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Compaction Grouting for remedial works of Settlement of CWIS(Cooling Water Intake Structure) of a Power Plant

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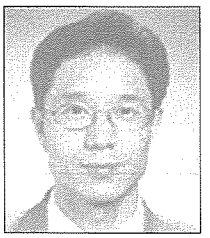

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1. Introduction

The unexpected settlement of the CW Intake Structure (CWIS) of Combined Cycle Power Plant 450MW CCPP in Bangladesh has been continuously observed after this structure was completed.

Several investigations based mainly on the CPT' result indicated that the very loose silty sand layer with high permeability below the CWIS existed due to losses of fine particles through the interface zone between the CWIS and sheet piles during rainy season but it didn't have reduced significantly a bearing capacity yet. Additionally, it was known that the settlement of CWIS was resulted from the area of very loose soils which had been enlarging as the severe difference of the elevation between ground water and river water would have been suddenly developing.

It was concluded that this phenomenon didn't have to be continued any more to prohibit CWIS from settling down. So, the remedial works focused on densifing loose soils were carried out promptly.

Herewith Compaction Grouting System(CGS) method was adopted in order to decrease voids among soil particles and to increase both the shear strength and the bearing capacity of this soils by forming rigid mortar piles support.

2. Excution of the works

Remedial works had been designed to cease additional settlement of the CWIS and to decrease the permeability

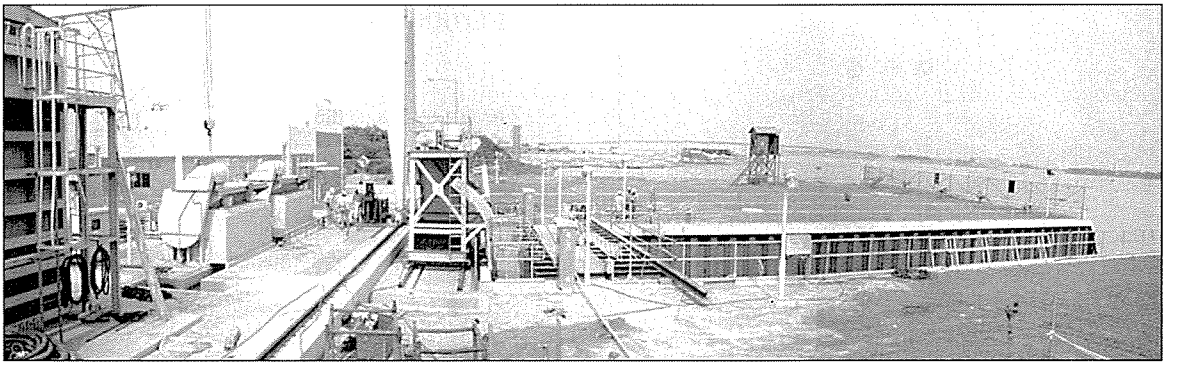


Fig. 1 Scenery of Intake Area

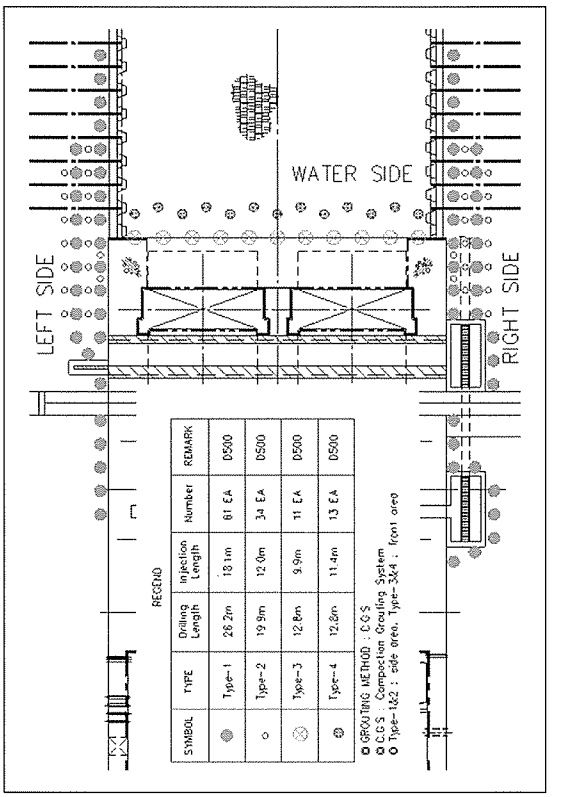


Fig. 2 Layout of CGS Work

of soils of the interface zone between the CWIS and the sheet piles based on the analysis results.

These works were executed in accordance with the Work Design Drawing.

3. Analysis of work result

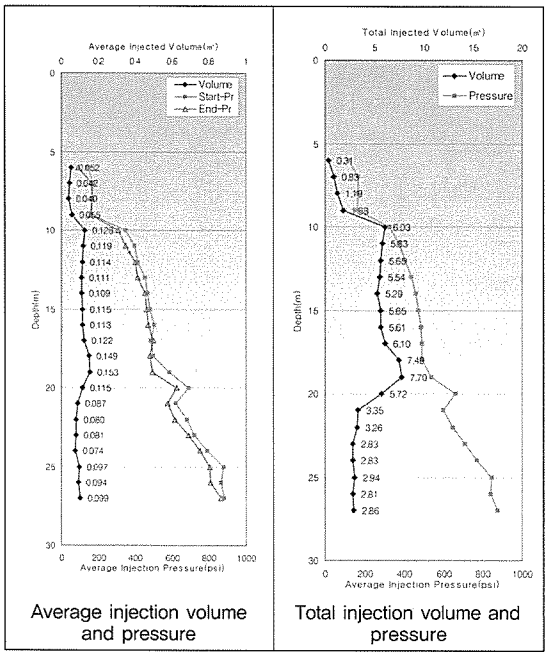
3.1 Analysis of Ground Characteristics after Injection

1) Injection Profile per depth for Hole at right side of the CWIS

Based on the analysis of Injection profile per depth for hole at right side of the CWIS as shown in the below graph, the density of soil layer under G.L-21.0m was high therefore injection pressure must also high. That's why injection volume was less. But from G.L-21.0m to G.L-10.0m, the injection pressure had been rather lower and the density also loose. Especially from G.L-19.0m to G.L-18.0m, the injection volume was the largest in quantities same as the CPT test result done before injection.

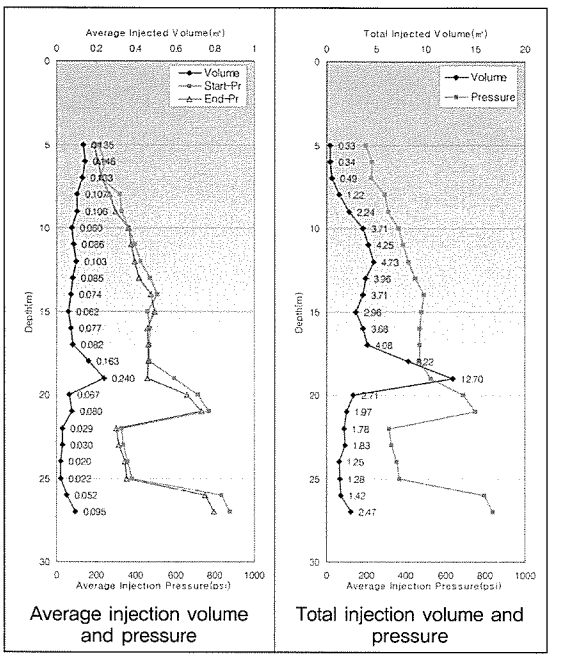
2) Injection Profile per depth for Hole at left side of the CWIS

Based on the analysis of Injection profile per depth for hole at right side of the CWIS as shown in the below



Average injection volume and pressure | Total injection volume and pressure

Fig. 3 Injection Profile per depth for Hole at right side of the CWIS



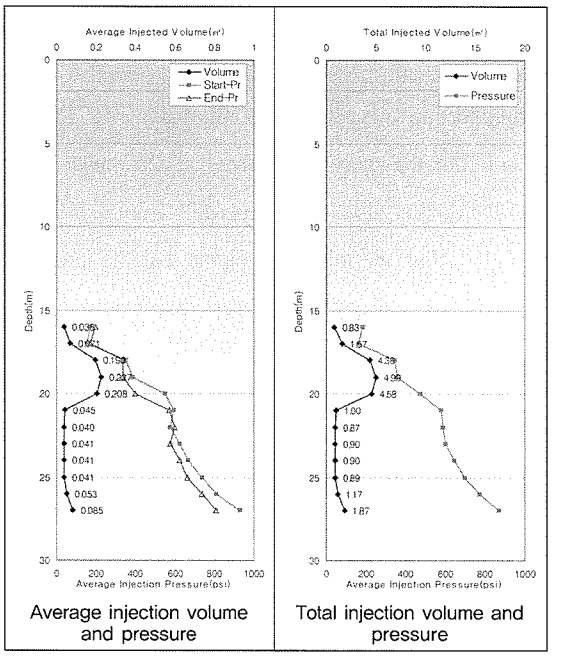
Average injection volume and pressure | Total injection volume and pressure

Fig. 4 Injection Profile per depth for Hole at left side of the CWIS

graph, the density of soil layer under G.L-20.0m was high therefore injection pressure must also high. That's why injection volume was less. But from G.L-20.0m to G.L-10.0m, the injection pressure had been rather lower and the density also loose. Especially from G.L-19.0m to G.L-18.0m, the injection volume was the largest in quantities same as the CPT test result done before injection.

3) Injection Profile per depth for Hole at water side of the CWIS

Based on the analysis of Injection profile per depth for hole at right side of the CWIS as shown in the below graph, the density of soil layer under G.L-21.0m was high therefore injection pressure must also high. That's



Average injection volume and pressure | Total injection volume and pressure

Fig. 5 Injection Profile per depth for Hole at water side of the CWIS

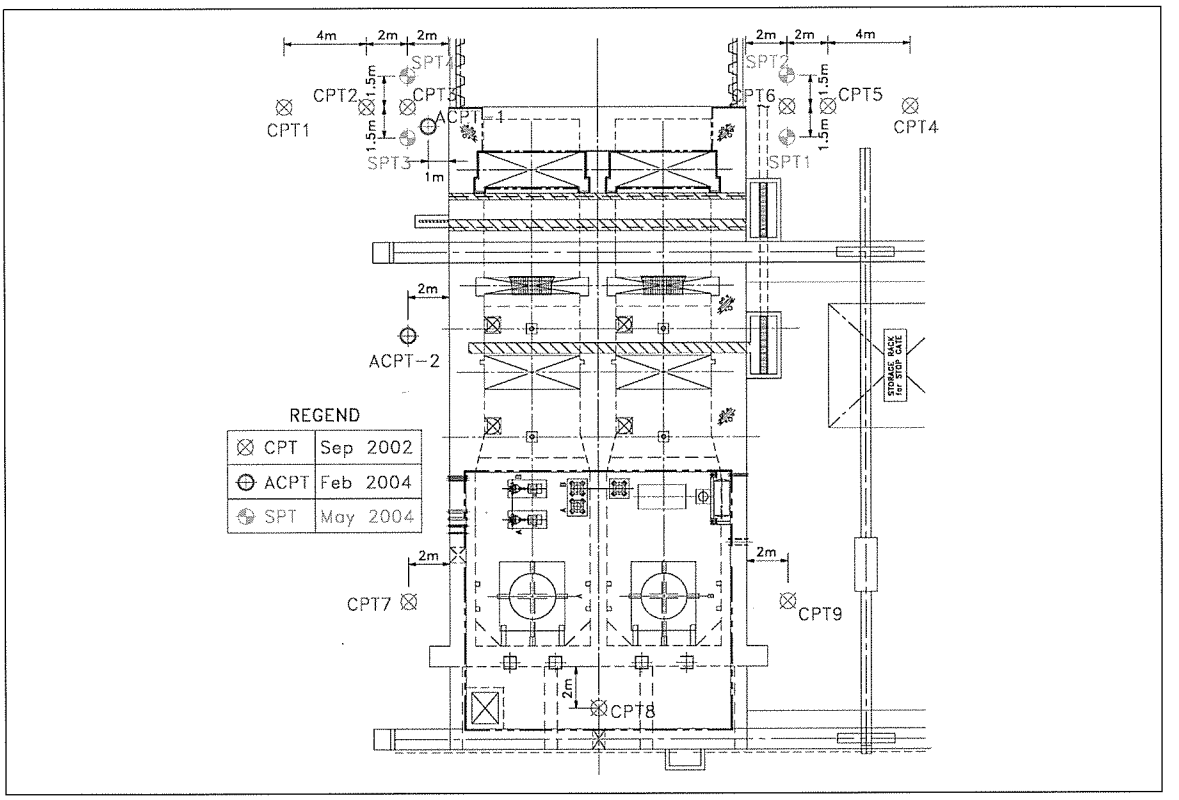


Fig. 6 CPT Test Location

why injection volume was less. But from G.L-21.0m to G.L-17.0m, the injection pressure had been rather lower and the density also loose. Especially from G.L-20.0m to G.L-18.0m, the injection volume was the largest in quantities same as the CPT test result done before injection.

3.2 Grouting Execution Effect Analysis by CPT Result

1) Subsurface Conditions by CPT result before grouting execution

The additional CPT's indicated the presence of a very loose to loose zone of sands and silty sands below 3m(G.L-18.5m) the base of CWIS(on southern side area), where it abuts the sheet piles(test location CPT 2, CPT 3, CPT 5 and CPT 6). But the subsurface profile at test locations CPT 1, CPT 4, CPT 7, CPT 8 and CPT 9 indicated the presence of a medium to very density zone of sand and sand silty.

2) Analysis of SPT Test result after Grouting Execution

Comparing the SPT result before and after remedial work as the below ;

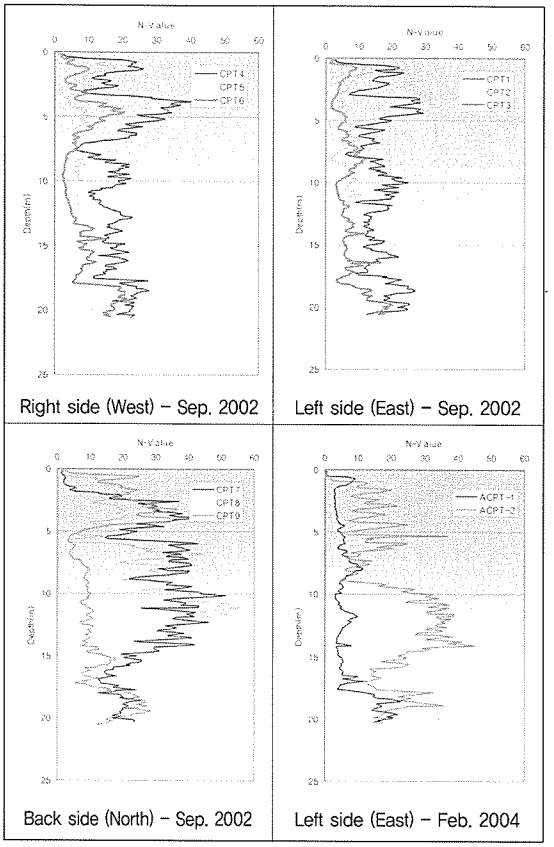


Fig. 7 Subsurface Conditions by CPT result before grouting execution

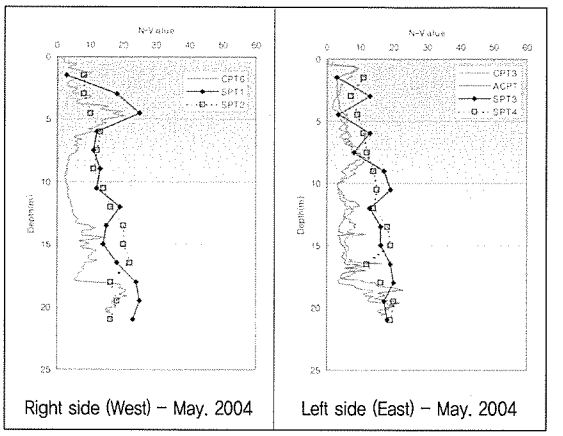


Fig. 8 Analysis of SPT Test result after Grouting Execution

3.3 Settlement Analysis after Grouting

1) Level Check Point Location

Fig. 9

2) Settlement Analysis

Based on the comparison of the settlement value for six points and water level data, it is concluded that settlement of the CWIS had been occurred in case water

Table 1.

Class	Right side (West)			Left side (East)			
	Before	After		Before		After	
Depth (m)	CPT6 (2002.9)	SPT1 (2004.5)	SPT2 (2004.5)	CPT3 (2002.9)	ACPT-1 (2004.2)	SPT3 (2004.5)	SPT4 (2004.5)
9.00	2.86	13	11	6.96	4.53	17	14
10.50	3.27	12	14	3.48	3.96	19	15
12.00	4.40	19	16	6.91	7.61	13	14
13.50	9.95	15	20	8.10	3.68	16	18
15.00	8.64	14	20	5.53	4.61	16	19
16.50	8.34	18	22	7.77	5.64	19	12
18.00	10.06	24	16	3.52	14.62	20	16
19.50	17.33	25	18	12.32	19.90	17	20
21.00	16.66	23	16	17.89	14.81	18	19
Remarks	N-Value : increase 52%(ave)			N-Value : increase 66%(ave)			

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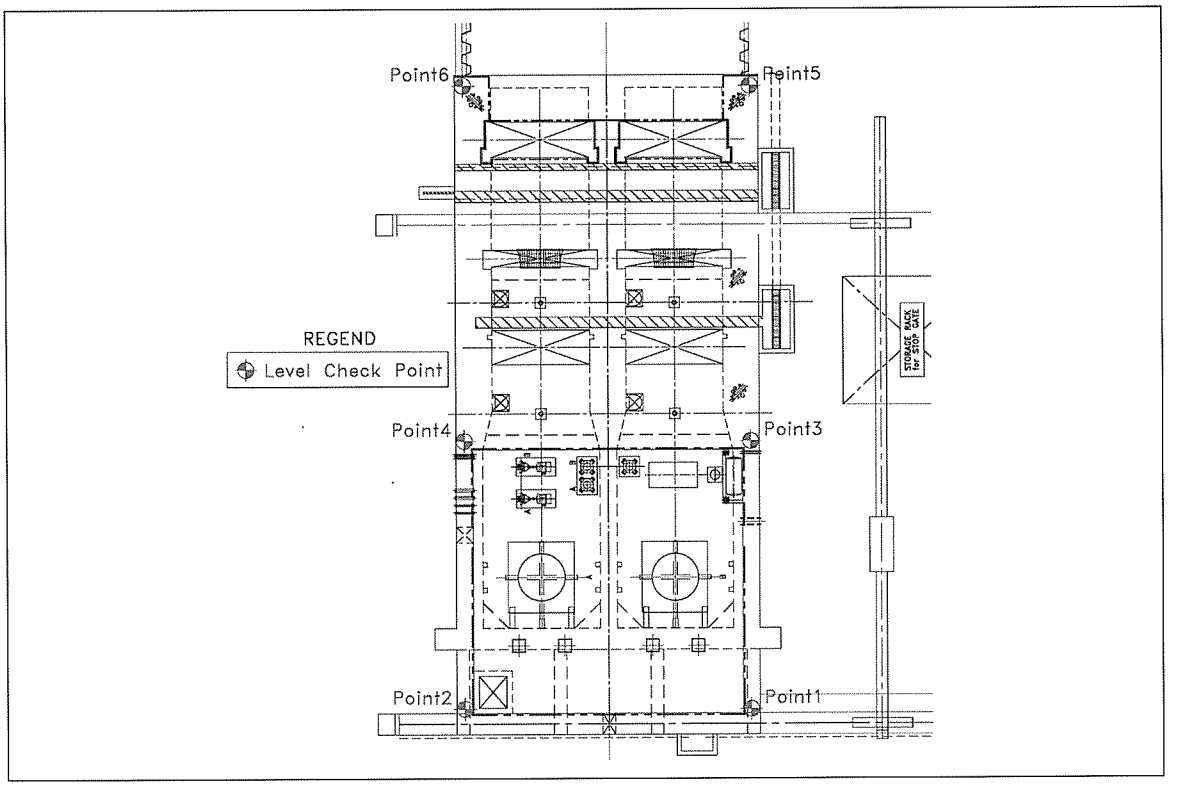
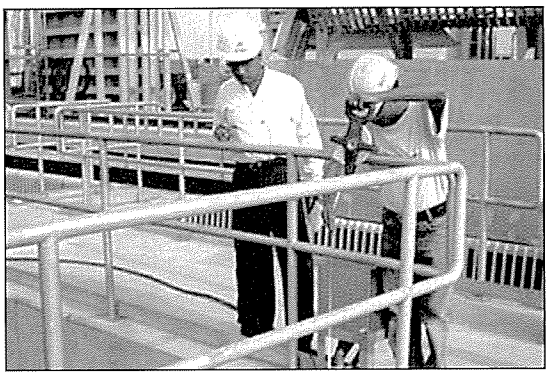
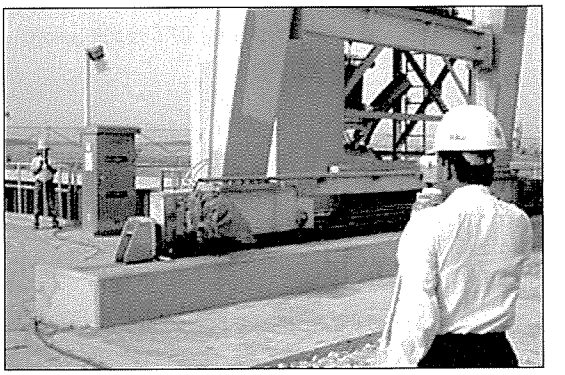


Fig. 9 Level Check Point Location



Water Level Check



Level Check

Fig. 10 Settlement Analysis

level had gone up and down as shown in the below graph. Compaction Grouting System(CGS) works had been executed since March 20, 2004, starting from the point on the right side of the CWIS. At the beginning stage, the settlement at the point 5 had occurred about 1mm due to water inflow during drilling works. However, after the completion of grouting execution on April 10, 2004, settlement has been no more in progress.

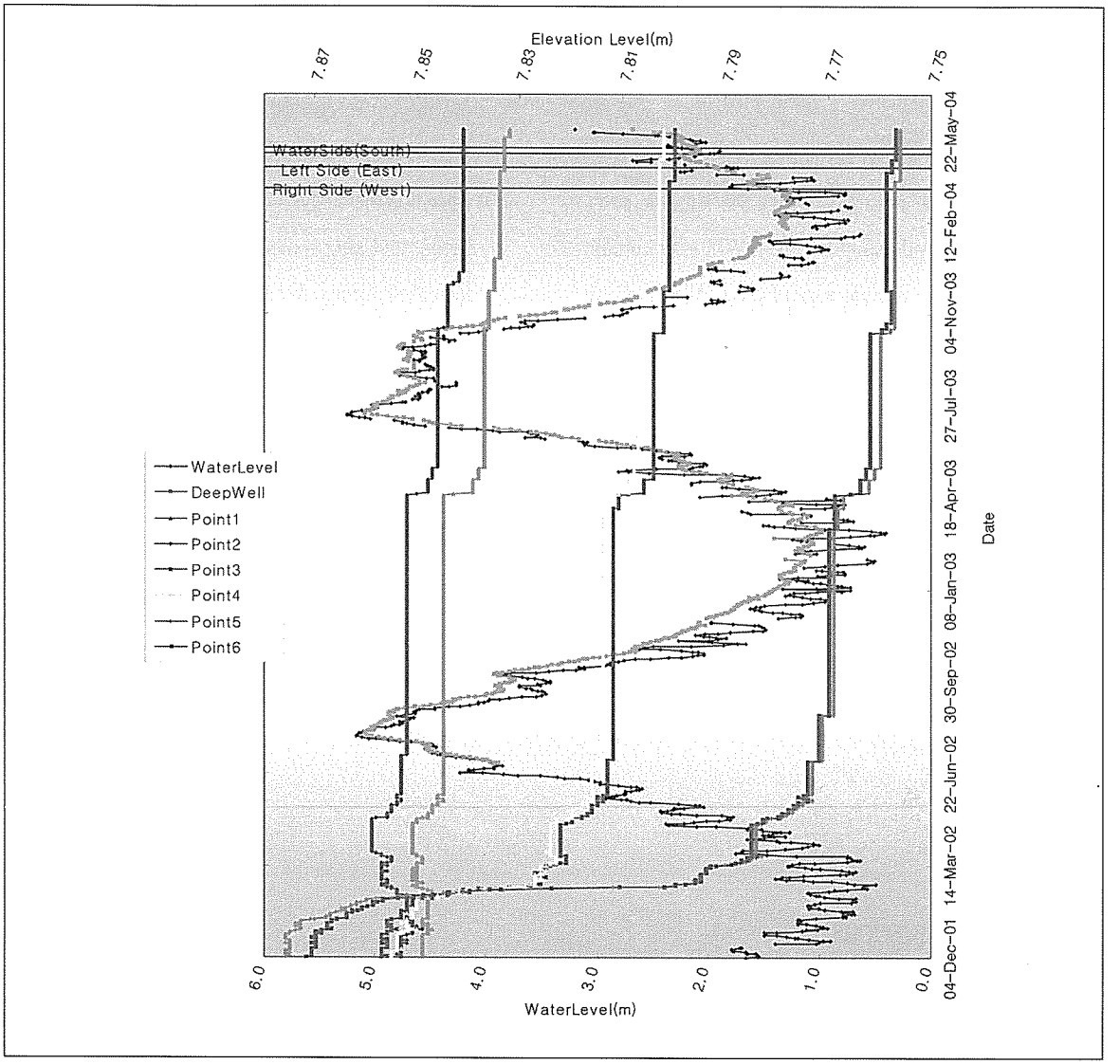


Fig. 11 Level Check Result

From April 11, 2004 to April 26, 2004, CGS works had been executed on the left side of the CWIS, settlement of the CWIS had been occurred about 1mm due to same reason as point 5. But after the completion of grouting execution, settlement of the CWIS has no more occurred at present.

4. Conclusion

CGS Works in accordance with the Work Design Drawing were executed for remediation of continuous settlement of CWIS of Power Plant and it was concluded that CGS Works was successful to cease the

settlement of CWIS.

The conclusion are summarized as follows

1) CGS works designed very close to the CWIS were executed at the right side(west), the left side(east) and the water side(south) of the CWIS after curtain grouting of the outside area of the CWIS finished to densify the disturbed loose soils below the Structure.
2) Based on the analysis of Injection profile per depth for hole, the density of soil layer under G.L-21.0m ~G.L-20.0m was high. But from G.L-21.0m to G.L-10.0m, the density was loose. Especially from G.L-20.0m to G.L-18.0m, the injection volume was the largest in quantities same as the CPT result done before remedial work.
3) Based on the analysis of comparing the SPT results before and after remedial work, N-value has been increased average 52~66% per depth. Soil condition has been much improved after CGS work.
4) Based on the comparison of the settlement value for six points and water level data, after the completion of CGS work, settlement of the CWIS has no more occurred at present.

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