %	Rb	68	ppm
CaO	3.466	mass %	Pb	0	mass %	Sr	250	ppm
Na_2O	0.702	mass %	Au	29	ppm	Ba	560	ppm
K_2O	2.821	mass %	Ag	0	mass %	Y	14	ppm
P_2O_5	0.031	mass %	Pt	0	ppm	Zr	85	ppm
H_2O	2.35	mass %	Hg	0	ppm	Th	3	ppm
S	0.0543	mass %	CD	0	ppm	U	1	ppm
Cl	2	ppm	As	16	ppm			

Indonesia Chemical Component Analysis								
Elements	Amount	Unit	Elements	Amount	Unit	Elements	Amount	Unit
SiO_2	51.46	mass %	V	206	ppm	Sb		ppm
TiO_2	1.159	mass %	Cr	27	ppm	Sn		ppm
Al_2O_3	23.729	mass %	Co	40	ppm	Bi		mass %
FeO	9.892	mass %	Ni	20	ppm	Mo	0	ppm
MnO	0.272	mass %	Cu	0.0073	mass %	W		ppm
MgO	1.357	mass %	Zn	0.0087	mass %	Rb	16	ppm
CaO	3.271	mass %	Pb	0.0007	mass %	Sr	309	ppm
Na_2O	1	mass %	Au		ppm	Ba	225	ppm
K_2O	0.268	mass %	Ag		mass %	Y	25	ppm
P_2O_5	0.122	mass %	Pt		ppm	Zr	105	ppm
H_2O	7	mass %	Hg		ppm	Th		ppm
S	0.0162	mass %	CD		ppm	U	1	ppm
Cl		ppm	As	0	ppm	F^-	37	ppm

Both sands are classified as well-graded sand (SW) according to USCS classification. However, it was noted that in Indonesian sand, medium sand and fine sand are clumps of clay aggregate.

2.4. Test Result

Leaching test result is shown in Table 4. As comparison, the results show differences between leaching test result of soil only (the value on brackets) and with chemical grouting contain. Several different results were obtained in the test result of Indonesian sand and Japanese sand. This may have been caused by the use of sand with different components. Moreover, in the leaching test carried out in Indonesian sand, it is consider that the component elution volume are decreased due to the influence of the grouting material, or on the contrary, the grouting material triggers the component elution and increases the component elution volume. Significant point regarding these points will be study below.

From the result of the leaching test, it is obvious that the pH value of sands exceed the Indonesian standards. As mentioned before, grouting materials contain high alkaline, and since immersion water is 5 times the specimen volume, it is too small, and causes the pH of immersion water tends to rise easily. Not to mention, since immersion water is using pure water, it is assumed to be the cause why pH is rising easily. In addition, as a reference, the result of the pH of improvement column using Portland cement is also shown in figure 7. In the case of Portland cement, it shows that the pH is about 12, which means the chemical grouting material has a lower value compared to Portland cement.

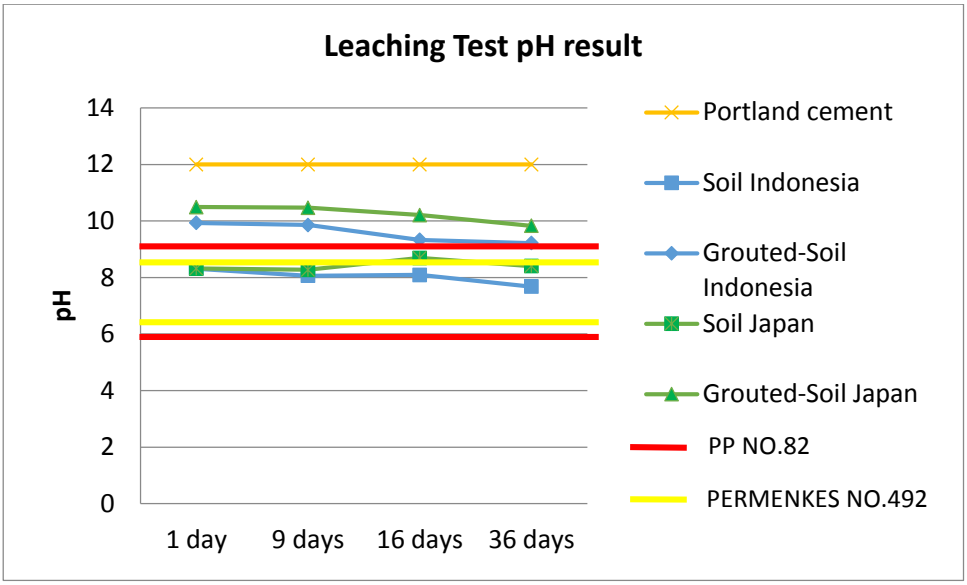


Figure 7 pH Test Result.

From the leaching test result of Indonesian sand, it can be obtained that pH, total dissolved solids (TDS), copper and fluoride were the elements that exceeded the standard of PP, No.82, 2001. However except pH, the amount of chemical leaching is below the standard limit of PERMENKES No.492 Th.2010.

Total dissolved solids (TDS) is the total amount (mass) of mobile ionic charge including minerals, salts, metals that are dissolved in 1L of water whose unit is indicated by mg/L (see figure 8). Based on the result of total dissolved solids (TDS), it is clear that the total amount of mobile ionic charge is much greater in the improvement column than in the sample with only sand. Nevertheless, the total amount of total dissolved solids (TDS) was greater than the standard value (1000 mg/L) on day 1 and day 9, but there was a tendency for total dissolved solids (TDS) to decrease with the lapse of time and it became lower than the regulation value on day 16 and day 36. The high TDS amount is assumed as consequence from increased of Na^+ and K^+ contained in grouting materials are eluted. However, since the amount of elution of these components decreases over time, it can also be assumed that the effect on the environment in the long term is not considerable.

Table 4 Leaching Test Results in 1 day, 9 days, 16 days and 36 days

PARAMETER		UNIT	PP, No. 82, 2001	PERMENKES No. 492, 2010	Leaching Test (Indonesia Sample)				Leaching Test (Japan Sample)			
			Water Quality Management and Water Pollution Control	Drinking Water Standards	Grouting Material				Grouting Material			
			Class 1		1 day	9 days	16 days	36 days	1 day	9 days	16 days	36 days
PHYSICAL												
Total Dissolved Solid	溶解固形分（蒸発残留物）	mg/L	1000		1575, (5)	1220, (17)	510, (13)	46, (9)				
Total Suspended Solid	浮遊物質量	mg/L	50		n.a., (89)	n.a., (59)	n.a., (41)	n.a., (59)				
Electric Conductivity	電気伝導度	µS/cm	-		2250, (7.72)	1743, (25.5)	728, (19.2)	76, (15)	178, (5.76)	64.7, (3.09)	38.5, (8.55)	41.7, (14.85)
ORGANIC CHEMISTRY												
pH		mg/L	6 - 9	6.5-8.5	9.93, (8.31)	9.86, (8.06)	9.33, (8.09)	9.22, (7.68)	10.49, (8.32)	10.47, (8.27)	10.21, (8.69)	9.83, (8.16)
NO3 as N	硝酸性窒素（Nとして）	mg/L	10	50	0.648, (1.33)	0.216, (0.427)	0.152, (0.331)	0.196, (0.166)				
Arsenic	ヒ素	mg/L	0.05	0.01	0.0005, (0.0002)	0.0003, (0.0002)	0.0001, (0.0001)	0.0058, (0.0001)	0.042, (0.044)	n.a., (0.091)	0.046, (0.151)	0.073 (0.058)
Cobalt	コバルト	mg/L	0.2		n.a., (0.301)	n.a., (0.152)	n.a., (0.344)	n.a., (n.a.)				
Barium	バリウム	mg/L	1	0.7	n.a. (0.011)	0.015, (0.009)	n.a., (0.007)	0.013, (0.004)				
Boron	ホウ素	mg/L	1	0.5	0.017, (0.017)	0.073, (0.044)	0.031, (0.073)	0.094, (0.03)	0.048, (n.a)	0.032, (n.a)	0.029, (n.a)	0.032, (0.411)
Selenium	セレン	mg/L	0.01	0.01	n.a., (n.a.)	n.a., (n.a.)	n.a., (n.a.)	n.a., (n.a.)	n.a., (0.181)	n.a., (0.083)	n.a., (0.045)	n.a., (0.021)
Cadmium	カドミウム	mg/L	0.01	0.003	n.a., (n.a.)	n.a., (n.a.)	n.a., (n.a.)	n.a., (n.a.)	0.004, (0.0047)	0.002, (0.003)	0.001, (0.0011)	0.002, (0.051)
Chrome (VI)	六価クロム	mg/L	0.05	0.05	n.a, (n.a.)	n.a., (n.a.)	n.a., (n.a.)	n.a., (n.a.)	n.a., (n.a)	n.a., (n.a)	n.a., (0.029)	0.004, (0.059)
Copper	銅	mg/L	0.02; 1 *	2	0.016, (n.a.)	0.025, (n.a.)	0.021, (n.a.)	0.027, (n.a.)	n.a., (0.008)	n.a., (0.011)	n.a., (0.006)	n.a., (0.051)
Iron	鉄	mg/L	0.3	0.3					0.012, (n.a)	0.012, (n.a)	0.012, (n.a)	0.018, (0.308)
Lead	鉛	mg/L	0.03	0.01	n.a. , (n.a.)	n.a., (n.a.)	n.a., (0.009)	n.a., (n.a.)	n.a., (n.a)	n.a., (0.005)	n.a., (n.a)	n.a., (0.039)
PHYSICS												
Manganese	マンガン	mg/L	0.1	0.4					n.a., (0.029)	n.a., (0.029)	n.a., (0.029)	n.a., (0.282)
Mercury	水銀	µg/L	1	1	0.24, (0.09)	0.18, (0.09)	0.09, (0.09)	0.36, (0.45)				
Zinc	亜鉛	mg/L	0.05	3	0.039, (0.007)	0.031, (0.015)	0.011, (0.007)	0.024, (n.a.)	0.022, (0.032)	0.025, (0.031)	0.031, (0.037)	0.033, (0.225)
Chloride	塩化物	mg/L	600	250	77.1, (5.71)	27.6, (4.28)	7.61, (2.85)	2.85, (1.9)	27.281, (0.0872)	3.568, (0.0642)	1.28, (0.0627)	0.887, (0.323)
Cyanide	シアン化物	mg/L	0.02	0.07	n.a. , (n.a.)	n.a., (n.a.)	n.a., (n.a.)	n.a., (n.a.)				
Flouride	フッ化物	mg/L	0.5	1.5	0.951, (n.a.)	1.187, (0.052)	0.832, (n.a.)	1.14, (n.a.)	n.a., (0.0374)	n.a., (0.0368)	n.a., (0.0852)	n.a. (0.101)
Nitirite as N	亜硝酸性窒素（Nとして）	mg/L	0.06	3	0.01, (0.069)	0.017, (0.047)	n.a., (0.035)	n.a., (n.a.)	n.a., (n.a)	n.a., (n.a)	n.a., (n.a)	n.a., (n.a)
Sulfate	硫酸塩	mg/L	400	250					n.a., (0.2761)	n.a., (0.6169)	n.a., (0.6698)	n.a., (1.096)

Legend:
- More than PP, No. 82, 2001 limitation
- More than PERMENKES No.492 limitation
- more than both limitation
- ( ) The amount of chemical leaching of only sand

Total suspended solid (TSS) is the amount of suspended solids floating in water. When the concentration of suspended solids in water is high, it can cause many problems in water flow and aquatic organisms. Since the role of chemical grouting material is to bind the soil, it is assumed to have an effect of reducing the amount of total suspended solids. From the leaching test result, it is obvious that total suspended solids (TSS) was significantly reduced. However, TDS and TSS are not ruled in PERMENKES No. 492 Th.2010 standard.

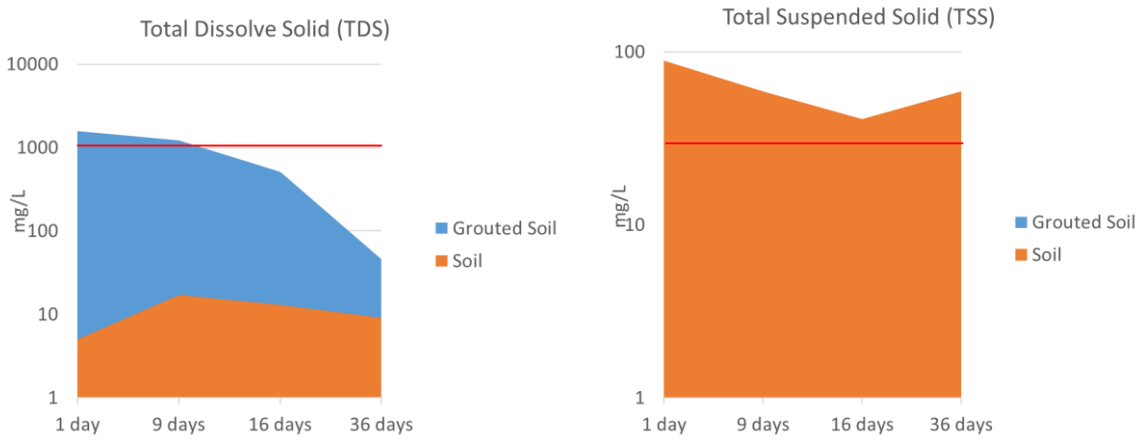


Figure 8 The Test Result on Indonesia sand (TDS and TSS)

For copper, on day 1 it showed smaller value than the standard value (PP, NO.82, 2001) but the immersion water on day 9, 16 and 36 showed higher value than the upper limit of standard value. On the other hand, copper was not detected in leaching test that used Japanese sand.

As shown in Table 3, it has been confirmed that Indonesian sand contains a lot of copper (0.0073%) compared to Japanese sand. Copper itself is originally a component which is not included in the grouting material and grouting material may trigger elution of copper. However, although the standard value was exceeded, the difference is very small. Furthermore, the standard states on conventional method (filtration, accumulation, and absorption/suction) related to water supply, the regulation's limit is 1 mg/L, and PDAM (Indonesian government-owned company) is applying this conventional method for water supply. Moreover, Ministry of Health regulation (No.492, 2010) stated that copper content in drinking water cannot exceeds 2 mg/L. This regulation is similar to other international standards (WHO, EU), cited from WHO the safety limit of copper consumption for human is 12 mg per day. Based on this fact, it can be assumed that copper has less effect on the environment.

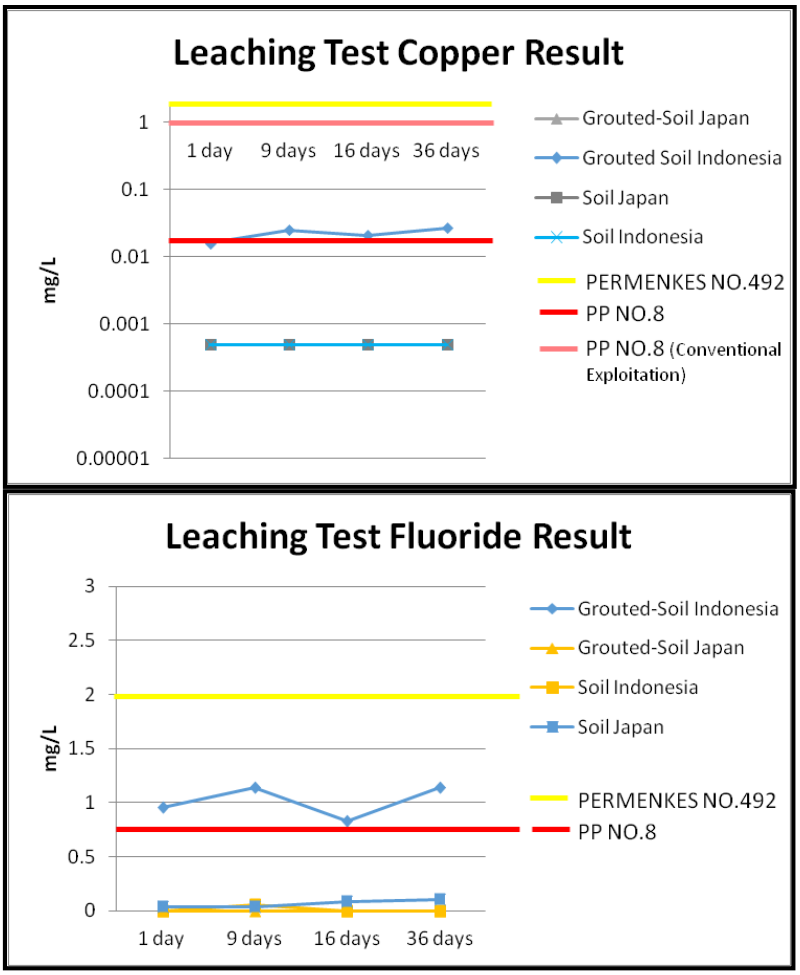


Figure 9 Leaching Test Result (Copper and Fluoride)

For fluoride, all the values from day 1 to 36 were higher than the upper limit of the standard value (see figure 9). On the contrary, fluoride was not detected in leaching test where Japanese sand was used. The cause of this phenomenon will be explained below.

According to previous research results, fluoride may be released from clay minerals in soil where pH is alkaline. This is because fluoride is a halogen element that has strong oxidizing power and reacts easily with alkali. As shown in Table 3, it has been confirmed that Indonesian sand contains 37ppm of fluoride and since chemical grouting is alkaline, it is assumed that it triggers the elution of fluoride that originally contained in sand. Ministry of Health regulation (No.492, 2010) stated that the upper limit of the fluoride content is 1.5 mg/L. WHO and EU also stated that the upper limit of the fluoride content is 1.5 mg/L. Since the result of this leaching test is lower than the regulations mentioned above, it can be assumed that fluoride also has no significant effect on the environment.

From the leaching test result of Japanese sand, except pH, elements elution were below standards. The amount of arsenic elution exceeded Indonesian standards on both samples of Japanese Sand, however the fact is presence of chemical grouting can reduce the arsenic elution. Arsenic slightly exceeded the standard (Both of Standards) value in the elution test result on day 36 of grouted soil leaching (see Figure 10). However it is significantly lower than leaching test result of only sand leaching test. As shown in Table 3, Indonesian sand does not contain arsenic. It is only detected in Japanese sand (16ppm).

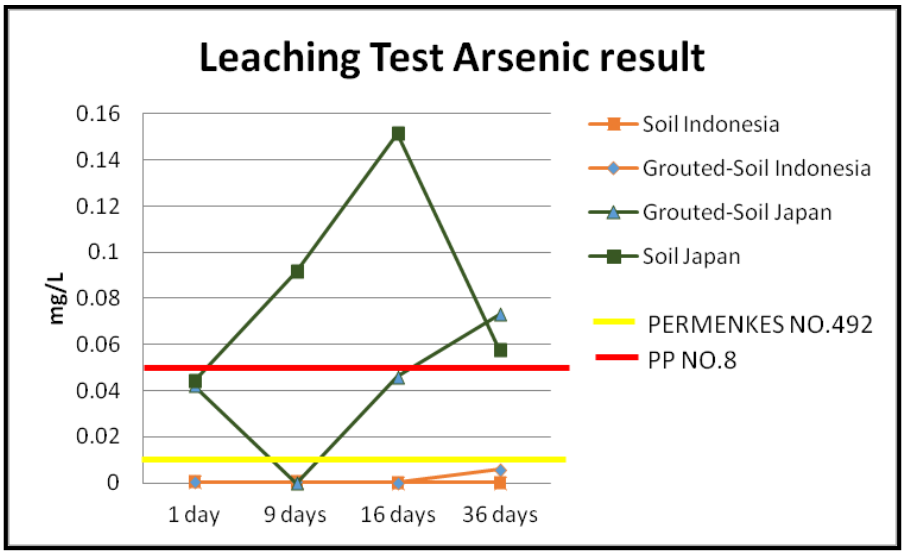


Figure 10 Leaching Test Result (Arsenic)

2.5. Conclusion

First and foremost, from the leaching test results, it can be concluded that pH was the only one that exceeded the Indonesia standard value for both Indonesian and Japanese sand. In addition, there were several items that exceed the standard value only on Indonesian sand. However, the excess amount of standard value is relatively smaller compared to pH. Since there is only one of the sands exceeding the standard, there is a doubt chemical affect the elution.

Furthermore, in case of pH, it is exceeded the standard value due to the characteristics of the chemical grouting material and this leaching test condition (immersion water five times of the specimen volume). Nevertheless, the pH value is smaller compared to when Portland cement was used. In case of actual construction field, because it will be diluted with a large amount of ground water, it is considered that the rise of pH is suppressed, and if the pH does not rises,

other components that exceeded the standard value in the leaching test is assumed to be sufficiently diluted as well.

Finally, the grouting material safety will be checked by the result of monitoring the groundwater in the bench scale test.

3. Performance Test

3.1. Purpose

Performance test was conducted to confirm the effectiveness of chemical grouting method.

3.2. Test Method

Performance test consists of uniaxial compressive strength test (UCS) and permeability test. Uniaxial compressive strength test was carried out based on ASTM D4219. In addition, permeability test was carried out based on ASTM D5084.

The method to produce specimens is the same as the leaching test. Uniaxial compressive strength and permeability at 7 days, 14 days and 28 days were checked.

3.3. Test Cases

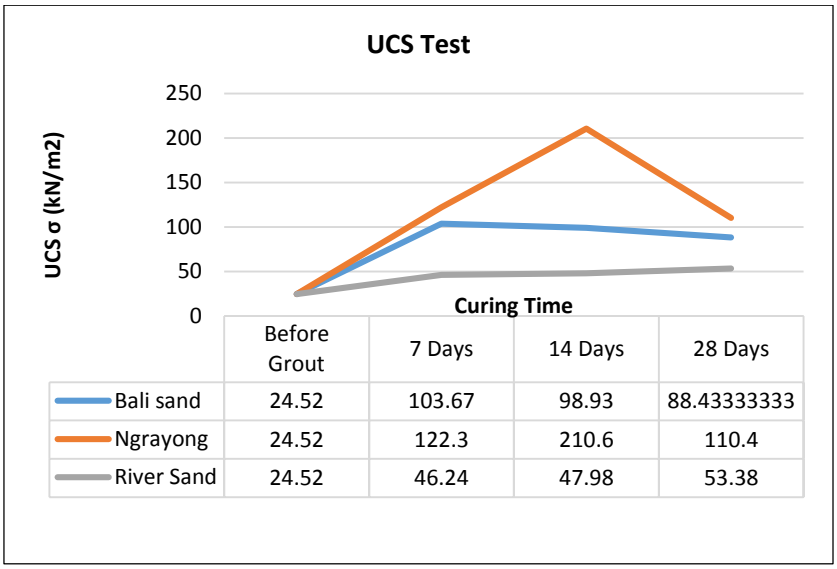
Same as in the leaching test, the test was conducted in Indonesia and Japan using sands from each country. River sand was used in the test in Japan, while in Indonesia the test was conducted using two types of sand; Ngrayong Formation sand from East Java and beach sand from Bali (See Figure 11).

Sand sample was crushed and mixed in order to generate well graded sand (SW based on USCS). Subsequently, sand and grouting material were poured into mold to make a specimen. The curing period of the specimen is 1 day, 7 days, 14 days and 28 days. As the starting performances of sand, the strength of loose sand is set to 24.5 kN/m^2 that is the strength of N value less than 2 (Bery and Saad, 2012) and permeability of well-graded soil based on USCS is set around 2.2×10^{-3} cm/s (West, 1995).

Figure 11 Sand Types for Performance Test

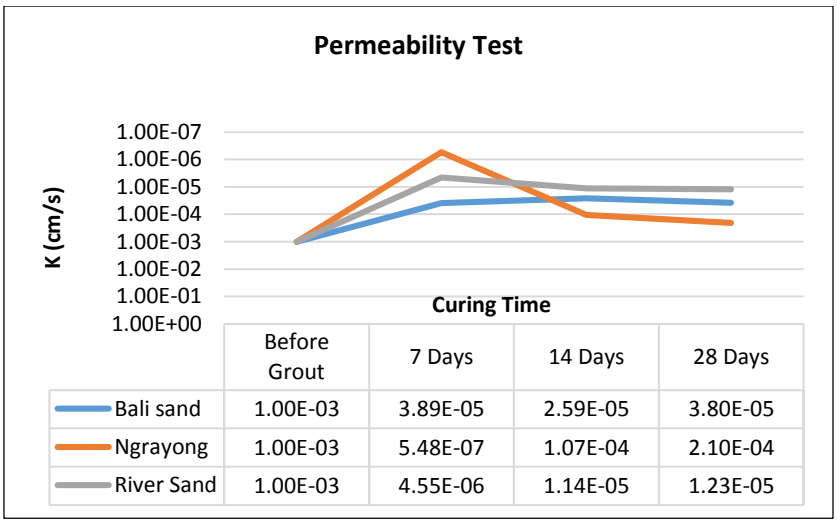
3.4. Test Results

From the uniaxial compressive strength test result (see Figure 12), the test results are varied depending on the sand type. The strongest uniaxial compressive strength can be seen in the improvement column in which Ngrayong sand was used, followed by Bali sand and Japanese river sand, the uniaxial compressive strength is approximately 50-200 kN/m^2. This order is considered based on the content of shape of the grain in the sand. Ngrayong sand has the most rounded and good sorting. However there is unusual pattern that shows in Ngrayong Sand UCS strength pattern. Furthermore in the table test, specimens were created by injecting the grouting material into the sand without applying pressure. On the other hand, in construction at the site, it is possible to further increase the strength of the improvement column by injecting the grouting material into the ground under pressure from the grouting machine. The increased strength of the improvement column by grouting material is sufficient to be used for tunnel drilling and dam repair. For instance, in the case of tunnel drilling, 90 kN/m^2 is required for pipe jacking method. From this fact, it can be confirmed that chemical grouting method can demonstrate sufficient effect in improving Ngrayong sand and Bali sand.



	Before Grout	7 Days	14 Days	28 Days
Bali sand	24.52	103.67	98.93	88.43333333
Ngrayong	24.52	122.3	210.6	110.4
River Sand	24.52	46.24	47.98	53.38

Figure 12 UCS Test Result



	Before Grout	7 Days	14 Days	28 Days
Bali sand	1.00E-03	3.89E-05	2.59E-05	3.80E-05
Ngrayong	1.00E-03	5.48E-07	1.07E-04	2.10E-04
River Sand	1.00E-03	4.55E-06	1.14E-05	1.23E-05

Figure 13 Permeability Test Result

The result of permeability test is shown in Figure 13. In spite of the differences in the three types of sand, it was confirmed that the improvement column was improved to a permeability coefficient around 10^{-4} to 10^{-6}. From this result, it can be concluded that chemical grouting method demonstrated sufficient effect on permeability improvement. This is a sufficient permeability used to temporary prevent leakage during improvement work by cement grouting in dam repair.

3.5. Conclusion

From performance test result, it can be confirmed that the improvement column create by chemical grouting method has sufficient strength and permeability. In the bench scale test conducted after this test, the effect on chemical grouting method once again will be confirmed.

V. Bench Scale Test

1. Test Purpose

The bench scale test was conducted with the purpose of confirming the effectiveness and safety of chemical grouting method in actual field.

2. Test Location

The location, whereas the test took place in Institut Teknologi Bandung, Jatinangor campus, located in Sumedang, West Java (see Figure 14). In geological point of view, test area is located in Qyu, young volcanic rock formation that contains tuffaceous sand as targeted layer (see Figure 15).

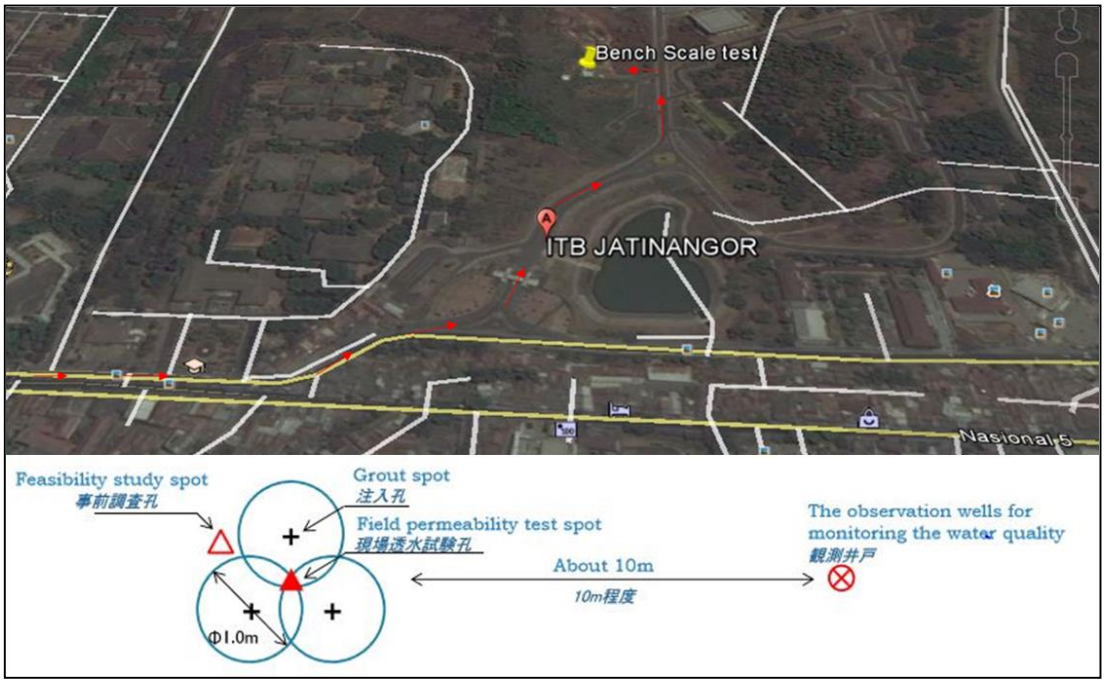


Figure 14 Bench Scale Test Locations and Set

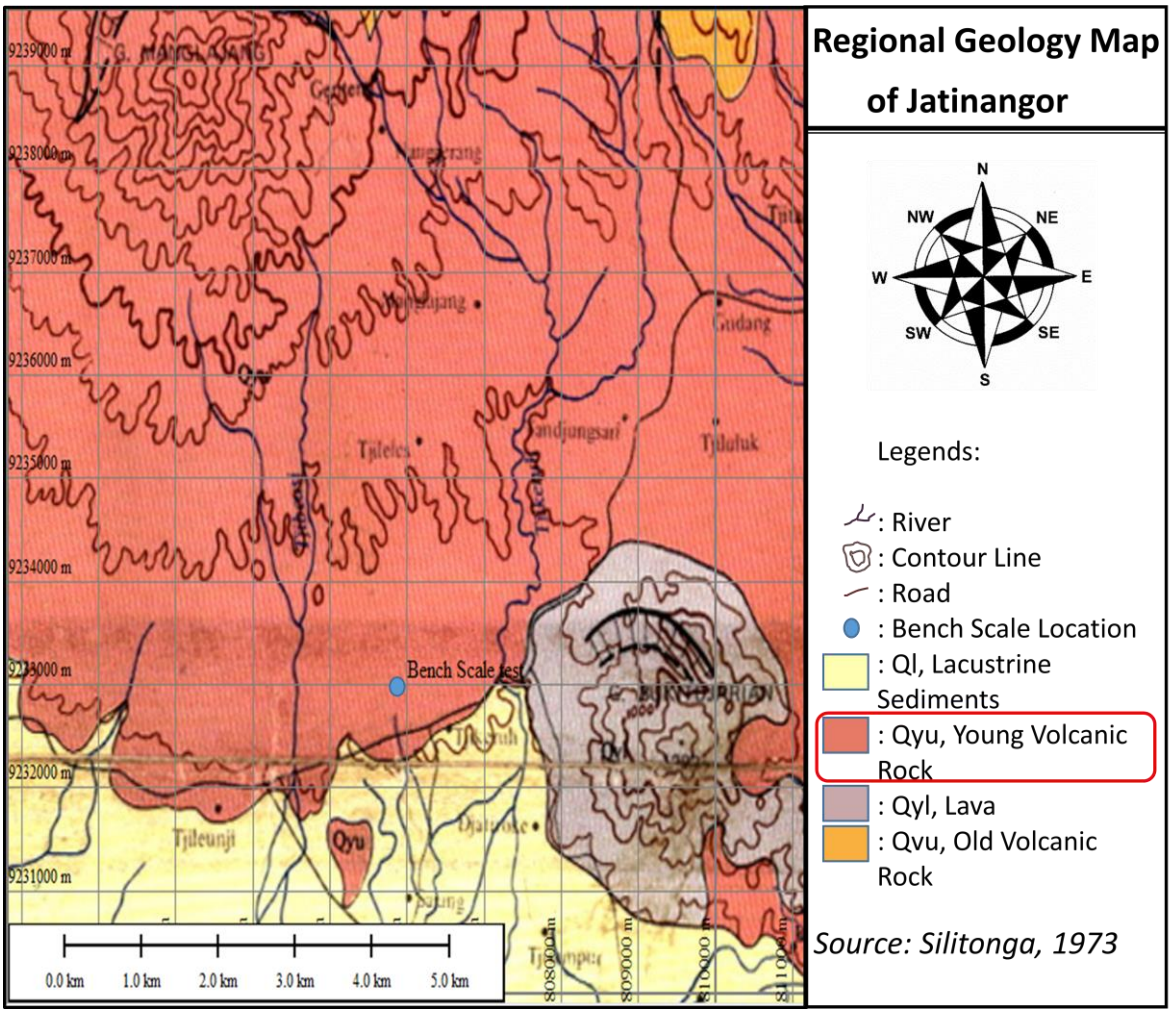


Figure 15 Geological Conditions around Test Location

3. Test Method

The bench scale test was planned based on Japan chemical grouting method standard (see Figure 14). The purpose of each hole is described below.

- Preliminary survey hole (1 hole) : A survey hole to check the sand layer which will be grouted
- Injection hole (3 holes) : Holes for grouting material injection
- Permeability test hole at the site (1 hole) : A hole to check ground permeability after grouting
- Observation hole (1 hole) : A hole to monitor groundwater after grouting

First, preliminary survey hole was drilled to examine the geological condition of test ground. As shown in the boring column figure, the sand layer which will be grouted is confirmed to

have 5.0 m to 6.3m depth. It was dark grey silt sand with N value 28 (see Figure 17). Figure 18 is a diagram which classified grouting form (penetration grouting or fracture grouting) from ground soil quality and hardness during chemical grouting. The plot (red) in the figure is the property of the sand layer which will be injected in this test. As shown in the figure, there is a possibility that penetration grouting and fracture grouting are mixed in the grouting form of target sand layer.

Subsequently, an observation hole and injection holes were drilled. The injection hole was designed to have 3 holes, with injection range in each hole is 1m in diameter and injection depth approximately 1 m (4.0 ~ 7.3 m) from target sand layer (5.0 ~ 6.3 m). (see Figure 16). The observation hole is located about 10m from the planned injection area with 8m depth. pH measurement and groundwater component analysis were carried out in the observation holes. pH measurement was conducted from before the start of construction and 18 days after injection is completed (every day). In addition, this measurement is conducted twice a month for 6 months thereafter. Component analysis of groundwater was carried out twice in total, once before injection and once 18 days after the injection.

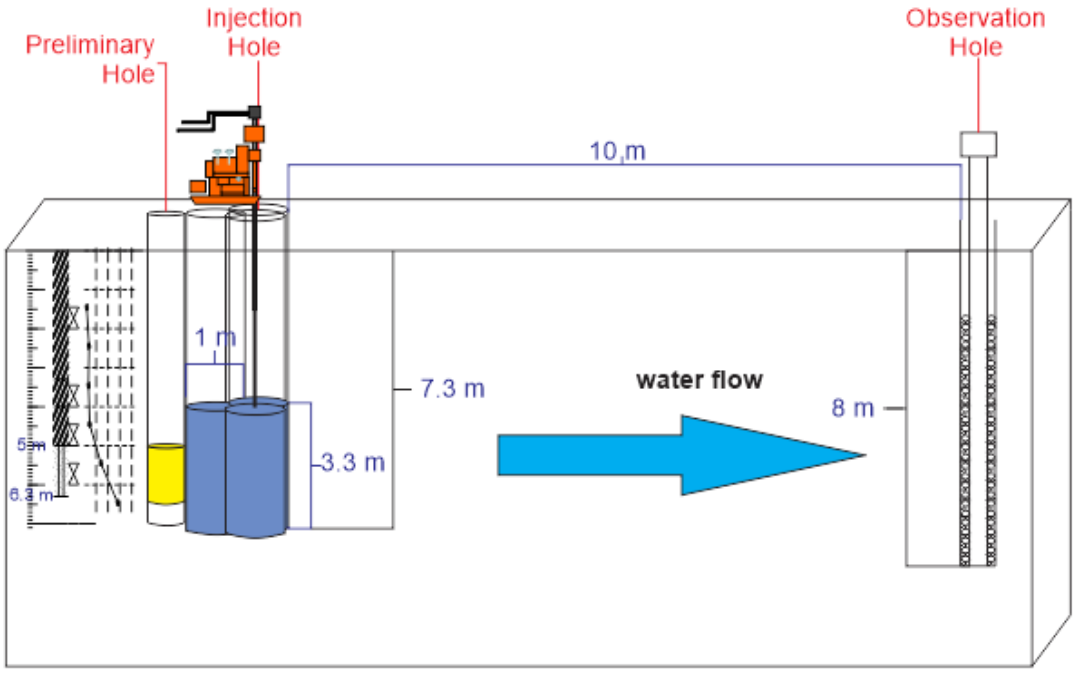


Figure 16 Planned Injection Area and Bench Scale Setting

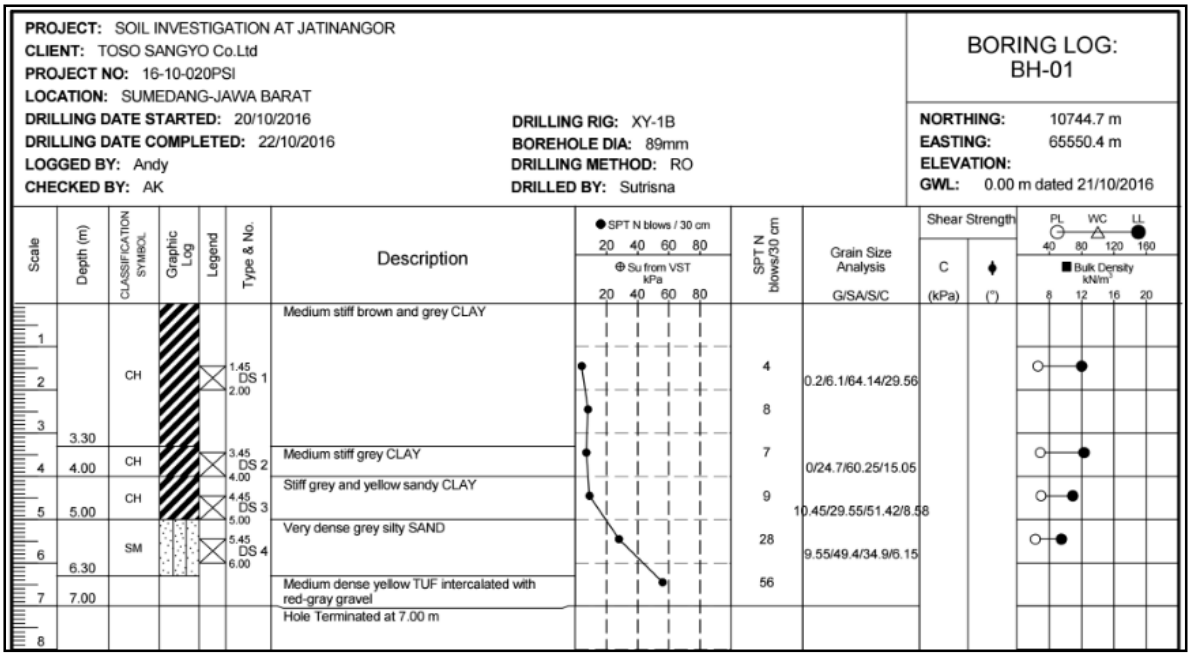


Figure 17 Boring Histogram (Preliminary Survey Hole)

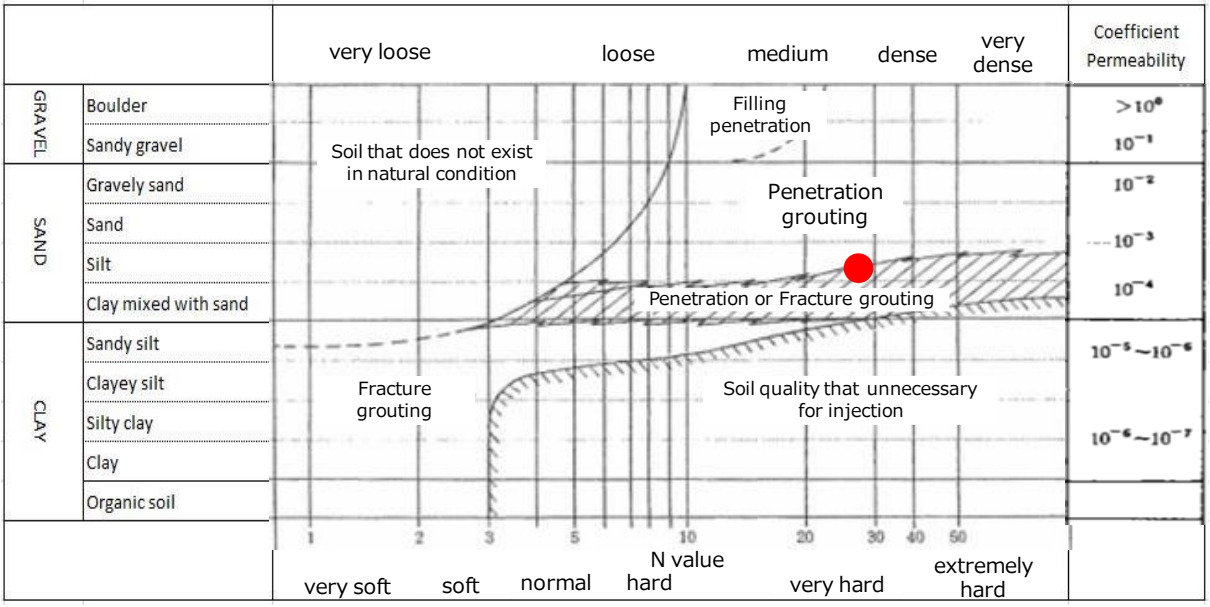
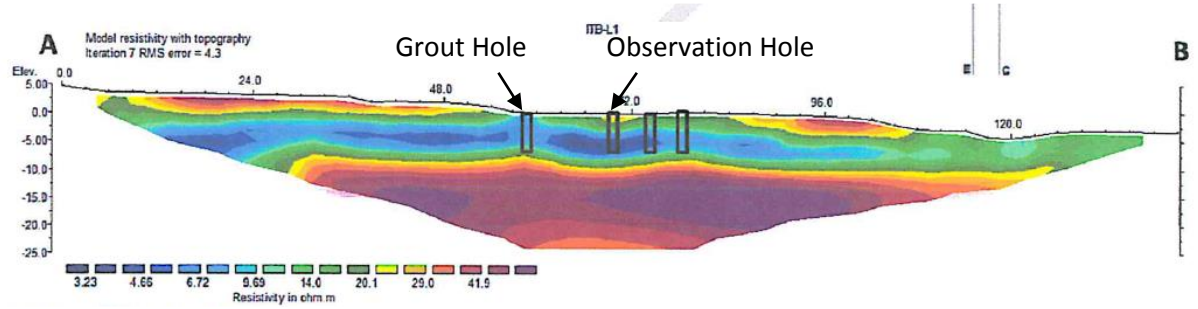


Figure 18 Relation between Soil Quality, Its Hardness and Injection Form

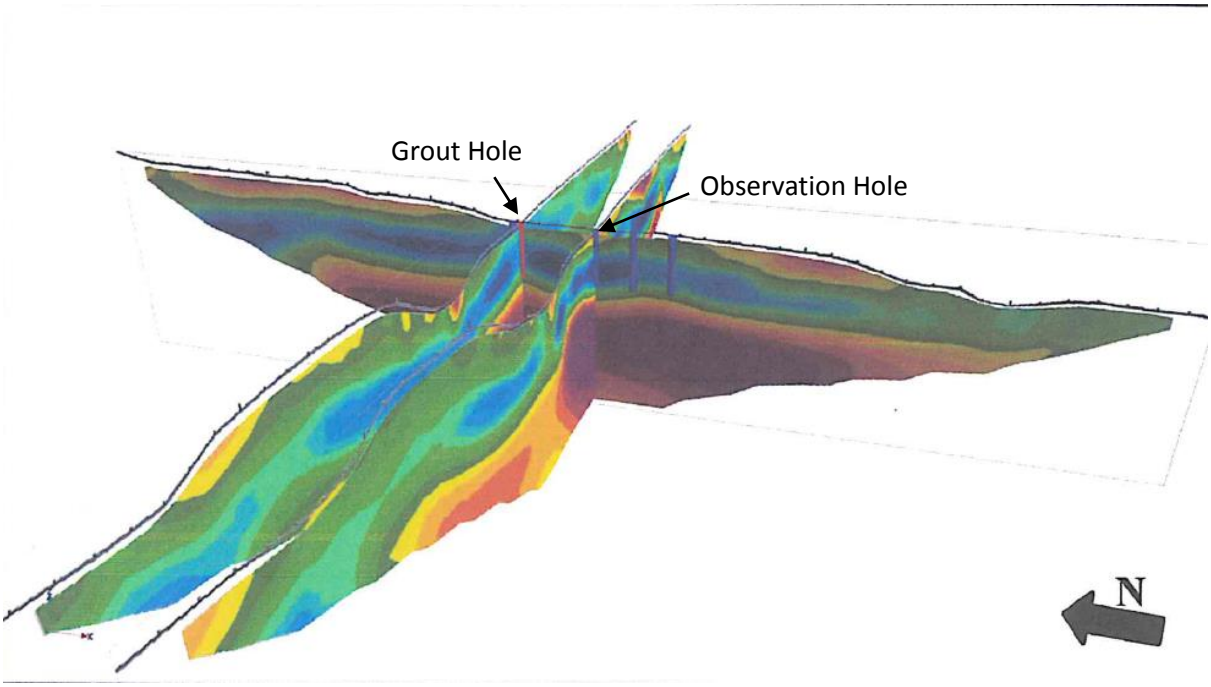
4. Ground water condition in the test area

The ground water condition in bench scale test area was surveyed by electrical exploration using resistivity. The survey result is shown in Figure 18. In the figure, the spot indicated with blue is the spot where the specific resistance value is small (10 Ohm・m or less) and the ground water is considered to be in aquifer. Furthermore, as shown in the figure, a continuous

aquifer can be seen near the depth at which the injection is made in the injection hole, and this aquifer is assumed to be continuous with the observation hole. Not to mention, around the test area, the ground is lowered from the injection hole toward the observation hole, and the assumed aquifer position also decreases from the injection hole toward observation hole. Therefore, it can be assumed that the flow direction of the groundwater also flows from the injection hole toward the direction of the observation hole.



Survey Result (2D)



Survey Result (3D)

Figure 19 Electrical Exploration Result using Resistivity

5. Test Result

5.1. Permeability

The results of permeability test before injection, conducted in preliminary survey hole, and the results of permeability test after injection, conducted in permeability test hole, are shown in Figure 20. It is confirmed that the coefficient of permeability was improved from $6.58x10^{-4}$ to $1.7x10^{-5}$ cm/s. This is similar to the results of Bali sand and Japanese river sand in the table test. If hydraulic gradient is assumed to be 1 and the flow is 57 cm per day, this means that it decreases 1.5 cm per day by injection. Furthermore, according to Japan chemical grouting method standard, it says that after chemical grouting, the permeability coefficient should be improved to around 10^{-4}～10^{-5} cm/s, which is in this test it is improved to those level. Therefore, it is assumed that sufficient improvement of permeability can be achieved even in Indonesian ground.

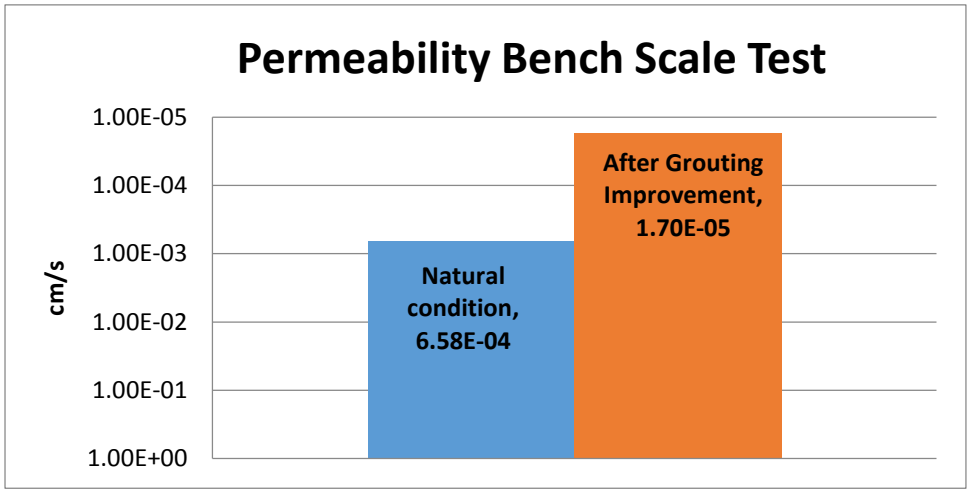


Figure 20　Permeability Test Result

5.2. Strength (N Value)

Regarding strength, the measurement result of N value for preliminary survey hole before the grouting is compared to the measurement result of N value for in site permeability test hole after grouting. In Figure 21, the measurement result of N value for in site permeability test hole is shown in boring histogram of preliminary survey hole with red mark.

The result is that the N value after chemical grouting is slightly larger in 4.0～5.0m depth area, while the N value after chemical grouting is slightly smaller in 5.0～6.0m. There was no clear increase in strength (increase in N value) due to chemical grouting.

As for the cause, it is estimate that especially when it mixed with gravel, the N value is larger than the actual value due to the effect of the gravel. Since there is about 10% of gravel mixed in the soil layer at 4.0～6.0m depth, the clear change of N value is most likely not visible.

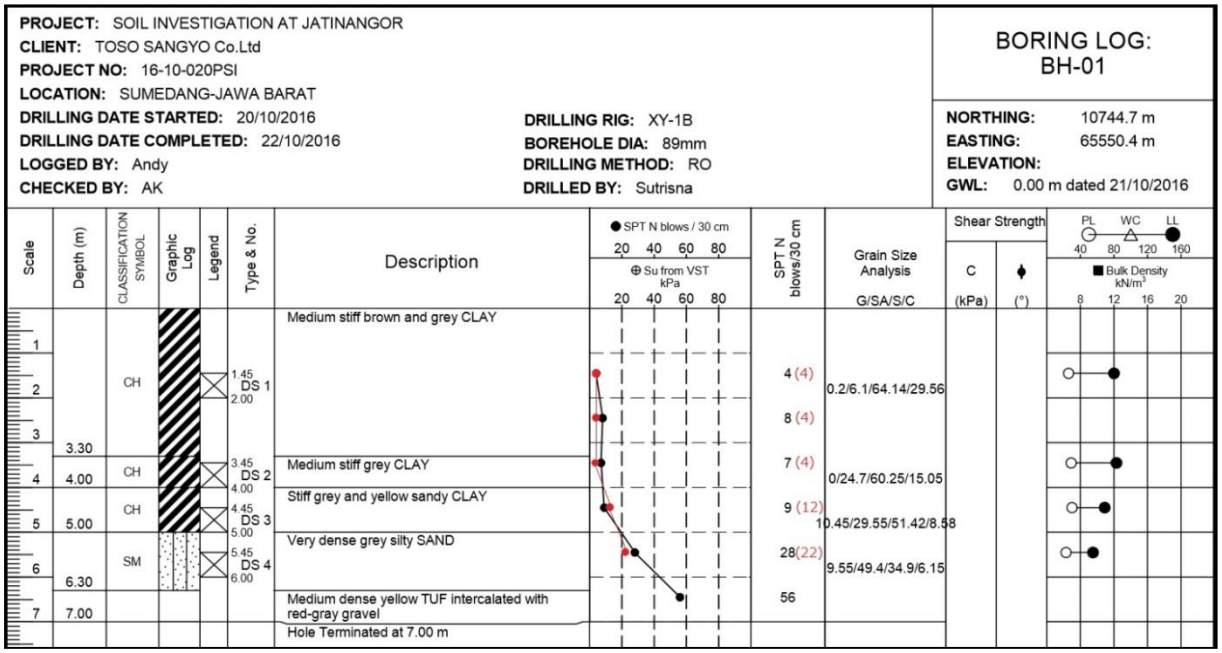


Figure 21 Boring Histogram

(red text indicates the N value measurement result after grouting)

5.3. pH

Based on the Japan standard of chemical grouting method, ground water pH monitoring in observation hole is done with the aim to confirm the influence of grouting material on groundwater. The monitoring result of pH is shown in Figure 21. The monitoring was carried out for 6 months since the chemical grouting injection. From the monitoring results, it shows that pH before the injection was 7.33 but after the injection, it was slightly increased and on the 17th day after the injection, pH value is 7.54. Subsequently, the pH raising is settled and pH on day 122 after injection was 7.71. In monitoring result, a slight rise in pH was observed after injection but according to the Indonesian standards (PP, No.82, 2001 and PERMENKES, No.492, 2010), the value is completely acceptable and it can be assumed that there is no problem on safety regarding pH.

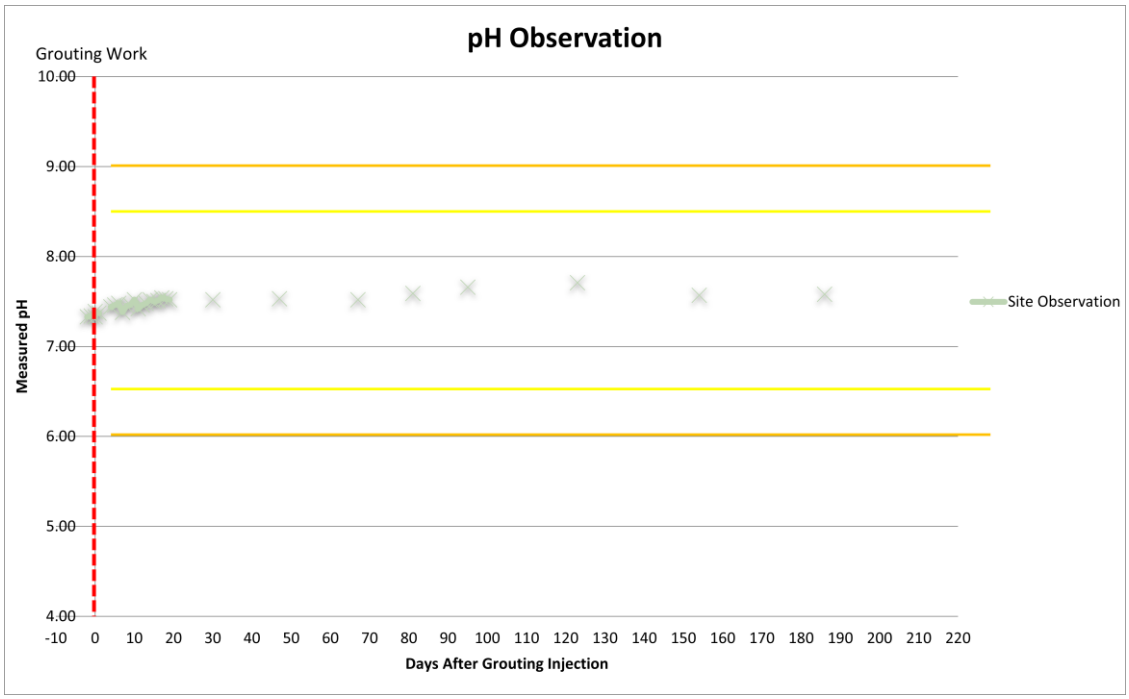


Figure 22 pH Monitoring and Laboratory Test

5.4. Component Analysis

Table 5 shows the component analysis results of groundwater sampled differences before chemical grouting and 18 days after grouting. Based on the result, the amount of chemical leaching of Iron (Fe) and free chlorine (Cl^-) exceeds the Indonesian standard value. For BOD (Biological Oxygen Demand) and Fluoride (F-) amount, difference caused by chemical grouting shows amount below the standards. Moreover chemical grouting is not contains any organics material, which means it should not affected BOD amount. Components that are exceeded the standard value on 18 days after grouting will be explained below.

In case of Iron, despite the fact it fell below the standard value before grouting, it exceeded the standard value 18 days after grouting. This was different results from the table test. In the table test conducted on Japanese sand, the elution amount of iron was small although the Japanese sand contained a relatively large amount of Fe0 (approximately 0.799% massL). From this fact, it can be assumed that the grouting material does not affect the elution of iron. Thus, it is considered leached from rock/soil which is volcanic product. As we know that volcanic product highly contains iron.

Free chlorine shows similar results which it fell below the standard value before grouting but then exceeded the standard value 18 days after grouting. Inorganic chlorides are often ionized

into chloride ions and metal ions in water, and because of their high solubility characteristic in water, they may be relatively abundant in groundwater.

In addition, for free chlorine the standard value of Indonesian standard (PP No.82, 2001) are very small compared to Indonesian Health Ministry standard (No 492, 2010) and WHO, EU standard values. Furthermore, the amount of free chlorine after 18 days was 2.12 mg/L, which was sufficiently small for the standard value of 5 mg/L. The concentration of chloride in groundwater can be easily influenced by human activities (Salminen, 2005), therefore, it can be considered that safety problem is not the issue for free chlorine.

Table 5 Chemical Leaching Test Result

PARAMETER		UNIT	PP, No. 82, 2001	PERMENKES No. 492, 2010	Bench Scale Test		
			Water Quality Management and Water Pollution Control	Drinking Water Standards			
			Class 1		Before Grout	After Grout 18 Days	After Grout 18 Days - Before Grout
PHYSICAL							
Temperature		oC	Deviated until 3		27.6	25.6	-2
Total Dissolved Solid	溶解固形分（蒸発残留物）	mg/L	1000		268	150	-118
Total Suspended Solid	浮遊物質量	mg/L	50		18	38	20
Electric Conductivity	電気伝導度	µS/cm	-				
ORGANIC CHEMISTRY							
pH		mg/L	6 - 9	6.5-8.5	7.3	7.52	7.52 (7.3)
BOD	生物化学的酸素要求量	mg/L	2		1.59	2.39	0.8
COD	化学的酸素要求量	mg/L	10		4.08	6.12	2.04
DO	溶存酸素	mg/L	6				
Phospate Total as P	リン酸塩（Pとして）	mg/L	0.2		0.145	0.2	0.055
NO3 as N	硝酸性窒素（Nとして）	mg/L	10	50	0.006	1.719	1.713
NH3-N	アンモニア性窒素	mg/L	0.5	1.5	0.005	0.003	-0.002
Arsenic	ヒ素	mg/L	0.05	0.01	n.a.	n.a.	n.a.
Cobalt	コバルト	mg/L	0.2		n.a.	n.a.	n.a.
Barium	バリウム	mg/L	1	0.7	0.026	0.086	0.06
Boron	ホウ素	mg/L	1	0.5	n.a.	0.071	0.071
Selenium	セレン	mg/L	0.01	0.01	n.a.	n.a.	n.a.
Cadmium	カドミウム	mg/L	0.01	0.003	0.0347	0.0023	-0.0324
Chrome (VI)	六価クロム	mg/L	0.05	0.05	n.a.	n.a.	n.a.
Copper	銅	mg/L	0.02; 1 *	2	0.0036	n.a.	-0.0036
Iron	鉄	mg/L	0.3	0.3	0.0791	0.4317	0.3526
Lead	鉛	mg/L	0.03	0.01	n.a.	n.a.	n.a.
PHYSICS							
Manganese	マンガン	mg/L	0.1	0.4	0.0968	n.a.	-0.0968
Mercury	水銀	µg/L	1	1	n.a.	n.a.	n.a.
Zinc	亜鉛	mg/L	0.05	3	0.0309	0.0101	-0.0208
Chloride	塩化物	mg/L	600	250	1.43	2.04	0.61
Cyanide	シアン化物	mg/L	0.02	0.07	n.a.	n.a.	n.a.
Flouride	フッ化物	mg/L	0.5	1.5	0.065	0.544	0.479
Nitirite as N	亜硝酸性窒素（Nとして）	mg/L	0.06	3	0.002	0.003	0.001
Sulfate	硫酸塩	mg/L	400	250	47.25	9.25	-38
Free Chlorine	遊離塩素	mg/L	0.03	5	n.a.	2.12	2.12
S as H2S	硫黄（硫化水素として）	mg/L	0.002	-	n.a.	n.a.	n.a.

Legend:
- More than PP, No. 82, 2001 limitation
- More than PERMENKES No.492 limitation
- more than both limitation
- ( ) The amount of chemical leaching of only sand

VI. Conclusion

From table test and bench test results, the following conclusion is drawn.

- Leaching test result on table test shows that pH and some items exceeded the water quality standards for drinking water in Indonesia. On this leaching test condition (specimen with 5 times immersion water volume), due to the characteristic of grouting material, the pH result shows that it exceeds the standard value. However, when compared to when Portland cement are used, the pH is lower. In case of construction in actual field, since it will be diluted with a large amount of ground water, it is assumed that the rise of pH can be suppressed and it can also be assumed that if the pH does not rise, other components exceeding the standard value in the leaching test can be sufficiently diluted.
- From the result of performance test in table test, it can be concluded that the improvement column by chemical grouting method has sufficient strength and sufficient permeability reduction.
- From the results of bench scale test, it can be concluded that the permeability was improved from 6.58×10^{-4} to 1.7×10^{-5} cm/s. Therefore, it can be said that even in Indonesian ground, sufficient improvement of permeability could be achieved.
- From the result of bench scale test regarding strength, it is clear that there was also the influence of the gravel contained in the target sand layer. Also there was no clear difference in N value between before and after grouting. However, as for strength, the improvement effects are confirmed on table test and there was no problem.
- From the result of groundwater monitoring in bench scale test, it is obvious that the pH value slightly increased after grouting. But it is bellow the Indonesian water quality standard. In addition, from the result of the water quality analysis on ground water, it shows some items that exceed Indonesian water quality standard. However it might caused by surrounding rock/soil. Furthermore, there are significance differents between Indonesian water quality standards. Based on the comparison with world water quality standards, PERMENKES No. 492, 2010 is more suitable to use as limitation standard.
- Based on these results, it can be concluded that the chemical grouting method has sufficient effect on increasing strength and water blocking on Indonesia ground. And it can also be concluded that the environment will not be affected. Therefore it can be considered as a very useful method for ground improvement.

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Final Report

INVENTORY SURVEY FOR DETERIORATED EARTH DAMS FOR REHABILITATION FOR VERIFICATION SURVEY WITH THE PRIVATE SECTOR FOR DISSEMINATING JAPANESE TECHNOLOGIES FOR GROUND IMPROVEMENT USING CHEMICAL GROUTING TECHNOLOGY

PT. Djawa Baru

Chapter I

Introduction

A. BACKGROUND

Based on the project with Toso Sangyo Co., Ltd on INVENTORY SURVEY FOR DETERIORATED EARTH DAMS FOR REHABILITATION FOR VERIFICATION SURVEY WITH THE PRIVATE SECTOR FOR DISSEMINATING JAPANESE TECHNOLOGIES FOR GROUND IMPROVEMENT USING CHEMICAL GROUTING TECHNOLOGY, PT Djawa Baru did send letter to Balai Bendungan on *December 13th, 2017 and* their reply was the data of all 12 (twelve) River Basin Territory of all dams in Indonesia *(attached- on Chapter I, B.1.), and* we did send a letter on *January 23rd, 2018* to Directorate of Operation and Maintenance, Directorate General of Water Resources of the Ministry of PUPR and got replied on *January 24th, 2018*, that they will give assistance support to the job and process with their internal procedural *(attached- on Chapter I, B.2.)*

B. Visits to BBWS:

- On February 27th, 2018 visit BBWS Bengawan Solo:

- On March 1st, 2018 visit BBWS Pompengan Jeneberang - Sulawesi Island:

- Below is several letters that PT Djawa Baru sends to ministry of PUPR include reply letter:

1). Letter to Balai Bendungan:

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No : 4/DB/XII/2017

Jakarta, 13 Desember 2017

Kepada Yth.
Bapak Ir. Bastari, M.Eng
Kepala Balai Bendungan
Direktorat Jenderal Sumber Daya Air
Kementerian Pekerjaan Umum dan Perumahan Rakyat
Gedung Balai Bendungan
Jl. Sapta Taruna Raya, Lebak Bulus
Jakarta Selatan 12310

Dengan hormat,

Bersama dengan surat ini kami mohon ijin memperkenalkan diri dari PT Djawa Baru sebagai team JICA Study didalam kegiatan survey study untuk rehabilitasi Bendungan di Indonesia. Kerjasama ini ditujukan untuk keperluan saling mendukung dan bekerjasama dalam kegiatan study survey untuk rehabilitasi Bendungan di Indonesia.

Adapun permohonan yang kami maksud adalah untuk bisa difasilitasi mengenai data Bendungan di Indonesia untuk keperluan pengisian data survey Bendungan di Indonesia yang nantinya akan dipergunakan untuk menganalisa, mempertimbangkan dan menentukan Bendungan yang akan direhabilitasi.

Mohon kiranya kami dibantu dan diijinkan untuk mendukung kegiatan kami ini. Atas perhatian dan persetujuannya diucapkan terima kasih.

Hormat Kami,
PT. Djawa Baru

PT. DJAWA BARU

Heriman Prakosa

In this letter PT Djawa Baru filed an application to be facilitated regarding the Dam data in Indonesia for the purpose of filling out the survey data of the Dam in Indonesia which will be used later in this project.

2). Letter to Director O&M Ministry of PUPR Directorate General of Water Resources and replied as disposition letter to Head of Sub-Operational and Maintenance of Bendungan and Danau:

PT. DJAWA BARU

Registered Office
Jl. Suntor no 25, Malang, Jawa Timur, Indonesia
Phone +62-341-362-764
Fax +62-341-322-480
E-mail info@djawabaru.com

Operational Office
Jl. Prof. Soepomo, S.H. 45F Jakarta 12810, Indonesia
Phone +62-21-829-8401, +62-21-833-0281
Fax +62-21-829-8373
E-mail info@djawabaru.com

No : SF/DB/I/2018
Perihal : Fasilitasi Data Bendungan
Lampiran :

Jakarta, 23 Januari 2018

Kepada Yth.
Up. Bapak Ir. Agung Djuhartono, CES
Direktur Bina Operasi dan Pemeliharaan
Direktorat Bina Operasi & Pemeliharaan
Direktorat Jendral Sumber Daya Air
Kementerian Pekerjaan Umum dan Perumahan Rakyat

di tempat

Dengan hormat,

Menindaklanjuti *Minutes of Meeting* tertanggal 25 April 2016 antara JICA, Balitbang Kementerian PUPR serta Toso Sangyo, Co. Ltd., kami mohon ijin memperkenalkan diri dari PT Djawa Baru sebagai team JICA Study dalam kegiatan survey study untuk rehabilitasi Bendungan di Indonesia.

Permohonan yang kami maksud adalah kiranya dapat difasilitasi perihal data Bendungan di Indonesia untuk pengisian data survey Bencungan di Indonesia yang akan digergunakan untuk menganalisa, mempertimbangkan dan menentukan Bendungan yang akan direhabilitasi. Adapun beberapa contoh data bendungan yang kami perlukan adalah sebagai berikut:

- Data Perbaikan
- Data Kerusakan seperti kebocoran, badan/tubuh bendungan atau lainnya.
- Data Penurunan Fungsional
- Data Pengeboran
- Data Penerima Manfaat dan Dampak Terhadap Sosial, Ekonomi & Lingkungan
- Data Stake-holder, seperti pasokan air untuk kebutuhan rumah tangga, budidaya ikan
- Data terkait lainnya, seperti perluasan dan/atau rehabilitasi sistem irigasi dan sumber dana

Demikian surat ini kami sampaikan, atas perhatian dan persetujuannya diucaptan terima kasih.

Hormat Kami,
PT. Djawa Baru

PT. DJAWA BARU

Hariman Frakosa

23/01/18

JAJA

739500

1/24/2018 Aplikasi TNDE

KEMENTERIAN PEKERJAAN UMUM DAN PERUMAHAN RAKYAT
DIREKTORAT JENDERAL SUMBER DAYA AIR
DIREKTORAT BINA OPERASI DAN PEMELIHARAAN
Jl. Pattimura No. 20 Kebayoran Baru Jakarta Selatan 12110. Telp. 021-7395500 Fax. 021-7244312

LEMBAR DISPOSISI

DARI/DITERIMA TGL (eksternal) : PT. DJAWA BARU / 2018-01-24 09:52:20.000
NOMOR DAN TGL : 07/DB/I/2018 / 23-Jan-2018
PERIHAL : ***FASILITASI DATA BENDUNGAN***

NO AGENDA : 6304/I/BOP/2018 Tanggal : 24-Jan-2018

Kepada Yth.
- ☐ Kasubdit. Perencanaan OP
- ☑ Kasubdit. OP Bendungan & Danau
- ☐ Kasubdit. OP Irigasi dan Rawa
- ☐ Kasubdit. OP Sungai dan Pantai
- ☐ Kasubdit. Fasilitas Jaringan SDA Daerah
- ☐ Kasubag. Tata Usaha
- ☐ Sekretaris

SIFAT
- ☐ Segera
- ☐ Mendesak
- ☐ Perlu perhatian Khusus
- ☐ Perhatikan Batas Waktu

Mohon Bantuan Saudara Agar :
- ☐ Diketahui sebagai informasi
- ☐ Mempelajari dan menyampaikan saran
- ☐ Melaksanakan sesuai dengan pembicaraan
- ☑ Diproses sesuai prosedur
- ☐ Koordinasi dengan unt terkait:
- ☐ Edarkan
- ☐ Menyimpan dalam file
- ☐ Hadir mewakili saya
- ☐ Menyiapkan bahan/jawaban
- ☐ Membicarakan dengan saya
- ☐ Jadwalkan/ atur rapat / pertemuan
- ☐ Ikut hadir / menunjuk wakil
- ☐ Dicopy dan asli kembali ke saya
- ☐ .....

Catatan Lain:

IR AGUNG DJUHARTONO CES
NIP :196006171990031001

https://soffice.pu.go.id/surat_masuk/inbox/detail_surat/4624.20180124.0005 1/1

Chapter II

Table Deteriorated Dam Investigation

The average dam at BBWS experienced drought due to weather conditions and also experienced siltation and quite high sedimentation, this might cause the dam's capacity to decrease as overall deterioration mechanism and distribution of dam failure.
The following is a recapitulation table of damage data collection that has occurred in each of the 6 BBWS, which are:

1. BRANTAS RIVER BASIN (Java Island)

1.Brantas River Basin

No.	Name of Dam	Problem																								Costruction Year		
		Allegedly Leaked	Broken-Down (Collapse)	Body Dam (damage, erosion)	Bitumen Surface damage due to Erosion	Building Protector Floor	Crack (dam, land, street)	Drought (dry season)	Grouting (Channel filling)	Path	Leakage	River Cliff (landslides, lightly damage) and Masonry Landslides (Erosion)	Irrigation Water Channel Broken (need improvement)	Inlet Channel Upper Stream was Broken	Paving Above Embankment Broken	Riverbank Damaged Due To Erosion	Symptoms of Reed Erosion on The Support Hill	Safety Fence	Sedimentation	Siltation	Seepage	Slope Condition: (damage by erosion, slighty damage, landslide, crack, replace)	Spillway Gate Leakage; Spillway channel worn-out; Spillway Erosion; Mercu Spillway	V-Notch (Seepage in the area, or slightly damaged)	Start	Completed	Ages to 2018
0001	Bajulmati	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2006	2015	3
0002	Banyu Urip	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2014	4
0003	Bening/ Widas	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1977	1984	34
0004	Canggah	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1920	98
0005	Cungkup	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1933	85
0006	Karangkates (SUTAMI)	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1964	1973	45
0007	Kedung Sengon	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1978	40
0008	Klampis	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	1974	1976	42
0009	Lahor	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1973	1975	43
0010	Ngepeh	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2007	11
0011	Nipah	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2015	3
0012	Oro-oro Ombo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2005	13
0013	Sampean Baru	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1979	1983	35
0014	Selorejo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1963	1970	48
0015	Sengguruh	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	1982	1988	30
0016	Sumberkepuh	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1939	79
0017	Wlingi	✓	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	1975	1977	41
0018	Wonorejo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1992	2001	17
	SUB TOTAL BBWS BRANTAS	2	1	0	0	0	1	3	0	0	3	0	1	0	0	0	0	0	1	0	0	0	1	0				

1. Leakage : 3 cases (Dam: Bajulmati, Sampean Baru, Wlingi);
2. Drought (dry season) : 3 cases (Dam: Canggah, Lahor, Sumberkepuh);
3. Allegedly Leaked : 2 cases (Dam: Sengguruh, Wlingi);
4. Broken-Down (collapse) : 1 case (Kedung Sengon Dam);
5. Crack (dam, land, street) : 1 case (Karangkates(Sutami) Dam);
6. Irrigation Water Channel Broken (need improvement) : 1 case (Klampis Dam);
7. Sedimentation : 1 case (Wlingi Dam);
8. Spillway Gate Leakage; Spillway channel worn-out; Spillway Erosion; Mercu Spillway: 1 case (Sengguruh Dam).

From the above information about the dam water level decrease at BBWS Brantas due to experiencing leakage (Bajulmati Dam, Sampean Baru, Wlingi) and experiencing drought results from weather or dry season (Dam Canggah, Lahor, and Sumberkepuh).

2. SOLO RIVER BASIN (Java Island)

2. Solo River Basin																													
No.	Name of Dam	Problem																									Costruction Year		
		Allegedly Leaked	Broken Down (Collapse)	Body Dam (damage; erosion)	Bitumen Surface damage due to Erosion	Building Protector Floor	Crack (dam, land, street)	Drought (dry season)	Grouting (Channel filling)	Path	Leakage	River Cliff (landslides, lightly damage) and Masonry Landslides (Erosion)	Irrigation Water Channel Broken (need improvement)	Inlet Channel Upper Stream was Broken	Paving Above Embankment Broken	Riverbank Damaged Due To Erosion	Symptoms of Reed Erosion on The Support Hill	Safety Fence	Sedimentation	Siltation	Seepage	Slope Condition (damage by erosion, slightly damage, landslide, crack, replace)	Spillway Gate Leakage; Spillway channel worn-out; Spillway Erosion; Mercu Spillway	V-Notch (Seepage in the area, or slightly damaged)	Start	Completed	Ages to 2018
0019	Botok	✓	-	✓	-	-	-	✓	-	-	-	✓	-	✓	✓	✓	-	-	✓	-	✓	✓	-	✓	-	1942	76
0020	Cengklik	-	-	-	-	-	-	-	-	-	✓	✓	✓	-	✓	-	-	✓	✓	-	-	✓	-	✓	1923	1931	87
0021	Dawuhan	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	1962	56
0022	Delingan	-	-	-	-	-	✓	✓	-	-	-	✓	-	-	-	-	-	-	-	-	-	✓	-	-	1920	1923	95
0023	Gebyar	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	-	-	1955	63
0024	Gondang	-	-	-	-	-	-	✓	-	-	✓	-	-	-	-	-	-	-	✓	-	-	-	-	-	1976	1986	32
0025	Gonggang	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2004	2011	7
0026	Kedung Bendo	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	1948	70
0027	Kedung Brubus	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	2008	10
0028	Kedung Uling	-	-	-	-	-	-	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1917	101
0029	Kembangan	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	1940	78
0030	Ketro	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	1975	1984	34
0031	Krisak	-	-	✓	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	✓	-	-	1943	75
0032	Lalung	-	-	-	✓	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-	✓	-	-	-	1940	78
0033	Mulur	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	1926	92
0034	Nawangan	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	✓	-	1974	1976	42
0035	Ngancar	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	✓	-	✓	-	-	-	-	-	1944	1946	72
0036	Nglambangan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	1997	21
0037	Notopuro	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	1941	77
0038	Pacal	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1927	1933	85
0039	Parangjoho	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	1973	1980	38
0040	Plumbon	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	1918	1928	90
0041	Pondok	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	1993	1995	23
0042	Prijetan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	1910	1916	102
0043	Sangiran	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	2000	18
0044	Saradan	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	1935	83
0045	Song Putri	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	1977	1984	34
0046	Telaga Pasir/ Sarangan	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1931	87
0047	Tlogo Ngebel	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	1930	88
0048	Wonogiri / Gajah Mungkur	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	1976	1982	36
	SUB TOTAL BBWS B. SOLO	1	0	2	1	0	1	22	0	0	3	3	1	1	2	1	1	2	18	4	2	5	3	2			

1. Leakage : 3 case (Dam: Cengklik, Gondang, Kedung Uling);
2. Drought (dry season) : 22 cases (Dam: Botok, Dawuhan, Delingan, Gondang, Gonggang, Kedung Bendo, Kedung Brubus, Kedung Uling, Kembangan, Ketro, Krisak, Lalung, Mulur, Nawangan, Ngancar, Notopuro, Pacal, Plumbon, Pondok, Sangiran, Saradan, Tlogo Ngebel);
3. Sedimentation : 18 cases (Dam: Botok, Cengklik, Dawuhan, Gondang, Kedung Brubus, Krisak, Lalung, Mulur, Nawangan, Ngancar, Notopuro, Parangjoho, Plumbon, Prijetan, Saradan, Song Putri, Tlogo Ngebel, Wonogiri/ Gajah Mungkur);
4. Siltation ; 4 cases (Dam: Kedung Bendo, Ngalmbangan, Pondok, Sangiran);
5. Slope Condition (damage by erosion, slightly damage, landslide, crack, replace) : 5 cases (Dam: Botok, Cengklik, Delingan, Gebyar, Lalung);
6. River Cliff (landslides, lightly damage) and Masonry Landslides (Erosion) ; 3 cases (Dam: Botok, Cengklik, Delingan);
7. Spillway Gate Leakage; Spillway channel worn-out; Spillway Erosion; Mercu Spillway : 3 cases (Dam: Gebyar, Krisak, Nawangan);
8. Body Dam (damage; erosion) : 2 cases (Dam: Botok, Krisak);
9. Paving Above Embankment Broken ; 2 cases (Dam: Botok, Cengklik);
10. Safety Fence : 2 cases (Dam: Cengklik, Ketro);
11. Seepage : 2 cases (Dam: Botok, Kembangan);
12. V-Notch (Seepage in the area, or slightly damaged) : 2 cases (Dam: Botok, Cengklik);
13. Allegedly Leaked : 1 case (Botok Dam);
14. Bitumen Surface damage due to Erosion : 1 case (Lalung Dam);
15. Crack (dam, land, street) : 1 case (Delingan Dam);
16. Irrigation Water Channel Broken (need improvement) : 1 case (Cengklik Dam);
17. Inlet Channel Upper Stream was Broken : 1 case (Botok Dam);
18. Riverbank Damaged Due To Erosion : 1 case (Botok Dam);
19. Symptoms of Reed Erosion on The Support Hill: 1 case (Ngancar Dam).

From the information above about the dam water level decrease at BBWS Bengawan Solo mostly due to experiencing drought results from weather or dry season (Botok Dam, Dawuhan, Delingan, Gondang, Gonggang, Kedung Bendo, Kedung Brubus, Kedung Uling, Kembangan, Ketro, Krisak, Lalung, Mulur, Nawangan, Ngancar, Notopuro, Pacal, Plumbon, Pondok, Sangiran, Saradan, and Tlogo Ngebel), as well as experience high sedimentation (Botok Dam, Cengklik, Dawuhan, Gondang, Kedung Brubus, Krisak, Lalung, Mulur, Nawangan, Ngancar, Notopuro , Parangjoho, Plumbon, Prijetan, Saradan, Song Putri, Tlogo Ngebel, Wonogiri / Gajah Mungkur).

3. CIREBON REGION (Java Island)

3. Cirebon Region

No.	Name of Dam	Problem																							Costruction Year		
		Allegedly Leaked	Broken-Down (Collapse)	Body Dam (damage; erosion)	Bitumen Surface damage due to Erosion	Building Protector Floor	Crack (dam, land, street)	Drought (dry season)	Grouting (Channel filling)	Path	Leakage	River Cliff (landslides, lightly damage) and Masonry Landslides (Erosion)	Irrigation Water Channel Broken (need improvement)	Inlet Channel Upper Stream was Broken	Paving Above Embankment Broken	Riverbank Damaged Due To Erosion	Symptoms of Reed Erosion on The Support net	Safety Fence	Sedimentation	Siltation	Seepage	Slope Condition: (damage by erosion, slightly damage, landslide, crack, replace)	Spillway Gate Leakage; Spillway channel worn-out; Spillway Erosion; Mercu Spillway	V-Notch (Seepage in the area, or slightly damaged)	Start	Completed	Ages to 2018
0049	Darma	-	-	-	-	-	✓	✓	-	-	✓	-	✓	-	-	-	-	-	-	✓	-	✓	-	-	1959	1962	56
0050	Jatigede	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2009	2014	4
0051	Setupatok	-	-	-	-	-	-	-	✓	-	✓	-	✓	-	-	-	-	-	-	-	✓	-	✓	-	1924	1927	91
0052	Situ Bolang	-	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1982	36
0053	Situ Ranca Bereum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1933	85
0054	Situ Sedong	-	-	✓	-	✓	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	✓	-	-	1918	100
	SUB TOTAL Cirebon Region	0	0	1	0	1	1	1	1	1	2	0	3	0	0	0	0	0	0	1	1	1	2	0			

1. Leakage : 2 cases (Dam: Darma, Setupatok);
2. Irrigation Water Channel Broken (need improvement) : 3 cases (Dam: Darma, Setupatok, Situ Sedong);
3. Spillway Gate Leakage; Spillway channel worn-out; Spillway Erosion; Mercu Spillway ; 2 cases (Dam: Setupatok, Situ Sedong);
4. Body Dam (damage; erosion) : 1 case (Situ Sedong Dam);
5. Building Protector Floor : 1 case (Situ Sedong Dam);
6. Crack (dam, land, street) : 1 case (Darma Dam);
7. Drought (dry season) : 1 case (Darma Dam);
8. Grouting (Channel filling) : 1 case (Setupatok Dam);
9. Path : 1 case (Situ Bolang Dam);
10. Siltation : 1 case (Darma Dam);
11. Seepage : 1 case (Setupatok Dam);
12. Slope Condition (damage by erosion, slightly damage, landslide, crack, replace): 1 case (Darma Dam).

From the above information about the dam water level decrease at BBWS Brantas due to experiencing leakage (Dam: Darma and Setupatok). At the Darma Dam the concrete membrane on the slope of the dam body had been broken, and then replaced by steel membrane (1972), the water gate for irrigation channel leaking at Darma Dam, meanwhile Setupatok Dam From the results of the survey, there were several locations of leaks, namely in the well of Penpen village, the Setupatok floodgate, the channel under the bridge of Jalan Setupatok Village. The difficulty is that the leak occurs underground, making it difficult to determine the exact point.

4. BANTEN and JAKARTA Region (Java Island)

4. Banten & Jakarta Region

No.	Name of Dam	Problem																							Costruction Year		
		Allegedly Leaked	Broken-Down (Collapse)	Body Dam (damage, erosion)	Bitumen Surface damage due to Erosion	Building Protector Floor	Crack (dam, land, street)	Drought (dry season)	Grouting (Channel filling)	Path	Leakage	River Cliff (landslides, lightly damage) and Masonry Landslides (Erosion)	Irrigation Water Channel Broken (need improvement)	Inlet Channel Upper Stream was Broken	Paving Above Embankment Broken	Riverbank Damaged Due To Erosion	Symptoms of Re	Safety Fence	Sedimentation	Siltation	Seepage	Slope Condition: (damage by erosion, slightly damage, landslide, crack, replace)	Spillway Gate Leakage; Spillway channel worn-out; Spillway Erosion; Mercu Spillway	V-Notch (Seepage in the area, or slightly damaged)	Start	Completed	Ages to 2018
0055	Gintung	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2011	7
0056	Karian	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0057	Krenceng	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1977	41
0058	Pongkor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1996	22
	SUB TOTAL Banten & Jakarta Region	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			

1. Broken-Down (collapse): 1 case (Gintung Dam).
2. Under Construction: Karian Dam

The Situ Gintung embankment collapsed and buried dozens of residents' houses. The disaster began from heavy rain Thursday afternoon March 26, 2009, until the Situ Gintung embankment broke down on Friday 27 March, 2009 in the morning result from heavy rain. Detikcom reporter monitoring, there are at least dozens of homes that have been submerged, more than 23 houses. Water soaked the house from Situ Gintung to Poncol towards Cireundeu. Not only houses, there are also some public facilities such as mosques, and others. Situ Gintung embankment broke down in March 2009, sending 2 million cubic meters of water to the lowland area, killing 91 people.

5. MESUJI SEKAMPUNG (Sumatera Island)

5. Mesuji Sekampung

No.	Name of Dam	Problem																							Costruction Year		
		Allegedly Leaked	Broken-Down (Collapse)	Body Dam (damage, erosion)	Bitumen Surface damage due to Erosion	Building Protector Floor	Crack (dam, land, street)	Drought (dry season)	Grouting (Channel filling)	Path	Leakage	River Cliff (landslides, lightly damage) and Masonry Landslides (Erosion)	Irrigation Water Channel Broken (need improvement)	Inlet Channel Upper Stream was Broken	Paving Above Embankment Broken	Riverbank Damaged Due To Erosion	Symptoms of Road Erosion on The Support Hill	Safety Fence	Sedimentation	Siltation	Seepage	Slope Condition: (damage by erosion, slightly damage, landslide, crack, replace)	Spillway Gate Leakage; Spillway channel worn-out; Spillway Erosion; Mercu Spillway	V-Notch (Seepage in the area, or slightly damaged)	Start	Completed	Ages to 2018
0059	Batutegi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1995	2003	15
0060	Way Jepara	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	1975	1978	40
0061	Way Linggo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2010	8
0062	Way Rarem	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓	-	-	-	-	1980	1984	34
	SUB TOTAL Mesuji Sekampung	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0			

1. Siltation : 2 cases (Dam: Way Jepara, Way Rarem);
2. Drought (dry season): 1 case (Way Jepara Dam).

The dam experienced a decrease in water level as a result of drought due to weather and silting (Way Jepara Dam, Way Rarem).In this dry season in 2017 makes Lake Wayjepara reservoir, East Lampung, unable to irrigate rice fields in three sub-districts, namely, Way Jepara, Labuhanratu and Brajaselebah Districts (12 Sep 2017). The head of irrigation KPD Wayjepara, Sulaman, through Marjianto's Operations and Maintenance, when met in his office on Tuesday (12/09/2017), said that the shrinking of lake water had been very alarming besides having a dry impact which also affected the forest conditions around the lake which had been inhabited by many people.

6. POMPENGAN JENEBERANG (Sulawesi Island)

6. Sulawesi Island																													
No.	Name of Dam	Problem																									Costruction Year		
		Allegedly Leaked	Broken Down (Collapse)	Body Dam (damage, erosion)	Bitumen Surface damage due to Erosion	Building Protector Floor	Crack (dam, land, street)	Drought (dry season)	Grouting (Channel filling)	Path	Leakage	River Cliff (landslides, lightly damage) and Masonry Landslides (Erosion)	Irrigation Water Channel Broken (need improvement)	Inlet Channel Upper Stream was Broken	Paving Above Embankment Broken	Riverbank Damaged Due To Erosion	Symptoms of Reed Erosion on The Support Hill	Safety Fence	Sedimentation	Siltation	Seepage	Slope Condition (damage by erosion, slightly damage, landslide, crack, replace)	Spillway Gate Leakage; Spillway channel worn-out; Spillway Erosion; Mercu Spillway	V-Notch (Seepage in the area, or slightly damaged)	Start	Completed	Ages to 2018
0063	Bakaru	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1976	1990	28
0064	Balambano	-	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1995	2001	17
0065	Bil-Bil	-	-	-	-	-	-	✓	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1991	1999	19
0066	Fiona	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2002	16
0067	Kalola	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1992	1995	23
0068	Karalloe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2013	2019	-
0069	Karebbe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2008	2011	7
0070	Larona (Batu Besi)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1975	1977	41
0071	Paselloreng	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2015	2019	-
0072	Ponre-Ponre	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2005	2008	10
0073	Salomekko	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1996	1998	20
	SUB TOTAL Sulawesi Island	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			

1. Drought (dry season) : 1 case (Bili-Bili Dam);
2. Grouting (Channel filling): 1 case (Balambano Dam);
3. Under Construction: Karalloe Dam and Passeloreng Dam

At BBWS Pompengan Jeneberang, Bili-Bili Dam has experienced a decrease in water level as a result of drought due to weather / drought conditions. Balambano Dam once did grouting in channel filling. Whereas in Balambano hydropower plant with underwater grouting work. This activity is to coat several hollow canals. This is to maintain the power and construction of the dam, said Yusri Yunus, Supervisor of Operation Hydro Plant. Canal filling aims to maintain the stability of the canal slope.

Chapter III

Individual feature

From the information presented in the previous chapter, there are 8 (eight) dams that have experienced leakage (Dam at BBWS Brantas: Bajulmati, Sampean Baru, Wlingi; Dam at BBWS B. Solo: Cengklik, Gondang, Kedung Uling; Dam at BBWS Cimanuk Cisanggarung: Darma, Setupatok). Most of the dams that have been delivered in the previous chapter have experienced problems with sedimentation and siltation and drought caused by the dry season.

As a result of the fact that the irrigation canal is not smooth or normally distributed the farmers or the community who depend on irrigation from the availability of water in the dam will not be able to enjoy the benefits of irrigation water and can result in delayed harvest or no harvest. Obviously this will harm the farmer and local community, in addition to delayed harvest or harvest failure, the community's need for raw water, electricity, and irrigation was also reduced and its distribution is not maximized.

Food insecurity due to drought not only causes malnutrition problems for children age below 5 years of age in East Sumba Regency, East Nusa Tenggara, but also threatens the smoothness of education. Hundreds of school-age children in the area are threatened with dropping out of school due to lack of fees.

In 2010 failure to harvest makes parents have no choice but to stop their children from elementary, junior and senior high school education. Some parents also choose to rest their children at home while helping them because the school is far from their home settlement and they do not have any transportation costs.

Photo sample drought problems:

Contoh foto masalah sedimentasi:

Contoh foto masalah bocor/rembes:

Grouting on the floor spill way,
Grouting approximately along 200 m, to the left 100 m and to the right 100 m from Spill way including in the body spill way

Chapter IV

Project Implementation Information

In the Ministry of Public Works and Housing there has been a project related to dams, including:

1. **Technical Assistance Services for Supporting the Implementation Management and Supervision of THE DAM OPERATIONAL IMPROVEMENT AND SAFETY PROJECT (DOISP)- LOAN IBRD 7669 – ID THE REPUBLIC OF INDONESIA MINISTRY OF PUBLIC WORKS AND HOUSING DIRECTORATE GENERAL OF WATER RESOURCES DIRECTORATE OF OPERATION AND MAINTENANCE**
   FINAL REPORT VOLUME I – MAIN REPORT JUNE 2017 Submitted by WIRATMAN & Associates in Joint venture with C. LOTTI & ASSOCIATI

   Inspection report Result of Hydro-Eletromechanical Equipment Condition up to June 2015 (page: 23-24) and up to December 2016 (page 40-41) :

   - Pengga Dam (February 21, 2012)

   Problems: In front of gate many sediment and water hyacinth (enceng gondok).
   Recommendation: Sediments and water hyacinth (enceng gondok) shall be flushed to downstream or dredged by dredger to spoil bank.

   - Batujai (February 21, 2012)

   Problems: In front of gate many sediment and water hyacinth (enceng gondok)
   Recommendation: Sediments and water hyacinth (enceng gondok) shall be flushed to downstream or dredged by dredger to spoil bank.

- Malahayu (May 3, 2012)

Problems: Much sediment In front of Guard sluice gates.
Recommendation: Sediments shall be flushed to downstream by opened flushing gate or dredged by dredger to spoil bank in order gates are not pressed by sediment.

Quoted from the conclusions & recommendations:
Criteria on Dam Operation and Maintenance Management has been finished, with the conclusion that dam OMM cannot be standardized due to every dam has its own characteristic, and always difference one to another. Anyway to decide the requirement of minimum personnel and equipment required it can be analyzed by using extreme damage of the dam resulted from the major safety inspection, in five year interval. (See Special Report, Readiness Criteria).

2. PROJECT DOCUMENT OF THE ASIAN INFRASTRUCTURE INVESTMENT BANK 2017 (AIIB)- DOISP II:

- **DAM OPERATIONAL IMPROVEMENT AND SAFETY PROJECT-2 – DOISP 2), LAND ACQUISITION AND RESETTLEMENT POLICY FRAMEWORK – LARPF, Environmental and Social Management Framework/ESMF in October 2016 (***Attachment 1: List of DOISP2 Subprojects that will be implemented in year 1***,** page: 106)

Recommended for dredging maintenance:

a. Ketro Dam in BBWS Bengawan Solo,
b. Penjalin Dam in BBWS Pemali Juana,
c. Greneng Dam in BBWS Pemali Juana,
d. Tempuran Dam in BBWS Pemali Juana,
e. Mrancang Dam in BWS Kalimantan III.

添付資料3　ダム安全管理専門家によるカモジンダム事前調査に関する報告書

JICA PROJECT UNTUK MEMPERKENALKAN TEKNOLOGI PERBAIKAN TANAH DENGAN MENGGUNAKAN “CHEMICAL GROUTING”

JICA PROJECT TO INTRODUCE SOIL IMPROVEMENT TECHNOLOGY USING "CHEMICAL GROUTING"

1. Latar Belakang
   - Proyek ini telah diperkenalkan oleh “Toso Songyo Co. Ltd”, team bantuan JICA sejak tahun 2016, namun pertemuan yang efektif baru bisa berlangsung setelah adanya Rapat antara PUS AIR, BBWS Citarum dan Toso Team pada tanggal 27 Desember 2017 yang diadakan di kantor Pus Air yang dipimpin oleh Kepala Pus Air Bapak DR. Eko Winar Irianto, MT.
   - Pada Rapat ini diantaranya telah disepakati bantuan JICA untuk Chemical Grouting akan dilaksanakan di Bendungan Kamojing yang terletak di Kabupaten Krawang dalam wilayah Balai Besar Wilayah Sungai Citarum, berdasarkan atas hasil “Verifikasi Survey” yang dilakukan “Toso Sangyo Co.Ltd. atas keempat bendungan yakni Batutegi, Cipancuh Indramayu, Ciburuy dan Kamojing (September 2017).
   - Hasil Verifikasi Survey menunjukkan bahwa di tubuh Bendungan Kamojing di identifikasi adanya rembesan/ bocoran pada kaki tubuh bendungan bagian hilir. Untuk menganalisis bocoran ini lebih jauh dipandang perlu dilakukan penelitian Mekanika tanah (Soil Investigasi) yang lebih mendalam.
   - Untuk mendeteksi kemungkinan rembesan, penelitian mekanika tanah dilakukan dengan permeability test dalam rangka mendapatkan “soil permeability parameter”. Penelitian ini dilaksanakan oleh SOFOCO . Selain itu penelitian juga dilakukan dengan tracer test dalam rangka untuk mengetahui bocorannya tubuh bendungan. Test ini dilakukan oleh NITTOC sendiri.
   - Secara garis besar “Geotechnical Investigation” ini mencakup “
     - Drilling pada 2 lokasi (upstream dan downstream)
     - Standar penetration test setiap interval 1,5 M kedalaman.

- Permeability test (hanya pada boring bagian upstream)
- Core drilling dengan core box nya
- Pemasangan PVC dengan gravel pack untuk Tracer test.

Laporan hasil investigasi secara lengkap dapat diberikan pada buku Permeability and soil investigation Report, Situ Kamojing Cikampek (SOFOCO 2019).

1. Background

• This project was introduced by "Toso Songyo Co. Ltd ", the JICA assistance team since 2016, but an effective meeting can only take place after the meeting between PUS AIR, BBWS Citarum and Toso Team on December 27, 2017 which was held at the Pus Air office led by the Head of Water Center Mr. DR. Eko Winar Irianto, MT.

• In this meeting, among others, it was agreed that JICA's assistance for Chemical Grouting would be carried out at the Kamojing Dam located in Krawang Regency in the Citarum River Basin Area, based on the results of the "Survey Verification" conducted "Toso Sangyo Co.Ltd. for the four dams namely Batutegi, Cipancuh Indramayu, Ciburuy and Kamojing (September 2017).

• Survey Verification results indicate that in the body of the Kamojing Dam there was seepage / leakage in the lower body of the dam's body. To analyze this leakage it is further deemed necessary to do more in-depth soil mechanics (Soil Investigation) research.

• To detect the possibility of seepage, soil mechanics research is carried out with permeability test in order to obtain "soil permeability parameters". This research was carried out by SOFOCO. In addition, research was also carried out with a tracer test in order to find out the leakage of the dam body. This test was carried out by NITTOC itself.

• Broadly speaking this "Geotechnical Investigation" includes "

– Drilling at 2 locations (upstream and downstream)

Penetration Standard penetration test for every 1.5 M depth interval.

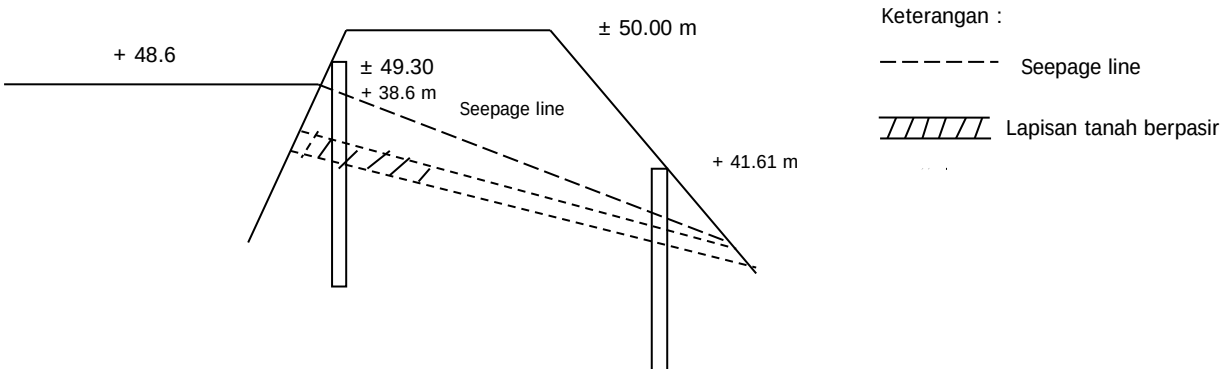
– Permeability test (only upstream boring)

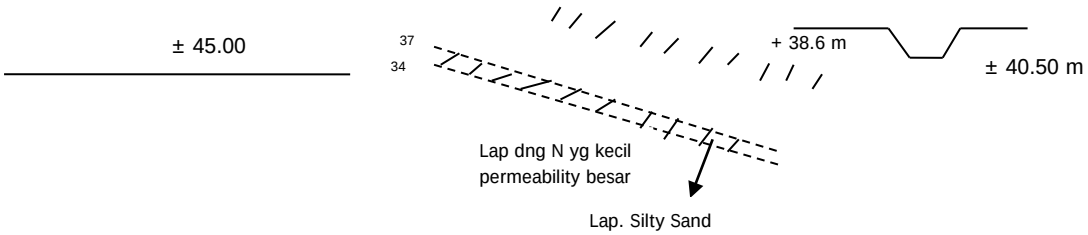
– Core drilling with the core box

– PVC mounting with gravel pack for Tracer test.

A complete report on the results of the investigation can be given to the Permeability and Soil Investigation Report book, Situ Kamojing Cikampek (SOFOCO 2019).

2. Tanggapan dan Rekomendasi atas laporan hasil penelitian permeability dan penyelidikan tanah pada tubuh bendungan Situ Kamojing.
   1) Penyelidikan Tanah dan Permeability atas tubuh bendungan Kamojing dilaksanakan berkat hasil rapat antara Pus Air, BBWS Citarum dan Toso Sangyu Co. Ltd. yang diselenggarakan di Pus Air pada.....
   2) Penyelidikan tanah dan permeability test tubuh bendungan Kamojing juga dilakukan berdasarkan ketentuan yang ditetapkan oleh Balai Keamanan Bendungan sesuai dengan persyaratan terlampir. (Hasil Diskusi tgl. 07 September 2018).
   3) Hasil penyelidikan tubuh bendungan memberikan indikasi-indikasi sbb :
      3.1. Penyelidikan SPT pada pengeboran kaki bendungan bagian Hulu.
         - Nilai SPT dari permukaan lubang boor (cl + 49.30 M) ke bawah semakin kecil/ lemah dengan nilai SPT yang paling rendah (IN) pada kedalaman anatara 5.5 s/d 5.95 M. Nilai SPT yang relatif kecil ini (antara 2 N s/d 5 N) terletak pada kedalaman tubuh bendungan pada posisi (antara 4.45 m s/d 10.45m), dimana struktur tanahnya merupakan campuran antar silty clay dengan pasir/ kerikil. Hal ini wajar karena lubang pengeboran tersebut terletak pada bagian hulu yang sangat dipengaruhi oleh ketinggian muka air Bendungan, yang kiranya sudah dalam keadaan jenuh, apalagi elevasinya sudah berada di bawah muka air tanah.
         - Berbeda dengan kondisi nilai SPT pada lubang pengeboran di bagian upstream. pada pengeboran di bagian downstream lapisan tanah yang diidentifikasi terdiri dari silty clay bercampur dengan pasir kasar/ kerikil terletak pada kedalaman 4,0 , s/d 6.0 m. Setelah itu nilai N berangsur-angsur semakin membesar sampai pada kedalaman 10.50 m dari permukaan pengeboran.
         - Berdasarkan pengamatan atas besarnya nilai N pada kedua lubang





2. Responses and Recommendations on the report on the results of permeability and land investigations in the Situ Kamojing dam body.

1) Land Investigation and Permeability of the Kamojing dam body was carried out thanks to the results of meetings between Pus Air, BBWS Citarum and Toso Sangyu Co. Ltd. held at Pus Air on .....

2) Investigation of land and permeability tests of the body of the Kamojing dam are also carried out based on the provisions stipulated by the Dam Security in accordance with the requirements attached. (Results of discussion on September 7, 2018).

3) The results of the dam body investigation provide the following indications:

3.1. SPT investigation on drilling the foot of the Upper Dam.

• The SPT value from the surface of the hole (cl + 49.30 M) down is getting smaller / weaker with the lowest SPT value (IN) at depth between 5.5 to 5.95 M. This relatively small SPT value (between 2 N s / d 5 N) lies in the depth of the dam body in the position (between 4.45 ms and 10.45 m), where the soil structure is a mixture of silty clay with sand / gravel. This is reasonable because the drilling hole is located in the upstream part which is very much influenced by the water level of the Dam, which would have been saturated, moreover the elevation was below the ground water level.

• Different from the condition of the SPT value on the drilling hole in the upstream section. on drilling in the identified downstream part of the soil consists of silty clay mixed with coarse sand / gravel located at a depth of 4.0 to 6.0 m. After that the N value gradually grows to a depth of 10.50 m from the drilling surface.

• Based on observations on the magnitude of the N value in both holes

3. Tanggapan dan Rekomendasi atas hasil uji “Tracer Test”

3.1. Tujuan dari tracer test ini adalah untuk mengidentifikasi adanya kebocoran/rembesan air yang terjadi pada kaki bendungan bagian hilir.

3.2. Tracer test ini dilakukan dengan menggunakan bubuk pewarna yang dimasukkan ke lubang bor bagian hulu dan kemudian diamati pada lubang bor bagian hilir apakah terjadi perubahan/pengaruh atas warna air yang bersumber dari lubang bor bagian hulu tersebut. Apabila tidak teridentifikasi adanya pengaruh warna dari air pada lubang bagian hulu, berarti kebocoran di hilir bendungan bukan berasal dari rembesan pada tubuh bendungan, tetapi kemungkinan berasal dari pengaruh resapan air hujan melalui bawah permukaan pada bagian hilir bendungan.

3.3. Pengamatan/monitoring “Tracer Test” dilakukan hampir setiap hari s/d hari yang ke 37, namun hasil pengamatan menyimpulkan bahwa kebocoran yang bersumber melalui tubuh bendungan tidak di ketemukan (tidak teridentifikasi).

3.4. Informasi secara informal kami peroleh suatu hasil perhitungan atas kecepatan maupun waktu perjalanan rembesan air (seepage) dari lubang bor dari upstream ke downstream adalah sbb :

- Kecepatan rembesan air V = 0.737 m/day.
- Waktu untuk merembes dari lubang bagian hulu ke lubang bagian hilir adalah T = 37 hari.

Dengan perhitungan diatas secara logika mestinya pengamatan/ monitoring terhadap perubahan warna pada lubang bor bagian hulu dimulai tidak pada hari pertama s/d hari ke 37, tapi semestinya pengamatan dilakukan mulai pada hari ke 35 setelah bahan pewarna dimasukkan ke lubang bagian hulu dan paling tidak sampai dengan hari ke 45.

3.5. Kalaupun toh dalam pengkajian terlihat adanya aliran dari lubang bor hulu ke lobang bor hilir, karena kecepatan aliran yang sangat lambat (V = 0.737 m/hari), aliran seepage tersebut tidak mengakibatkan butir-butir tanah yang dilaluinya hanyut bersama aliran seepage, ini berarti tidak membahayakan struktur dari tubuh bendungan tersebut.

3. Responses and Recommendations on the results of the "Tracer Test" test

3.1. The purpose of this tracer test is to identify water leaks that occur at the foot of the

downstream dam.

3.2. This tracer test is carried out by using dye powder which is inserted into the upstream borehole and then observed in the downstream drill hole if there is a change / influence over the color of the water sourced from the upstream borehole. If there is no effect on the color of the water in the upstream hole, it means that the leak in the lower reaches of the dam does not originate from seepage in the body of the dam, but probably comes from the influence of rainwater through the subsurface in the lower reaches of the dam.

3.3. Observation / monitoring of "Tracer Test" was carried out almost every day until the 37th day, but the results of the observation concluded that the leakage originating through the dam's body was not found (not identified)

3.4. Informally, we obtain a calculation result of the speed and time of seepage of the boreholes from upstream to downstream as follows: – Water seepage speed V = 0.737 m / day. – The time to seep from the upstream hole to the downstream hole is T = 37 days. With the above calculations logically, the monitoring of color changes in the upstream borehole should not start on the first day until the 37th day, but observations should be made starting on the 35th day after the dye is inserted into the upstream hole and at least until with day 45.

3.5. Even though in the assessment there was a flow from the upstream drill hole to the downstream drill hole, because the flow velocity was very slow (V = 0.737 m / day), the seepage flow did not result in the soil grains drifting along with the seepage flow, this means endanger the structure of the dam's body.

4. Pengamatan atas hasil permeability test :

Secara umum kelulusan/ permeability pada lapisan tubuh bendungan dari permukaan pengeboran sampai dengan kedalaman 6.0/7.0 m terdiri dari lapisan tanah yang mempunyai nilai permeability besar (10^{-3} s/d 10^{-4}), dimana makin dalam nilai permeabilitynya makin kecil (. 10^{-5}).

Mendekati elevasi 37.00/38.00 m (posisi lapisan tanah dibawah pondasi bendungan) didapati lapisan silty clay yang bercampur dengan pasir kasar sehingga angka permeabilitynya menurun sampai $1.4.10^{-4}$ (lulus air).

4. Observation of permeability test results:

In general, the graduation / permeability of the dam body layer from the drilling

surface up to a depth of 6.0 / 7.0 m consists of soil layers which have a large permeability value (10-3 to 10-4), where the deeper the permeability value becomes smaller (10 -5).
Approaching the elevation of 37.00 / 38.00 m (the position of the soil layer under the dam foundation) found silty clay layer mixed with coarse sand so that the permeability number decreased to 1.4.10-4 (water pass).

5. Hasil Grain Size Distribution, baik pada lubang bor di upstream maupun pada lubang bor di downstream, didapati lapisan silty clay bercampur pasir di bawah pondasi bendungan yang mengarah ke downstream pada elevasi + 37.00 – 38.00 (di hulu) sampai elevasi + 27.00 – 28.00 m (lubang pengeboran bagian downstream), yang merupakan lapisan panrus.

Kesimpulan & Rekomendasi :

a) Terindikasi adanya rembesan pada tubuh bendungan yang bergerak dari tinggi muka air reservair (+ 48.6) ke lubang bor di hulu (El + 45.3 m) sampai di lubang bagian hilir dengan elevasi ± 37.00 m (Elevasi pondasi bendungan pada posisi ± 40.00). Dengan demikian garis seepage yang terjadi tidak memotong pada kaki tubuh bendungan bagian hilir (aman).
b) Rembesan diatas terjadi pada lapisan tubuh bendung yang nilai N nya kecil. Serta pada lapisan tanah yang terdiri dari silty clay bercampur pasir dengan nilai permeabilitynya juga cukup besar (antara 1.24 E $^{-03}$ s/d 2.11 E $^{-04}$).
c) Berdasarkan atas kondisi diatas, untuk mengatasi bocoran pada tubuh bendungan dapat ditempuh dengan 2 (dua) alternatif.
   c.1. Dengan melakukan grouting (sudah barang tentu dengan menggunakan tekanan rendah supaya tidak terjadi tracture) pada kedalaman di tubuh bendungan antara elevasi 40.00 m s/d 45.00 m.
   c.2. Seperti apa yang disarankan pada studi D/D Rehabilitasi dan peningkatan Situ-situ di wilayah Sungai Citarum tahun 2015 oleh PT. Puser Bumi, yakni dengan penambahan timbunan pada bagian downstream (± sepanjang 80 m) untuk menyelaraskan profil bendungan sekaligus menutup bagian yang ada rembesannya).

d) Dari hasil penyelidikan tanah yang di lakukan oleh SUFOCO (2019) juga teridentifikasi adanya lapisan berpasir yang terletak di bawah pondasi bendungan (± El 37 s/d 34), lapisan ini secara teori dapat menimbulkan rembesan pada pondasi bendungan, namun berhubung dengan sedimentasi bendungan Kamojing yang sudah mencapai elevasi 45.50 m (studi EV Lagadar (2016)), yang berarti lapisan sedimen tersebut sudah merupakan lapisan blanket, maka penanganan pondasi dari rembesan di bawah pondasi tidak perlu lagi di lakukan.

5. Grain Size Distribution results, both in the upstream borehole and in the downstream borehole, found silty clay layers mixed with sand under the dam foundation which leads to downstream at + 37.00 - 38.00 (upstream) to elevation + 27.00 - 28.00 m (downstream drilling hole), which is the panrus layer.

Conclusions & Recommendations:

a) There is indication of seepage in the body of the dam moving from the reservoir water level (+ 48.6) to the upstream drill hole (El + 45.3 m) to the downstream hole with an elevation of ± 37.00 m (Elevation of the dam foundation at ± 40.00). Thus the seepage line that occurs does not cut down on the lower body of the dam's body (safe).

b) Seepage above occurs in the weir body layer with a small N value. As well as on the soil layer consisting of silty clay mixed with sand, the permeability value is also quite large (between 1.24 E - 03 to 2.11 E-04).

c) Based on the above conditions, to overcome leaks in the dam body can be reached with 2 (two) alternatives.

c.1. By doing grouting (of course using low pressure so that there is no tracture) at the depth in the body of the dam between the elevation of 40.00 m to 45.00 m.

c.2. As what was suggested in the D / D study on the rehabilitation and improvement of Situ Situ in the Citarum River area in 2015 by PT. Puser Bumi, that is by adding a pile to the downstream (± 80 m long) to harmonize the profile of the dam while closing the part of the seepage).

d) From the results of an investigation of the land carried out by SUFOCO (2019) it was also identified the presence of sandy layers located under the dam foundation (± El 37 to 34), this layer could theoretically cause seepage on the dam foundation, but due to sediment the Kamojing dam has reached an elevation of 45.50 m (EV Lagadar (2016)

study), which means that the sediment layer is already a blanket layer, so handling the foundation of seepage under the foundation does not need to be done anymore.

4. Saran dan Kesimpulan :

4.1. Dari Penyelidikan tanah teridentifikasi adanya aliran rembesan (seepage line) yang menghubungkan antara tinggi muka air reservair (± 48.6 m), tinggi muka air tanah pada lobang bor di hulu (± 46.6 m) dan tinggi muka air pada lobang bor di hilir (± 38.6). Hal ini berarti seepage line yang terjadi tidak memotong kaki tubuh bendungan bagian hilir. Berarti aman di tinjau dari segi keamanan bendungan.

4.2. Selain terlihat adanya lapisan silty clay yang bercampur dengan pasir kasar pada tubuh bendungan yang berbatasan dengan aliran rembesan (pada elevasi 45.3 m – 44.00 m (di lobang upstream) dan elevasi ± 38.00 – 38.50 m (di lobang bagian downstream), juga pada lapisan di bawah pondasi bendung antara El 30.00 – 32.00 m terdapat lapisan silty sand yang potensial dapat di lewati aliran rembesan di bawah bendungan (karena permeabilitynya cukup besar). Namun sepanjang sedimentasi di daerah genangan (Reservair) tidak di ganggu, tidak menimbulkan masalah bocoran, kecuali kalau sedimentasi yang ada akan dikeruk dalam rangka memperbesar volume tampungan, agar diwaktu musim banjir besar tidak terjadi limpasan.

4.3. Apabila terpaksa sedimentasi akan digali, disarankan agar Elevasi kedalaman galian tidak melebihi Elevasi dasar Reservoir yang asli.

4.4. Hasil kajian “Tracer test” menunjukkan bahwa tidak terindikasi adanya penyebaran zat pewarna pada lobang bor bagian hulu ke lobang bor bagian hilir, karena kurang tepatnya waktu pengamatan dibanding dengan hasil perhitungan perambatan aliran air antara lubang bor bagian hulu dan lobang bor bagian hilir. Seandainya hasil uji coba menunjukkan adanya aliran rembesan dari lobang bor di hulu ke lobang bor ke hilir, karena kecepatan aliran yang sudah sangat lambat (V = 0.737 m/ hari), aliran ini tidak akan

bisa melarutkan butir-butir tanah di jalur aliran yang dimaksud, berarti masih aman-aman saja.

4.5. Rembesan yang terlihat pada kaki tubuh bendungan bagian hilir, yang diprediksi bersumber pada resapan air hujan, debitnya juga diperkirakan tidak besar. Maka untuk menanggulangi masalah ini disarankan : daerah sekitar rembesan yang kondisi struktur tanahnya sudah labil, dikeruk dan dipadatkan kembali dengan tanah yang cukup baik, sekaligus sebagai penambahan timbunan pada daerah tersebut sepanjang ± 80 m untuk menyelaraskan profil bendungan dan menutup bagian yang ada rembesannya.

4. Suggestions and Conclusions:

4.1. From the investigation of the land it is identified that there is a seepage line that connects the water level of the reservoir (± 48.6 m), the ground water level in the drill hole in the upstream (± 46.6 m) and the water level in the drill hole downstream (± 38.6) This means that the seepage line that occurs does not cut the lower body of the dam's foot. It means safe in terms of dam safety.

4.2. In addition to the silty clay layer that is mixed with coarse sand on the dam body which borders on seepage flow (at an elevation of 45.3 m - 44.00 m (in the upstream hole) and elevation of ± 38.00 - 38.50 m (in the downstream hole), also in the layer under the weir foundation between El 30.00 - 32.00 m there is a silty sand layer that has the potential to pass through the seepage below the dam (because the permeability is quite large), but during sedimentation in the inundation area (Reservoir) is not disturbed, it does not cause leakage problems unless existing sedimentation will be dredged in order to increase the volume of storage, so that during the big flood season there will be no runoff.

4.3. If forced sedimentation will be excavated, it is recommended that the excavation depth should not exceed the original Reservoir elevation.

4.4. The results of the "Tracer test" study showed that there was no indication of the spread of dyes in the upstream drill hole to the downstream drill hole, due to the inaccurate observation time compared to the calculation of water flow propagation between the upstream and downstream drill holes. If the results of the trial show a seepage flow from the upstream drill hole to the drill hole downstream, because the flow velocity has been very slow (V = 0.737 m / day), this flow will not be able to dissolve the soil grains in the intended flow path , means it's still safe.

4.5. Seepage that is seen in the lower body of the dam's body, which is predicted to be sourced from rainwater infiltration, the discharge is also not expected to be large. So to

overcome this problem, it is recommended: the area around the seepage where the soil structure conditions are labile, dredged and re-compacted with good soil, as well as adding deposits to the area of ± 80 m to harmonize the profile of the dam and cover the seepage.

Demikian laporan yang dapat Kami sampaikan, semoga bermanfaat.

Jakarta, Mei 2019

(Ir. S. Soeradji, Dipl. HE)

添付資料4 PUSAIRの要請書

MINISTRY OF PUBLIC WORKS AND HOUSING
AGENCY FOR RESEARCH AND DEVELOPMENT
RESEARCH CENTER FOR WATER RESOURCES
Jalan Ir. H. Juanda 193, Bandung 40135, Phone (022) 2501083, 2504053, 2501554, 2500507
Fax. (022) 2500163, PO Box 841, E-mail: pusat@pusair-pu.go.id, http: //www.pusair-pu.go.id

No : HL 0104 -Lc/289

Bandung, May 29, 2019

Attention to:
TOSO SANGYO CO., LTD.
5-1 Gobancho Chiyoda-ku,
Tokyo 102-0076 Japan

Subject: **Request for Additional Activities of Chemical Grouting Technology Dissemination in Indonesia**

Regarding to the JICA project titled "Verification Survey with Private Sector for Disseminating Japanese Technologies for Ground Improvement using Chemical Grouting Technology", we would like to request additional document and workshop regarding chemical grouting technology system in Japan.

Herewith we sincerely request you the following items related to chemical grouting technology:

1. Transferring the guide-book of construction operation procedure in Japan
2. Workshop in Indonesia from Japanese Chemical Grouting Association regarding to:
   a) Institutional and operation of the Association
   b) Sharing R&D information
   c) Exchange of engineers and researchers in the future
   d) Sharing information on construction accidents

Sincerely yours,

Prof. Dr. Eko Winar Irianto.
Director

添付資料5 セミナー資料（1）

JICA PROJECT

VERIFICATION SURVEY WITH THE PRIVATE SECTOR FOR DISSEMINATING JAPANESE TECHNOLOGIES FOR GROUND IMPROVEMENT USING CHEMICAL GROUTING TECHNOLOGY

－ About “CHEMICAL GROUTING TECHNOLOGY” －

JICAプロジェクト

薬液注入技術を用いた地盤改良工法の普及・実証事業
－ 薬液注入技術について－

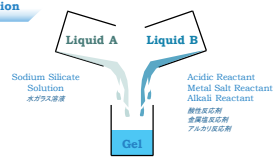
TOSO SANGYO Co., Ltd.
January 28, 2020

Definition of “Chemical Grouting Method”

薬液注入工法の定義

Chemical Grouting Method is a method in which injected chemical permeates pore spaces in granular soils and solidifies it.
薬液注入工法は地盤の間隙に薬材を浸透させ地盤を固化させる工法

Fundamental action
基本作用



The mixture of Liquid (A) and Liquid (B) becomes gel in the designed time span
A液とB液の混合液が設定された時間でゲル化

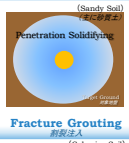
Mechanism of “Chemical Grouting Method”

薬液注入工法のメカニズム

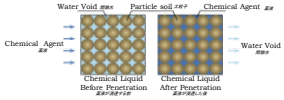
There are 2 forms for Chemical Grouting.
薬液注入工法には2つの形態がある

Penetration Grouting
浸透注入

(Sandy Soil)
（主に砂質土）



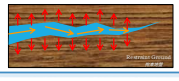
Chemical Agent penetrated into the void of the soil particle, soil strength increased by hardening, to bond the soil particle and to improve the water-stopping.
土粒子の間隙に薬液が浸透し、硬化することで、土粒子を接着して地盤の強度を増加させたり、止水性を向上させる。



Fracture Grouting
割裂注入

(Cohesive Soil)
（主に粘性土）

A phenomenon that the chemical Agent is injected into the veins, homo gel strength (hardening strength of Chemical Agent) after hardening to form amount of large Chemical Agent fraction branch in the soil, to increasing strength of composite soil .
薬液が脈状に注入される現象で、硬化後のホモゲル強度（薬液単体が硬化した強度）が大きい薬液を地盤中に多くの割裂脈を形成し、複合地盤としての強度を増加させる。



Proposed Technology

提案する技術

Chemical Grouting Technology
薬液注入技術

- **Materials with stable quality, performance, and safety**
  安定した品質、性能、安全性を有する材料
- **Suitable technology for various soil and purpose**
  多様な土壌と目的に適した技術
- **Proper construction management method**
  適切な施工管理方法

Verification summary in JICA Project

実証試験概要

Conduct 3 step test to verify Safety and Effectiveness
安全性と効果の確認をするために3段階の試験を実施する

	Step1	Step2	Step3
Verification category 検証カテゴリー	*“Effectiveness and Safety” verification 「効果と安全性」検証*		*“Field construction” verification 「実地施工」検証*
Test scale 試験規模	*Table test テーブルテスト*	*Bench scale test ベンチスケールテスト*	*Dam site test ダムサイト試験*
Test site 試験実施場所	*Japan 日本* / *Indonesia インドネシア*	*Indonesia インドネシア*	*Indonesia インドネシア*
Person in charge 試験実施者	*Kyushu University 九州大学* / *Institute Technology Bandung (ITB) バンドン工科大学*	*Institute Technology Bandung (ITB) バンドン工科大学*	*PT. NITTOC CONSTRUCTION 日特インドネシア*
Effect Verification 効果検証	*Strength Permeability Coefficient 強度 透水係数* / *Effect using Indonesian sand インドネシア砂での効果の確認*	*Verification through the actual site より現場工事に近い形での確認*	*Permeability Coefficient 透水係数*
Safety Verification 安全性検証	*De-test components 成分溶脱試験* / *De-test components using Indonesian sand インドネシア砂での成分溶脱確認*	*Verification through the actual site より現場工事に近い形での確認*	*pH pH*

Safety issues

安全性について

- **There is anxiety regarding to the chemical material, two accidents were recorded by the use of chemical Acrylamide in Japan (1974) and Indonesia (1975).**
  日本(1974)とインドネシア(1975)でアクリルアミドの使用により 2件の事故が発生しました。
- **Dangerous type of chemical grouting that forbidden to use due to the toxicity about 150 to 413 mg/kg (According to ATSDR).**
  薬液注入材に含まれる危険なタイプの化学物質は、その毒性のために使用が禁止されています。

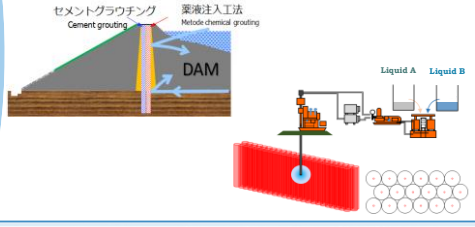
- **The verification of safety and effect was confirmed by ITB.**
  安全性と効果の検証は、ITBによって確認されました。

Chemical Grouting as Auxiliary Method
補助工法としての薬液注入工法

Restoration of DAM to its original function by stopping seepage
止水により、本来のダムの機能を修復

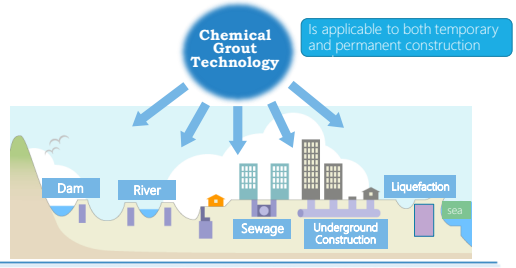
STEP 2 : Cement grouting
→ ensure the long-term durability

STEP 1 : Chemical grouting method
→ Ensure water stoppage



Application to Chemical Grout Technology
薬液注入技術の展開

Besides the application to Water-leaking Dams and others, Chemical Grout Technology can be used to the urban development.
ダムやその他漏水箇所への適用に加え、薬液注入技術は都市土木への利用も可能です。



Potential Users in Indonesia
インドネシアにおける潜在案件

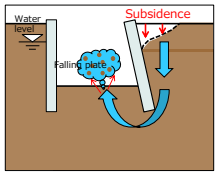
Chemical Grouting can be effective at the constructions in Urban Development (Map for construction plan).
薬液注入は、都市の地下構造物構築で効果的を発揮します。

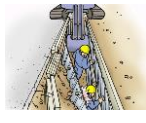
Major Issues in Urban Development
都市土木における問題点

- **During execution of construction works, there are several challenges; water drainage due to excessive loads and vibration, failure of infrastructures due to soft/loose soil.**
  地下構造物の建設には、軟弱地盤や水の漏水など、いくつかの問題があります。
- **For example in tunnel construction, risk such as sediment/water flooding, heaving etc. might disturb the construction.**
  例えば、トンネル構築の際、泥水の流出、地盤沈下などの問題が発生する可能性があります。
- **The liquefaction caused by the earthquake that results in collapse of infrastructures and structures.**
  地震による液状化現象により、インフラや構造物に影響があります。

Sediment disaster
土砂による災害

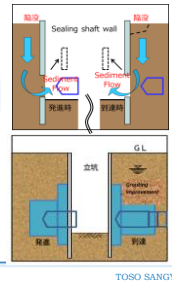
- **During execution of construction works, there are several threat such as deformation of surrounding grounds, and drainage of groundwater results in failure of ground surface and structures.**
  軟弱地盤での施工では、周囲の地盤の変形や地下水の影響などにより不具合が生じます。



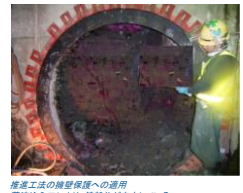


Application of chemical grout
薬液注入工の適用

- **Chemical grouting is a perfect method to countermeasure construction problems.**
  薬液注入工法は、これらの問題を解決するのに最適な方法です。

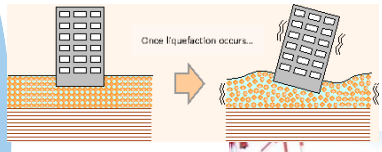


Application for the wall protection on pipe jacking
Since chemical grouting, pore wall become stable.



推進工法の掩壁保護への適用
薬液注入工により、掩部分が自立している

The liquefaction phenomenon
液状化現象



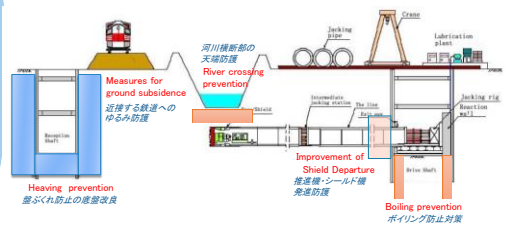
Countermeasure work against liquefaction on quay

港湾の液状化対策工事

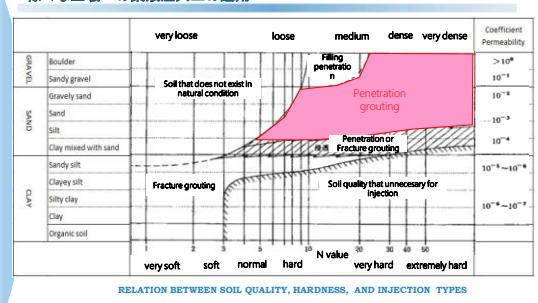
Subway and sewage tunnel construction
地下鉄、下水道建設

Soil reinforcement and water stopping of shaft and wall barrier

地盤の補強と止水



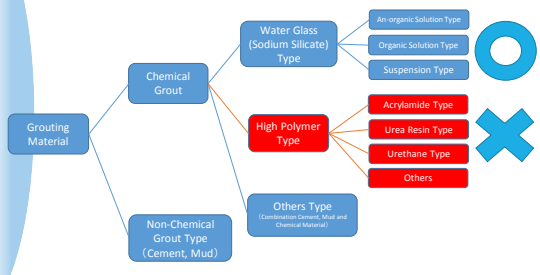
Application of Chemical Grouting in Various Types of Soil
様々な土壌への薬液注入工の適用



RELATION BETWEEN SOIL QUALITY, HARDNESS, AND INJECTION TYPES

土質と注入形態の関係図

Types of Grouting in Japan
地盤注入材の分類



Superiority of Silicates Types Chemical Grouting
水ガラス系薬液注入剤の優位性

N:non-flammable L:low M:moderate H:high

Type 種類	Penetration in Ground Units 浸透性	Durability 耐久性	Ease of Application 適用性	Potential Toxicity 毒性	Flammability of Materials 可燃性	Relative Costs 価格
Silicates 水ガラス系	H	M	H	L	N	L
Portland-cement-based grout セメント系	L	H	M	L	N	L
Acrylates アクリルアミド系	H	M	H	M	L	H
Lignins リグニン系	H	M	H	H	L	H
Urethanes ウレタン系	M	H	M	H	H	H
Resins レジン系	L	H	M	H	M	H

Source: "Engineering and Design-CHEMICAL GROUTING" by U.S. Army Corps of Engineers, 2003.

Sodium Silicate Uses
水ガラスの用途

Deterjent, Soap etc. 石鹸・洗剤

(Na_2O for washing and whitening)

Using for washing, whitening, water softener, and *buffering*, and widely used as soap additional material.

Casting 鋳物

(SiO_2 for adhesion)

Using for sand casting as aggregate for create mold, but using also to bond sand become solid. Reacted by the present of carbon dioxide.

Civil Engineering work 土木

(SiO_2 for solidifying and reinforcement)

Using for chemical grouting material or instant solidified cement for soil improvement.

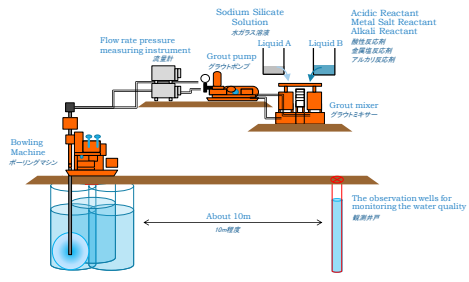
Paper and paper pulp 紙・パルプ

Using for material that stabilizes hydrogen peroxide when removing ink on waste paper or bleaching paper or pulp.

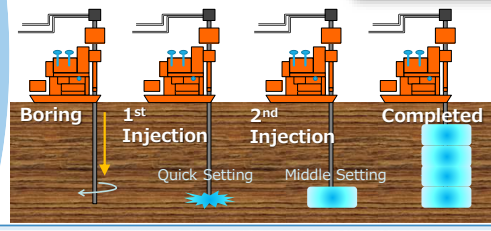
Silica Source シリカ源

Using for silica gel (dryer material) or white carbon (material for preventing bottom side erosion of thin paper) by using chemical decomposition.

Construction equipment
施工機材



Construction procedures
施工手順



Advantages of Chemical Grouting
薬液注入工の強み

1. Stopping Seepage and Strengthening the ground 止水効果と土壌強化

Permeates through granular pores of the soil particle and increase in efficiency of the water-stoppage with soil strength. C=80KN/m^2
土粒子間に浸透し硬化することで、地下水の止水に効果があり、強度も上昇する。

2. Flexible method 仮設・本設の使い分けが可能

Purpose	Application	Ingredient
Auxiliary Method 仮設	Protection of Defective Part of Earth Retaining Wall 土留め欠損部の防護 他	Sodium Silicate and Hardening agent
Main Method 本設	STRUCTURE FOUNDATION 構造物基礎 他	Specific Grade of Sodium Silicate and Hardening agent

3. Limited Duration Effect 限定的な効果持続

The effect about stopping-water vanishes within few years because of Elution of silica component.
1) The effect vanishes when the improvement ground is deformed by the vibration due to external load.
2) The effect remains consistent for more than few years if the applied chemical agent is in good condition.

シリカ成分の溶出により、一般的には数年で効果がなくなります。
1)振動や地下水の影響により、効果がなくなります。
2)状況が良ければ数年に渡り効果が持続する場合もあります。

4. Easiness of Construction 施工容易性

Using small machine. 小型機械での施工が可能。

Terima kasih

添付資料6 セミナー資料（2）

一般社団法人　日本グラウト協会の紹介

Introduction of
General Incorporated Association
JAPAN GROUTING ASSOCIATION

技術委員　　竹内　仁哉

Technical Committee

JINYA TAKEUCHI

日本グラウト協会概要
Outline of Japan Grout Association

（1）設立目的 (Purpose of establishment)

本会は、社会資本の整備及び既設構造物の維持管理に当たり、地盤の安定及び地下水の流動防止に最も適している注入工法の研究開発とこれらの正常な普及啓蒙、技術向上とを図り、もって安全・品質に優れた社会資本整備と環境保全に寄与することを目的とする。

Association aims to improve social capital and maintenance the existing structures by conducting research and development of injection methods that are most suitable for ground stability and prevention of groundwater flow, as well as their normal dissemination and technical improvement. The purpose is to contribute to the development of social capital with excellent safety, quality and environmental conservation.

日本グラウト協会概要
Outline of Japan Grout Association

（2）協会の沿革 (History of the association)

1964年	日本LW協会として発足 Established in Japan as LW Association
1974年	日本薬液注入協会に名称を変更 Changed the name to Japan Chemical Injection Association
1976年	建設大臣の許可を得て 社団法人 日本薬液注入協会　設立 Established Japan Chemical Injection Association with permission from the Minister of Construction
2004年	社団法人 日本グラウト協会に名称変更 Change the name to Japan Grout Association
2013年	一般社団法人 日本グラウト協会に名称変更 Name changed to Japan Grout Association

日本グラウト協会概要
Outline of Japan Grout Association

（3）協会の所在地 (Association Address)

1）本部事務局（東京都）Headquarter (Tokyo)
〒(Zip Code)112-0004
東京都文京区後楽1丁目1番2号（春日ビル9F)
(Kasuga Building 9F)1-2-2 Koraku, Bunkyo-ku, Tokyo
TEL：03-3816-2681　FAX：03-3816-3588

2）支　部 (Branch)
- 北海道支部（札幌市）Hokkaido Branch (Sapporo City)
- 東 北 支 部（仙台市）Tohoku Branch (Sendai City)
- 関 東 支 部（東京都）Kanto Branch (Tokyo)
- 北 陸 支 部（新潟市）Hokuriku Branch (Niigata City)
- 中 部 支 部（名古屋市）Chubu Branch (Nagoya City)
- 関 西 支 部（大阪市）Kansai Branch (Osaka City)
- 中 国 支 部（広島市）Chugoku Branch (Hiroshima City)
- 九 州 支 部（福岡市）Kyushu Branch (Fukuoka City)

日本グラウト協会概要
Outline of Japan Grout Association

（4）協会の会員数 (Membership of Association)

1）正会員 (Regular member)
注入工法により地盤安定に関連のある事業を行う団体
（薬液注入工事　施工会社）　　正会員数64社
An organization that conducts business related to ground stability using the injection method (chemical solution injection construction company), 64 regular members

2）賛助会員 (Supporting member)
本会の事業を賛助する団体
（注入材料メーカー、販売商社、機械製造業者）　助会員数52社（3団体）
Organizations (injection material manufacturers, sales trading companies, machine manufacturers) supporting the business of the Society, 52 supporting members (3 organizations)

日本グラウト協会の事業
Japan Grouting Association Business

定款上の主な事業
Main business in the Articles of Association

（Ⅰ）注入工法に関する企画、調査、研究開発に係る事業
Business related to planning, investigation, and research and development related to injection methods

（Ⅱ）注入工法の普及啓蒙を図る事業
Project to raise awareness of the injection method

（Ⅲ）注入工法の技術向上を図る事業
Business to improve the technology of injection method

（Ⅳ）その他本会の目的を達成するために必要な事業
Other businesses necessary to achieve the objectives of the Society

日本グラウト協会の事業
Japan Grouting Association Business

（Ⅰ）注入工法に関する企画、調査、研究開発に係る事業

Business related to planning, investigation, and research and development related to injection methods

1）調査・研究開発 (Investigation-Research and Development)

a. 注入工法の最適化を図るための事業

Business to optimize the injection method

b. 生産性と信頼性の向上を図るための支援策の検討

Examining support measures to improve productivity and reliability

c. 高圧噴射撹拌工法（本設対応）の施工・技術指針の策定

Formulation of construction and technical guidelines for high-pressure jet mixing method

d. 長期耐久性に関する調査研究

Research on long-term durability

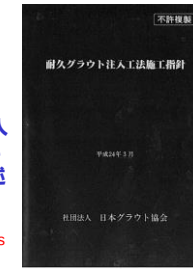
日本グラウト協会の事業
Japan Grouting Association Business

耐久グラウト注入工法施工指針

Guidelines for construction of long-term grout injection method

（平成24年3月発刊）

(Published in March 2012)



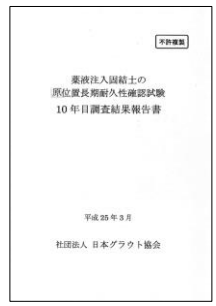
液状化対策、耐震補強工事などにおいて長期耐久性能が要求される場合の薬液注入工法の施工指針を記述した資料。注入材料の長期耐久性能の試験結果についても記述

A document describing construction guidelines for chemical injection methods when long-term durability is required in liquefaction countermeasures, seismic reinforcement work, etc. Also describes the long-term durability test results of the injection material

日本グラウト協会の事業
Japan Grouting Association Business

長期耐久性確認試験報告書（5年目）
Long-term durability confirmation test report (5th year)

（10年目/10th year）



日本グラウト協会の事業
Japan Grouting Association Business

2）薬液注入工法の施工実績に関する調査

Survey on construction results of chemical injection method

3）薬液注入工法の施工管理機器・チャート紙の認定

Certification of construction management equipment and chart paper for chemical injection method

a. 協会認定型流量計の認定および定期検査証の発行

Approval of association-certified flowmeters and issuance of periodic inspection certificates

b. 協会認定チャート紙（流量記録紙）の認定

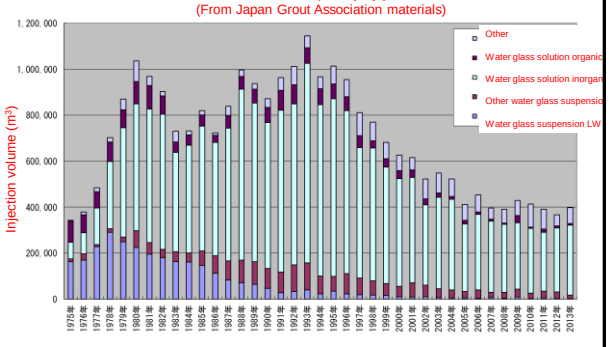
Association chart paper (flow rate recording paper) authorization

c. 使用注入材料の協会登録

Registered as an injection material association

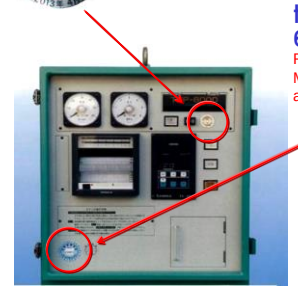
日本グラウト協会の事業
Japan Grouting Association Business

Construction quantity by year
(From Japan Grout Association materials)



日本グラウト協会の事業
Japan Grouting Association Business

（一社）日本グラウト協会が認定した
(A company) Certified by Japan Grout Association
流量計には認定証が表示されている
A certificate is displayed on the flow meter



協会が指定した整備工場で6か月毎に定期検査を実施
Regular inspections every 6 months at Maintenance factory designated by association


○April –○September year ｡｡

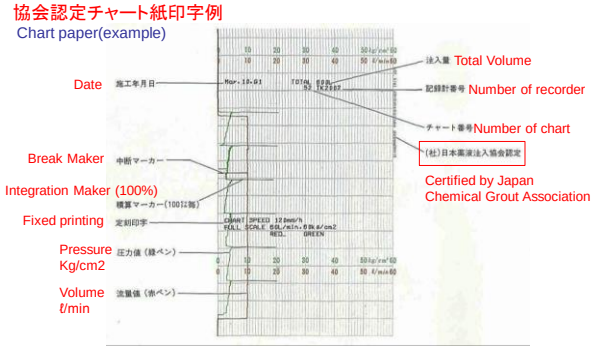

○October –△March year ｡｡


△ April –△September year ｡｡


△October –◎March year ｡｡

日本グラウト協会の事業
Japan Grouting Association Business

協会認定チャート紙印字例
Chart paper(example)



日本グラウト協会の事業
Japan Grouting Association Business

（Ⅱ）注入工法の普及啓蒙を図る事業 (A project to raise awareness of the injection method)

（対象者：発注者、総合建設業、設計事務所他） (Target person: Ordering party, General construction industry, Design office, etc.)

1）協会活動の普及啓蒙 (Enlightenment of association activities)

2）関係行政施策への支援・協力 (Support and cooperation for related administrative measures)

a. 関係行政通達等の会員への周知 (Notifying members of relevant administrative notices)

b. 行政機関・都道府県等の行政施策への協力・支援 (Cooperation and support for administrative measures by administrative agencies and prefectures)

c. 展示会・イベントの後援 (Sponsoring exhibitions and events)

日本グラウト協会の事業
Japan Grouting Association Business

3）講師派遣による普及啓蒙

Spread explanation by sending instructor

・技術説明会の開催（毎年、主要都市で開催）

Technical briefing (held in major city annually)

・日本下水道事業団研修センターの研修会での講師担当

Workshop in Training Center by in charge lecturer

4）工法に関する窓口相談対応

Consultation service regarding construction methods

・薬液注入工法の設計・施工・管理に関する問い合わせに対応

Responding to inquiries regarding design, construction, and management of chemical injection methods

5）資料集等の改訂・発行及び頒布

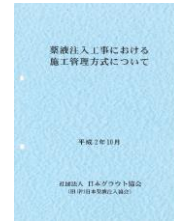
Revision / issue and distribution of materials

日本グラウト協会発刊図書
Publications by Japan Grouting Association

薬液注入工事における施工管理方式について　1990年発刊
Construction management of Chemical Grouting Work
Published in October 1990

1990年の建設省通達に対し、協会としての取組みを記述

This publication describes activities of the Association in complying with 1990 Notification issued by the Ministry of Construction



日本グラウト協会発刊図書
Publications by Japan Grouting Association

薬液注入工 設計資料 令和元年度版
Chemical Grouting Work
- design- 2019 edition

薬液注入工 積算資料 令和元年度版
Chemical Grouting Work
- estimate- 2019 edition

各資料共、毎年改訂。（国土交通省の照査を受けています。）
Each edition of publications has been amended under verification of the Ministry of Land, Infrastructure, Transport and Tourism, each year.

日本グラウト協会発刊図書
Publications by Japan Grouting Association

薬液注入工 施工資料
Chemical injection work materials
（平成30年度改訂）(Revised in 2018)

新訂 New Revision
正しい薬液注入工法
Correct chemical injection method

日本グラウト協会の事業
Japan Grouting Association Business

（Ⅲ）注入工法の技術向上を図る事業

Business Plan for Improving technology of Injection method

・グラウト技術の信頼性の確保と技術継承を図ることを目的とする

Purpose is to ensure the reliability of grouting technology and to inherit technology.

1）登録グラウト基幹技能者講習事業と更新申請

Person of registration grout nucleus skill class business and update application

・更新講習と認定講習の実施、国土交通大臣への登録5年ごとの更新申請.

Update class and enforcement of the course of lectures for qualifying, Update application every registration five years to the Minister of Land, Infrastructure and Transport

2）国家資格取得支援講習

National qualification support class

登録グラウト基幹技能者
Registration for Skilled Workers

（1）役割　　33職種42団体 (Role: 42 groups of 33 occupations)

建設現場での技能労働者のトップ（総括職長）として、安全管理・品質管理等の横断的な調整指導を実施。

Head (general foreman) of skilled workers at construction site, should carry out cross-sectional coordination guidance on safety management and quality control.

登録グラウト基幹技能者
Registration for Skilled Workers

（2）受講資格 (H21年度より実施)

Qualifications (Implemented in 2009)

・実務経験10年以上、職長経験3年以上
10 years or more of work experience, 3 years or more of foreman experience

・1、2級土木施工管理技士、ジェットグラウト技士
1st and 2nd class civil engineering management engineer, jet grout engineer

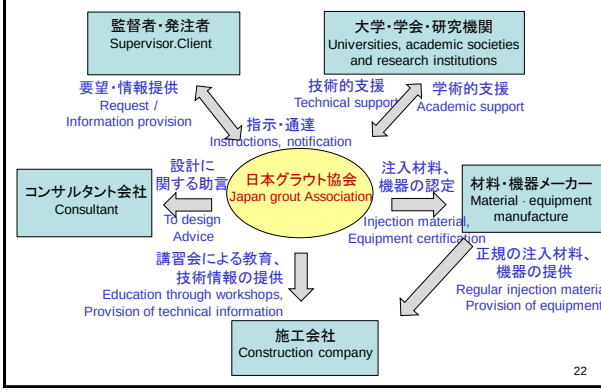
（3）概要 (Overview)

①薬液注入・ジェットグラウト・岩盤グラウトの3部
3 Parts : Chemical grouting, Jet grouting, Bedrock Grouting

②1年に1回講習・試験、5年で更新講習を実施
Courses / examinations once a year, renewal classes in 5 years

③H29年度末で約700人弱の有資格者数
Numbers of qualified persons as of end of 2017: approximately 700

日本グラウト協会の事業
Japan Grouting Association Business



薬液注入工事に起因する
事故事例とその後の対応

Accident cases and subsequent responses caused by chemical injection work

事故事例とその後の対応（1）
Accident cases and subsequent responses (1)

発生時期：1974年
Occurrence time: 1974

事故内容：井戸水を利用していた住民の健康被害
Accidents: Health hazard to residents who used well water

使用材料：アクリルアミド系材料
Materials used: Acrylamide materials

この事故を教訓として、建設省から指針が策定・通達された。
Lessons learned from this accident were formulated by the Ministry of Construction

（グラウト協会もこの指針策定に協力した) (Association of grout cooperated with this guidance development, too）

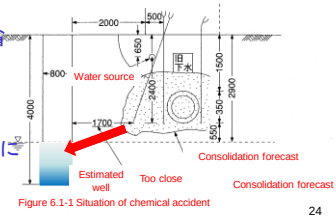


Figure 6.1-1 Situation of chemical accident

事故事例とその後の対応（1）
Accident cases and subsequent responses (1)

【指針の主な内容 Main contents of the guidelines】

ⅰ）高分子系の材料（アクリルアミド系、尿素系、ウレタン系）は使用は禁止。
Use of polymer materials (acrylamide, urea, urethane) is prohibited

ⅱ）使用できる材料は水ガラス系薬液のみで、劇物やフッ素化合物を含まないものとする。
Only water glass chemicals can be used, and no deleterious substances or fluorine compounds are included.

ⅲ）注入範囲から10m以内に複数の観測井戸を設置し、地下水の水質を観測する。
Install multiple observation wells within 10m from the injection range to observe the quality of groundwater

ⅳ）「土質」「地下埋設物」「地下水」「公共用水域など」について、事前調査を実施する。
Conduct preliminary surveys on soil quality, underground structures, groundwater, public water areas, etc.

事故事例とその後の対応（2）
Accident cases and subsequent responses (2)

発生時期：1990年
Occurrence time: 1974

事故内容：シールド工事の圧気が地表部まで到達・噴出し、道路が陥没。
Accident : Shield construction pressure reaches the surface. Eruption, road collapsed

事故原因：複数の原因が重なっているが、主なものは薬液注入量の不正・ごまかし
Cause of accident: Multiple causes overlap, but the main one is volume of chemical injection, Cheating

「薬液注入工事に係る施工管理」について、建設省から行政指導が通達される。
Administrative guidance is issued by Ministry of Construction on “Construction Management for Chemical Injection”

事故事例とその後の対応（2）
Accident cases and subsequent responses (2)

事故事例とその後の対応（2）
Accident cases and subsequent responses (2)

【通達の主な内容Main contents of notification】

ⅰ）注入材料の品質ならびに納入数量の証明を材料メーカーが行う。
Materials maker performs proof of the quality of infusion materials and the delivery amount

ⅱ）材料の納入時には監督職員が立ち会い数量などを確認する。
The supervision staff is present at the time of the delivery of materials and confirms amount

ⅲ）注入の記録はチャート紙に記録されるが、チャート紙の取り扱いについても定めるものとする。監督員が立ち会った時にはサインをする。
The recording of the injection is recorded on the chart paper, but the handling of the chart paper is also defined. Sign when the supervisor is present.

ⅳ）契約時に、設計内容を条件明示として請負者に開示する。
Time of a contract, disclose design contents as condition clear statement in a contractor.

ⅴ）施工計画打合せ時に請負者から提出する必要項目を定め、それをもとに協議を行う。
Necessary items to be submitted by contractor during the construction plan meeting will be determined and discussion will be conducted based on that.

事故事例とその後の対応（2）
Accident cases and subsequent responses (2)

【グラウト協会で取り決めた通達への具体的な対応】
(Specific response to notifications arranged by Grout Association)

ⅰ）通達の主旨に即した対応を決め、「施工管理方式について」という冊子を作成し、全国説明会を実施して、広報活動を行った。
Respond the notification through correspondence, by created a booklet “About construction management method”, held a nationwide briefing session, and conducted publicity activities.

ⅱ）協会が認定流量計として機種を開発・選定して不正ができないようにし、指定工場による定期整備を義務づけた。
Association developed and selected a model as a certified flow meter to prevent fraud and required regular maintenance by designated factories.

ⅲ）施工管理項目を明確化し、日報用紙なども統一化することで、監督職員のチェックを容易にできるようにした。
By clarifying the construction management items and compile the daily reports, supervisor can check easily.

原位置長期耐久性確認試験
Long-term durability confirmation test in-situ

薬液注入固結土の原位置長期耐久性確認試験①
Long-term durability confirmation test in-situ for chemical injection solidified soil ①

【試験の背景】(Background of the Test)

ⅰ)薬液注入工は工事を安全に施工するための仮設工であったが、時代の変遷、社会の要求より、「長期耐久効果」が期待されるようになった。(The chemical injection work was a temporary work for the safe construction, but the “long-term durability effect” has come to be expected from the changing times and the demands of society).

- 危険物タンク基礎地盤の改良 (Improvement of dangerous goods tank foundation)
- 護岸の基礎 (Revetment foundation)
- 空港の耐震化・液状化対策 (Anti-quake/liquefaction measures at airport)
- 電力施設の耐震補強 (Seismic reinforcement of power facilities)

ⅱ)実験室レベルの試験と大規模フィールド試験の違いを証明するために、1999年、日本グラウト協会が「原位置長期耐久性確認試験」を実施した。(To prove the difference between laboratory-level tests and large-scale field tests, in 1999, the Japan Grout Association conducted an “in-situ long-term durability verification test”).

薬液注入固結土の原位置長期耐久性確認試験②
Long-term durability confirmation test in-situ for chemical injection solidified soil ②

【試験の概要】(Summary of Test)

ⅰ)試験場所：茨城県波崎郡波崎町
Test place : Hasaki-cho, Hasaki-gun, Ibaraki

ⅱ)使用薬液 (Used chemical solution)

- アルカリ系無機薬液(30孔64.5m³)
  Alkaline inorganic chemicals (30 holes 64,5m3)
- アルカリ系有機薬液(30孔64.5m³)
  Alkaline organic chemicals (30 holes 64,5m3)
- 中性・酸性系薬液(37孔79.5m³)
  Neutral and acidic chemicals (30 holes 79,5m3)

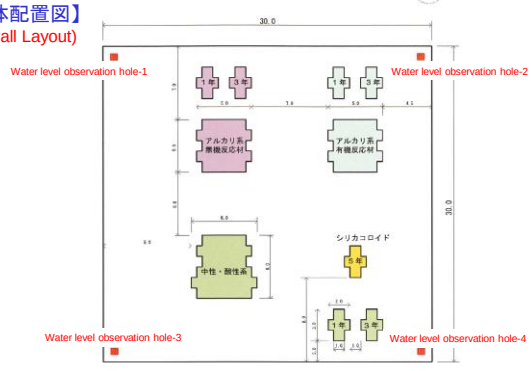
ⅲ)注入工法：ダブルパッカ工法 (Injection method : Double packer)

ⅳ)注入深度：GL－6m ～ GL－11m までの5m区間 (Injection depth : 5m for GL-6m ~ GL-11m)

ⅴ)対象土質：砂質土(一部礫混じり) (Target soil : sandy soil (mixed with some gravel) ⅵ)注入率：40% (Injection rate : 40%)

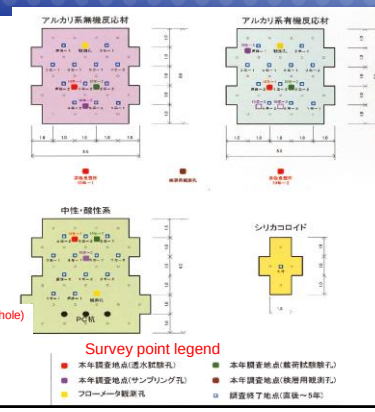
薬液注入固結土の原位置長期耐久性確認試験③
Long-term durability confirmation test in-situ for chemical injection solidified soil ③

【全体配置図】
(Overall Layout)



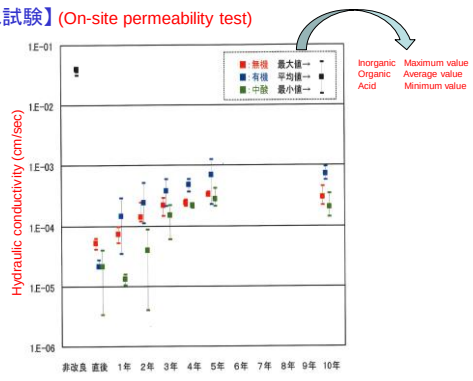
薬液注入固結土の原位置長期耐久性確認試験④
Long-term durability confirmation test in-situ for chemical injection solidified soil ④

【調査位置詳細図】
(Detailed survey location map)



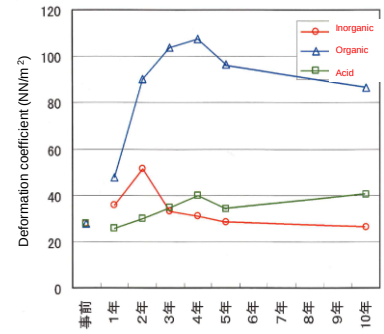
薬液注入固結土の原位置長期耐久性確認試験⑤
Long-term durability confirmation test in-situ for chemical injection solidified soil ⑤

【現場透水試験】(On-site permeability test)



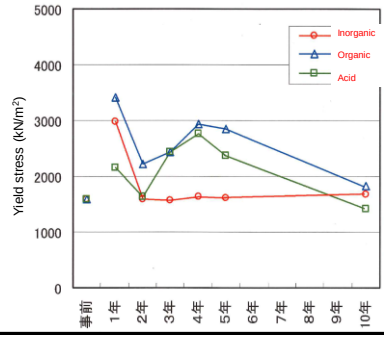
薬液注入固結土の原位置長期耐久性確認試験⑤
Long-term durability confirmation test in-situ for chemical injection solidified soil ⑤

【孔内水平載荷試験－変形係数】(Horizontal loading test – deformation coefficient in hole)



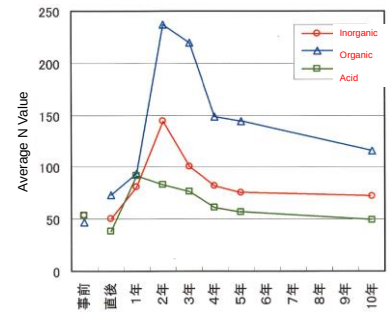
薬液注入固結土の原位置長期耐久性確認試験⑤
Long-term durability confirmation test in-situ for chemical injection solidified soil ⑤

【孔内水平載荷試験－降伏応力】(Horizontal loading test – yield stress in the hole)



薬液注入固結土の原位置長期耐久性確認試験⑤
Long-term durability confirmation test in-situ for chemical injection solidified soil ⑤

【標準貫入試験－N値】(Standard Penetration Test)



薬液注入固結土の原位置長期耐久性確認試験⑥
Long-term durability confirmation test in-situ for chemical injection solidified soil ⑥

【試験結果の総評】(Summary of Test Result)

ⅰ）遮水性等に関しては、いずれの薬液でも改良効果を持続している
In case of water stop, any chemical solutions continue to improve

ⅱ）強度面に関しては、コア採取できたことや水平載荷試験結果より、高い低いはあるものの改良効果が持続している。
In case of strength, based on the result of core sampling and horizontal loading test, the improvement effect has been increased even not stable

ⅲ）10年間の耐久性は確認されたと思われる。
10 years of durability has been confirmed

- 薬液注入することにより、粒度構成が粘性分の増加に寄与した（シリカ分の増加）By injecting the chemical solution, the particle size composition contributed to increase the viscosity (silica content)
- その結果、粒子間にシリカ分が残り、間隙が小さくなり、遮水性に寄与した。As a result, silica remained between the particles and the gap was reduced, contributing to water stop
- 砂質土でありながら粘性土の性状が付与され、コア採取が可能となった。Although it was sandy soil, it was given the property of cohesive soil, and core collection became possible.

添付資料7 新技術評価制度

Dec. 06, 2018

Badan Penelitian dan Pengembangan PUPR
litbang.pu.go.id/

Certification/Adoption process of new technologies for infrastructure development and contribution of private Sector in Indonesia
BALIT BANG_Kementerian Pertahanan Republik Indonesia

Aims: to assure that the proposed technology is suitable to be implemented in Indonesia, with some consideration including: supply chain management, human resources readiness, spare part warranty, natural condition, etc. It is important to ensure technology's sustainability and to minimize dependency on producer, especially technology from foreign country.

Principally, the technology should give **value-added** to **construction effectivity and efficiency**, in addition, it also should be **environmental friendly**.

基本的条件：提案技術が、サプライチェーンマネジメント、人材の確保状況、補修機材の保証、自然条件等を含めて考慮し、インドネシアにおいて事業化されることが適切であるかを確認するため。

原則：技術は建設の効果と効率性に価値を与えるものであること、加えて、環境に優しいものでなければならない。

インドネシアにおける民間企業貢献およびインフラ開発のための新技術認証プロセス

出典： Certification/Adoption process of new technologies for infrastructure development and contribution of private sector in Indonesia_Penilaian Kesesuaian Teknologi (PKT) : Clearing House Technology)_Disaster Management Collaboration Dialogue

対象技術

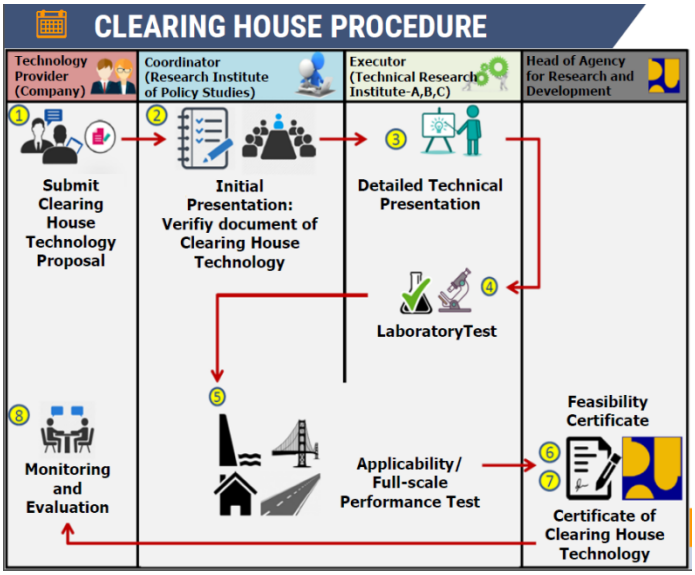
新技術（材料、構造、装置）

工法（システム、工程、仕様）

The proposed technology is an infrastructure technology that intended for **public service**

- Support **local industry** development
- Employ **local manpower**
- Give an improvement on **quality, acceleration, effectivity** and **efficiency** of infrastructure's project
- **Safe** for society and environment
- **Not include any prohibited products** according to Government law

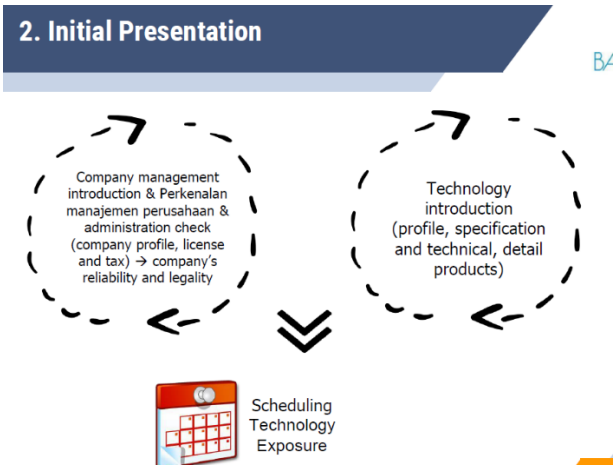
・新技術：公共サービスに参入しようとするインフラ技術
・国内産業の育成を支援する。
・国内人材を雇用する。
・インフラプロジェクトの品質、スピード、効果および効率を改善する。
・社会、環境への安全
・法律によって禁止されている製品を含まないこと。



許認可の手続き

技術提案 ⇒ 評価のための情報提出・プレゼンテーション ⇒ 試験室でのテスト ⇒ 適用性・フルスケールでの試験 ⇒ 認定、モニタリング・評価

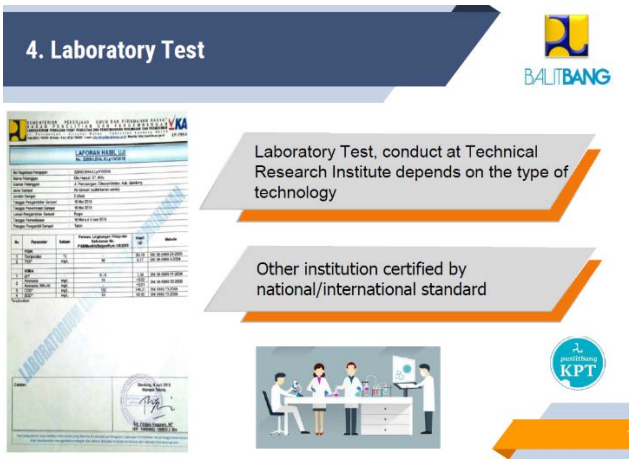
"Test"の定義？？：プレゼンではラボテスト ⇒ 1年（雨期・乾期）の実証試験 ⇒ フルスケール（後述５ページ）での実証・評価



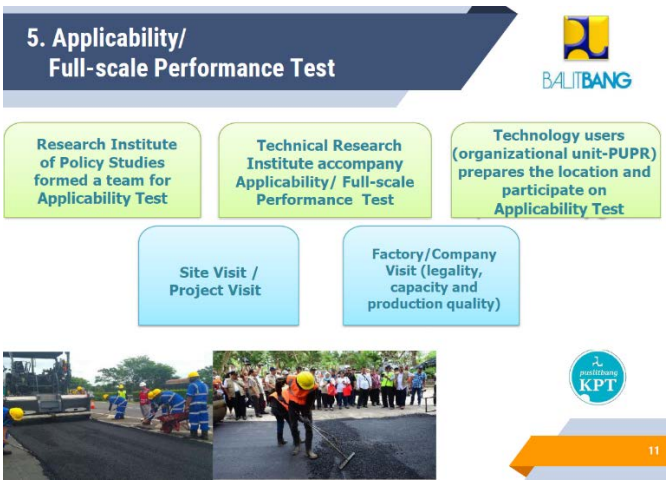
当初の提案プレゼン
・企業マネジメント紹介と企業管理のチェック）
（企業の信頼性と合法性を確認するため、企業概要）
・技術紹介
（技術概要、特記事項と技術、製品の詳細）

技術の詳細

研究機関、地方政府、関連協会、技術のユーザー、他の研究機関



ラボテスト：技術の種類に応じて、研究機関で実施する。



フルスケールでの実証試験：
適用性試験・試験チームの編成
適用性 ⇒ フルスケールでの実証試験 ⇒ 技術採用団体（PU の関連部局）が場所を提供し、適用性試験に参画する。

この間、プロジェクトサイトの試験、工場・会社を訪問し、法令遵守、能力・品質を確認する。

認定証
提案企業は、試験室テストおよび適用性テストに合格する。

BalitBang（Clearing House）による改善提案
認証は、提案技術がインドネシアのインフラ開発計画に適用されることを表明する。

モニタリング・評価：プロジェクトサイトを訪問し、ユーザーよりヒアリングし、試験結果を審査し報告する。

添付資料8 日本およびインドネシアにおける協会活動の事例

（１）日本グラウト協会

日本には、質の高い仕事を提供する専門工事業の団体として、注入工法に関する調査・研究開発、普及啓蒙及び技術向上等の事業により、安全で品質に優れた社会資本整備と環境保全に寄与することを目的として、一般社団法人日本グラウト協会（昭和３９年 日本Ｌ･Ｗ協会として創設）が存在する。施工業者を中心に、材料供給業者、機材供給業者、商社および学術機関で構成されている。一般社団法人としての公益性を保持しつつ、注入工法の研究開発、普及、事故の分析等の調査や啓蒙活動を行って社会インフラ整備に貢献している。

一般社団法人日本グラウト協会 ウェブサイトより

目的

本会は、社会資本の整備及び既設構造物の維持管理に当たり、地盤の安定及び地下水の流動防止に最も適している注入工法の研究開発とこれらの正常な普及啓蒙、技術向上とを図り、もって安全・品質に優れた社会資本整備と環境保全に寄与することを目的としております。

定款上の事業

（１） 注入工法に関する企画、調査、研究開発に係る事業
- ①最適な注入工法に関する調査研究
- ②長期耐久性に関する調査研究
- ③施工実績等調査
- ④施工管理機器の認定等の事業

（２） 注人工法の普及啓蒙を図る事業
- ①資料集・専門図書等の発行・編集及び頒布・配布
- ②技術説明会等の開催
- ③関係行政施策推進の協力・支援
- ④関係機関及び関係団体との連携による普及啓蒙
- ⑤工法に関する問い合わせ対応

（３） 注入工法の技術向上を図る事業
- ①登録グラウト基幹技能者講習（認定講習・更新講習）
- ②２級土木（薬液注入）施工管理技士資格取得支援事業（講習会の開催）
- ③関係機関及び関係団体等への技術支援（講師派遣）
- ④技術向上を図るための継続教育

（４） その他本会の目的を達成するために必要な事業

（２）インドネシア国内の各セクターにおけるAssociationの活動事例

インドネシアの協会は、各セクター必要とする品質を確保し、社会に説明責任を果たすための研修、セミナー・ワークショップ、資格試験制度を実施している。各協会は、各セクターの規模、規制基準、優先テーマに応じたプログラムを作り上げている。

① インドネシア溶接協会

建設・プラント業界は、溶接の品質を確実にすることを求めている。ISO/UK の品質管理基準に適合するために、IWA（Indonesian Welding Association）は、IIW（International Institute of Welding）と連携し、溶接や非破壊検査の技術者認定、セミナー、海外との交流、大規模プロジェクトにおける就業機会の紹介等の活動を行ない、溶接技術者の育成と確保を行っている。

以下に、2018 年に実施された研修・教育コース、次期、受講料を示す。

INDONESIAN WELDING ASSOCIATION

Secretariat : Jl. Siliwangi No. 77, Baleendah, Kab. Bandung 40258 West Java. Indonesia
Email : Indonesianweldingassociation@gmail.com
Telp/Fax : +6222-6006371
Mobile : +62811217060

FORM

TRAINING	SCHEDULE 2018 Check the Box	FEES *Check the Box*
NDT 5 METODA : Check the Box ☐ Level 2 ☐ Level 3	Date 10 to 25 Every Month ☐ Jan ☐ Feb ☐ Mar ☐ Apr ☐ Mei ☐ Jun ☐ Jul ☐ Aug ☐ Sep ☐ Oct ☐ Nov ☐ Dec	☐ Renewal : Rp 6.000.000 ☐ New : Rp 10.000.000
☐ WELDER : ✓ MMA ✓ TIG ✓ MIG ✓ SAW ✓ SW ✓ RW ✓ Plasma Cut	All the Time	☐ Renewal : Rp 3.000.000 ☐ New : Rp 5.000.000
☐ IWA and ASNT CP 189 NDT level 3 for NDT5METHODS	Date 10 to 25 Every Month ☐ Jan ☐ Feb ☐ Mar ☐ Apr ☐ Mei ☐ Jun ☐ Jul ☐ Aug ☐ Sep ☐ Oct ☐ Nov ☐ Dec	Rp 15.000.000
☐ International Welding Inspector (IWI) ©	☐ 10 Mar 2018 to 14 Apr 2018 ☐ 10 Jun 2018 to 10 Jul 2018 ☐ 10 Sep 2018 to 10 Oct 2018	☐ Renewal : Rp 10.200.000 ☐ New : Rp 17.000.000
☐ International Welding Engineering (IWE)	☐ 10 Mar 2018 to 14 Apr 2018 ☐ 10 Jun 2018 to 10 Jul 2018 ☐ 10 Sep 2018 to 10 Oct 2018	☐ Renewal : Rp 12.000.000 ☐ New : Rp 20.000.000

Sertifikat/*certificate* : *Issued by* (*Under License / Corporate Partner*)

ARCMART GSI SLV Halle ASNT IIW

(date) ,(month) ,2018

Trainee Candidate

Secretariat : Jl. Siliwangi No. 77, Baleendah, Kab. Bandung 40258 West Java. Indonesia
Email : Indonesianweldingassociation@gmail.com
Telp/Fax : +6222-6006371
Mobile : +62811217060

② インドネシア電気技術士協会（APEI）・インドネシア電気工事会社協会（AKLI）

電気設備については、ESDM No. 5/2014 on Electric Power Accreditation and Certification Procedures によって電気設備の品質確保と資格認定が行われてきた。2018 年の the Ministry of Energy and Mineral Resources Regulation No. 38 of 2018 on Electric Power Accreditation and Certification Procedures（“Permen ESDM No. 38/2018”）が施行され、電気設備の検査基準制度に加えて、電気工事士の資格制度が導入された。

Professional Certification for Electricians

Because of the frequent and avoidable accidents resulting from inadequate electrical installations made by unqualified ‘electricians’, and recognising the lack of certified professionals in Bali, the Naga Loka Foundation undertook to contribute to improving the qualification of electricians in North Bali. In 2010, a partnership was established with Sekolah Menengah Kejuruan Negri No 3 (SMKN3), a reputable Government Vocational Training School in Singaraja. Among other courses it offers the official 3-year curriculum programme for electrician vocational studies

In cooperation with the Association of Indonesian Professional Electricians (APEI) and the Association of Indonesian Electrical Contractors (AKLI), SMKN3 with the support of Naga Loka Foundation delivers a specific training programme for electricians addressing all aspects of electrical installation, followed by a formal examination and test for the granting of a proficiency certificate in electrical installation. This is recognised throughout Indonesia. The holders of this proficiency certificate are in high demand in both the public and private sectors, especially in the hospitality industry.

電気工事士の専門家資格

技術能力を持たない電気工事士や有資格制度に対する理解不足から、繰り返される避け得る事故を防ぐため、Naga Loka 財団は、バリ州の電気工事士の能力強化を支援してきた。州立職業訓練高等学校（Sekolah Menengah Kejuruan Negri No 3 (SMKN3): State Vocational High School）は、バリ州シンガラジャ市にある評価の高い職業訓練校で 3 年間の電気技術の教育を実施している。

インドネシアの 2 つの協会（電気技術士協会、電気工事会社協会：Association of Indonesian Professional Electricians (APEI) and Association of Indonesian Electrical Contractors (AKLI)と連携して、電気設備の設置に必要な研修プログラムに加えて、熟練資格を取得するための公的試験を実施している。資格取得者は、インドネシアの公共・民間セクターで評価されている。

Future Electricians Practice Wiring

Girls Placed First & Fourth in Their Class

Well Trained Electricians Ensure Bali’s Growing Infrastructure Will Be Safe

出典：Yayasana Naga Loka_Bali Province

Accreditation and Certification Procedures in Electric Power Sector

The Implementation of the Technical Personnel Competency Test

Pursuant to Permen ESDM 38/2018, regarding the implementation of the Engineer competency test, the written submission of the accredited Engineering Competency Certification Institution to the Director-General not only required the competency test schedule plans, the list of competency test participants, the list of competency test team members, and the competency testing place. However, it also need the submission of the list of tested competency unit in accordance with the occupation position of the electric power sector. 技術者の資格試験は、電気工事技師の試験に関して、試験の実施スケジュール、試験場所、受験者リスト、試験官、電力セクターにおける職位に合致する受験機関リストを求める。

Certification Obligation for the Assessor

Permen ESDM No. 38/2018 requires the assessors to have the assessor competency certificates. The Assessor Competency Certificate is issued by the accredited Assessor Competency Certification Institution with the appropriate field based on the qualification level in accordance with the prevailing laws and regulations in the electric power competency certification sector.

電気設備検査官は、検査官資格認定研究所が発効する各分野の品質レベルに応じた資格認定証を所持しなければならない。

出典：Accreditation and Certification Procedures in Electric Power Sector _www.indonesiarealestatelaw.com/

③ 下水道事業者協会

FORKALIM (Forum Komunikasi Air Limbah Permukiman: Domestic Wastewater Operators Association）

Pada hari Rabu tanggal 6 Februari 2019 telah diselenggarakan RAKERNAS FORKALIM di Hotel Ambhara. RAKERNAS ini bertujuan untuk memperkuat eksistensi FORKALIM sebagai Asosiasi Pengelola Air Limbah Domestik. RAKERNAS ini dihadiri oleh banyak anggota FORKALIM yang terdiri dari PDAM, UPT PAL, dan PD PAL dari seluruh Indonesia.

Diharapkan FORKALIMdapat menjadi mitra bagi pemerintah yang berperan dalam meningkatkan ilmu pengetahuan, teknologi, kelembagaan dll. Kegiatan FORKALIM didanai oleh IUWASH PLUS sebagai mitra kerjasama/lembur donor. Kedepannya, akan diadakan program twinning yang bertujuan untuk mempertemukan satu mentor dengan satu atau lebih mentee untuk memperdalam atau lebih mempelajari sebuah topik yang spesifik dengan sasaran keberhasilan yang terukur.

出典：PD PAL Jaya（ジャカルタ下水道公社）

2019 年 2 月、FORKALIM（Wastewater Operator Association：下水道事業者協会）の全国ワーキンググループ会合が、ジャカルタ市内で開催された。FORKALIM は、インドネシア全国の PDAM（水道公社）、UPT PAL（Unit Pelaksana Teknis Daerah/Regional Technical Implementation Unit/下水道局）、PD PAL（下水道公社）を会員とする協会で、下水道科学、技術、行財政制度を強化する役割を持ち、政府との連携機関である。将来、助言者と被助言者に、特定の話題（topics）について測定可能な成功の目標値（measurable success goal）を持って、より深く理解・学ぶプログラムを予定する。

Agency for Research and Development,
Ministry of Public Works and Public Housing

FINAL REPORT (SUMMARY)

(REPUBLIC OF INDONESIA)
VERIFICATION SURVEY WITH THE PRIVATE SECTOR FOR DISSEMINATING JAPANESE TECHNOLOGIES FOR GROUND IMPROVEMENT USING CHEMICAL GROUTING TECHNOLOGY

February 2020
(2020)

Japan International Cooperation Agency (JICA)
Toso Sangyo Co., Ltd.

Chapter 1. Outline of the Survey

1-1 Background and Purpose of the Survey

The Chemical Grouting Technology is an auxiliary technology for construction and rehabilitation of infrastructure. Republic of Indonesia, where economic development is remarkable, the construction and management of infrastructure such as the construction of large-scale and deep underground structures in large cities, the stable supply of irrigation water and urban water, and the rehabilitation of aging dams are important issues.

The purpose of this survey is to confirm the following items through demonstration tests and to contribute to the economic development of Indonesia.

i) The effectiveness and safety of chemical grouting technology will be verified through collaboration between research and public institutions, and a technical and social basis for the future dissemination of chemical grouting technology in Indonesia will be established.

ii) Advantage of the technology is recognized among client organizations such as contractors and others as well as project execution agencies.

iii) Build a business model through understanding the supply chain and business volume, collecting information on services provided, investment scale/organization form, etc.

1-2 Outline of the Survey

Outline of the Survey is described as follows;

Verification Survey with the Private Sector for Disseminating Japanese Technologies for Ground Improvement using Chemical Grouting Technology

Development Needs in Indonesia

➢NCICD has implemented for land subsidence measures and infrastructure development on transportation, flood mitigation, water resource and sewerage, which are urgent issues.
➢Urban infrastructure shall be installed underground for sustaining densely populated Jakarta.
➢Aged irrigation earth dams requires rehabilitation due to ageing such as leakage and erosion of dam body.

Subjects of Verification Survey

Verification on Effects and Safety

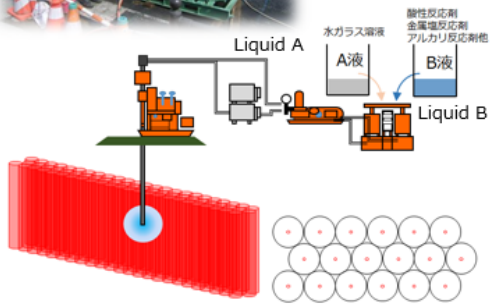
- Effects on ground improvement & safety
- Applicability on underground infrastructure and aged dam

Dissemination Activities

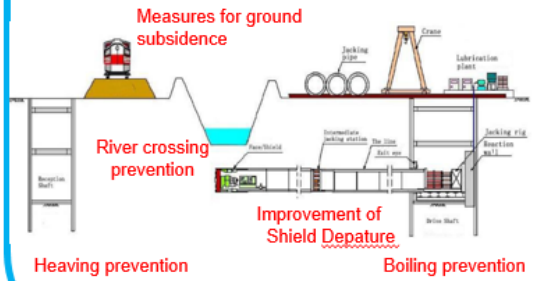
- Seminar and workshop
- Knowledge Co-creation Program
- Verification test
- Technical manual (Design & Execution)
- Supporting research & Public Relation

Chemical Grouting Technology

~Chemical Grouting Technology~
Mixing two liquids, injecting into ground and solidifying soil.



Verification of Applicability on Underground Infrastructure and Aged Dams



Toso Sangyo Co., Ltd.

Effects on Indonesia

➢ Contributes on economic growth through MRT and Sewerage Project
➢ Combination of water glass & cement milk is effective for rehabilitating aged dams.
➢ Dam construction project requires many years. Dam rehabilitation sustains water resource management with low cost and short term.

Effects on Japanese Private Sector

Job Opportunity & New Business

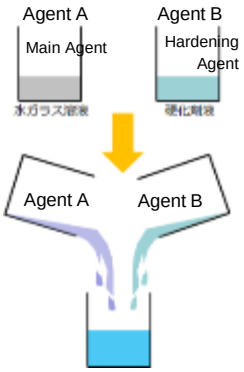
➢Product increase of water glass and Maintaining operation rate
➢Oversea business development

Exchange with Research Institution

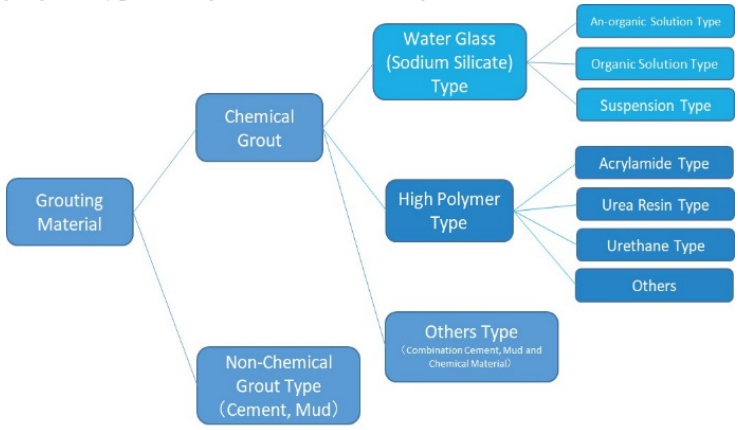
➢Universities & Institutions collaborate in both countries for standardizing Japanese technology.

Information of Products / Technologies to be provided

Name	Solution Type Inorganic Grout (Product Name: GEOKEEP®)
Specification	GEOKEEP® consists of two liquids, Agent-A and Agent-B of which chemically react and solidify silica (SiO_2)-polymer through mixing with equal volume. Agent-A: Alkali metal silicate (main ingredient) and Water Agent-B: Hardening ingredient and Water Water glass and hardening ingredient (Sodium, Hydrogen carbonate and/or Cement) are used for chemical grouting. Gelation time and strength of sand gel are designed to any condition through arranging the type of ingredient and mixing ratio.

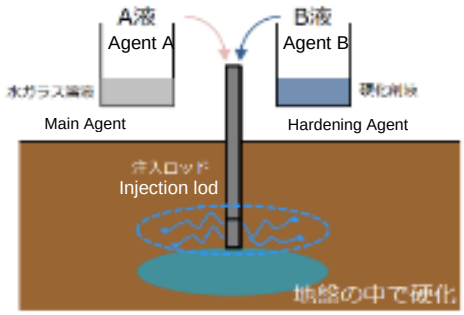


Mixing and consolidated



Types of Grouting

Test peiece of solidified sand



Solidifying in the Soil

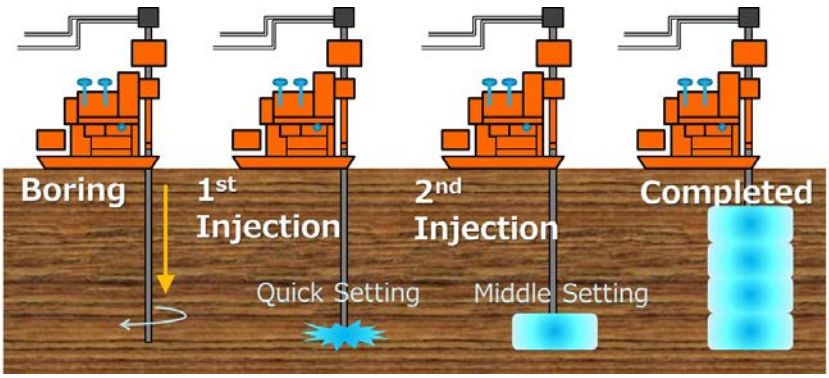
Soft soil is solidified in the ground

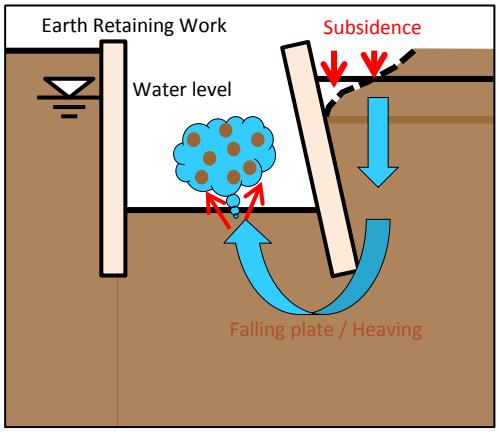
Representative Chemical Grouting Material is:

Solution Type Inorganic Grout (quick setting)

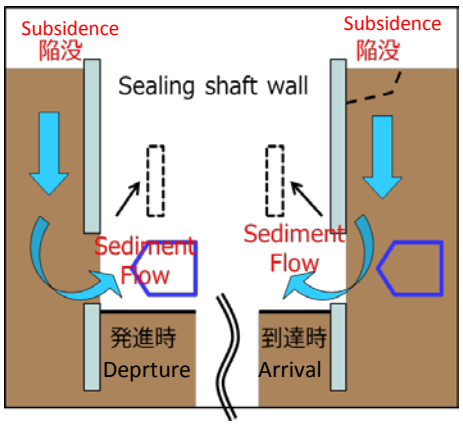
GEOKEEP #320E

Agent A (200 ℓ)		Agent B（200 ℓ）	
Main Agent ＃12	80 ℓ	#320 Hardening Agent	20kg
Water	120 ℓ	Water	194 ℓ
Standard Gelation Time		approx. 10 seconds (at 20℃)	
Strength of Sand Gel		About 0.5N/mm² (Construction equipment trafficable)	

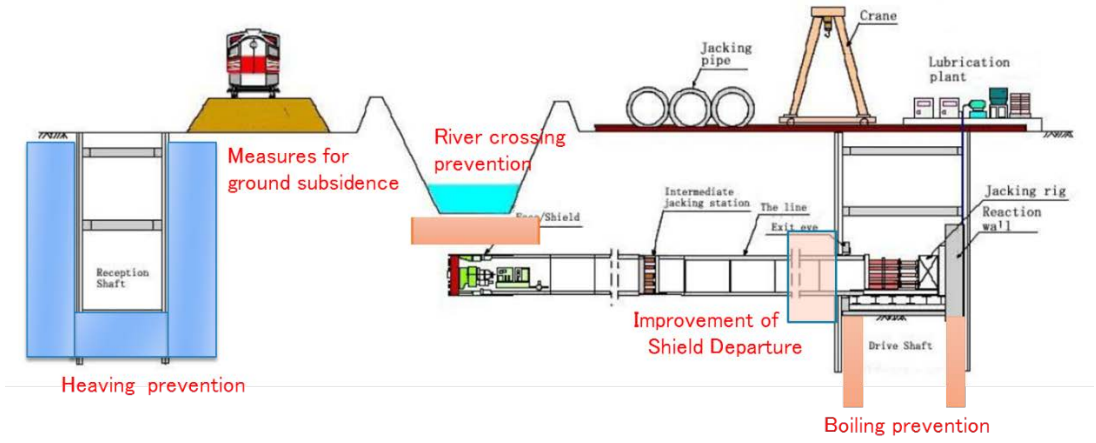
Characteristics	Chemical grouting technology has following characteristics: (i) Solidifying soil particles, void of which chemicals fill without changing their nature. (ii) Grouted chemical solidifies and enhances impermeability of soil. (iii) Applied ingredients for chemically solidifying are water glass (Main Agent) and Hardening Agent. Gelation time can be designed from several seconds to several hours. Construction Procedure 
	Main Agent of Water glass is named Sodium Silicate, the main composition are SiO_2 (Silicon dioxide) and Na_2O (Sodium oxide). Water glass is highly safe chemical agent made from natural substance, since glassy callet of quartz sand dissolved by alkali (sodium ash) processes to liquid in pressure cooker. Water glass is used not only for chemical grouting of civil works but for water supply treatment, soap and detergent, pulp and silica gel (desiccant). This include a familiar material used such as living ware, food and product contacting hand. Bicarbonate soda, which is a main substance of GEOKEEP #320 Hardening Agent, is also highly safe substance used for food additive. GEOKEEP is used for construction works for safety measure with a long truck record. Various specification of chemical grouting material is properly selected in accordance with the nature of construction project and the type of ground condition.



Ground improvement of trench method



Ground Improvement of Microtunneling Shaft



Ground Improvement of Railway and River Structure

Source: Microtunneling Association edited by JICA Survey Team

Figure -1 Applied Ground Improvement at Urban Infrastructure Project

Chapter 2. Project Implementation Method

2-1 Basic Concept of the Survey

The Chemical Grouting Technology is a standardized technology and has been widely used in Japan since Ministry of Construction (reformed to present Ministry of Land, Infrastructure, Transportation and Tourism) issued Provisional Guideline for Construction Management Applying Chemical Grouting Technology (No. 160/MOC dated 10th July 1974). This technology is an auxiliary technology applied for construction of underground structure such as tunnel, sewer pipe. This technology has many advantages in the underground construction project where various infrastructure occupy and it has been commonly used for urban infrastructure project. This technology has a good performance in stopping leakage. Therefore, it can be applied for construction of dam and reservoir.

However, it is a new technology that is not used in Indonesia. There are strong concerns over public health caused by organic-chemical agent. This Survey's main objective is the followings;

i) Joint working with institution and project executing agencies in both countries,
ii) Advantage of the technology is recognized among client organizations such as contractors and others as well as project execution agencies,
iii) Providing the design and construction manual (Technical Manual)
iv) Establishment of grouting association (tentatively named) in order to disseminates the technology

This Survey aims to promote the dissemination of chemical grouting technology in Indonesia, centering on "verification tests" and "dissemination activities". At the same time, a business model in Indonesia based on the premise of dissemination of chemical grouting technology will be examined with implementing measures for environmental and social considerations.

As for verifying the effectiveness and safety, following three-step examinations were carried out for an in-depth understanding of chemical grouting technology as well as verification of its applicability and advantages.

i) First step examination: Table test
ii) Second step examination: Bench scale test
iii) Third step examination: Demonstration of execution and management

As for dissemination activity, workshop and seminar were held at the end of each step examination. Knowledge Co-creation Program in Japan provided site-visits of the construction site and lecture/ discussion with institutions. Technical manual was reviewed to match with Indonesian requirement.

In creating a business model, it is important to verify it from a broad perspective which include promotion of quality control methods based on the technical manuals, dissemination of the technology by public organizations, research and development of the technology, net-working with partner companies and investigation of the investment risks, etc.

2-2 Expected Outputs

Four outputs are expected following;

Output-1	Effects and safety of chemical grouting technology are verified through collaboration between research and public institutions in both Japan and Indonesia. A technical and social basis for the future dissemination of chemical grouting technology in Indonesia will be established.
Output-2	Applicability of the technology is verified by conducting the construction demonstration in ITB, and in Jakarta.
Output-3	This technology is widely used in future through dissemination activities.
Output-4	Business development plan is prepared.

2-3 Implementation Structure

The chemical grouting technology is a new technology in Indonesia, and applied to civil work construction (public works) as ground improvement technology. In order to promote the business development after gaining the understanding of customers by demonstrating the applicability of technology from the perspective of technological social contributions, such as technology safety/ reliability, technology dissemination, development effects and environmental and social considerations, the survey was conducted by the following implementation system with the support of research and public institutions in both Japan and Indonesia.

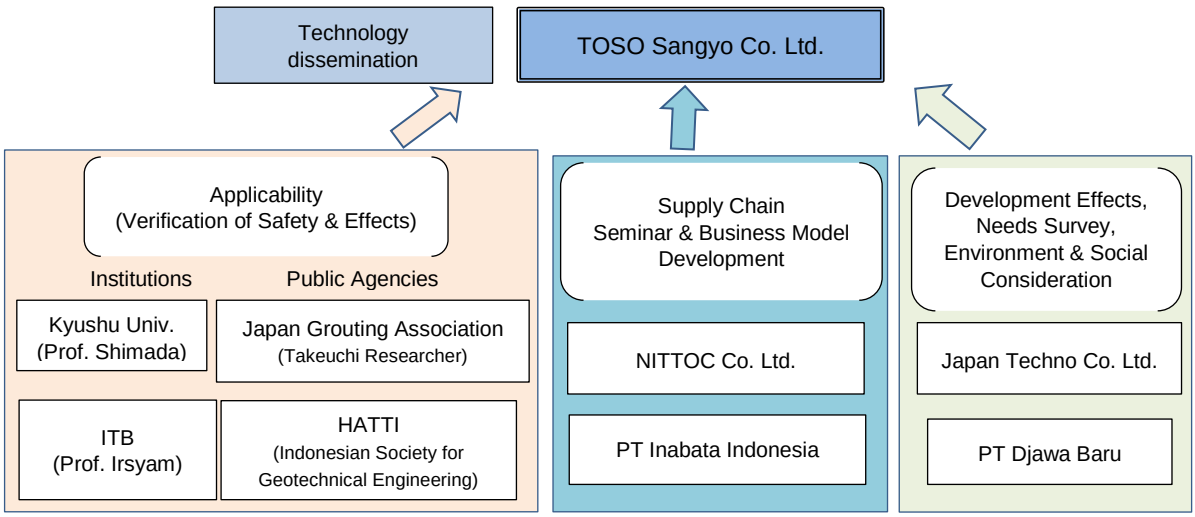


Figure-2 Implementation Structure of the Survey

2-4 Implementation Schedule

Chemical Grouting Technology has not been applied in Indonesia. Three sub-project were executed as follows;

i) Table test and Bench-scale test supported by institutions of Kyushu Univ., ITB and HATTI in order to verify the applicability, safety and effects,

ii) Seminar, knowledge co-creation program in Japan, and demonstration test (construction briefings) were conducted for the promotion and deepening understanding of the technology

iii) Technical manuals suitable for Indonesian requirements were examined through workshops, and establishment of a grout association (tentative name) was proposed in order to ensure proper operation of the technology.

Table-1 Implementation Schedule

Year	2016	2017	2018	2019-2020
①Technology Promotion & Business Model Development	★ Technical Seminar	★ Co-creation Knowledge Program in Japan		★ Demonstration of Execution & Management
②Verification of Applicability (Safety & Effects)	Labo & Bench Scale Test (Kyushu Univ./ ITB/Dam Site)			
③Supporting for Technology dissemination		★ Workshop & Hand-over of Technical Manual	★ Supporting on Grouting Association Establishment (tentative name)	★
④Conclusion				★ Concluding Seminar

Chapter 3 Achievement of the Survey

3-1 Understanding the Construction Project applied Chemical Grouting Technology through Knowledge Co-creation Program

Since the chemical grouting technology is a new technology in Indonesia, understanding the practice of deep underground construction and management of aged infrastructure is indispensable for introduction and standardization of this technology. Therefore, Indonesian experts (five participants) were invited in order to 1) understand the main points of technology application, design and construction management, and their role in infrastructure management and 2) carry out the work smoothly by sharing the technical requirements suitable for the local conditions in Indonesia with engineers in both countries.

Table-2 Participants of Knowledge Co-Creation Program

Organization	Position or Title
Research Center for Water Resources	Head of Experimental Station for Hydraulic Structure and Geotechnics
Research Center for Water Resources	Head of Standardization Sub Division
River Basin Organization of Citarum	Section Head of Operational and Maintenance
Center of DAM	Section Head of East DAM I
Directorate of Building Development, Ministry of Public Works	Assistant for Commitment Maker Officer

Source: JICA Survey Team

Prof. Imam A. Sadisun, who is an expert of geo-technology engineering and a member of Survey Team from ITB, participated as a facilitator of the activities conducted in Japan as well as a technical promoter in Indonesia. This program achieved deepening the understanding and knowledge of the chemical grouting technology and gaining the knowledge on the role of the central and local governments in the management and operation in Japan. By understanding the history of technology and application conditions in Japan, the necessity of the on-site verification tests, PR for engineers in Indonesia, technical manuals that meet Indonesian requirements, technology dissemination measures, technology exchange and establishment of grout association, was able to be shared and contributed to the establishment of cooperative relationships for the program implementation.

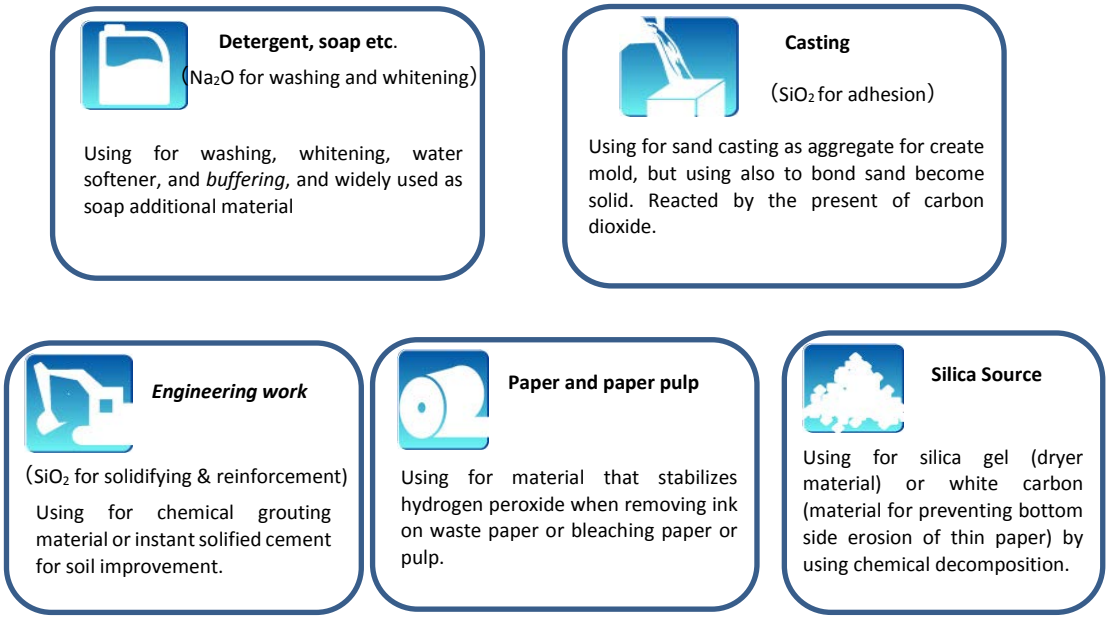
Source: JICA Survey Team

Figure-3 Technology Demonstration (NITTOC Sashima Center)

3-2 Verification on Safety and Ground Improvement Effects

(1) Use of Sodium Silicate

Sodium Silicate is a safe and environmentally friendly inorganic material used for various purposes in daily life and industry, such as detergents and soaps, for molds, construction work, paper, white carbon (silicic anhydride), etc.



Source: JICA Survey Team

Figure-4 Various Uses of Sodium Silicate

(2) Result of Verification Test

This project verified effects, safety and workability of the chemical grouting technology in cooperation with Kyushu University and ITB, a leading academic institution in Indonesia, in order to foster an understanding of the safety aspects and applicability of the technology. It is believed that the results of the demonstration tests conducted on both the academic and practical aspects will contribute to the dissemination of chemical grouting technology in Indonesia in the future.

(i) Result of the Safety Test

Dissolution test was conducted in accordance with EA NEN 7375:2004 (dissolution standard method in Netherland) to verify the effects on environment and safety.

The test specimen was immersed in pure water five times its volume, and the immersion water was changed on days 1, 9, 16, and 36 after the start of immersion. In addition, dissolution test was also performed on a specimen made of only sand without sodium silicate. The Test result is described below.

Only pH of both sands of Indonesian and Japanese exceeded the standard value. In addition, there were some parameters that exceeded the standard value with only Indonesian sand or Japanese sand. However, compared to pH, the amount in excess of the standard value was small. In addition, since only one of the sands exceeded the standard value, this must be due to the influence of the components

derived from the sand used in the test, not the injected material.

pH exceeded the standard value due to the test condition, which applies immerged pure water of 5 time volume of test piece. This exceeding value of pH is still less than dissolution test result of Portland cement concrete. Injected sodium silicate in practical works is diluted and pH exceeding is suppressed by a large amount of ground water. If the pH does not increase, it is assumed that other parameters that exceed the standard value in the dissolution test will be sufficiently diluted.

Groundwater before and after bench scale tests in ITB Campus were also examined. BOD/COD, nitrite nitrogen, cadmium, iron, zinc and free chlorine exceeded drinking water quality standard in Indonesia. It is presumed to be caused by components contained in soil and groundwater since the water quality value fluctuated with time and the parameters are not included in the chemical grouting. Regarding pH, it dropped significantly from the test value of the table test, indicating that it was diluted with groundwater.

Table-3 Desollution Test Result of Sands in Japan and Indonesia (Table Test)

PARAMETER	UNIT	PERMENKES No. 492, 2010 Drinking Water Standards	Leaching Test (Indonesia Sample)				Leaching Test (Japan Sample)			
			Grouting Material				Grouting Material			
			1 day	9 days	16 days	36 days	1 day	9 days	16 days	36 days
ORGANIC CHEMISTRY										
pH		6.5-8.5	9.93 (8.31)	9.86 (8.06)	9.33 (8.09)	9.22 (7.68)	10.49, (8.32)	10.47, (8.27)	10.21, (8.69)	9.83, (8.16)
Phospate total P	mg/L		-	-	-	-	n.a.	n.a.	n.a.	n.a.
NO3 as N	mg/L	50	-0.682	-0.211	-0.179	0.03	-	-	-	-
NH3-N	mg/L	1.5	-	-	-	-	-	-	-	-
Arsenic	mg/L	0.01	0.0003	0.0001	0	0.0057	-0.002	-0.091	-0.105	0.01
Cobalt	mg/L		-0.301	-0.152	-0.344	n.a.	-	-	-	-
Barium	mg/L	0.7	-0.011	0.006	-0.007	0.009	-	-	-	-
Boron	mg/L	0.5	0	0.029	-0.042	0.064	0.048	0.032	0.029	-0.379
Selenium	mg/L	0.01	n.a.	n.a.	n.a.	n.a.	-0.181	-0.083	-0.045	-0.021
Cadmium	mg/L	0.003	n.a.	n.a.	n.a.	n.a.	-0.0007	-0.001	-0.0001	-0.0493
Chrome (VI)	mg/L	0.05	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	-0.029	-0.056
Copper	mg/L	2	0.016	0.025	0.021	0.027	-0.008	-0.011	-0.006	-0.051
Iron	mg/L	0.3	-	-	-	-	0.012	0.012	0.012	-0.289
Lead	mg/L	0.01	n.a.	n.a.	-0.009	n.a.	n.a.	-0.005	n.a.	-0.039
PHYSICS										
Manganese	mg/L	0.4	-	-	-	-	-0.029	-0.029	-0.029	-0.282
Mercury	µg/L	1	0.15	0.09	n.a.	-0.09	-	-	-	-
Zinc	mg/L	3	0.032	0.016	0.004	0.024	-0.010	-0.006	-0.0064	-0.191
Chloride	mg/L	250	71.39	23.32	4.76	0.95	27.193	3.503	1.217	0.563
Cyanide	mg/L	0.07	n.a.	n.a.	n.a.	n.a.	-	-	-	-
Flouride	mg/L	1.5	0.951	1.135	0.832	1.14	-0.037	-0.036	-0.085	-0.101
Nitirite as N	mg/L	3	-0.059	-0.03	-0.035	n.a.	n.a.	n.a.	n.a.	n.a.
Sulfate	mg/L	250	-	-	-	-	-0.276	-0.616	-0.669	-1.096

Source: JICA Survey Team

Table-4 Desollution Test Result of ITB (Bench-scale Test)

PARAMETER	UNIT	PERMENKES No. 492, 2010	Bench Scale Test	PARAMETER	UNIT	PERMENKES No. 492, 2010	Bench Scale Test
		Drinking Water Standards	After Grout 18 Days - Before Grout			Drinking Water Standards	After Grout 18 Days - Before Grout
ORGANIC CHEMISTRY				PHYSICS			
pH	mg/L	6.5-8.5	7.52 (7.3)	Manganese	mg/L	0.4	-0.0968
BOD	mg/L		0.8	Mercury	µg/L	1	n.a.
COD	mg/L		2.04	Zinc	mg/L	3	-0.0208
Phospate Total (P)	mg/L		0.055	Chloride	mg/L	250	0.61
NO3 as N	mg/L	50	1.713	Cyanide	mg/L	0.07	n.a.
NH3-N	mg/L	1.5	-0.002	Flouride	mg/L	1.5	0.479
Arsenic	mg/L	0.01	n.a.	Nitirite as N	mg/L	3	0.001
Cobalt	mg/L		n.a.	Sulfate	mg/L	250	-38
Barium	mg/L	0.7	0.06	Free Chlorine	mg/L	5	2.12
Boron	mg/L	0.5	0.071	S as H2S	mg/L	-	n.a.
Selenium	mg/L	0.01	n.a.				
Cadmium	mg/L	0.003	-0.0324				
Chrome (VI)	mg/L	0.05	n.a.				
Copper	mg/L	2	-0.0036				
Iron	mg/L	0.3	0.3526				
Lead	mg/L	0.01	n.a.				

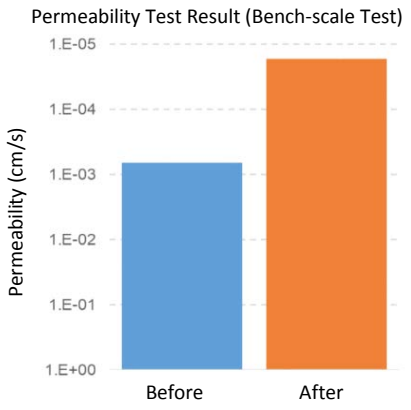
Source: JICA Survey Team

(ii) Result of Ground Improvement Test (Permeability Test)

The purpose is to verify the failure of equipment, to confirm the improvement of water permeability and their impact on groundwater, by performing construction using construction machines, injection specifications, and management methods used in actual construction. For the construction management and construction management items, the method actually used in Japan was adopted.

i) Calibration of flow meter
ii) Photo management
iii) Material management
iv) Grouting procedure management
v) Grouting quantity management
vi) Gelation time management
vii) Grouting pressure management

Bench-Scale Test (Boring, Management of Gel Time and Injection Quantity)



Water Permeability

Soil Improved Sample (Left: in detail)

Source: JICA Survey Team

Figure-5 Water Permeability Test (Bench-Scale Test)

3-3 Needs Survey

(1) Needs of Aged Dam

73 dams of 6 BBWSs of DPUPR in Jawa, South Sulawesi and South-east Sumatora were surveyed.

Damaged dams were 48 dams equivalent to 65% of surveyed dams. The major issues in dam management were drought, soil deposits, turbidity and silt, and erosion of body. Leakage was detected in 17 dams, and major causes were aged gate, failure of spill way and others. Rehabilitation of the embankment by chemical grouting (including cement milk) was carried out at three dams, Kedung Uling Dam, Darma Dam and Balambano Dam (estimated value). In addition, it was confirmed that there was a need for chemical injection for the repair of the hydroelectric dam waterway (Balambano Dam).

In addition, damage to the dam embankment due to earthquakes and floods is gaining attention, and the World Bank and AIIB are implementing dam rehabilitation projects. Their project components are mostly dredging and replacement of aged gate, but rehabilitation of dam embankment is also planned.

Controled leakage

Errosion due to seepage

Source: JICA Survey Team

Figure-6 Aged Earth Dam for Irrigation

(2) Needs of Urban Infrastructure

Jakarta Sewerage Project (Zone-1 and Zone-6) is implemented by Japanese ODA. Sewer is planned in soft ground where groundwater level is high and a serious land subsidence is proceeding. In Zone-1, the microtunneling method will be adopted for large and medium-diameter trunk pipelines (approximately 36 km about 50 % of total sewer) with a diameter of 800 mm or more. Traffic congestion is normal on the narrow roads, and once an accident such as a road collapse occurs, it causes serious economic and social problems. Therefore, In order to reduce the impact of pipeline construction work on roads, buildings, railways, MRT/LRT, rivers, and other structures, ground improvement technology can be adopted. Sewerage projects in Medan, Makassar and Pakanbaru are also being implemented and measures have been demanded to prevent accidents on soft ground in lowlands.

Jakarta Province are implementing integrated traffic network of MRT, LRT and elevated bus lane in order to sustain the urbanization from population increase and traffic congestion. MRT of North-South Line Phase-1 inaugurated in 2019. Construction projects of Phase-2 of North-South Line and East-West line are in progress. Deep underground construction project requires ground improvement technology which can be applied to narrow and high groundwater site condition. Chemical grouting technology is an advantageous in such projects.

3-4 Technical Manual and Guide Book

(1) Position of Chemical Grouting Technology in Ground Improvement

DPUPR, Ministry of Transportation and HATTI (Indonesian Society for Geotechnical Engineering) have implemented a joint working of standardization in 2019, since quality management of ground improvement works becomes urgent. Chemical grouting technology has been listed in No.11 Soil Grouting.

Table-5 Classification of Ground Improvement Technology in Indonesia

No	Method of Ground Improvement
1	Sotne Column
2	Depth Cement Mixing (DCM)
3	Stone Column / Vibro Replacement
4	Kolum Grout Modullar
5	Preloading
6	Viboro Floatation / Compaction
7	Dynamic Compaction
8	RIC (Rapid Impact Compaction)
9	Dynamic Replacement
10	CFG Pile (Cement Fryash Gravel)
11	**Soil Grouting**
12	Sand Compaction Pile

Surce: Penyusunan Manual Ground Improvement 2019-20_HATTI

(2) Concluding Workshop

Workshop was held for concluding the project, and discussions were made on the contents of the technical manual and the mechanism for appropriately utilizing and developing chemical grouting technology.

The following three points were mainly discussed;

i) Based on Japan's experience with chemical grouting technology, the government confirmed the necessity of establishing a grouting association in Indonesia

ii) Chemical grouting technology is a new technology in Indonesia, and the information provided by the Japanese side was significant.

iii) Projects for dam construction are underway, and further technical research cooperation on chemical grouting technology have been requested.


Source: JICA Survey Team

Figure-7 Concluding Workshop on Chemical Grouting Technology

(3) Contents of Technical Manual

Technical Manual consist of two parts, Technical Manual for Design (including cost estimation), and Guide-Book of Construction Procedure (execution management). Based on the knowledge of Japan, it has been edited to contribute to the design, ordering and construction management of chemical grouting technology which meet the requirements of Indonesia. This Technical Manual is created with the cooperation of Kyushu University, ITB and HATTI.

Table-6 Contents of Technical Manual

Chemical Grouting Method - Technical Manual	
Part I Overview of Chemical Grouting Method 1. Definition and Scope of Chemical Grouting 2. System for Chemical Grouting 3. Current Method in Use 4. Procedural Steps for Studying and Executing the Chemical Grouting Method 5. Glossary **Part II Design of Chemical Grouting Method** 1. Feasibility Study 2. Determination of Design Related Items 3. Calculation Formulas for Obtaining Scope of Improvement 4. Safety 5. Effect Check 6. On-site Grouting Test	**Part III Execution of Chemical Grouting Method** 1. Execution Plan 2. Execution and Management 3. Execution Machinery 4. Documents Submitted **Part IV Cost Estimation of Chemical Grouting Method** 1. Overview of Cost Estimation 2. Cost Estimation for Double Pipe Strainer Method 3. Cost Estimation for Double Packer Method 4. Management Costs 5. Expenses Not Included in Cost Estimation Documents 6. Examples of Cost Estimation

Chemical Grouting Method - Guide-Book Of Construction Procedure	
1. Execution Plan 1.1 Feasibility Study 1.2 Execution Plan Document **2. Execution and Management** 2.1 Execution Flow Chart 2.2 Execution Management Items 2.3 Execution Devices 2.4 Execution Methods and Management **3. Execution Machinery** 3.1 Grouting Machines and Tools 3.2 Drainage Treatment Machines and Tools 3.3 Plant 3.4 Execution Yard 3.5 Power and Construction Water	**4. Documents Submitted** 4.1 Types of Documents Submitted 4.2 Material Quality Certificate 4.3 Material Quantity Certificate 4.4 Chart Paper 4.5 Daily Report 4.6 Photos

3-4 Demonstration Test of Execution and Closing Seminar

The Project was summarized, and the technical manual, the mechanism, the construction method, the quality control and the dissemination were introduced. Approximate 150 experts participated from public works agencies, construction companies, consultants and others. Both Japanese and Indonesia side confirmed the ground improvement effects, the safety, and importance of the quality management and the technology development.

It was mentioned that construction accidents increased due to no standardization on geo-technology, earthquake, landslide and so on. Experts also raised strong concerns on ground improvement technologies, because selection of ground improvement technology classified into 12 category and design method of individual technology have not been established.

Venue and Participants

Presenters

Left: w/o Right: with(solidified sand)

Execution test

Figure-8 Demonstration Test of Execution and Closing Seminar

3-5 Self-reliant and Continual Activity of Counterpart Organization

In public works, it is important that the public and private sectors follow social ethics, develop efficient and feasible technologies, and balance business and social contributions. Japan Grouting Association has provided activities such as standardization, research and technology development project, disseminating technology, training and legal certification for human resource development.

This Survey introduced the social responsibility, organization and activity of Japan Grouting Association which could be a template for Indonesian association. DPUPR aware the significance of association and requested technical exchange with both countries. Seminar with demonstration test of execution and workshop were held in order to establish a task force for association. The Survey Team supports the following self-reliant activity of Indonesian organization that can contribute to development of underground infrastructures.

ⅰ) Sharing design manual, execution plan, cost estimation, public procurement system and others upon request
ⅱ) Sharing R&D information, and paper presentation to HATTI
ⅲ) Sharing information on construction accidents
ⅳ) Exchange of engineers and researchers in future
ⅴ) Dispatch of expert and lecture, and supporting grouting association

Chapter 4 Conclusion

In Indonesia, efforts are underway to disseminate the ground improvement technology, such as standardization. Chemical grouting technology is one of the powerful ground improvement technology that enable construction of deep underground structures. In this survey, in cooperation with DPUPR and institutions (ITB and HATTI), the applicability of the technology in Indonesia was verified, and technical manuals (design manuals and construction guidebooks) necessary for dissemination were prepared.

4-1 Achievements of the Survey

This Survey achieved followings;

i) Verified the applicability of chemical grouting technology (ground improvement effect, safety, solution on socio-economic issue and development effects on infrastructure development)
ii) Construction accidents of existing microtunneling works in Medan and others suggested the applicability of the technology.
iii) Technical Manual, in which Japanese manual is modified appropriate to Indonesian requirement.
iv) Social significance of Grouting Association, which contributes to human resource development/training and quality management certification, research and technical development, design and execution management, and public procurement system.

4-2 Recommendation to JICA and Public Organizations

For public works, procurement authority is left to the government. New technology does not always

provide enough standardization and technology selection system. Design procedure and procurement system generally prioritize technology which has a proven track records. Japanese excellent technology sometimes faces such hurdle. DB (design-build) procedure is commonly applied in new project such as sewerage. Some procurement procedure sometimes awards low-cost and low-quality proposal. Construction work is interrupted due to low-quality and low-cost technical proposals, which leads to contractors withdrawing and significant delay of the construction schedule.

Provisional Guideline for Construction Management Applying Chemical Grouting Technology in Japan was standardized in 1974 due to groundwater pollution accident. Since then, technical standards and public procurement system have improved subsequently. Present technology has 45 years' experience. In addition to technical seminars, it is indispensable to transfer technology as a whole, including design methods that take quality and external economy into account, and construction management standards such as clarification of conditions and design changes. Japanese excellent technology, which is advantageous in LCC (life-cycle cost), will be disseminated through public - private - partnership in both countries.

The Survey proposes technical transfer supported by Japanese Government on following subjects:

i) Planning and design capacity enhancement of ground improvement technology
ii) Quality management and procurement system of ground improvement technology
iii) Establishment of Public-Private- Partnership framework for disseminating (tentatively named, Grouting Association in Indonesia)

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(1) Planning and Design Capacity of Ground Improvement for Underground Infrastructure

Construction of large-scale underground infrastructure projects is increasing, and once land subsidence and collapse of landslides occur, they will have a tremendous effect on traffic such as roads and railways, buildings, river embankments, etc. DPUPR, Kem Hub (Kementerian Perhubungan Republik Indonesia) and HATTI just started standardization of 12 ground improvement technology including stone column, depth cement mixing, soil grouting and others. Therefore, understanding of the features, applicability of each technology and acquisition of the design ability is necessary.

(2) Quality Management and Procurement System of Ground Improvement Technology

Ground improvement technology, which is expected to cause massive damage to traffic and buildings due to construction accidents, is required to ensure the quality of construction and prevent construction accidents before they occur. Therefore, it is indispensable for public procurement system

to select the most competent contractor through designating certified technology and qualified engineer as well as the contract condition with technical specification (performance regulation).

(3) Public - private - partnership for dissemination (tentatively named, Grouting Association in Indonesia)

Regarding (1) and (2) above mentioned, implementation of activities for developing the chemical grouting technology in Indonesia, including research activities, design, estimation, construction management, and research exchange with overseas, which are carried out as a part of the HATTI-sponsored standardization of ground improvement method in collaboration with the public and private sectors and research institutes, is considered useful.