Republic of the Union of Myanmar
Ministry of Construction, PW

The Project for Improvement of Road Technology in Disaster Affected Area in Myanmar

Completion Report on Pilot Project

(Phase Ⅱ-2)

Behavior Observation Work for High Embankment at Kywe Chan Ye Kyaw Bridge Approach Road

June 2015

Japan International Cooperation Agency
（JICA）

Pegasus Engineering Corporation
Oriental Consultants Global Co., Ltd.

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JR
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Republic of the Union of Myanmar
Public Works, Ministry of Construction

Project for Improvement of Road Technology in Disaster-affected Areas in Myanmar

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1. Purpose & Background of High Embankment Behavior Observation

South half of Ayeyarwady region is composed of soft ground area of river delta. MOC has been trying to develop the road network since Nargis on 2008. Around 50 long bridges have been constructed in the restricted budget and construction time. Almost of their approach road embankment is constructed on soft ground with around 7 meters height or more. One of the issues on road development is the stability and settlement of high embankment at the approach road to bridges. Some of them had collapse failure and almost of approach roads has big settlement. The gap on the joints with abutments are more than 50 cm. JICA decided to assist the solution methods as one of the capacity building of MOC for road construction. Originally, the main purpose was the technical transfer of countermeasure work of soft ground treatment works. However, MOC has not enough budget and allowable time for such work, and JICA team was obliged to shift the main purpose to the behavior observation methods about the high-embankment, which has some risk of stability and consolidation settlement.

2. Outline of High Embankment and Ground Condition

The target site was south approach road to Kyaw Chan Ye Kyaw (KCYK) Bridge.
This bridge construction was suspended since 2012 because of shortage of budget. In early 2014, MOC has decided to restart the construction of south side approach road by the budget of Ayeyarwady region government budget. The work was ordered to Shwe War Linn International co., Ltd, and they started embankment work since March 2014.

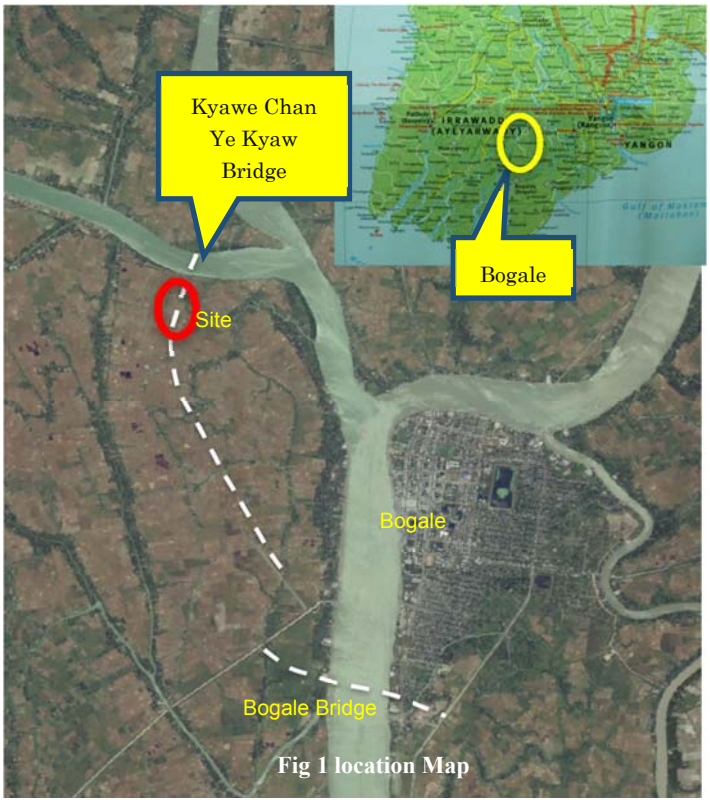


Fig 1 location Map

Photographs of the construction site: (as of March 2014 before embankment work start)

Photo 1 Abutment

Photo 2 Abutment and piers

Photo 3 Piers from river side

Photo 4 Side View of the Slope Embankment: (as of May 2015 on completion of embankment)

Here shows Design Drawing of the embankment.

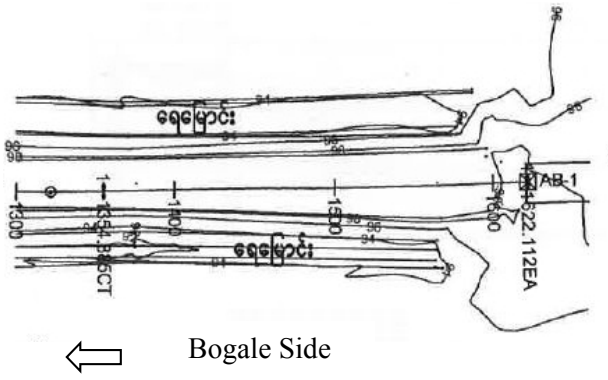


Fig 2 Plan

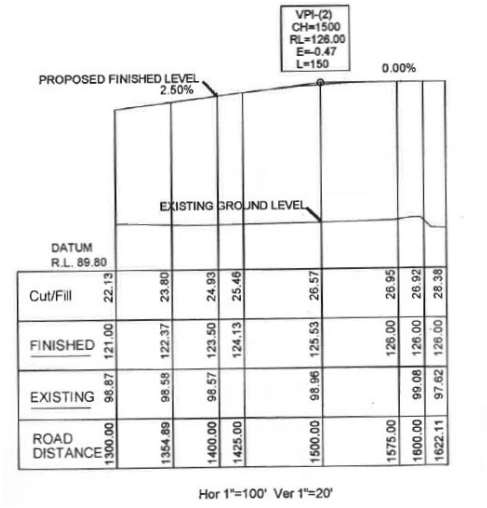


Fig 3 Profile (adjacent of abutment)

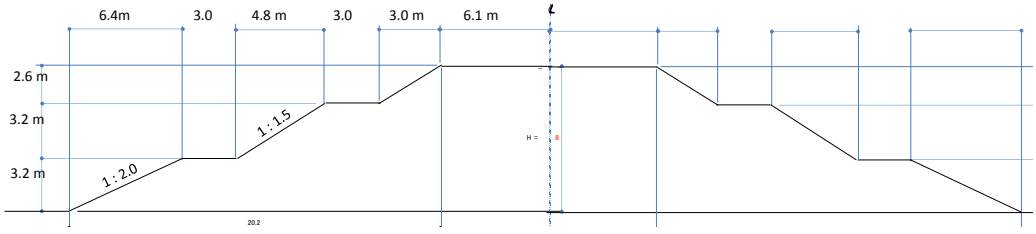


Fig 4 Cross-section of Embankment

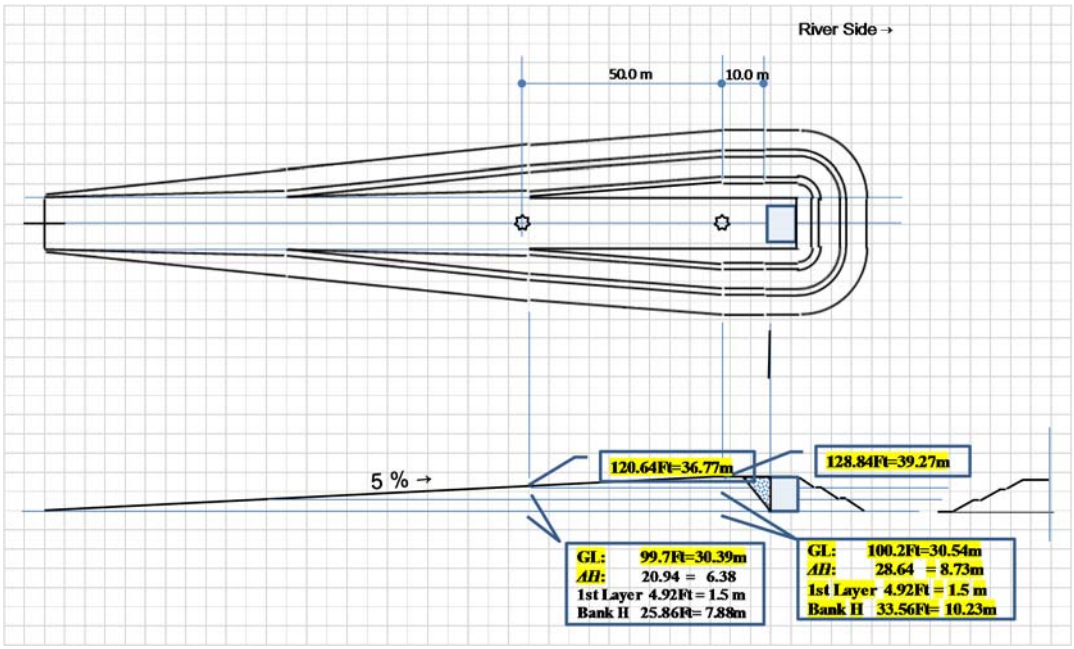


Fig 5 Plan & Profile

MOC staff and JICA experts' team has discussed about the behavior observation methods and started the preparation of necessary equipment. Prepared equipment were as follows:

Table 1 List of Equipment including Boring Survey Machine)

Boring machine	1	Drilling & sampling
Total Station	1	Measurement of ground behavior
Settlement board (Photo5)	4	Measurement of settlement
Pore water pressure gauge with 50 m cable (Photo6)	3	Measurement of Pore Pressure
Water level gauge with 50 m cable (Photo8)	1	Underground water level
Inclination gauge with 50 m cable (Photo7)	1	Measurement of inclination
Data Logger (Photo4)	1	Data acquisition/Recording
Plastic Survey stack 1.2m	16 box	Survey work
Slope Stability Analysis application	1	Analysis of slope stability

Boring survey was conducted first from Feb 2014 under the cooperation of Bridge Research Laboratory (BRL). The survey results were summarized as the "Report on subsurface soil investigation KCYK Bridge (Approach Road)[1]" by BRL.

The soil stratum of the ground used for the analysis are as follows:

[1] (refer Soft Copy "Soil Test Reports SRL" in acquired document in Folder M-1)

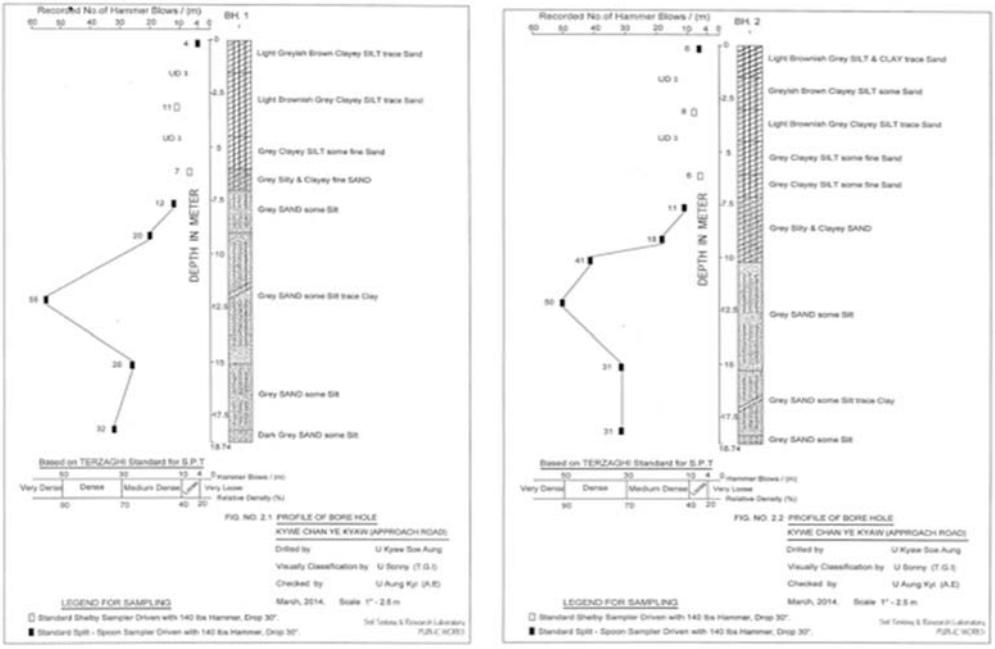


Fig 6 Soil stratum – Boring Log

The ground is composed of around 7 meter soft ground on the stable sandy layer. During this boring survey, the original road, which was banked in 2009, was found that it was constructed without compaction. Therefore following two specific work were required.

a) Removal of original road embankment with around 1.5 meter height and 5 meter width
b) Removal of bottom sludge in the side canal

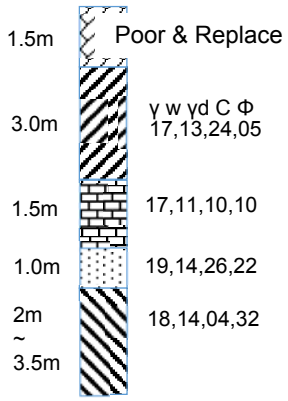


Fig 7. Decided typical cross section of soil stratum from Fig 6

Photographs of the construction site: (as of March 2014 before embankment work start)

Photo 5 Excavation of Existing road

Photo 6 Existed canal along road

Embankment work was started from March 2014 and suspended at the height of 0.9 meters during the rainy season between June 2014 and December 2014. The work re-started from January 2015 and completed in end of April 2015.

Table 2 Construction Schedule (Earth work) (As of March 2014)

Year	2014										2015		
Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Vol./Month (M3)	0	4,250	4,000	0	0	0	0	2,800	3,500	8,400	14,515	20,000	19,000
Vol. Accumulated	0	4,250	8,250	8,250	8,250	8,250	8,250	11,050	14,550	22,950	37,465	57,465	76,465

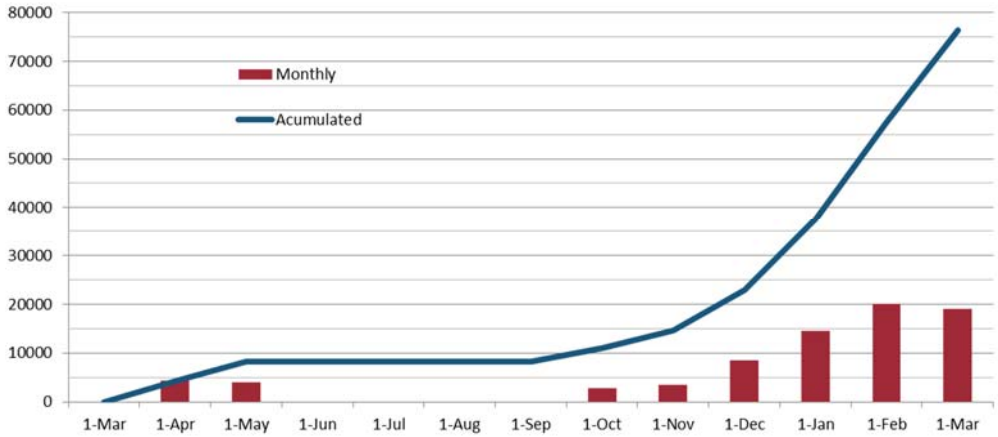


Fig 8 Construction Schedule (Earth work) As of March 2014

3. Preliminary Analysis for Stability & Settlement

Based on the data from boring survey, Preliminary analysis was executed as one of the TCP Workshop. This workshop was done total 15 times between June 3 and Dec 10 of 2014

Photo 7 Analysis workshop 1

Photo 8 Analysis workshop 2

Participants from MOC side were 12 persons as shown below:

Table 3 List of Participants

Name	Title
Daw Hnin Yu Aung	S.A.E Office RRL PW MOC
Daw Khaing Nyein Soe,	S.A.E Office RRL PW MOC
Daw Nay Chi Oo	J.A.E Office RRL PW MOC
U Kyaw Thuya	Work Charge Office RRL PW MOC
Daw Phoo Pyae Sone Tint	Work Charge Office RRL PW MOC
U Sunny	Technician Grade 1. Office BRL PW MOC
U Phone Wai	Technician Grade 1. Office BRL PW MOC
Daw Kalyar Khine	S.A.E Office BRL PW MOC
Daw Khin Moe Moe	S.S.A.E Office BRL PW MOC
Daw Sandar Ko	Technician Grade 3. Office BRL PW MOC
Daw Mya Thandar	Technician Grade 3. Office BRL PW MOC
U Than Aung	Work Charge Office BRL PW MOC

3.1 Stability analysis

Stability analysis was conducted mainly by free application software and original methods by MS Excel. The details of the analysis methods were shown in Page 17 of the Text Book[2] used in WS.

Table 4 List of Analysis methods for slope stabilization

	Analysis by	Max. Layer	Berm	Figure draw	Remarks
Method A	EXCEL	1	Without	Automatic	For initial introduction
Method B	EXCEL	1	Without	Automatic	To know relation R & Fs
Method C	EXCEL	2	Without	none	To master analysis methods
Method D	GeoStudio	3	Without	Automatic	
Method D'	GeoStudio	3	With	Automatic	
Method E	EXCEL	5	Without	none	For reference in Appendix

[2] Practical Training about Checking Methods for Stability & Settlement of High Embankment on Soft Ground (Folder E:6-2-7 pilot project 2-2)

The analysis results are somewhat different according to analysis method as shown in below:

Table 5 Summary Table and Figure about Stability Analysis

	Sf	Circle center	R(m)
A) Excel methods A by Free application	1.24	10,16	19
B) Excel method B	1.20	10,19	25
C) Excel methods C	1.24	9,16	20
D) GeoStudio Slope/W without berms	1.27	10,16	20
D') GeoStudio Slope/W with berms	1.30	10,16	20

(Refer to Page 23 of the Textbook)

Although the stability factors varies according each method, all calculation results are in critical values for the stability.

Note: Road Research Laboratory requested the supply of full-dress Analysis Software for stability analysis. JICA donated "Geo-Slope" in May 2015.

3.2 Consolidation Settlement

Consolidation settlement is categorized generally as follows and explained 2nd consolidation as the main subject of this WS.

Table 6 Kinds of Settlement

	Kinds of settlement	Brief Explanation
1	Immediate Settlement	Deformation will complete relatively & quickly after loading. Resulting from shearing of a cohesive soil layer and resulting from compression deformation of a loose sandy soil layer
2	Primary consolidation settlement	This phenomenon will occur due to expulsion of pore water pressure, and directly affect to design and construction.
2	Secondary consolidation settlement	It is generally thought that "Secondary consolidation settlement" (creep) is due to changes in soil structure, although no reliable theory has been proposed as yet

Above three kinds of Analysis methods were explained and practical trainings were conducted by plotting curve of actual data in a white graph paper.

Table 7 Outline of 3 kinds of analysis methods

Calculation method	Equation	Characteristic of the method
e-log p curve	$S_c = H (e_i - e_f)/(1+e_i)$	Most general and adaptable any situation of consolidation settlement
Cc- method	$S_c = H\ Cc / (1+e_i) \log (p_f/p_i)$	Useable in normal consolidation condition only
mv method	$S_c = H\ m_v\ \Delta p$	Useable in normal consolidation condition only

S_c : Consolidation settlement

H: Thickness of consolidating layer (m)

e_i: Void ratio of initial vertical effective stress p_i in the e-log p curve

e_f: Void ratio of pf = pi + Δp in case of an increase in vertical effective stress due to embankment loading in the e-log p curve

Cc: Completion Index (dimension less)

p_i : Initial vertical effective stress (kN/m^2)

p_f : An increased vertical effective stress due to embankment ($p_f = p_i + \Delta p$) (kN/m^2)

Mv: Coefficient of volume compressibility of a soft soil layer (m^2/kN)

Δp: Increment of vertical effective stress due to embankment (kN/m^2)

Final settlement volume was estimated to be 55 cm through the WS training. However, the estimation results varied according to the 3 kinds of analysis methods in Table 7 and the ability of each trainees. Below table is an example of the difference of Cc and Pc point value according to the each analyzers' analysis results using e-log curve methods as shown in p34 of the Text.

Table 8 Example of difference of analysis according to the each personnel ability

Person	1	2	3	4	5	6
Cc	0.30	0.22	0.23	0.29	0.16	0,11
Yield pressure	1.65	120	190	89	45	165
Yield e	0.81	0.81	0.83	0.84	0.86	0.81

(2014/11/24)

4. Study about the countermeasures for high embankment

Stability analysis results were shown in Table 5. Any of the results of safety factors were critical ones and needed careful attention during construction.

Following countermeasures were agreed to conduct to ensure the safety factors of slope.

a) Removal of sludge in the bottom of side canal and refilling by sand
b) Removal of existing road embankment with insufficient compaction
c) Mixing of sand (around 30%) with fill soil (from around the site) to increase the safety factor by improving internal friction angle

Although any countermeasure work for the settlement was not conducted, a few examples of the countermeasures were introduced from the Table 9.

Table 9: Applicability of Countermeasures for Settlement and Stability

Theory	Typical methods		Settlement		Stability			Deform			**Applicability in Myanmar**
			Acceleration of consolidation settlement	Reducing of total settlement	Increasing of strength by consolidation	Increasing of Resistance for sliding	Reducing of Sliding force	Isolation of stress	Reducing of stress	Securing of Trafficability	
Consolidation & drainage	Drain of Surface water									○	○
	Sand mat		○							○	○
	Slow banking method				○						△
	Surcharge		○		○						△
	Vertical drain	Sand drain	○		○						
		Pre-fabricated drain	○		○						
	Vacuum Consolidation		○		○						
	Ground water level reduction		○		○						△
Compaction	Vibratory compaction	**Sand pile**	○	○	○	○			○		
		Rod compaction		○							
		Vibro-floatation		○							
		Vibro-tamper		○							
	Static compacted sand pile		○	○	○	○			○		
Solidification	Shallow soil stabilization			○		○		○		○	○
	Deep mix	Mechanical mix		○		○		○	○		
		Jet grouting		○		○		○	○		
	Lime pile			○		○					
	Chemical grouting			○		○					
	Freezing					○					
Excavation & replacement				○		○		○			△
Load reduction	Embankment by Light Weight materials/soil	Styrofoam block		○			○		○		
		Bubble-mix soil		○			○		○		
		Formed bead-mixed soil		○			○		○		
	Culvert			○			○		○		△
Embankment Reinforcement						○				○	
Structural Counter-measure	Counterweight filling					○					○
	Sheet pile					○		○			
Laying of reinforced materials (Ex. Geo-textile)						○				○	△

5. Behavior Observation methods

Following 5 kinds of observation work were executed by site engineers of MOC. The frequency of observation was planned originally as follows, but the actual frequencies were somewhat different from this plan.

Table 10 Frequency and Duration of Observation

Period (month)	During construction	After Construction			
		First	Second	3-6	6-(24)
Frequency (Every)	Once a day	Once a week	Once every 2 week	Once a month	Once a month

The all of data were send to RRL (as quality control center) and JICA Experts team. The data was processed to graphs or figures by the team to get the clear understanding of the observation results.

5.1 Settlement Board

This equipment is ordered by RRL to local manufacturer. (Cost is around Ks??)

(Photo and Figure with scale)

6 settlement-boards were set on the location of road shoulders with the interval of 50 meters. On the processing of embankment work, the center steel rods and cover PVC pipes were extended. Problems were the occurrence of bending of the center rods by the horizontal pressure due to the embankment heavy equipment.

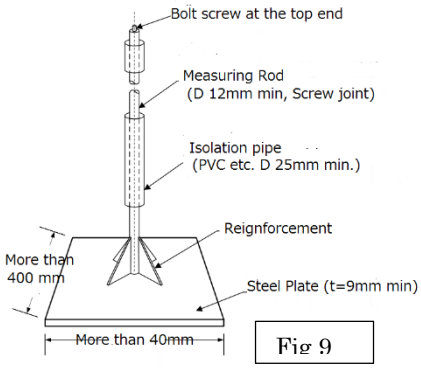


Fig 9

Photo 9

Measurement of level height of the rod top was done by survey equipment.

5.2 Three-Dimensional survey pegs

Considering the rotting during the survey period, 12 Plastic pegs were installed at the both side of embankment. Half of them were in toe positions of embankment and half were 10 m from the toe line.

The movement of pegs were surveyed by total station equipment after the training of total station equipment operation. However, the survey results are not satisfactory one. Unexpected and unreasonable movement were detected. The reasons were considered as follows:

a) Handling error of survey equipment and calculation mistakes

b) Lateral force by the earth pressure due to heavy equipment work

Fig 10 Arrangement of Survey Peg

5.3 Inclinometer

4-inclinometer guide pipes were installed at the toe position of embankment. Inclinometer will show the horizontal movement of the ground on the assumption that the bottom of the guide pipe is placed on the stable soil stratum and it should be a fixed point. The lateral movement will be calculated by measuring the inclination of each depth. Measurement was done at 0.5 meter interval during inserting and extracting the inclinometer. The data will be collected in data logger.

Photo 10

5.4 Pore-pressure gauge

3-mesuring equipment were installed on the position of road center. Before starting the embankment work, drilled holes up to hard stratum and installed pore pressure gauge in the bottom of borehole. Both side of gauge (up and down) was sealed by cement milk and sands to protect the influences of outside water pressure. The lead lines to get the data were placed under the embankment bottom and extended to the outside of toe of embankment. The data was read by Data Logger directory.

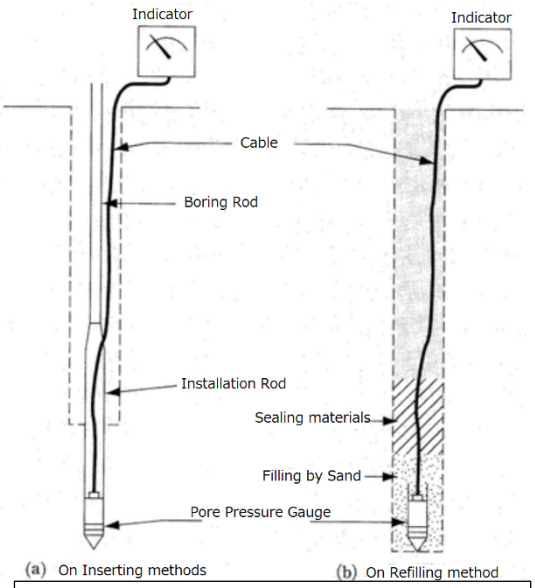


Fig 11 Arrangement of Pore Pressure gauge

5.5 Under ground water level

One well with D10cm was drilled up to 9 meters depth on the position of toe near the highest points of embankment. Underground water level was measured by electrical water detector.

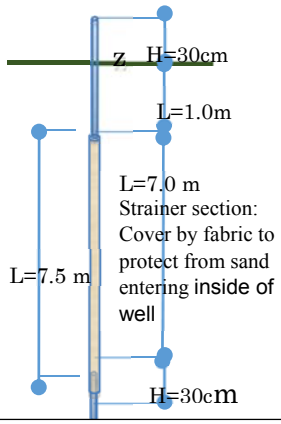


Fig 12 Arrangement of Water well

6. Behavior Observation results

Raw Observation results are shown in MS Excel sheets as shown in Attachment-2: Measurements Records.

6.1 Three-D survey peg movement

a) Horizontal movement

12 points movement is shown as below

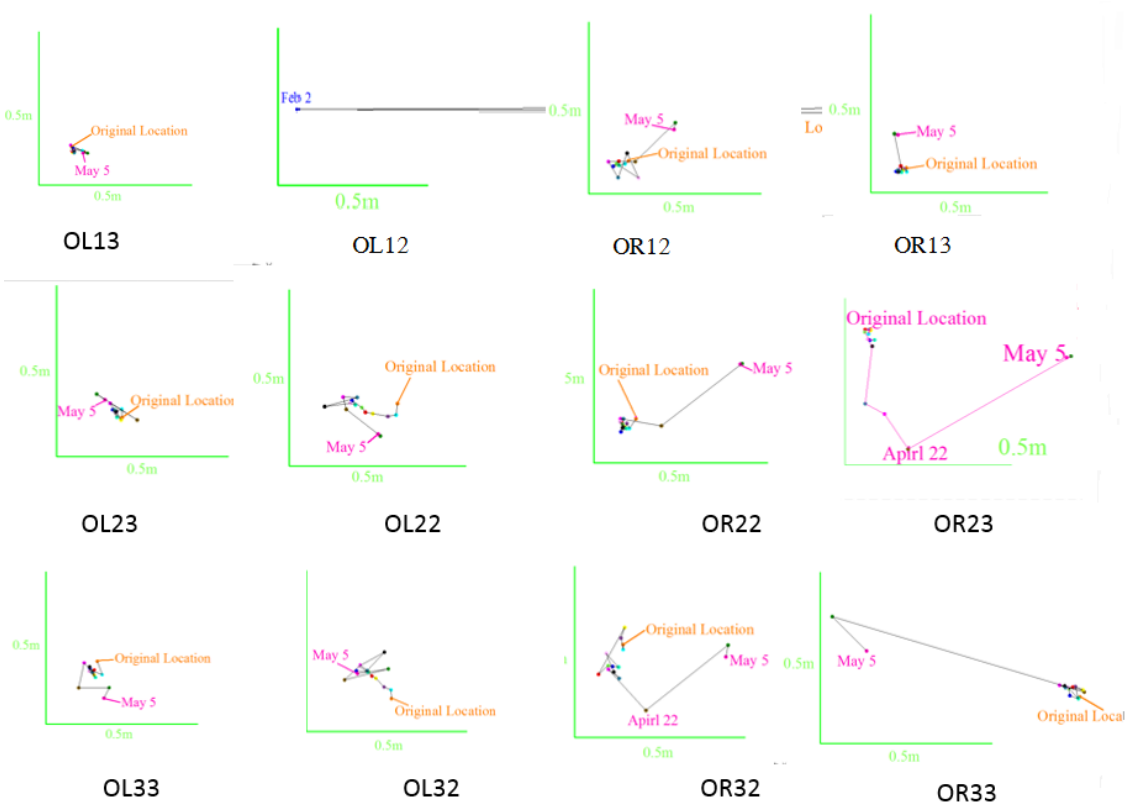


Fig 13 Holizontal Movement of survey Peg

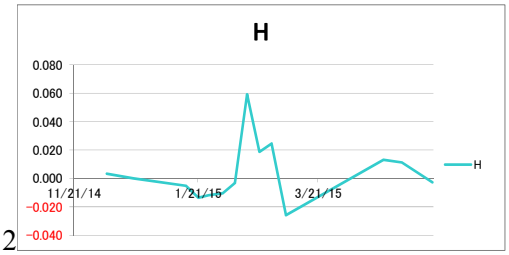
The maximum distance of the movement is around 0.6 m at Peg R23 during latest 2 weeks between April and May. It is after the completion of embankment. There is no dangerous phenomenon in spite of such big movement results. Some of the movement distance and the speed was not seem to a reasonable value since the embankment itself is in stable conditions.

b) Lateral movement & Vertical Movement vs Time elapse

Figure 14 (in two pagers) shows 12 points movement with time elapse, OR is right side and OL is left side.

However, these figures shows no theoretical movement.

OR12



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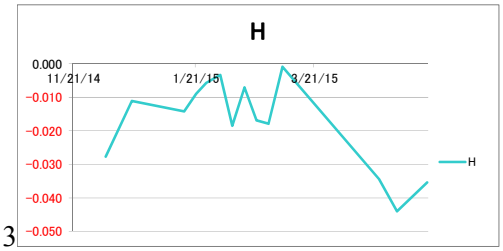

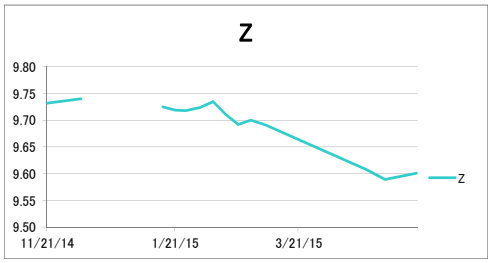

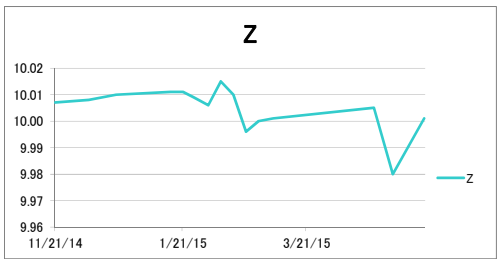

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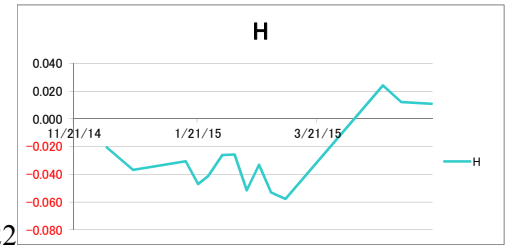

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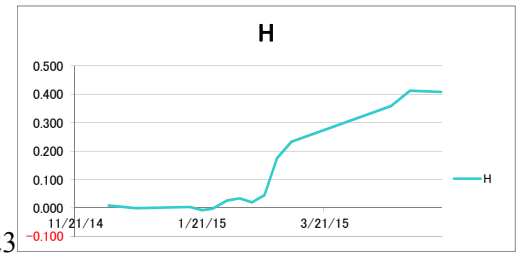

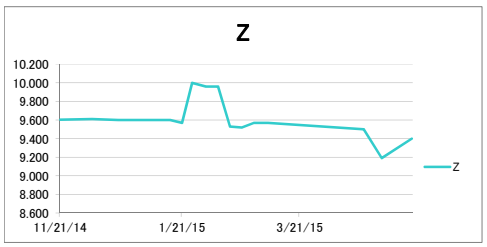

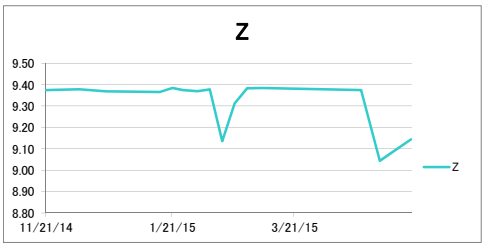

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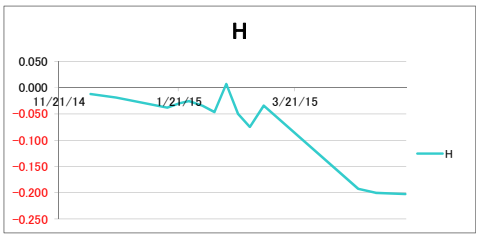

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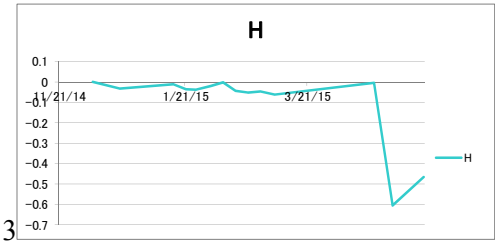
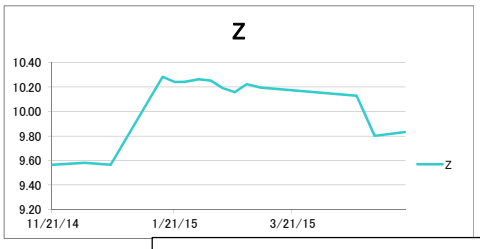




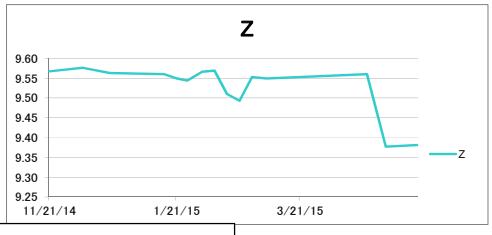
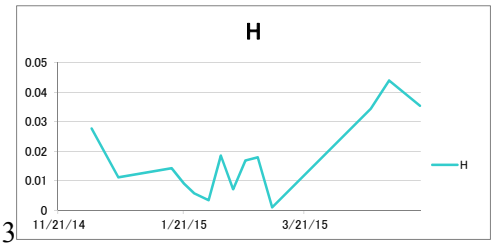
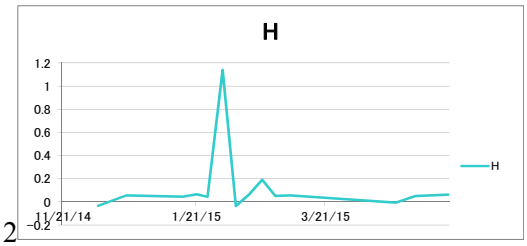


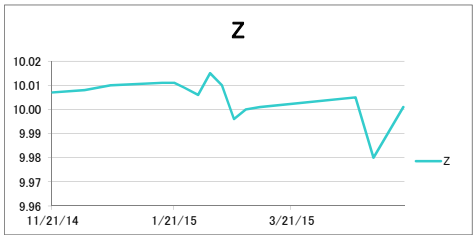
Fig 14-1 Lateral and Vertical Movement of survey Peg

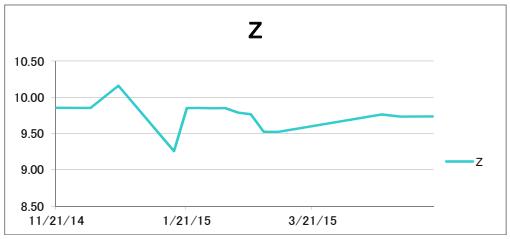
OL13



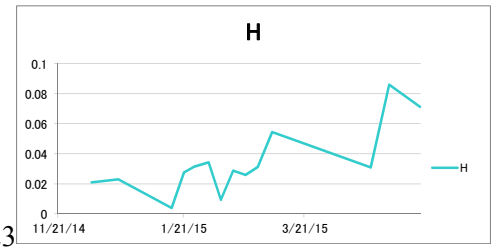
OL12



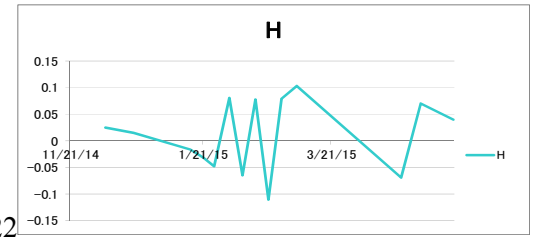


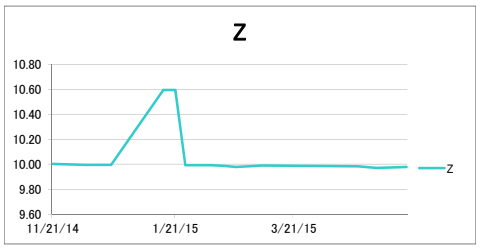


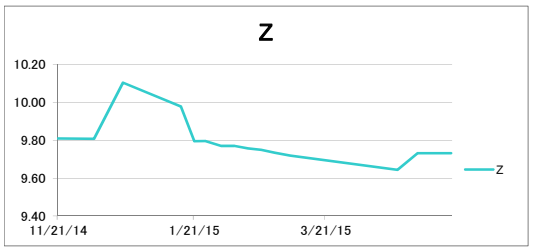
OL23



OL22







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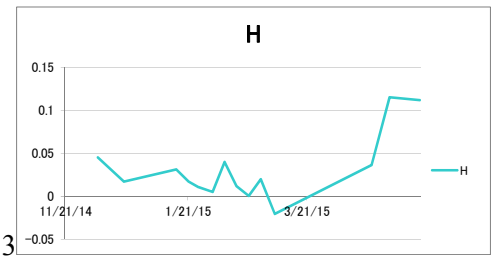
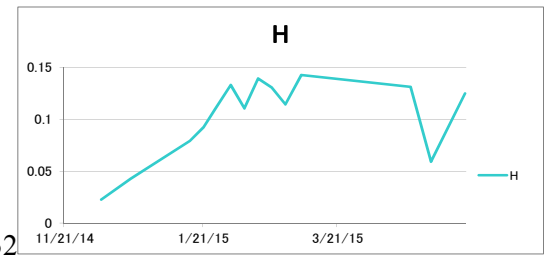
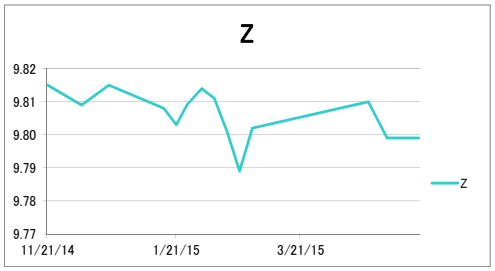


OL32





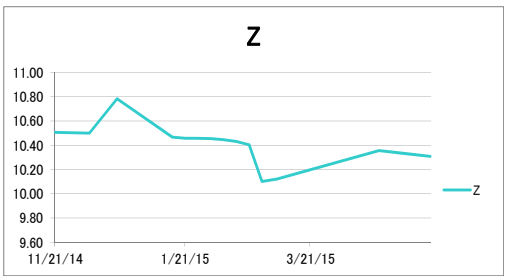
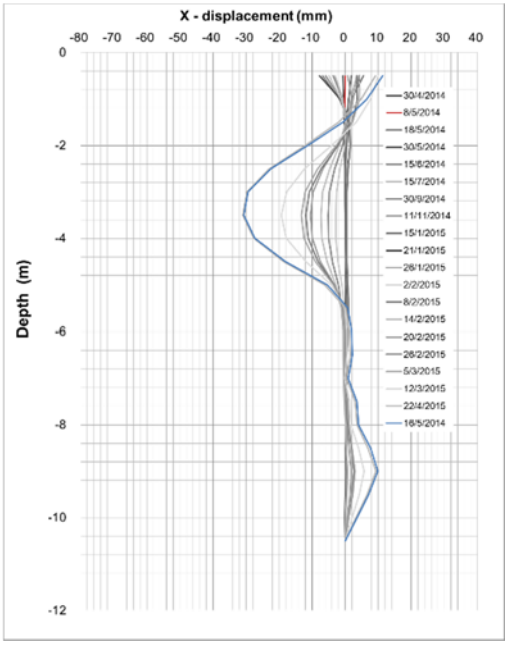
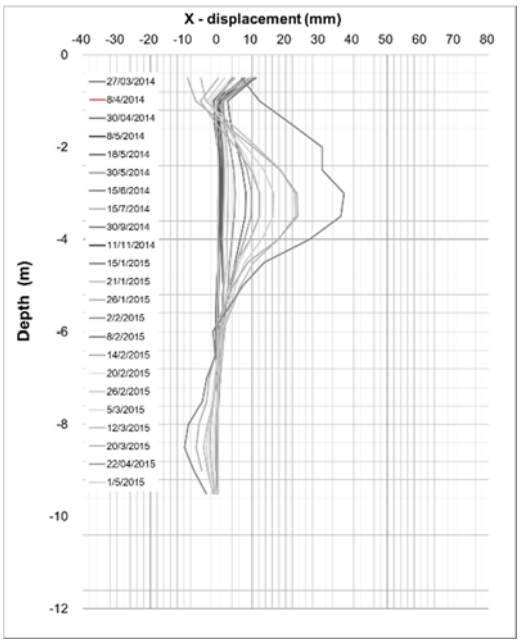


Fig 14-2 Lateral and Vertical Movement of survey Peg

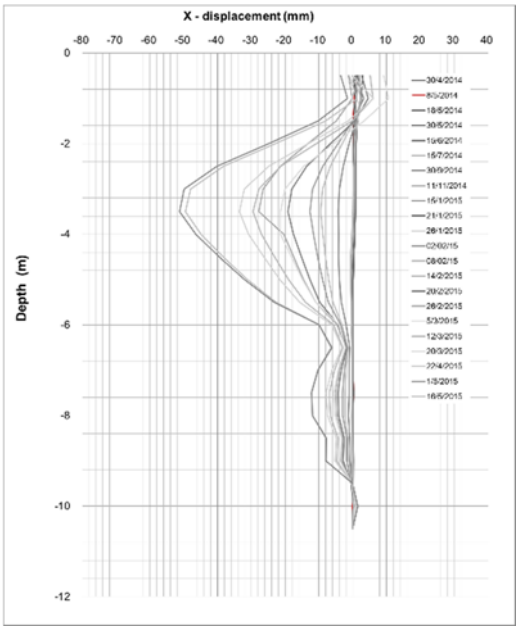
6.2 Inclinometer_analysis results



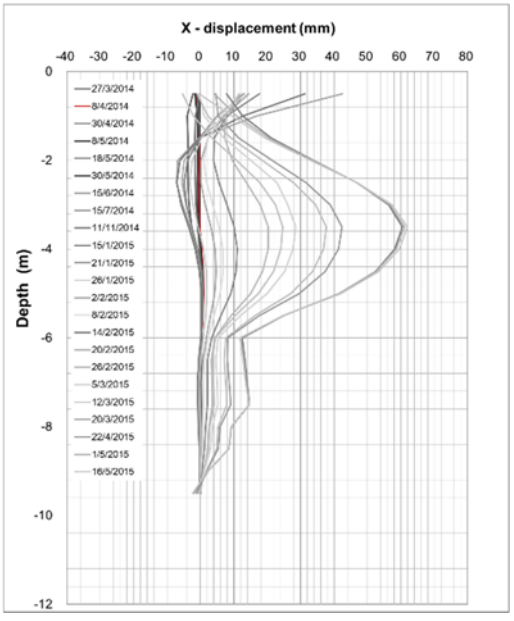
1L-1



1R-1



1L-2



1R-2

Fig 15 Lateral Movement of underground

The data shows the maximum movement (around 5 cm) occurred in the depth of 3-3.5 meters. However, the movement of the ground surface is just a few mm. It is different from the data by Three-D survey results.

6.3 Settlement-board data and the heights of embankment

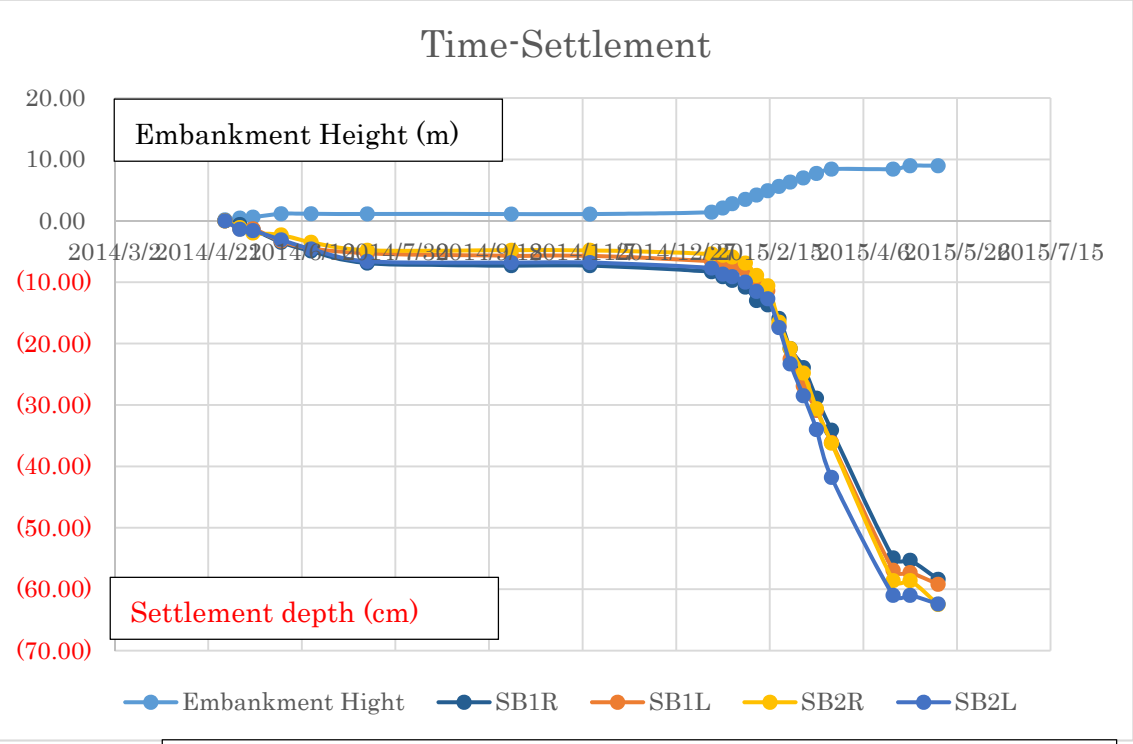


Fig 16 Relationship between Embankment Height (m) & Settlement depth (cm)

Settlement-board data and the heights of embankment with pore pressure (in water level expression) and underground water level data results are shown in below:

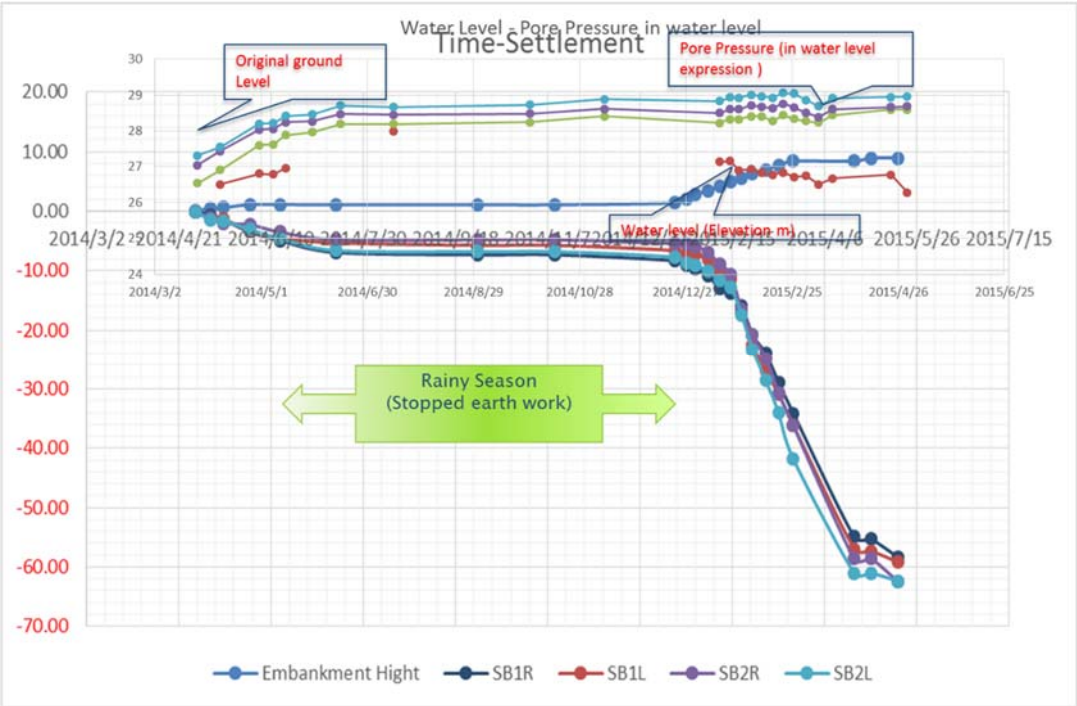


Fig 17 Relationship between Embankment Height (m) & underground water level (m)

7. Comparison of Preliminary analysis and Observation results

Following is the comparison figures about settlement between preliminary analysis and actual observation results.

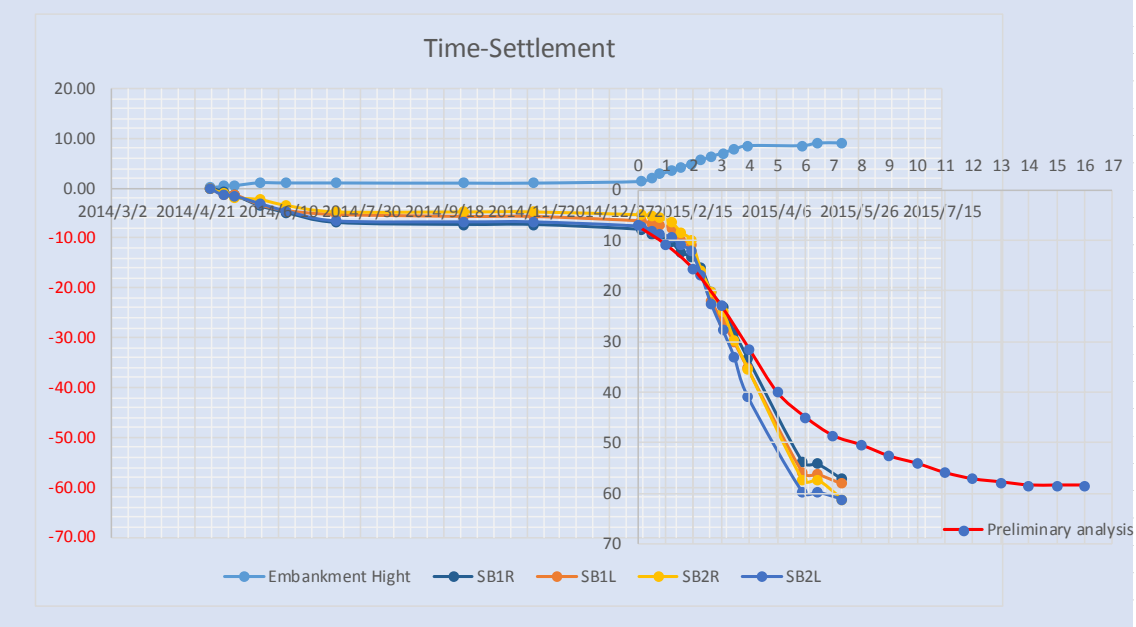


Fig 18 Comparison between preliminary analysis results and actual settlement

Settlement volume is around 60 mm (2015/5/16), which is roughly same as expected. Subsidence speed (around 2 months after finished embankment work) are earlier than expected. This might be for the ratio of silt in clay was more than we expected

8. Enquire results about the OJT Training

TCP team conducted enquete on the final OJT workshop for analysis of stability & settlement on December 10, 2014. The question format sample is shown below:

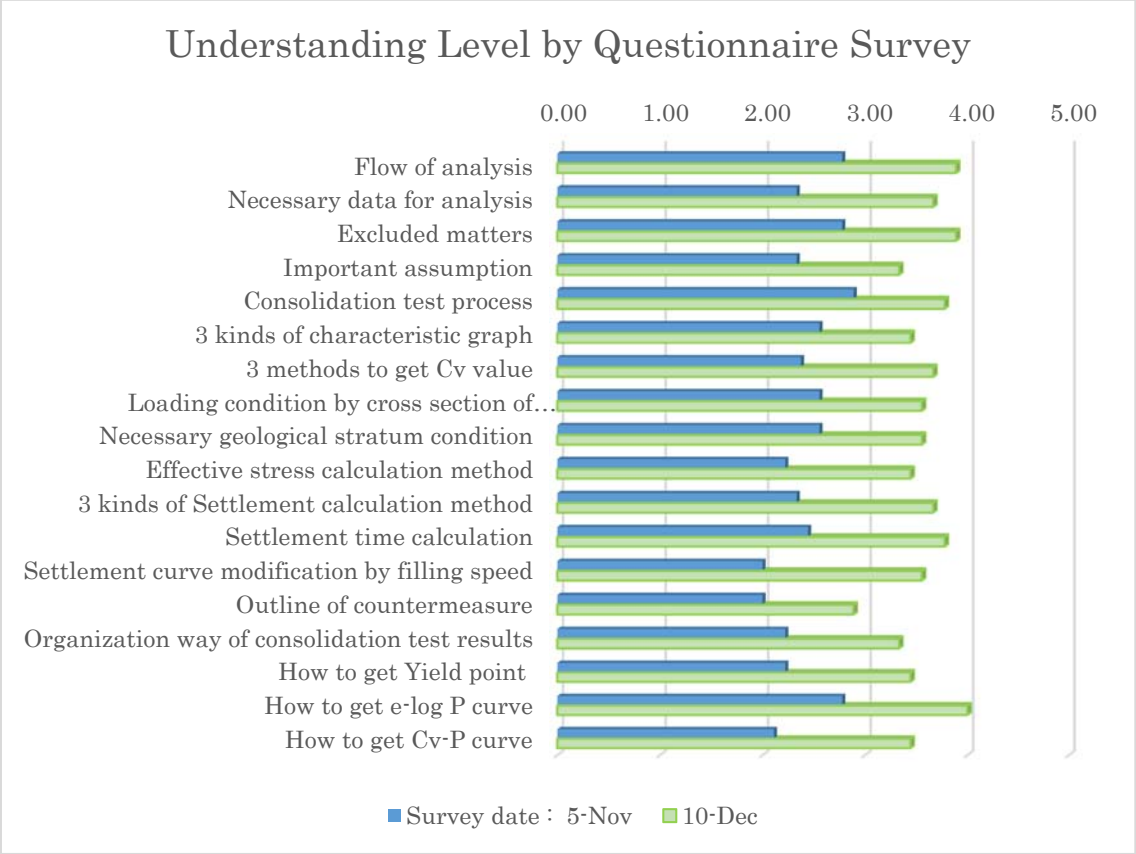
Score list about understanding level by trainee

	Page in manual	Item described in manual/ex:	Understanding Level 2014/12/03	Understanding Level 2014/12/09
Part 2 Consolidation settlement	P1	Flow of analysis	5, 4, (3), 2, 1	5, (4), 3, 2, 1
	P2	Necessary data for analysis	5, 4, (3), 2, 1	5, (4), 3, 2, 1
	P3	3 kinds of settlement	5, (4), 3, 2, 1	(5), 4, 3, 2, 1
		Important assumption	5, 4, (3), 2, 1	5, 4, (3), 2, 1
	P4-5	Consolication test process	5, 4, (3), 2, 1	5, 4, (3), 2, 1
	P6-7	3 kinds of characteristic graph	5, 4, (3), 2, 1	5, 4, (3), 2, 1
	P7-8	3 methods to get Cv value	5, 4, (3), 2, 1	5, 4, (3), 2, 1
	P10	Loading condition by cross section of embankment	5, (4), 3, 2, 1	5, (4), 3, 2, 1
	P10-11	Necessary geologica stratum condition	5, (4), 3, 2, 1	5, (4), 3, 2, 1
	P12	Effective stress calculation method	5, 4, (3), 2, 1	5, (4), 3, 2, 1
	P14	3 kinds of Settlement calculation method	5, 4, (3), 2, 1	5, 4, (3), 2, 1
	P18-19	Settlement time caculation	5, 4, (3), 2, 1	5, (4), 3, 2, 1
	P21-22	Settlement curve modification by Fillig speed	5, 4, (3), 2, 1	5, (4), 3, 2, 1
	P23	Outline of countermeasure	5, (4), 3, 2, 1	5, (4), 3, 2, 1
	A27-36	Organization way of consildation test results	5, 4, 3, (2), 1	5, 4, 3, (2), 1
	A37	How to get Yield point	5, 4, (3), 2, 1	5, 4, (3), 2, 1
	A37	How to get e-log P curve	5, 4, (3), 2, 1	5, (4), 3, 2, 1
	A38	How to get Cv-P curve	5, 4, 3, (2), 1	5, 4, 3, (2), 1

Plese put round mark on applicable number 5 is Well, Most ---------- and ---------- 1 is none.

Your name Daw Hnin Yu Aung

The result of the enquete is summarized as follows:



All of items score on Dec 10 is increasing comparing those on Nov 5. Understanding level for countermeasure work looks low comparing with other items. Because they are just explained without any practical OJT training.

9. Suggestion for future construction of High-embankment on soft ground

Followings are suggestions from the review of this trial measurement TCP.

Compaction of slope surface: (As of 15th June, 2015)	After entering rainy season, slope surface were eroded by rain. Since this slope will be left around 2 years more until the opening of the bridge, following counter measures are recommended; ● Slope tamping or cutting slope later from marginal width ● Use an Impermeable sheet as a cover instead of net (it is now used) ● Make drainage gutters along the longitudinal slope with lining by Vinyl sheets, at a both sides within one meter inside of shoulder to prevent the rainy water run down the cross sectional slope. We found few dragon holes on east (left) side berm. It is necessary to keep eye on them and take a proper counter measures like mentioned above.

Settlement Board:	Settlement boards were installed at the location of shoulder of the cross sectional slope. However, some of them are on the slope and another are inside of the road. Two reasons will be considered: 1) original survey of settlement board was not correct or 2) moved artificially by earth or machine during construction. These factors should be avoided in future measurements.
Revision of Contract of Embankment work:	Responsibility of measurement will inflict to Construction Company. It is desirable to add appropriate specification for measurement in the construction contract, which includes settlements of measurement instruments, protection of them, measurement and report of measurements results. In addition, put a provision of penalties in case of instrument's damage, and also mention that the measurement results, for example difference in volume, will be reflected to revision of payment.
Execution of Counter-measure work:	It is common that high embankment on soft soil ground need some kinds of countermeasure. If executing of countermeasures are difficult from the restriction of budget or construction period, we recommend at least monitoring settlement (by settlement boards) and surface movement (by survey pegs around slope) to detect any sign of slope failure for safety.
Quality Control:	Sufficient compaction of soil is the basic conditions of embankment constriction. It is required the establishment and execution of appropriate quality control provision in the specification.
Transfer of the work to the successors	The person in charge for the measurement works were obliged to change three times between March 2014 and June 2015, and this becomes one of the reasons why the data shows unreasonable results. It is necessary to prepare good manual in advance and have an opportunity of work transfer of the work contents on the changing of personnel

Appendix－1Installation of Equipment & Monitoring Training Photo

Assembling of Guide Pipe for Inclinometer

Guidance for treatment of Inclinometer

Practical Training of Inclinometer

Data processing of inclinometer measurement

3-D Measurement, Training of Total-Station

Practical Training of 3-D Measurement

Appendix－1Installation of Equipment & Monitoring Training Photo

Preparation of Filling materials for bored hole for pore-pressure gauge

Measuring of Pore Pressure by Data logger

Casing for underground water level

Measuring of Underground water level by electric detector

Settlement Board & Training of measurement

Initial measurement of settlement board after setting at site

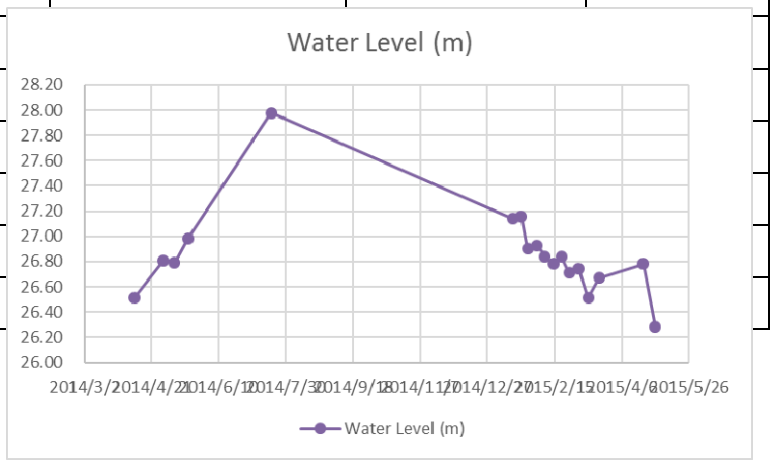
Appendix– 2

Row data of Measurements results

Contents

Ground water level

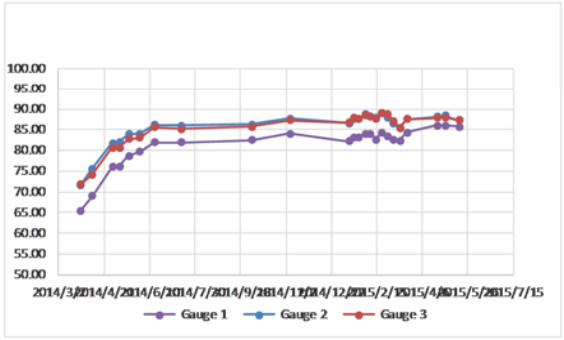
Water level				
Date	Time	Elevation of Well head (m)	Measurement (m)	Water Level (m)
2014/4/8	14:40	27.78	1.27	26.51
2014/4/30	11:30	27.78	0.97	26.81
2014/5/8	8:00	27.78	0.99	26.79
2014/5/18	10:30	27.78	0.80	26.98
2014/7/19	13:00	27.78	-0.20	27.98
2015/1/15	15:00	27.78	0.64	27.14
2015/1/21	12:00	27.78	0.62	27.16
2015/1/26	9:00	27.78	0.88	26.90
2015/2/2	14:00	27.78	0.85	26.93
2015/2/8	15:00	27.78	0.94	26.84
2015/2/14	15:00	27.78	1.00	26.78
2015/2/20	16:00	27.78	0.94	26.84
2015/2/26	16:00	27.78	1.07	26.71
2015/3/5	16:00	27.78	1.04	26.74
2015/3/12	16:00	27.78	1.27	26.51
2015/3/20	16:00	27.78	1.11	26.67
2015/4/22	17:00	27.78	1.00	26.78
2015/5/1	11:00	27.78	1.50	26.28
2015/5/16	14:00	27.78	1.6	26.18



(Refer: Excel file: Observation data_1.xslx>sheet “Water level” in folder L-3 2 Observation data)

Pore Pressure

Gauge 1		(Conversion factor: 0.106)		Gauge 2	(Conversion factor: 0.116)		Gauge 3	(Conversion factor: 0.114)	
Date	Time	Reading	Pressure (kP)	Time	Reading	Pressure (kP)	Time	Reading	Pressure (kP)
2014/3/26	10:10	617	65.40	15:55	618	71.69	9:00	630	71.82
2014/4/8	14:40	651	69.01	14:40	652	75.63	14:40	651	74.21
2014/4/30	11:30	717	76.00	11:30	705	81.78	11:30	707	80.60
2014/5/8	8:00	719	76.21	8:00	707	82.01	8:00	708	80.71
2014/5/18	10:30	743	78.76	10:30	723	83.87	10:30	726	82.76
2014/5/30	13:00	751	79.61	13:00	725	84.10	13:00	729	83.11
2014/6/15	15:00	773	81.94	15:00	743	86.19	15:00	751	85.61
2014/7/15	10:00	773	81.94	10:00	741	85.96	10:00	747	85.16
2014/9/30	13:00	778	82.47	13:00	744	86.30	13:00	752	85.73
2014/11/11	15:00	793	84.06	15:00	756	87.70	15:00	766	87.32
2015/1/15	15:00	776	82.26	15:00	746	86.54	15:00	761	86.75
2015/1/21	12:00	785	83.21	12:00	755	87.58	12:00	770	87.78
2015/1/26	15:00	785	83.21	15:00	755	87.58	15:00	769	87.67
2015/2/2	14:00	793	84.06	14:00	765	88.74	14:00	776	88.46
2015/2/8	15:00	793	84.06	15:00	760	88.16	15:00	773	88.12
2015/2/14	15:00	780	82.68	15:00	757	87.81	15:00	769	87.67
2015/2/20	16:00	796	84.38	16:00	768	89.09	16:00	781	89.03
2015/2/26	16:00	786	83.32	16:00	759	88.04	16:00	779	88.81
2015/3/5	16:00	780	82.68	16:00	746	86.54	16:00	764	87.10
2015/3/12	16:00	777	82.36	16:00	736	85.38	16:00	749	85.39
2015/3/20	16:00	796	84.38	16:00	755	87.58	16:00	768	87.55
2015/4/22	17:00	811	85.97	17:00	760	88.16	17:00	771	87.89
2015/5/1	11:00	811	85.97	11:00	762	88.39	11:00	772	88.01
2015/5/16	14:00	809	85.75	14:00	753	87.35	14:00	765	87.21



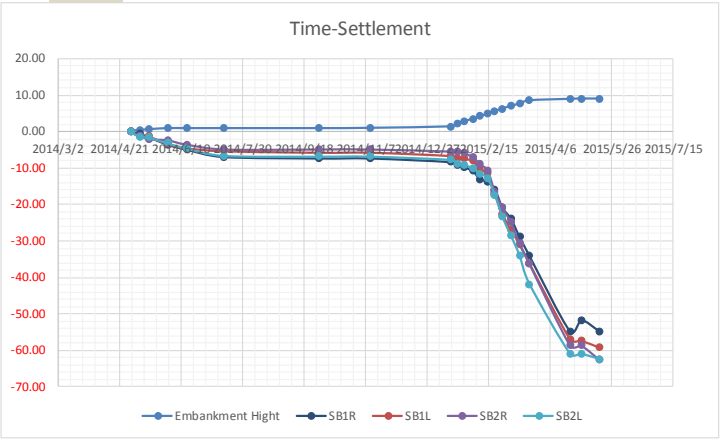
From above data, Graph is made easily by using function of EXcel

(Refer: Excel file: Observation data_1.xslx>sheet “Pore Pressure” in folder L-3 2 Observation data)

Settlement

Settlement

Date	SB1R Ground Elevation (m)	SB1R Embankment Hight (m)	SB1R Befor rod joint level (m)	SB1R Top of Rod Elevation	SB1R Rod Length (m)	SB1R Ground Elevation (m)	SB1R Accumulated settlement (cm)	SB1L Befor rod joint level (m)	SB1L Top of Rod Elevation	SB1L Rod Length (m)	SB1L Ground Elevation (m)	SB1L Accumulated settlement (cm)	SB2R Befor rod joint level (m)	SB2R Top of Rod Elevation	SB2R Rod Length (m)	SB2R Ground Elevation (m)	SB2R Accumulated settlement (cm)	SB2L Befor rod joint level (m)	SB2L Top of Rod Elevation	SB2L Rod Length (m)	SB2L Ground Elevation (m)	SB2L Accumulated settlement (cm)
Initial	28.08	0.00	28.08			28.080	SB1R	SB1L			SB1L	SB1L	SB2R			SB2R	SB2R	SB2L			SB2L	SB2L
2014/4/30	28.23	0.15	0.158	29.900	1.825	28.075	0.0	0.158	30.375	1.825	28.550	0.0	0.158	30.118	1.825	28.293	0.0	0.158	30.16	1.825	28.336	0.0
2014/5/8	28.53	0.45		29.894	1.825	28.069	-0.6		30.362	1.825	28.537	-1.3		30.107	1.825	28.282	-1.1		30.15	1.825	28.322	-1.4
2014/5/15	28.68	0.60		29.886	1.825	28.061	-1.4		30.362	1.825	28.537	-1.3		30.098	1.825	28.273	-2.0		30.15	1.825	28.320	-1.6
2014/5/30	28.98	0.90		29.865	1.825	28.040	-3.5		30.342	1.825	28.517	-3.3		30.095	1.825	28.270	-2.3		30.13	1.825	28.305	-3.1
2014/6/15	28.98	0.90		29.851	1.825	28.026	-4.9		30.330	1.825	28.505	-4.5		30.083	1.825	28.258	-3.5		30.12	1.825	28.290	-4.6
2014/7/15	28.98	0.90		29.831	1.825	28.006	-6.9		30.322	1.825	28.497	-5.3		30.070	1.825	28.245	-4.8		30.10	1.825	28.270	-6.6
2014/9/30	28.98	0.90		29.827	1.825	28.002	-7.3		30.318	1.825	28.493	-5.7		30.070	1.825	28.245	-4.8		30.09	1.825	28.268	-6.8
2014/11/11	29.08	1.00		29.827	1.825	28.002	-7.3		30.318	1.825	28.493	-5.7		30.070	1.825	28.245	-4.8		30.09	1.825	28.268	-6.8
2015/1/15	29.48	1.40		29.817	1.825	27.992	-8.3		30.309	1.825	28.484	-6.6		30.064	1.825	28.239	-5.4		30.08	1.825	28.259	-7.7
2015/1/21	30.17	2.09		31.634	3.650	27.984	-9.1		32.128	3.650	28.478	-7.2		31.887	3.650	28.237	-5.6		31.90	3.650	28.249	-8.7
2015/1/26	30.87	2.79		31.628	3.650	27.978	-9.7		32.126	3.650	28.476	-7.4		31.884	3.650	28.234	-5.9		31.90	3.650	28.245	-9.1
2015/2/2	31.57	3.49		31.617	3.650	27.967	-10.8		32.120	3.650	28.470	-8.0		31.874	3.650	28.224	-6.9		31.89	3.650	28.236	-10.0
2015/2/8	32.27	4.19		31.595	3.650	27.945	-13.0		32.096	3.650	28.446	-10.4		31.854	3.650	28.204	-8.9		31.87	3.650	28.221	-11.5
2015/2/14	32.97	4.89		31.588	3.650	27.938	-13.7		32.086	3.650	28.436	-11.4		31.837	3.650	28.187	-10.6		31.86	3.650	28.209	-12.7
2015/2/20	33.67	5.59		33.391	5.475	27.916	-15.9		33.854	5.475	28.379	-17.1		33.603	5.475	28.128	-16.5		33.64	5.475	28.162	-17.4
2015/2/26	34.37	6.29		33.342	5.475	27.867	-20.8		33.800	5.475	28.325	-22.5		33.560	5.475	28.085	-20.8		33.58	5.475	28.103	-23.3
2015/3/5	35.07	6.99		33.311	5.475	27.836	-23.9		33.756	5.475	28.281	-26.9		33.520	5.475	28.045	-24.8		33.53	5.475	28.051	-28.5
2015/3/12	35.78	7.70		33.261	5.475	27.786	-28.9		33.716	5.475	28.241	-30.9		33.462	5.475	27.987	-30.6		33.47	5.475	27.996	-34.0
2015/3/20	36.60	8.52		35.034	7.300	27.734	-34.1		35.489	7.300	28.189	-36.1		35.231	7.300	27.931	-36.2		35.22	7.300	27.918	-41.8
2015/4/22	36.98	8.90		36.651	9.125	27.526	-54.9		37.106	9.125	27.981	-56.9		36.832	9.125	27.707	-58.6		36.85	9.125	27.726	-61.0
2015/5/1	37.08	9.00		37.561	10.004	27.557	-51.8		38.016	10.039	27.977	-57.3		36.832	9.125	27.707	-58.6		36.85	9.125	27.726	-61.0
2015/5/16	37.08	9.00		37.530	10.004	27.526	-54.9		37.997	10.039	27.958	-59.2		36.793	9.125	27.668	-62.5		36.84	9.125	27.712	-62.4



(Refer Excel file: Observation data_1.xslx>

Sheet “Settlement” in folder L-3 2 Observation data)

Inclinometer

initial — IR2 26/03/2014

Elevation	Depth (m)	X+	X-	X+ - X- / 2
-0.50	0.50	-23	106	-65
-1.00	1.00	-3	92	-48
-1.50	1.50	12	76	-32
-2.00	2.00	16	69	-27
-2.50	2.50	0	88	-44
-3.00	3.00	-21	110	-66
-3.50	3.50	-42	129	-86
-4.00	4.00	-53	137	-95
-4.50	4.50	-9	95	-52
-5.00	5.00	23	61	-19
-5.50	5.50	52	34	9
-6.00	6.00	48	40	4
-6.50	6.50	-6	93	-50
-7.00	7.00	-26	115	-71
-7.50	7.50	-47	133	-90
-8.00	8.00	-28	113	-71
-8.50	8.50	8	80	-36
-9.00	9.00	3	83	-40
-9.50	9.50	-5	96	-51

1 — IR2 27/3/2014

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-21	110	-66	-0.04	-0.20
1.00	-5	96	-51	-0.12	-0.16
1.50	12	76	-32	0.00	-0.04
2.00	21	68	-24	0.12	-0.04
2.50	2	87	-43	0.06	-0.16
3.00	-20	110	-65	0.02	-0.23
3.50	-46	133	-90	-0.16	-0.25
4.00	-58	145	-102	-0.27	-0.08
4.50	-12	99	-56	-0.14	0.18
5.00	22	62	-20	-0.04	0.33
5.50	53	34	10	0.02	0.37
6.00	51	36	8	0.14	0.35
6.50	-1	90	-46	0.16	0.20
7.00	-25	114	-70	0.04	0.04
7.50	-47	132	-90	0.02	0.00
8.00	-28	113	-71	0.00	-0.02
8.50	8	79	-36	0.02	-0.02
9.00	3	84	-41	-0.02	-0.04
9.50	-5	97	-51	-0.02	-0.02

2 — IR2 8/4/2014

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-40	132	-86	-0.88	-1.43
1.00	-7	100	-54	-0.25	-0.55
1.50	14	78	-32	0.00	-0.31
2.00	22	67	-23	0.16	-0.31
2.50	1	91	-45	-0.04	-0.47
3.00	-25	120	-73	-0.29	-0.43
3.50	-53	145	-99	-0.55	-0.14
4.00	-62	152	-107	-0.49	0.41
4.50	-7	100	-54	-0.06	0.90
5.00	32	58	-13	0.25	0.96
5.50	62	29	17	0.31	0.72
6.00	57	34	12	0.31	0.41
6.50	0	92	-46	0.14	0.10
7.00	-24	117	-71	0.00	-0.04
7.50	-45	135	-90	0.00	-0.04
8.00	-25	117	-71	-0.02	-0.04
8.50	10	82	-36	0.00	-0.02
9.00	5	86	-41	-0.02	-0.02
9.50	-3	98	-51	0.00	0.00

3 (ground level) — IR2 30/4/2014

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-27	133	-80	-0.63	-1.15
1.00	3	100	-49	-0.04	-0.51
1.50	20	77	-29	0.14	-0.47
2.00	29	67	-19	0.31	-0.61
2.50	2	95	-47	-0.10	-0.92
3.00	-26	125	-76	-0.41	-0.82
3.50	-52	148	-100	-0.59	-0.41
4.00	-59	155	-107	-0.49	0.18
4.50	-5	105	-55	-0.12	0.68
5.00	33	62	-15	0.18	0.80
5.50	63	33	15	0.25	0.61
6.00	61	39	11	0.29	0.37
6.50	2	98	-48	0.06	0.08
7.00	-20	116	-68	0.10	0.02
7.50	-42	139	-91	-0.02	-0.08
8.00	-24	119	-72	-0.04	-0.06
8.50	13	85	-36	0.00	-0.02
9.00	9	89	-40	0.00	-0.02
9.50	-1	101	-51	-0.02	-0.02

4 (layer 1) — IR2 8/5/2014

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-33	132	-83	-0.74	-1.74
1.00	-4	104	-54	-0.27	-1.00
1.50	18	79	-31	0.06	-0.74
2.00	26	67	-21	0.25	-0.80
2.50	2	95	-47	-0.10	-1.04
3.00	-24	126	-75	-0.39	-0.94
3.50	-49	149	-99	-0.55	-0.55
4.00	-58	155	-107	-0.47	0.00
4.50	-7	105	-56	-0.16	0.47
5.00	33	65	-16	0.12	0.63
5.50	63	35	14	0.20	0.51
6.00	61	36	13	0.35	0.31
6.50	3	95	-46	0.14	-0.04
7.00	-21	121	-71	-0.02	-0.18
7.50	-40	139	-90	0.02	-0.16
8.00	-23	121	-72	-0.06	-0.18
8.50	13	87	-37	-0.04	-0.12
9.00	8	90	-41	-0.04	-0.08
9.50	0	103	-52	-0.04	-0.04

5 (layer 2) — IR2 18/5/2014

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	11	83	-36	1.17	-0.31
1.00	5	91	-43	0.18	-1.47
1.50	16	81	-33	-0.02	-1.66
2.00	20	74	-27	-0.02	-1.64
2.50	-3	98	-51	-0.27	-1.62
3.00	-28	124	-76	-0.43	-1.35
3.50	-52	147	-100	-0.57	-0.92
4.00	-60	155	-108	-0.51	-0.35
4.50	-7	105	-56	-0.16	0.16
5.00	32	67	-18	0.06	0.33
5.50	61	36	13	0.14	0.27
6.00	60	35	13	0.35	0.12
6.50	2	96	-47	0.10	-0.23
7.00	-22	121	-72	-0.04	-0.33
7.50	-43	140	-92	-0.06	-0.29
8.00	-24	121	-73	-0.08	-0.23
8.50	13	85	-36	0.00	-0.14
9.00	7	89	-41	-0.04	-0.14
9.50	-1	105	-53	-0.10	-0.10

6 (first month) — IR2 30/5/2014

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	35	80	-23	1.72	-2.31
1.00	0	109	-55	-0.29	-4.03
1.50	24	89	-33	-0.02	-3.74
2.00	29	83	-27	-0.02	-3.72
2.50	5	109	-52	-0.33	-3.70
3.00	-29	141	-85	-0.80	-3.38
3.50	-63	170	-117	-1.27	-2.58
4.00	-70	177	-124	-1.17	-1.31
4.50	-10	119	-65	-0.51	-0.14
5.00	33	75	-21	-0.08	0.37
5.50	67	40	14	0.18	0.45
6.00	69	40	15	0.43	0.27
6.50	12	98	-43	0.27	-0.16
7.00	-15	125	-70	0.02	-0.43
7.50	-37	147	-92	-0.08	-0.45
8.00	-19	127	-73	-0.10	-0.37
8.50	16	92	-38	-0.08	-0.27
9.00	12	96	-42	-0.08	-0.18
9.50	3	109	-53	-0.10	-0.10

7 — IR2 15/6/2014

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	162	75	44	4.42	12.83
1.00	229	-116	173	9.00	8.41
1.50	132	-12	72	4.26	-0.59
2.00	47	64	-9	0.74	-4.85
2.50	-20	128	-74	-1.23	-5.59
3.00	-55	163	-109	-1.78	-4.36
3.50	-65	175	-120	-1.41	-2.58
4.00	-66	176	-121	-1.06	-1.17
4.50	-9	120	-65	-0.51	-0.10
5.00	34	73	-20	-0.02	0.41
5.50	73	36	19	0.39	0.43
6.00	73	36	19	0.59	0.04
6.50	11	98	-44	0.25	-0.55
7.00	-19	131	-75	-0.18	-0.80
7.50	-42	151	-97	-0.27	-0.61
8.00	-18	128	-73	-0.10	-0.35
8.50	16	91	-38	-0.06	-0.25
9.00	11	96	-43	-0.10	-0.18
9.50	3	108	-53	-0.08	-0.08

8 — IR2 15/7/2014

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	642	-484	563	25.67	42.51
1.00	444	-310	377	17.37	16.84
1.50	181	-65	123	6.34	-0.53
2.00	37	77	-20	0.27	-6.88
2.50	-30	145	-88	-1.78	-7.14
3.00	-60	181	-121	-2.25	-5.36
3.50	-71	189	-130	-1.82	-3.11
4.00	-66	181	-124	-1.17	-1.29
4.50	-8	125	-67	-0.59	-0.12
5.00	35	78	-22	-0.10	0.47
5.50	74	39	18	0.35	0.57
6.00	77	37	20	0.65	0.23
6.50	15	100	-43	0.29	-0.43
7.00	-16	134	-75	-0.18	-0.72
7.50	-36	152	-94	-0.16	-0.53
8.00	-17	134	-76	-0.20	-0.37
8.50	22	95	-37	-0.02	-0.16
9.00	16	99	-42	-0.06	-0.14
9.50	7	112	-53	-0.08	-0.08

Please put next data in here! (27/4/2015)

initial — 26/03/2014

Elevation	Depth (m)	X+	X-	X+ - X- / 2
-0.50	0.50	-23	106	-65
-1.00	1.00	-3	92	-48
-1.50	1.50	12	76	-32
-2.00	2.00	16	69	-27
-2.50	2.50	0	88	-44
-3.00	3.00	-21	110	-66
-3.50	3.50	-42	129	-86
-4.00	4.00	-53	137	-95
-4.50	4.50	-9	95	-52
-5.00	5.00	23	61	-19
-5.50	5.50	52	34	9
-6.00	6.00	48	40	4
-6.50	6.50	-6	93	-50
-7.00	7.00	-26	115	-71
-7.50	7.50	-47	133	-90
-8.00	8.00	-28	113	-71
-8.50	8.50	8	80	-36
-9.00	9.00	3	83	-40
-9.50	9.50	-5	96	-51

9 — IR2 11/11/2014

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	439	-338	389	18.54	31.24
1.00	324	-217	271	13.01	12.71
1.50	162	-60	111	5.85	-0.31
2.00	50	56	-3	0.96	-6.16
2.50	-23	130	-77	-1.33	-7.12
3.00	-66	175	-121	-2.25	-5.79
3.50	-80	185	-133	-1.92	-3.54
4.00	-74	179	-127	-1.29	-1.62
4.50	-14	120	-67	-0.61	-0.33
5.00	30	74	-22	-0.12	0.29
5.50	69	36	17	0.31	0.41
6.00	73	31	21	0.70	0.10
6.50	12	95	-42	0.33	-0.59
7.00	-19	127	-73	-0.10	-0.92
7.50	-42	148	-95	-0.20	-0.82
8.00	-26	129	-78	-0.29	-0.61
8.50	15	90	-38	-0.06	-0.33
9.00	9	96	-44	-0.14	-0.27
9.50	0	107	-54	-0.12	-0.12

10 — IR2 15/1/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	171	-84	128	7.86	12.95
1.00	137	-35	86	5.46	5.10
1.50	103	-4	54	3.50	-0.37
2.00	46	49	-2	1.02	-3.87
2.50	-12	108	-60	-0.65	-4.89
3.00	-55	157	-106	-1.66	-4.24
3.50	-79	175	-127	-1.70	-2.58
4.00	-77	171	-124	-1.19	-0.88
4.50	-13	112	-63	-0.43	0.31
5.00	31	64	-17	0.10	0.74
5.50	68	29	20	0.43	0.63
6.00	70	30	20	0.65	0.20
6.50	7	92	-43	0.29	-0.45
7.00	-23	123	-73	-0.10	-0.74
7.50	-47	142	-95	-0.18	-0.63
8.00	-29	124	-77	-0.25	-0.45
8.50	12	85	-37	-0.02	-0.20
9.00	7	90	-42	-0.06	-0.18
9.50	-3	104	-54	-0.12	-0.12

11 — IR2 21/1/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	171	-84	128	7.86	12.95
1.00	137	-35	86	5.46	5.10
1.50	103	-4	54	3.50	-0.37
2.00	46	49	-2	1.02	-3.87
2.50	-12	108	-60	-0.65	-4.89
3.00	-55	157	-106	-1.66	-4.24
3.50	-79	175	-127	-1.70	-2.58
4.00	-77	171	-124	-1.19	-0.88
4.50	-13	112	-63	-0.43	0.31
5.00	31	64	-17	0.10	0.74
5.50	68	29	20	0.43	0.63
6.00	70	30	20	0.65	0.20
6.50	7	92	-43	0.29	-0.45
7.00	-23	123	-73	-0.10	-0.74
7.50	-47	142	-95	-0.18	-0.63
8.00	-29	124	-77	-0.25	-0.45
8.50	12	85	-37	-0.02	-0.20
9.00	7	90	-42	-0.06	-0.18
9.50	-3	104	-54	-0.12	-0.12

12 — 26/1/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	173	-90	132	8.02	13.26
1.00	124	-23	74	4.95	5.24
1.50	81	9	36	2.78	0.29
2.00	40	58	-9	0.72	-2.50
2.50	-15	118	-67	-0.92	-3.21
3.00	-56	157	-107	-1.68	-2.29
3.50	-71	174	-123	-1.51	-0.61
4.00	-65	164	-115	-0.80	0.90
4.50	-3	107	-55	-0.12	1.70
5.00	40	60	-10	0.37	1.82
5.50	74	25	25	0.63	1.45
6.00	74	27	24	0.80	0.82
6.50	8	92	-42	0.31	0.02
7.00	-21	123	-72	-0.06	-0.29
7.50	-41	143	-92	-0.08	-0.23
8.00	-25	123	-74	-0.14	-0.14
8.50	15	84	-35	0.06	0.00
9.00	10	90	-40	0.00	-0.06
9.50	0	104	-52	-0.06	-0.06

13 — IR2 2/2/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	144	-90	117	7.43	14.41
1.00	117	-18	68	4.71	6.98
1.50	72	30	21	2.17	2.27
2.00	21	75	-27	-0.02	0.10
2.50	-26	123	-75	-1.25	0.12
3.00	-58	158	-108	-1.74	1.37
3.50	-66	165	-116	-1.23	3.11
4.00	-55	153	-104	-0.37	4.34
4.50	8	89	-41	0.47	4.71
5.00	60	40	10	1.19	4.24
5.50	91	7	42	1.35	3.05
6.00	78	19	30	1.04	1.70
6.50	7	92	-43	0.29	0.65
7.00	-23	121	-72	-0.06	0.37
7.50	-39	137	-88	0.08	0.43
8.00	-22	119	-71	0.00	0.35
8.50	20	79	-30	0.27	0.35
9.00	14	85	-36	0.18	0.08
9.50	-2	104	-53	-0.10	-0.10

14 — IR2 8/2/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	108	-17	63	5.20	11.48
1.00	84	-14	49	3.95	6.28
1.50	52	47	3	1.41	2.33
2.00	1	97	-48	-0.88	0.92
2.50	-39	139	-89	-1.84	1.80
3.00	-59	165	-112	-1.90	3.64
3.50	-60	163	-112	-1.06	5.55
4.00	-48	149	-99	-0.14	6.61
4.50	20	80	-30	0.90	6.75
5.00	75	25	25	1.80	5.85
5.50	106	5	51	1.70	4.05
6.00	82	17	33	1.17	2.35
6.50	5	95	-45	0.18	1.19
7.00	-19	121	-70	0.02	1.00
7.50	-33	134	-84	0.27	0.98
8.00	-17	116	-67	0.16	0.72
8.50	23	76	-27	0.39	0.55
9.00	16	83	-34	0.27	0.16
9.50	-2	104	-53	-0.10	-0.10

15 — IR2 14/2/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	234	-119	177	9.86	17.64
1.00	84	1	42	3.64	7.78
1.50	20	71	-26	0.27	4.13
2.00	-23	113	-68	-1.70	3.87
2.50	-58	147	-103	-2.39	5.57
3.00	-71	163	-117	-2.11	7.96
3.50	-63	153	-108	-0.92	10.07
4.00	-43	133	-88	0.29	10.99
4.50	32	55	-12	1.66	10.70
5.00	97	-8	53	2.93	9.05
5.50	121	-34	78	2.80	6.12
6.00	76	10	33	1.19	3.32
6.50	-3	92	-48	0.08	2.13
7.00	-25	116	-71	0.00	2.05
7.50	-31	121	-76	0.57	2.05
8.00	-18	107	-63	0.33	1.47
8.50	23	65	-21	0.61	1.15
9.00	18	68	-25	0.61	0.53
9.50	-7	98	-53	-0.08	-0.08

16 — IR2 20/2/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	42	-36	39	4.24	11.85
1.00	12	87	-38	0.41	7.61
1.50	-39	136	-88	-2.27	7.20
2.00	-82	179	-131	-4.26	9.47
2.50	-96	194	-145	-4.13	13.73
3.00	-74	175	-125	-2.41	17.86
3.50	-35	134	-85	0.04	20.28
4.00	-5	105	-55	1.64	20.24
4.50	86	13	37	3.62	18.60
5.00	173	-71	122	5.77	14.98
5.50	180	-81	131	4.97	9.21
6.00	76	18	29	1.02	4.24
6.50	-5	105	-55	-0.23	3.21
7.00	-24	124	-74	-0.14	3.44
7.50	-14	114	-64	1.06	3.58
8.00	-12	108	-60	0.43	2.52
8.50	38	60	-11	1.02	2.09
9.00	38	60	-11	1.19	1.06
9.50	-5	102	-54	-0.12	-0.12

initial — 26/03/2014

Elevation	Depth (m)	X+	X-	X+ - X- / 2
-0.50	0.50	-23	106	-65
-1.00	1.00	-3	92	-48
-1.50	1.50	12	76	-32
-2.00	2.00	16	69	-27
-2.50	2.50	0	88	-44
-3.00	3.00	-21	110	-66
-3.50	3.50	-42	129	-86
-4.00	4.00	-53	137	-95
-4.50	4.50	-9	95	-52
-5.00	5.00	23	61	-19
-5.50	5.50	52	34	9
-6.00	6.00	48	40	4
-6.50	6.50	-6	93	-50
-7.00	7.00	-26	115	-71
-7.50	7.50	-47	133	-90
-8.00	8.00	-28	113	-71
-8.50	8.50	8	80	-36
-9.00	9.00	3	83	-40
-9.50	9.50	-5	96	-51

17 — IR2 26/2/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-91	195	-143	-3.21	-5.34
1.00	-126	240	-183	-5.55	-2.13
1.50	-157	270	-214	-7.43	3.42
2.00	-143	249	-196	-6.94	10.85
2.50	-104	212	-158	-4.67	17.78
3.00	-63	174	-119	-2.17	22.45
3.50	-18	127	-73	0.53	24.62
4.00	15	95	-40	2.25	24.09
4.50	113	-3	58	4.50	21.83
5.00	206	-97	152	6.98	17.33
5.50	208	-98	153	5.89	10.35
6.00	80	29	26	0.88	4.46
6.50	-3	113	-58	-0.35	3.58
7.00	-20	133	-77	-0.25	3.93
7.50	-1	112	-57	1.37	4.17
8.00	-6	114	-60	0.43	2.80
8.50	52	56	-2	1.39	2.37
9.00	51	56	-3	1.53	0.98
9.50	-7	121	-64	-0.55	-0.55

18 — IR2 5/3/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-48	151	-100	-1.43	-0.35
1.00	-138	245	-192	-5.89	1.08
1.50	-179	285	-232	-8.19	6.98
2.00	-163	267	-215	-7.71	15.16
2.50	-122	125	-124	-3.25	22.88
3.00	-69	178	-124	-2.37	26.13
3.50	-13	122	-68	0.74	28.51
4.00	22	84	-31	2.62	27.77
4.50	126	-24	75	5.20	25.15
5.00	229	-125	177	8.02	19.95
5.50	223	-121	172	6.67	11.93
6.00	72	31	21	0.68	5.26
6.50	-5	113	-59	-0.39	4.58
7.00	-24	129	-77	-0.25	4.97
7.50	4	101	-49	1.70	5.22
8.00	-5	109	-57	0.55	3.52
8.50	61	45	8	1.80	2.97
9.00	58	45	7	1.90	1.17
9.50	-15	122	-69	-0.74	-0.74

19 — IR2 12/3/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-87	197	-142	-3.17	-1.02
1.00	-163	274	-219	-7.00	2.15
1.50	-208	318	-263	-9.45	9.15
2.00	-197	307	-252	-9.23	18.60
2.50	-151	262	-207	-6.65	27.83
3.00	-84	201	-143	-3.15	34.48
3.50	-10	121	-66	0.82	37.63
4.00	37	70	-17	3.21	36.81
4.50	167	-52	110	6.61	33.60
5.00	299	-188	244	10.74	26.99
5.50	276	-168	222	8.72	16.25
6.00	68	42	13	0.37	7.53
6.50	-6	115	-61	-0.45	7.16
7.00	-23	135	-79	-0.35	7.61
7.50	30	82	-26	2.62	7.96
8.00	-4	111	-58	0.53	5.34
8.50	99	25	37	2.99	4.81
9.00	85	25	30	2.86	1.82
9.50	-18	134	-76	-1.04	-1.04

20 — IR2 20/3/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-47	115	-81	-0.68	4.62
1.00	-154	244	-199	-6.20	5.30
1.50	-226	330	-278	-10.07	11.50
2.00	-221	320	-271	-9.99	21.57
2.50	-172	273	-223	-7.31	31.55
3.00	-97	205	-151	-3.50	38.86
3.50	-10	111	-61	1.02	42.36
4.00	46	41	3	3.99	41.34
4.50	192	-85	139	7.80	37.34
5.00	325	-223	274	11.99	29.55
5.50	291	-186	239	9.39	17.56
6.00	58	46	6	0.08	8.17
6.50	-11	114	-63	-0.53	8.08
7.00	-30	132	-81	-0.43	8.62
7.50	36	60	-12	3.19	9.05
8.00	-8	107	-58	0.53	5.85
8.50	98	3	48	3.42	5.32
9.00	88	12	38	3.19	1.90
9.50	-30	134	-82	-1.29	-1.29

21 — IR2 22/4/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-128	234	-181	-4.77	7.82
1.00	-205	309	-257	-8.57	12.58
1.50	-291	396	-344	-12.75	21.16
2.00	-291	394	-343	-12.93	33.91
2.50	-222	328	-275	-9.45	46.84
3.00	-112	220	-166	-4.11	56.29
3.50	24	85	-31	2.25	60.40
4.00	99	7	46	5.77	58.15
4.50	267	-163	215	10.93	52.38
5.00	439	-334	387	16.59	41.46
5.50	365	-255	310	12.32	24.86
6.00	38	69	-16	-0.80	12.54
6.50	-11	118	-65	-0.61	13.34
7.00	-34	140	-87	-0.68	13.96
7.50	92	12	40	5.32	14.63
8.00	-1	102	-52	0.78	9.31
8.50	168	-63	116	6.20	8.53
9.00	120	-12	66	4.34	2.33
9.50	-45	154	-100	-2.01	-2.01

22 — IR2 1/5/2015

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-167	282	-225	-6.55	4.17
1.00	-226	343	-285	-9.70	10.72
1.50	-295	412	-354	-13.16	20.42
2.00	-295	408	-352	-13.30	33.58
2.50	-228	342	-285	-9.86	46.88
3.00	-112	231	-172	-4.34	56.74
3.50	31	83	-26	2.44	61.08
4.00	109	7	51	5.98	58.64
4.50	279	-164	222	11.19	52.67
5.00	450	-336	393	16.86	41.48
5.50	375	-258	317	12.58	24.62
6.00	41	79	-19	-0.94	12.03
6.50	-9	125	-67	-0.72	12.97
7.00	-32	149	-91	-0.82	13.69
7.50	98	16	41	5.36	14.51
8.00	2	109	-54	0.70	9.15
8.50	173	-61	117	6.26	8.45
9.00	126	-10	68	4.42	2.19
9.50	-45	165	-105	-2.23	-2.23

23 — IR2 16/5/2015

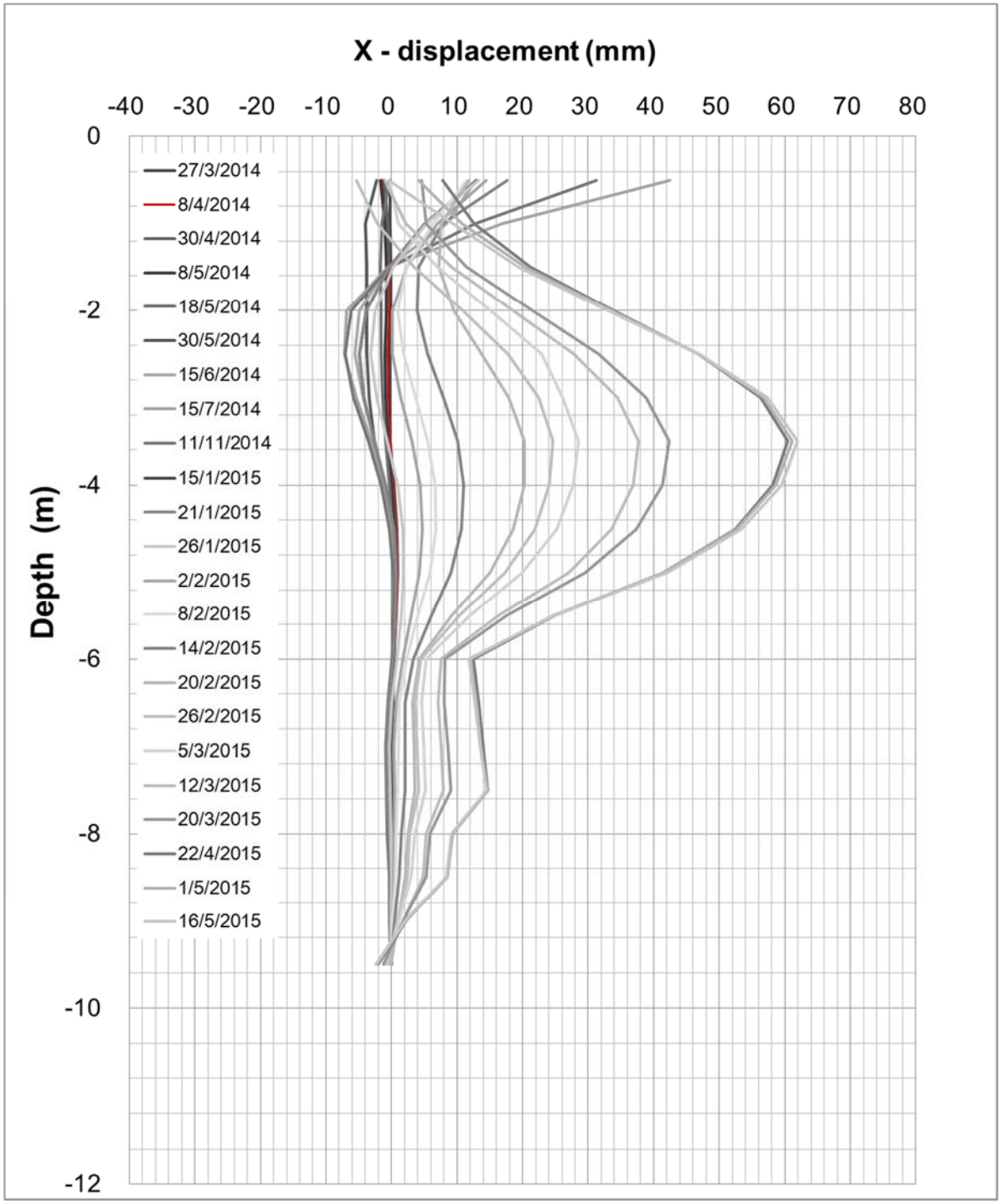
Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-172	441	-307	-9.90	-0.45
1.00	-225	352	-289	-9.86	9.45
1.50	-305	432	-369	-13.77	19.32
2.00	-303	428	-366	-13.87	33.09
2.50	-236	359	-298	-10.37	46.96
3.00	-115	241	-178	-4.60	57.33
3.50	36	87	-26	2.46	61.94
4.00	116	8	54	6.10	59.48
4.50	291	-162	227	11.40	53.38
5.00	464	-340	402	17.23	41.99
5.50	389	-264	327	12.99	24.76
6.00	42	81	-20	-0.96	11.77
6.50	-6	133	-70	-0.82	12.73
7.00	-31	157	-94	-0.96	13.55
7.50	104	21	42	5.38	14.51
8.00	7	114	-54	0.70	9.13
8.50	180	-50	115	6.18	8.43
9.00	133	-14	74	4.65	2.25
9.50	-47	171	-109	-2.39	-2.39

24 — IR2 27/3/2014

Depth (m)	X+	X-	X+ - X- / 2	Section Disp. (mm)	Accum. Disp. (mm)
0.50	-21	110	-66	-0.04	-0.20
1.00	-5	96	-51	-0.12	-0.16
1.50	12	76	-32	0.00	-0.04
2.00	21	68	-24	0.12	-0.04
2.50	2	87	-43	0.06	-0.16
3.00	-20	110	-65	0.02	-0.23
3.50	-46	133	-90	-0.16	-0.25
4.00	-58	145	-102	-0.27	-0.08
4.50	-12	99	-56	-0.14	0.18
5.00	22	62	-20	-0.04	0.33
5.50	53	34	10	0.02	0.37
6.00	51	36	8	0.14	0.35
6.50	-1	90	-46	0.16	0.20
7.00	-25	114	-70	0.04	0.04
7.50	-47	132	-90	0.02	0.00
8.00	-28	113	-71	0.00	-0.02
8.50	8	79	-36	0.02	-0.02
9.00	3	84	-41	-0.02	-0.04
9.50	-5	97	-51	-0.02	-0.02

(Refer: Excel file: IR2-n.xslx sheet “IR2-n” in folder L-3 2 Observation data)

Sample of underground displacement



This graph are written automatically by function of Excel file

(Refer: Excel file: IR2-n.xslx>sheet “chart” in folder L-3 2 Observation data)

3-D Measurement

Date		2014/11/21		
No.	Point	N	E	Z
1	BM1	4000.000	2000.000	10.000
2	BM2	3965.978	1888.713	10.284
3	TP1	3923.114	1913.962	9.817
4	TP2	4021.627	1866.196	10.095
5	OR12	3941.854	1854.753	9.732
6	OR13	3934.258	1861.055	9.583
7	OR22	3914.759	1815.071	9.603
8	OR23	3906.935	1821.140	9.375
9	OR32	3889.998	1771.504	9.566
10	OR33	3881.495	1776.773	9.567
11	OL12	3985.685	1817.803	9.854
12	OL13	3993.387	1811.554	10.007
13	OL22	3955.981	1783.263	9.809
14	OL23	3963.669	1776.807	10.002
15	OL32	3927.891	1744.225	10.506
16	OL33	3935.799	1737.541	9.815

Date		2014/12/7		
1	BM1	4000.000	2000.000	10.000
2	BM2	3965.977	1888.713	10.281
3	TP1	3923.113	1913.966	9.823
4	FSP	3935.948	1799.060	10.356
5	OR12	3941.843	1854.743	9.740
6	OR13	3934.247	1861.056	9.591
7	OR22	3914.770	1815.051	9.610
8	OR23	3906.921	1821.135	9.379
9	OR32	3889.983	1771.504	9.581
10	OR33	3881.492	1776.768	9.576
11	OL12	3985.698	1817.881	9.853
12	OL13	3993.377	1811.588	10.008
13	OL22	3955.948	1783.259	9.808
14	OL23	3963.694	1776.806	9.994
15	OL32	3927.918	1744.224	10.500
16	OL33	3935.755	1737.557	9.809

Date		2014/12/20		
1	BM1	4000	2000	10
2	Free	3995.37	1894.499	10.053
3	TP2	4021.627	1866.196	10.095
4	TP4	3965.425	1922.304	9.617
5	OR12			
6	OR13	3934.255	1861.048	9.587
7	OR22	3914.785	1815.044	9.601
8	OR23	3906.934	1821.137	9.369
9	OR32	3890.017	1771.498	9.566
10	OR33	3881.525	1776.76	9.563
11	OL12	3985.703	1817.858	10.159
12	OL13	3993.379	1811.562	10.01
13	OL22	3955.944	1783.236	10.104
14	OL23	3963.686	1776.791	9.994
15	OL32	3927.927	1744.202	10.783
16	OL33	3935.767	1737.525	9.815

Date		2015/1/15		
1	BM1	4000	2000	10
2	BM2	3965.978	1888.716	10.254
3	BM3	4019.552	1973.918	9.7
4	BM4	4048.274	1896.454	9.65
5	TP2	4021.627	1866.196	10.095
6	OR12	3941.84	1854.724	9.725
7	OR13	3934.251	1861.045	9.577
8	OR22	3914.774	1815.039	9.597
9	OR23	3906.932	1821.142	9.366
10	OR32	3890.048	1771.509	10.283
11	OR33	3881.515	1776.782	9.56
12	OL12	3985.723	1817.872	9.257
13	OL13	3993.371	1811.556	10.011
14	OL22	3955.952	1783.193	9.978
15	OL23	3963.662	1776.804	10.594
16	OL32	3927.954	1744.177	10.466
17	OL33	3935.754	1737.531	9.808

		2015/1/21		
		N	E	Z
1	BM1	4000	2000	10
2	BM2	3965.978	1888.716	10.254
3	BM3	4019.552	1973.918	9.7
4	BM4	4048.274	1896.454	9.65
5	TP2	4021.627	1866.196	10.095
6	OR12	3941.851	1854.725	9.719
7	OR13	3934.263	1861.039	9.571
8	OR22	3914.787	1815.029	9.589
9	OR23	3906.934	1821.125	9.385
10	OR32	3889.911	1771.432	10.24
11	OR33	3881.523	1776.752	9.549
12	OL12	3985.728	1817.853	9.85
13	OL13	3993.376	1811.554	10.011
14	OL22	3955.956	1783.172	9.795
15	OL23	3963.688	1776.786	10.594
16	OL32	3927.961	1744.164	10.458
17	OL33	3935.771	1737.531	9.803
18	FREE	3922.967	1908.7	9.41

		2015/1/26		
		N	E	Z
1	BM1	4000	2000	10
2	BM2	3965.98	1888.723	10.241
3	BM3	4019.552	1973.918	9.7
4	BM4	4048.274	1896.454	9.65
5	TP2	4021.627	1866.196	10.095
6	OR12	3941.844	1854.718	9.718
7	OR13	3934.252	1861.031	9.57
8	OR22	3914.782	1815.032	10
9	OR23	3906.927	1821.124	9.375
10	OR32	3889.936	1771.46	10.242
11	OR33	3881.519	1776.741	9.544
12	OL12	3985.723	1817.865	9.852
13	OL13	3993.38	1811.554	10.009
14	OL22	3955.969	1783.162	9.796
15	OL23	3963.692	1776.785	9.992
16	OL32	3927.975	1744.154	10.457
17	OL33	3935.77	1737.518	9.809

Date		2015/2/2		
		N	E	Z
1	BM1	4000	2000	10
2	BM2	3965.979	1888.723	10.242
3	BM3	4019.552	1973.918	9.7
4	BM4	4048.274	1896.454	9.65
5	TP2	4021.627	1866.196	10.095
6	OR12	3941.836	1854.709	9.724
7	OR13	3934.248	1861.026	9.575
8	OR22	3914.76	1815.027	9.958
9	OR23	3906.902	1821.139	9.37
10	OR32	3889.934	1771.473	10.262
11	OR33	3881.499	1776.744	9.566
12	OL12	3985.714	1815.857	9.847
13	OL13	3993.385	1811.557	10.006
14	OL22	3955.989	1783.134	9.77
15	OL23	3963.692	1776.78	9.991
16	OL32	3927.977	1744.116	10.455
17	OL33	3935.776	1737.517	9.814
18	free	3952.924	1875.933	9.764

Date		2015/3/5		
		N	E	Z
1	BM1	4000	2000	10
2	BM2	3965.99	1888.717	10.183
3	BM3	4019.552	1973.918	9.7
4	BM4	4048.274	1896.454	9.65
5	TP2	4021.627	1866.196	10.095
6	OR12	3941.845	1854.695	9.691
7	OR13	3934.246	1861.026	9.573
8	OR22	3914.798	1815.026	9.566
9	OR23	3906.68	1821.183	9.385
10	OR32	3889.926	1771.461	10.194
11	OR33	3881.529	1776.714	9.549
12	OL12	3985.73	1817.837	9.523
13	OL13	3993.383	1811.55	10.001
14	OL22	3955.999	1783.109	9.719
15	OL23	3963.711	1776.772	9.989
16	OL32	3927.995	1744.125	10.121
17	OL33	3935.794	1737.498	9.803
18	free	3952.863	1856.281	12.475
19				

		2015/4/22		
		N	E	Z
1	BM1	4000	2000	10
2	BM2	3965.99	1888.717	10.183
3	BM3	4019.552	1973.918	9.7
4	BM4	4048.274	1896.454	9.65
5	TP2	4021.627	1866.196	10.095
6	OR12	3941.852	1854.773	9.608
7	OR13	3934.267	1861.042	9.564
8	OR22	3914.780	1815.165	9.502
9	OR23	3906.577	1821.254	9.375
10	OR32	3889.798	1771.554	10.128
11	OR33	3881.509	1776.786	9.56
12	OL12	3985.716	1817.889	9.763
13	OL13	3993.373	1811.594	10.005
14	OL22	3955.964	1783.118	9.644
15	OL23	3963.662	1776.851	9.982
16	OL32	3927.949	1744.079	10.355
17	OL33	3935.712	1737.480	9.810
18	free	3952.863	1856.281	12.475

Date		2015/5/1		
		N	E	Z
1	BM1	4000	2000	10
2	BM2	3965.99	1888.717	10.183
3	BM3	4019.552	1973.918	9.7
4	BM4	4048.274	1896.454	9.65
5	TP2	4021.627	1866.202	10.075
6	OR12	3941.963	1854.889	9.589
7	OR13	3934.354	1861.021	9.572
8	OR22	3914.957	1815.375	9.189
9	OR23	3906.854	1821.744	9.044
10	OR32	3889.972	1771.816	9.801
11	OR33	3881.729	1776.052	9.377
12	OL12	3985.69	1817.869	9.732
13	OL13	3993.369	1811.605	9.98
14	OL22	3955.864	1783.218	9.732
15	OL23	3963.725	1776.737	9.97
16	OL32	3927.959	1744.219	10.337
17	OL33	3935.678	1737.569	9.799
18	free	3946.589	1874.118	9.567

		2015/5/16		
		N	E	Z
1	BM1	4000	2000	10
2	BM2	3965.99	1888.717	10.183
3	BM3	4019.551	1973.918	9.7
4	BM4	4048.274	1896.454	9.65
5	TP2	4021.627	1866.199	10.086
6	OR12	3941.943	1854.885	9.601
7	OR13	3934.351	1861.031	9.576
8	OR22	3914.955	1815.37	9.399
9	OR23	3906.85	1821.731	9.144
10	OR32	3889.962	1771.806	9.831
11	OR33	3881.629	1776.152	9.381
12	OL12	3985.72	1817.859	9.734
13	OL13	3993.369	1811.59	10.001
14	OL22	3955.894	1783.208	9.732
15	OL23	3963.721	1776.757	9.978
16	OL32	3927.969	1744.119	10.307
17	OL33	3935.678	1737.563	9.799
18	free	3946.529	1874.127	9.568

(Refer Excel file: 3-D Excel_4.xslx>sheet: “BO” in folder L-3 2 Observation data)