TECHNICAL OPINION REPORT

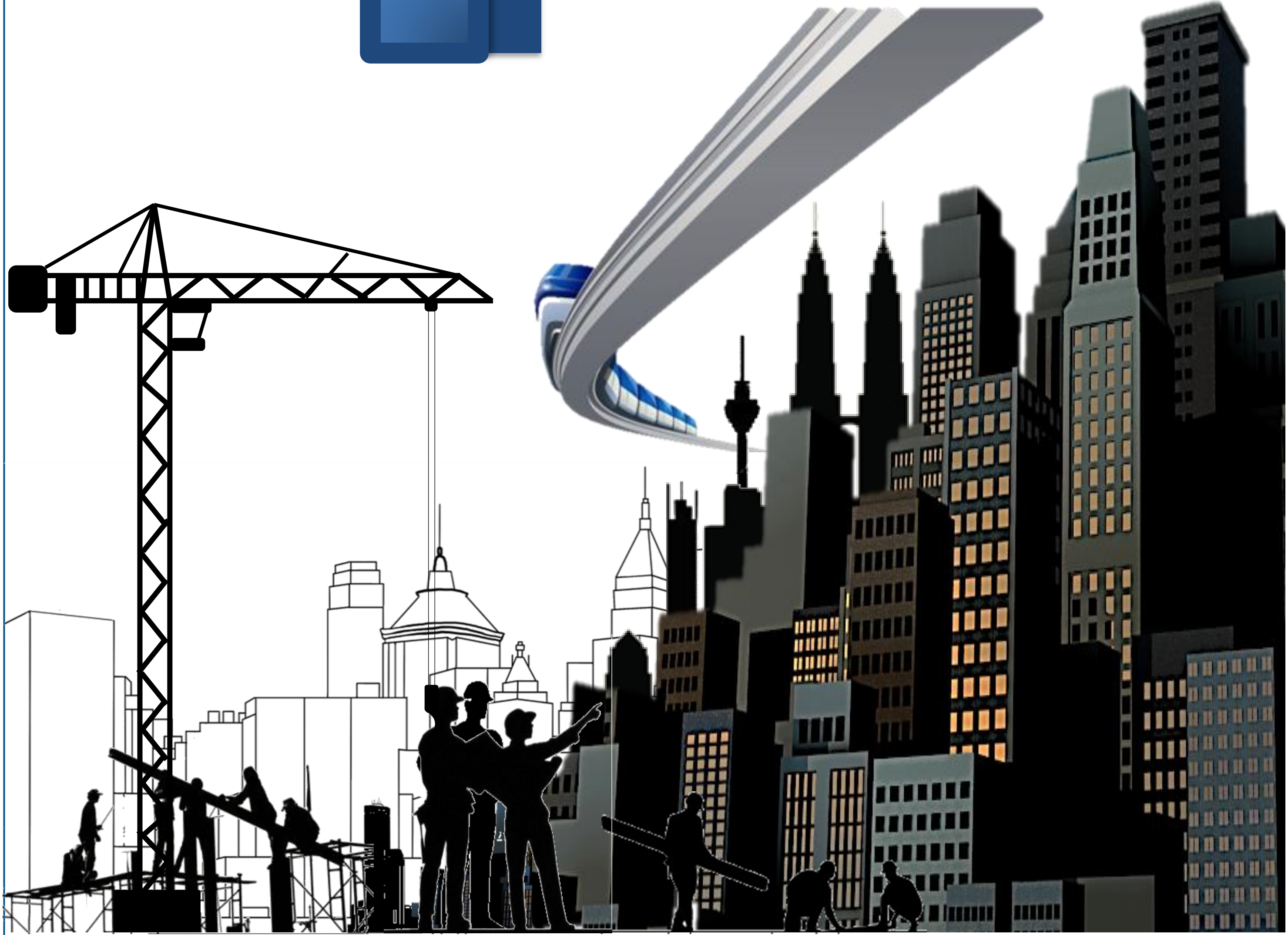
SUBMITTED TO CIDB MALAYSIA | SEPTEMBER 2017

PRODUCT

YJACK

APPLICANT

YJACK Technology Sdn. Bhd.



FOREWORD

Construction Industry Development Board (CIDB Malaysia) is a statutory body enacted under the Act 520 in 1994. Its mission is to develop Malaysian Construction Industry towards global competitiveness. To support that mission, a number of functions were formulated and one of them is to encourage the improvement of construction techniques and materials. Under that function, CIDB is to carry out assessment and appraisal of innovations of any kind of product and technology related to construction and to publish its finding, in the form of Technical Opinion.

This Technical Opinion will provide a reference to the relevant / interested parties in the construction industry. CIDB assess innovation based on application and evaluation by its Technical Opinion. Applicants may use it as a supporting document for regulatory and approving authorities, architects, engineers and others in dealing with the new products and technologies.

This Technical Opinion is prepared on behalf of CIDB by The Technical Expert Panel on construction products, construction material and technology in Construction Industry. The Technical Expert Panel was set-up by CIDB and its members are drawn from experts that represent relevant sectors in the construction industry.

This Technical Opinion has been modelled based on international recommended practice.

CIDB Technical Expert Panel Committee for YJACK

Technical Expert Panel

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Prof. Dr. Mohd. Raihan Taha	(Technical Expert Panel)	Universiti Kebangsaan Malaysia (UKM)
Ir. Dr Chan Swee Huat	(Technical Expert Panel)	The Institution of Engineers Malaysia (IEM)
Ir. Som Pong Pichan	(Technical Expert Panel)	Jabatan Kerja Raya (JKR)
Dr. HM Abdul Aziz bin KM Hanifah	(Technical Expert Panel)	LR Two Consult Sdn. Bhd.

Secretariat

Natasha Binti Dzulkalnine	Construction Research Institute of Malaysia (CREAM)

GENERAL PROVISIONS

The purpose of this report is to assist respective parties, both the applicant and the granting approval authority, to understand issues with regard to the specification and the uses of the product under study. This report shall not be considered as approval.

Special note should be taken of the provisions and limitations set out and the period of validity of the Technical Opinion.

Technical Opinion is initially given a term of validity of three (3) years from the date of issue in the expectation that, after that period, the subject will no longer be an innovation. They can be reviewed within the first twelve (12) months and again as necessary during the life of the products or system described in the document. The limitation on the validity of the opinions should not be interpreted as implying a similarly limited life expectancy of the products or system described in the Technical Opinion. However, if experience shows poor overall standard of quality or performance, the Technical Opinion will be withdrawn.

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Definition

Technical Opinion Programme	A programme initiated by CIDB with the aim to evaluate products, materials, components or system with regard to, but not limited to IBS. It normally covers wide range of innovative products to be used in local construction industry
Technical Expert Panel	Individuals are selected based on their expertise in geotechnical engineering
YJACK	YJACK is a type of flat jack for use in bi-directional pile load test

Abbreviation

API	Application Programming Interface
BD	Bi-directional
CIDB	Construction Industry Development Board
CREAM	Construction Research Institute of Malaysia
FEM	Finite Element Modelling
IBS	Industrialised Building System
ICP	Industrial Concrete Products Sdn Bhd
IEM	The Institution of Engineers Malaysia
JKR	Jabatan Kerja Raya
Mc	Crack Moment
MLT	Maintained Load Test
MS	Malaysian Standard
Pc	Equivalent Crack Load
P_{max}	Ultimate Load
QA	Quality Assurance
QC	Quality Control
QLT	Quick Load Test
SC	Spun Concrete
SL	Static Load
UKM	Universiti Kebangsaan Malaysia

Symbols

kN	kilonewton
kNm	kilonewton metre
MPa	megapascal
tn	ton
cm	centimetre
mm	millimetre
m	metre
%	percentage
Ø	diameter
≥	greater than or equal to
≤	less than or equal to

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1.0 IDENTIFICATION

1.1 Name of Product

YJACK

1.2 Country of Origin

Malaysia

1.3 Dates of Evaluation

22nd September 2014	:	First meeting of Technical Expert Panel
8th March 2016	:	Second meeting of Technical Expert Panel
14th March 2017	:	Third meeting of Technical Expert Panel

1.4 Purpose

YJACK is a patented jack designed for bi-directional (BD) static pile load test on driven piles (Paten #: PI2014000539). Professional YJACK adopts bladder sealing technology (Patent #: CN201694784U).

1.5 Applicant & Address

YJACK Technology Sdn. Bhd.
Level 16, 1 Sentral,
KL Sentral,
50470, Kuala Lumpur

Contact	Telephone	:	03-20929274
	Fax	:	03-20929201
	Hand Phone	:	012-3259090
	Contact Person	:	Mr. Yeow Leong Swee

2.0 DESCRIPTION

2.1 General Description of Product

YJACK is a pile test instrument to carry out static pile load testing using bi-directional (BD) test method. It is an alternative method to the conventional maintained load test using Kentledge blocks or reaction piles methods.

2.2 Elements of Product

2.2.1 Components

YJACK comprises of two main components: the cylinder shell (in red colour) and piston shell (in grey colour) (Figure 2.1). It is a press jack that the pressure load is applied by using hydraulic capsule unit instead of piston hydraulic jack. YJACK is connected in spliced joint (between two pile sections) which will be installed by pile driving hammer like a normal driving pile into the ground.

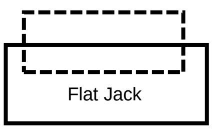
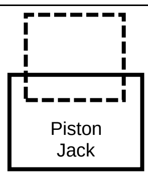
Figure 2.1: YJACK components

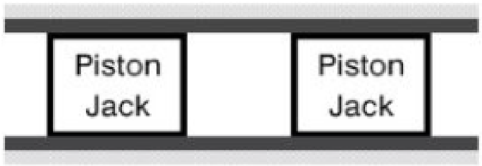
2.2.2Technology

The core technology of YJACK adopts a flat jack (or multiple jacks) to conduct BD pile tests on all pile types such as driven/jack-in close-ended reinforced concrete piles, open-ended and offshore piles, as well as cast in-situ micro-API and bored piles.

Table 2.1 shows the comparison of YJACK technology with other BD pile tests.

Table 2.1: Comparison of YJACK Technology with other BD Pile Tests

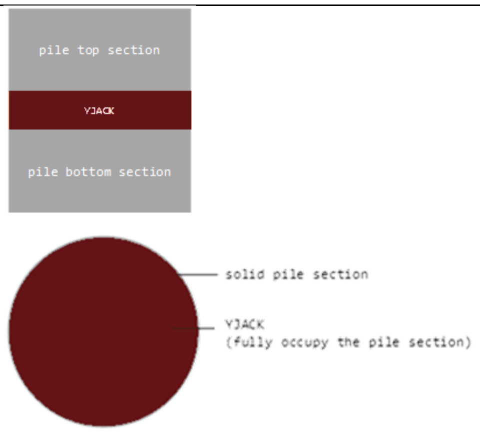
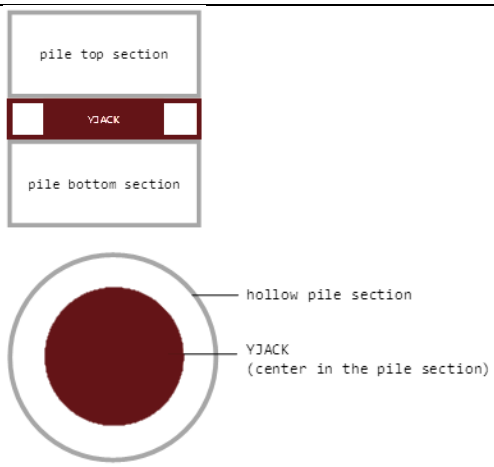
Comparisons	YJACK Technology	Other Technology
Technology	Flat Jack using bladder seal technology	Piston Jack using oil seal technology
Jack Designs		
Jack Applications	Since 2006: • Cast in-situ drilled piles After 2014 with world's patents: • Drive / jack-in close-ended piles • Drive / jack-in close-ended piles • Cast in-situ API-micro piles	Since 1980s: • Cast in-situ drilled piles
Jack Fabrications for	Conical blocks attached at the top and bottom of the jacks. The sediments will	Steel plates attached at the top and bottom of the jacks. The sediments will

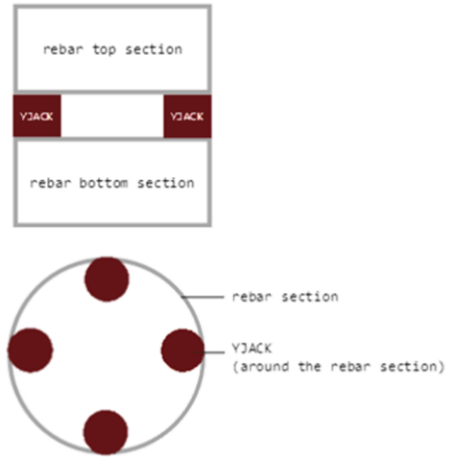
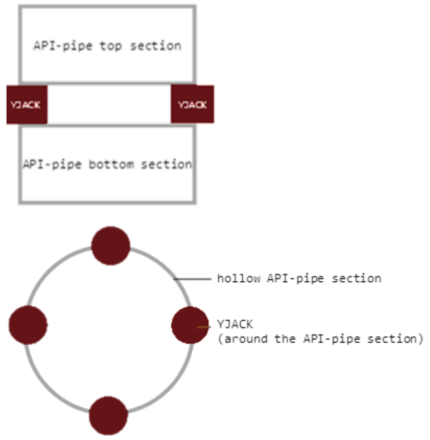
drilled piles	not be stuck at the top of the jack. Solid concrete formed.  Bottom conical shape to allow the concrete to flow easily from bottom to top. No sediments block at bottom.	be stuck at the top of the steel plate. Soft concrete formed.  Bottom steel plate with flat shape will block concrete and sediments to flow. Soft concrete formed.

2.2.3<u>*Types of YJACK*</u>

There are four types of YJACK:C, O, B, and M, which are applied to closed ended piles, open ended piles, API micro piles, and bored piles, respectively. Table 2.2 describes the characteristics of each of these YJACK:

Table 2.2: Types of YJACK

Type	Description	Illustration
Type C	This type of YJACK is designed for close-ended piles such as reinforced concrete, spun concrete and steel pipe piles with pile shoes. The steel H-pile is classified as close-ended piles.	
Type O	This type of YJACK is designed for open ended piles such as spun concrete and steel pipe piles without pile shoes, as well as offshore open-ended piles. The major difference of YJACK Type O compared to Type C is that Type O allows soil to move past through the YJACK location during pile driving. The physical design of Type O and C is similar.	

Type B	The major difference of YJACK compared to ojack (o-cell or o-jack) is the jack design, YJACK uses flat jack technology, whereas ojack uses piston jack.	
Type M	This type of YJACK is specifically designed for micro piles with API as the structural element of the piles.	

2.2.4 Installation Process

YJACK is installed by pile driving hammer like a normal driving pile into the ground. The installation process is as follows:

i. Splice the YJACK at the end bearing (i.e. 0m from pile toe);
ii. Pile positioning, check verticality and then continue driving;
iii. Hydraulic hoses and telltales are attached and fixed along the pile body; and
iv. End of pile driving and completion of the YJACK installation.

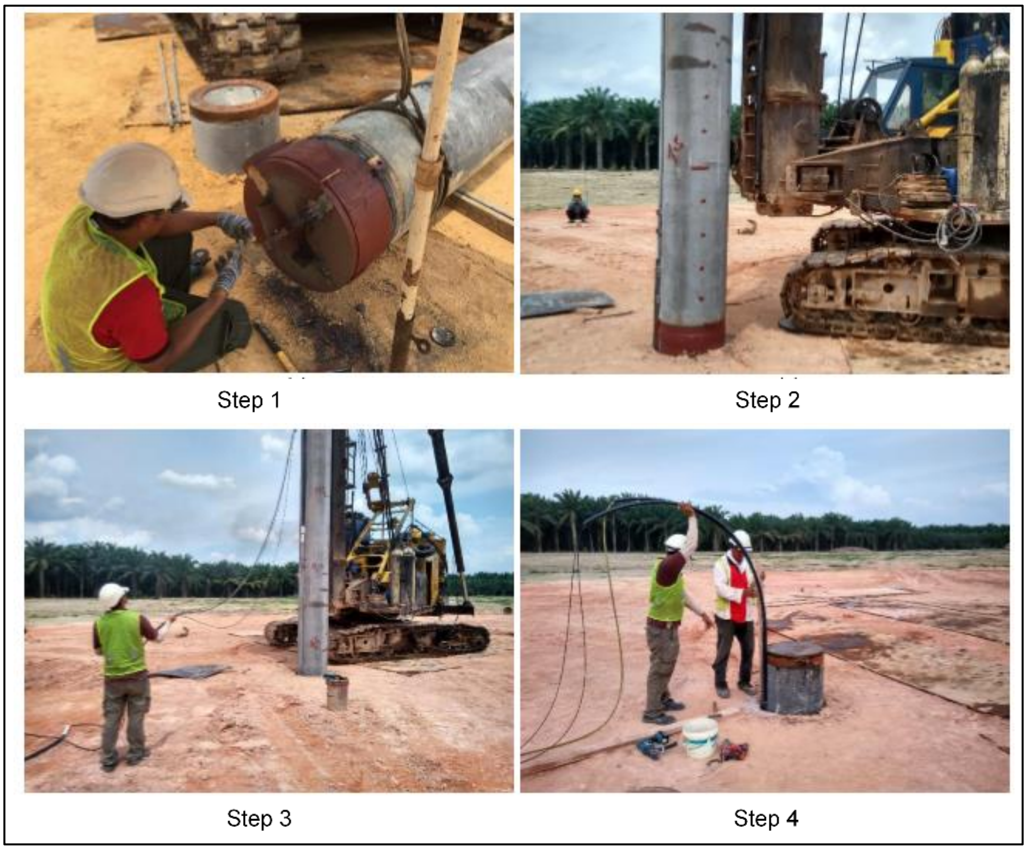


Figure 2.2: YJACK type C installation process

2.3 Usage Application

YJACK is a patented innovation to carry out bi-directional (BD) pile test in static load (SL) pile bearing testing. It is an alternative method to conventional maintained load test using kentledge blocks or reaction piles methods.

3.0 LIST OF BI-DIRECTIONAL PILE LOAD TEST

3.1 Bored Pile Test

Table 3.1 shows the list of YJACK bi-directional bored pile tests.

Table 3.1: List of YJACK bi-directional bored pile tests

Date	Contractor/Piling	Project Title/Site/Scope of Work	Tonnage
9th April 2015	Khiap Hup Construction & Engineering Sdn Bhd	Membina Jambatan Konkrit Menyeberangi Sungai Jelai Di Kampung Gemunchor, Mukim Cheka 1, Lipis, Pahang DM (bored piles design/ testing near Jerantut-Lipis)	490
1st April 2016	Geospec Piletech Sdn Bhd	Cadangan Pembinaan Jalan dan Jambatan Menghubungi Kawasa Antara Bangunan Maybank dan Kawasan Ming Court Garden Si Sembulan, Kota Kinabalu, Sabah.	600
26th April 2016	Econpile (M) Sdn Bhd	Spice-Piling and Basement Works to Hotel, Jalan Tun Dr. Awang, Mukim 12, Daerah Barat Daya, Pulau Pinang.	3,030

7th May 2016	Top Down Construction Sdn Bhd	Pembinaan Jalan Utama Jaringan Jalan dalam Kampus dan Kerja-Kerja Infrastruktur di Universiti Malaysia Kelantan, Kampus Jeli.	1,600
16th August 2016	Geospec Piletech Sdn Bhd	New Sarawak Museum and Annex Building, Section 31, Kuching Town Land District at Jln Tun Abang Haji Openg, Sarawak.	2,800
15th September 2016	Geospec Piletech Sdn Bhd	Proposed Commercial Cum Residential Development & Transport Hub at Tanjung Aru, Kota Kinabalu, Sabah. Flyover with Road Widening Works at Chainage 0+84m Jalan Kepayan & On Road Reserves.	2,820
26th November 2016	AP-COL Geotechnics Sdn Bhd	KK Metro Town (Hotel and Shopping), Off Jalan TUaran, Kota Kinabalu, Sabah.	3,300
30th November 2016	Sunway Geotechnics (M) Sdn Bhd	Proposed RC8 Condominium for Sunway College, Bandar Sunway.	2,000
5th December 2016	Pintaras Geotechnics Sdn Bhd	38 Storey Pinnacle Condo at Kuala Lumpur, for bored piles diameter BP1200mm and BP2400mm for YJACK test load YJ2000tn and YJ8000tn respectively.	10,000
10th March 2017	PC Geotechnics Sdn Bhd (Peck Chew Piling)	Proposed Design and Build, Testing and Commissioning of Extension and Refurbishment Works to the Existing Shopping Complex Compete with Infrastructure Works to Aeon Maluri Shopping Centre, Malan Jejaka, Taman Maluri, Cheras, 55100, Kuala Lumpur.	2,340
Letter Award	Geospec Piletech Sdn Bhd	Proposed Subdivision for 10 storey Town & Regional Planning Department Headquarters Block at Jalan Tasik, District of Kinabalu, Sabah.	600
Letter Award	Musyati Sdn Bhd (Geospec Piletech Sdn Bhd)	Proposed Pan Borneo Highway, Package WPC 08 – Batang Mukah Load Test, Sarawak.	3,120
16th March 2017	AP-COL Geotechnics Sdn Bhd	KK Metro Town (Hotel and Shopping), Off Jalan Tuaran, Kota Kinabalu, Sabah.	1,700
10th April 2017	PC Geotechnics Sdn Bhd (Peck Chew Piling)	AEON Maluri Shopping Mall Extension, Taman Maluri, Kuala Lumpur.	1,560
14th April 2017	Top Down Construction Sdn Bhd	Cadangan Tebatan Banjir Lembangan Sungai Muar Johor. Pembinaan Pintasan Belemang di Sungai Muar dan Kerja-Kerja Berkaitan.	1,700
22nd April 2017	ChengalJati Sdn Bhd	Bi-Directional Test with Pile Instrumentation at SUKE – Pakej CA1	5,400
28th April 2017	Kelpile Geotechnics Sdn Bhd	Verdepalm Project Malaysia, Johor (Bio-Xcell Technical Park at Nusajaya)	2,000
8th April 2017	TBT Piling (Sabah) Sdn Bhd	Proposed Development of 3 Block of 16-stroey Condominium (768-units) with Roof Top Sky Lounge, Jalan Bundusan, District of Penanpang (Triconic Tower)	1,500
Letter Award	Geospec Piletech Sdn Bhd	Multi-Storey Mixed-Use Commercial Cum Hotel Development at Jalan Nenas, Kota Kinabalu, Sabah.	5,000
30th April 2017	Khiap Hup Resources Sdn Bhd	Bi-Directional Test at Jambatan Gua Musang, Kelantan.	5,000
5th May 2017	Dong Yue Construction Sdn Bhd (bored piles)	Forest City Landmark Tower, Forest City, Mukim Tanjung Kupang, Daerah Johor Bahru, Johor Darul Takzim.	22,600
22nd June 2017	Techright Resources Sdn Bhd	Proposed Expressway from Putrajaya to KLIA (MEX 2).	20,000
23rd June 2017	Geospec Piletech Sdn Bhd	Proposed Pan Borneo Highway, Package WPC 08 – Batang Tatau Load Test, Sarawak.	3,880

3.2 Concrete Pile Test

Table 3.2 shows the list of YJACK bi-directional concrete pile tests.

Table 3.2: List of YJACK bi-directional concrete pile tests

Date	Contractor/Piling	Project/Site	Tonnage
7th January 2014	YJACK Technology Sdn Bhd	YJACK Pilot Test at Kota Kinabalu, Sabah (the first YJACK in the word on driven pile)	320
9th December 2014	YJACK Technology Sdn Bhd	Proposed Sekolah Rendah Agama (SRA) Pantai Dalam, Kuala Lumpur, Wilayah Persekutuan.	100
6th February 2015	Sichuan Construction Sdn Bhd	88 Unit Teras Vila Riadah 2 Tingkat Di Atas Blok 1, Lot 227, Pekan Pasir Bogak, Pulau Pangkor, Daerah Manjung, Negeri Perak Darul Ridzuan.	40
7th February 2015	Sichuan Construction Sdn Bhd	1 Blok Hotel Pelancongan 4 Tingkat di Atas Blok 4, Lot 227, Pekan Pasir Bogak, Pulau Pangkor, Daerah Manjung, Negeri Perak Darul Rizuan.	160
21st December 2015	Aliah Enterprise	Carry out Bi-Directional Pile Load Test by Using YJACK Method at Muar, Johor.	240
20th December 2015	Cylonix Geotechnics Sdn Bhd	Carry out Bi-Directional Pile Load Test by Using YJACK Method at Bahau, Negeri Sembilan.	650
18th January 2016	Cylonix Geotechnics Sdn Bhd	Carry Our Bi-Directional Pile Load Test by using YJACK Method at Hulu Langat in Klang Valley	200
15th February 2016	Cylonix Geotechnics Sdn Bhd	Carry out Bi-Directional Pile Load Test by using YJACK Method at Gombak in Selangor	180
10th March 2016	Cylonix Geotechnics Sdn Bhd	DBKL Missing Road Bukit Jalil, Jalan Jalil Perkasa 7 ke Jalan Barat, Bukit Jalil, Kuala Lumpur.	1,840
30th March 2016	Cylonix Geotechnics Sdn Bhd	Carry out Bi-Directional Pile Load Test by Using YJACK Method at Bangi Heights in Kajang.	400
8th April 2016	WZS KenKeong Sdn Bhd	Privitisation of Lebuhraya Persisiran Pantai Barat (Taiping – Banting) Section 9 – Kg. Lekir to Changkat Cermin Interchange, Perak.	10,350
28th June 2016	Geospec Piletech Sdn Bhd	Pembinaan Jabatan Sg. Sawit, Betong, Sarawak.	160
11th July 2016	Cylonix Geotechnics Sdn Bhd	Carry out Bi-Directional Pile Load Test by using YJACK Method at Kangsar, Perak.	300
25th August 2016	Cylonix Geotechnics Sdn Bhd	Villaku, Pulau Pangkor, Daerah Manjung, Negeri Perak Darul Rizuan.	260
12th October 2016	Wangsatama Sdn Bhd	Pembinaan Semula Kuarters Kakitangan Jabatan Kebajikan Masyarakat (JKM) di Taman Sinar Harapan Tampoi, Johor Bahru.	520
8th November 2016	Pembinaan Jemerlang Sdn Bhd	Proposed Pulau Indah Elevated Highway, Pulau Indah, Selangor.	800
12th January 2017	Billion Engineering Sdn Bhd	Cadangan Membina dan Menyiapkan Dua, Block Empat Tingkat Bangunan Sra Ehyaul Falah 2, Sungai Besar Serta Kerja-Kerja Berkaitan, Daerah Bernam Selangor Darul Ehsan.	280
28th April 2017	Kelpile Geotechnics Sdn Bhd	Verdepalm Project Malaysia, Johor (Bio-Excell Technical Park at Nusajaya).	2,000
Letter of Intend	Dong Yue Construction Sdn Bhd	Corest City Landmark Tower, Forest City, Mukim Tanjung Kupang, Daerah Johor Bahru, Johor Darul Takzim.	5,800

4.0 BASIS OF APPRAISAL

4.1 Document Received from the Applicant

The following documents were received from YJACK Technology Sdn. Bhd. For product evaluation by the Technical Expert Panel:

i. Product Brochure (*see Appendix A, YJACK Technology Sdn. Bhd.*);
ii. Structural Laboratory Tests Report (*see Appendix B, YJACK Technology Sdn. Bhd.*);
iii. Finite Element Modelling (FEM) Analysis Report (*see Appendix C, YJACK Technology Sdn. Bhd.*);
iv. Validation Test of YJACK Bi-directional Pile Load Test – A Case Study at Kangsar (*see Appendix D, YJACK Technology Sdn. Bhd.*); and
v. Validation Test of YJACK Bi-directional Pile Load Test – A Case Study at Muar (*see Appendix E, YJACK Technology Sdn. Bhd.*).

5.0 STANDARDS, SPECIFICATIONS AND TESTS

5.1 Compression and Bending Tests

Compression and bending tests were conducted based on the following standards:

i. Malaysian Standard for Precast Concrete Piles: MS/1314 (2004)
ii. JKR Standard Specifications for Building Works: JKR/20800-0183 (2014)

under the test criteria as shown in Table 5.1 and Table 5.2 (see Appendix B):

Table 5.1: Compression test criteria

ICP SC Grade 80, Class B Pile Body*	Axial Working Load (kN)	Ultimate Compression Load (kN)
Spun Concrete SC300Ø	844 (= 86tn)	1,688 (= 2 x Working Load)
Spun Concrete SC400Ø	1,501 (=153tn)	3,002 (= 2 x Working Load)

*Manufactured by Industries Concrete Products (ICP), Spun Concrete, Grade 80, Class B

Table 5.2: Bending test criteria

ICP SC Grade 80, Class B Pile Body*	Crack Moment, M_c (kNm)	Equivalent Crack Load, P_c (kN)
Spun Concrete SC300Ø	23	34 (use L = 6m specimen)
Spun Concrete SC400Ø	54	80 (use L = 6m specimen)

*Manufactured by Industries Concrete Products (ICP), Spun Concrete, Grade 80, Class B

The results of both the compression and bending tests are as shown in Table 5.3 and Table 5.4, respectively (see Appendix B):

Table 5.3: Test Results for Ultimate Compression Load for Pile Body and YJACK Connector

Specimens	Technical Data Published by ICP Piles	Experimental Test Results
	Ultimate Compression Load (kN)	Ultimate Compression Load (kN)
SC300Ø (Spun Pile Body)	1,688	1,588*
YJ300Ø (YJACK Connector)	N/A	1,750 (3.7%)
SC400Ø (Spun Pile Body)	3,002	Not tested due to lab limitations (performed by FEM analysis)
YJ400Ø (YJACK Connector)	N/A	

*The test result is slightly lower than the technical data published in the catalogue
() The values in the bracket denote the variances of the experimental results

Table 5.4: Test Results for Ultimate Bending Load for Pile Body and YJACK Connector

Specimens	Technical Data Published by ICP Piles			Experimental Test Results	
	Crack Moment, M_c (kN)	Equivalent Crack Load, P_c (kN)	Ultimate Load, P_{max} (kN)	Crack Load, P_c (kN)	Ultimate Load, P_{max} (kN)
SC300Ø (Spun Pile Body)	23	34	61	41	77
YJ300Ø (YJACK Connector)	N/A	N/A	N/A	64 (88%)	81 (33%)
SC400Ø (Spun Pile Body)	54	80	140	107	172
YJ400Ø (YJACK Connector)	N/A	N/A	N/A	116 (45%)	181% (29%)

() The values in the bracket denote the variances of the experimental results

5.2 Finite Element Modelling

The finite element modelling (FEM) analysis was carried out to examine the functionality and durability of YJACK 300 and YJACK 400 in resisting pile compression and bending during pile driving, as to comprehend compression tests which were not able to be conducted in the laboratory due to the limited loading capacity.

The results of the FEM analysis were shown in Table 5.5 and Table 5.6, for both YJACK 300mm and 400mm, respectively (see Appendix C).

Table 5.5: Static study analysis for 300mm YJACK

Force (kN)	0	200	400	600	800	1000	1200	1400	1600	1750
Displacement (cm)	0	0.0038	0.0075	0.0113	0.0150	0.0188	0.0225	0.0263	0.0301	0.0329
Stress (MPa)	0	44.9	89.9	134.8	179.8	224.7	269.6	314.6	359.5	393.2
Minimum Factor of Safety	0	7.82	3.91	2.61	1.96	1.56	1.3	1.12	0.98	0.89

Table 5.6: Static study analysis for 400mm YJACK

Force (kN)	0	250	500	750	1000	1250	1500	1750
Displacement (cm)	0	0.009	0.018	0.027	0.036	0.044	0.053	0.062
Stress (MPa)	0	60.6	121.2	181.8	242.3	302.9	363.5	424.1
Minimum Factor of Safety	0	5.8	2.9	1.93	1.45	1.16	0.97	0.83

5.3 Validation Test of YJACK Bi-directional Pile Load Test – A Case Study in Kangsar

Two YJACK validation correlation tests were performed at a project site in Kangsar, from 2nd to 8th June 2016.

5.3.1 YJACK Test Result

YJACK test results measured at site are shown in Figure 5.1 and Figure 5.2 (see Appendix D):

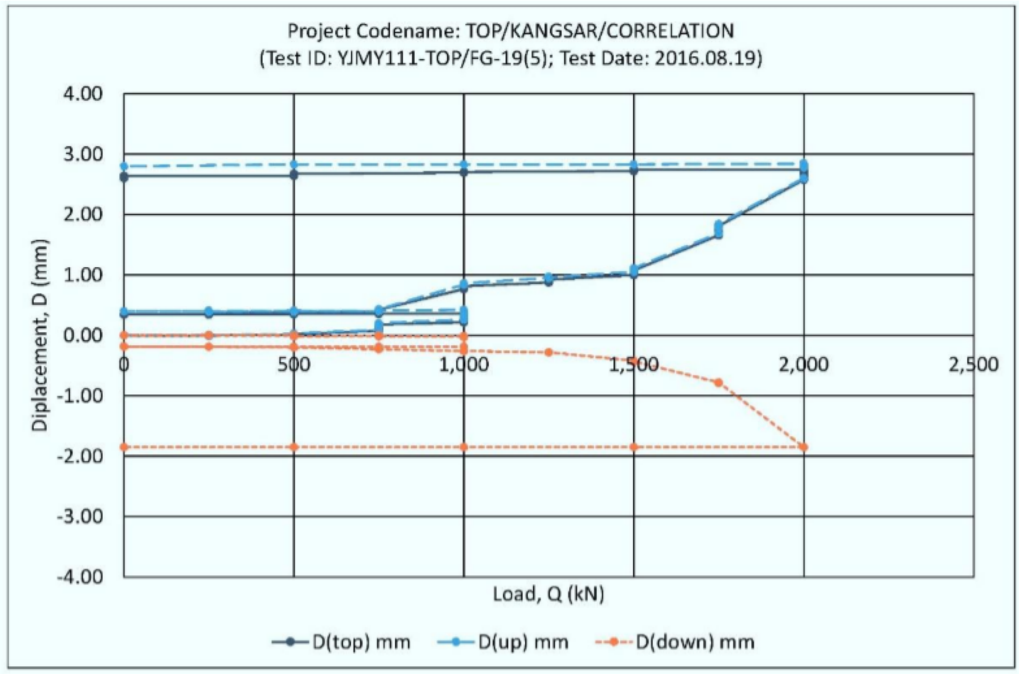


Figure 5.1: YJACK bidirectional pile test result – FG-19(5)

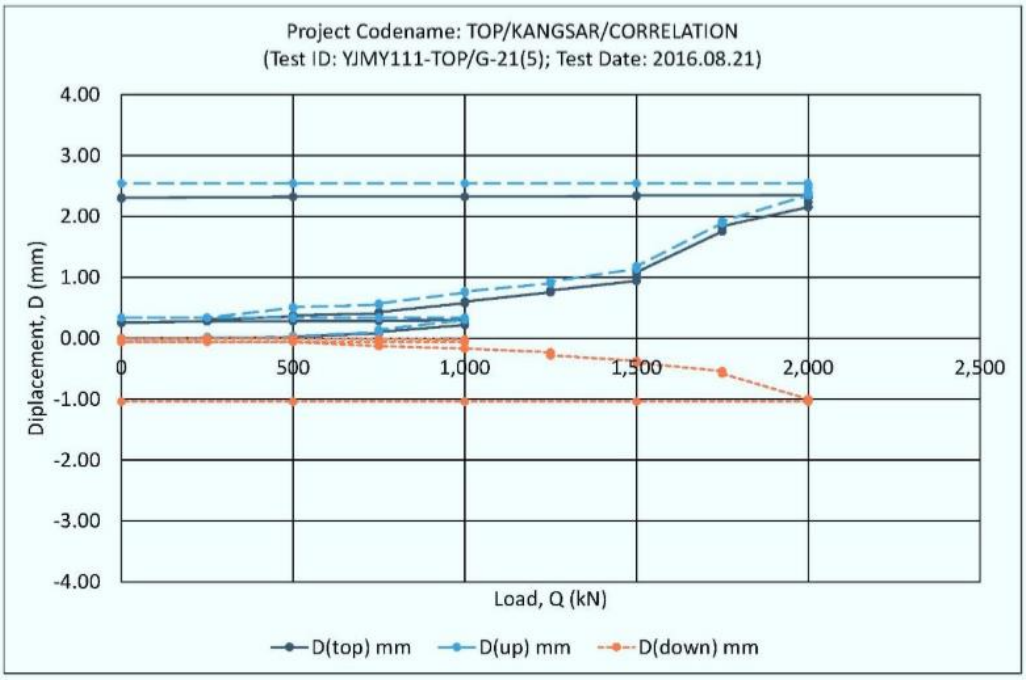


Figure 5.2: YJACK bidirectional pile test result – G-21(5)

5.3.2 Comparison with MLT Result

For comparison purpose, MLTs using kentledge were carried out after the YJACK tests. The comparisons between the MLT and interpreted YJACK test results are shown in Figure 5.3 and Figure 5.4. To note, the conversion of YJACK test results from Section 5.3.1 to Section 5.3.2 is not demonstrated and detailed in the validation report submitted by the Applicant.

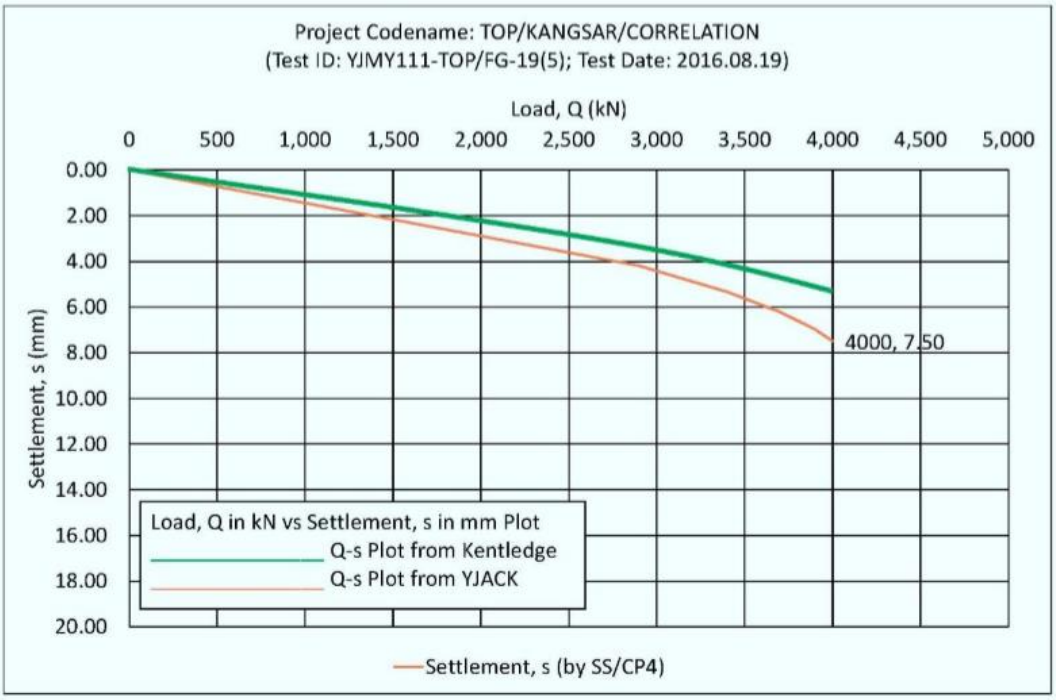


Figure 5.3: Comparison between MLT result and interpreted YJACK test result – FG-19(5)

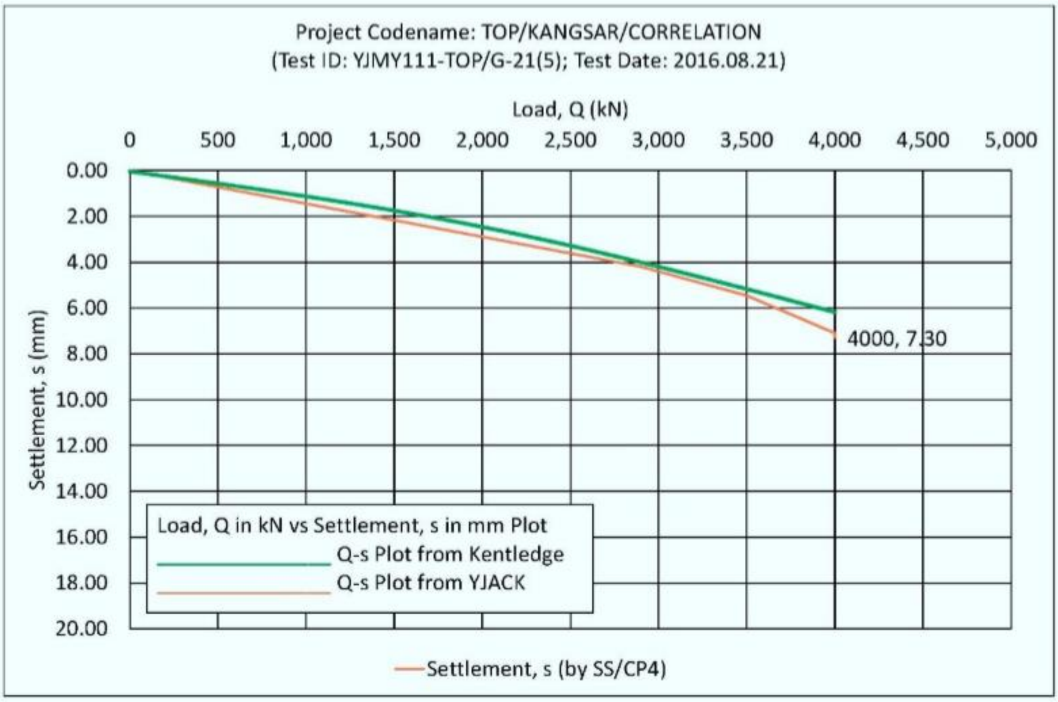


Figure 5.4: Comparison between MLT result and interpreted YJACK test result – G-21(5)

5.4 Validation Test of YJACK Bi-directional Pile Load Test – A Case Study in Muar

Four YJACK validation correlation tests were performed at a project site in Muar, from 10th to 12th October 2015.

5.4.1 YJACK Test Result

YJACK test results measured at site are shown in Figure 5.5 to Figure 5.8 (see Appendix E):

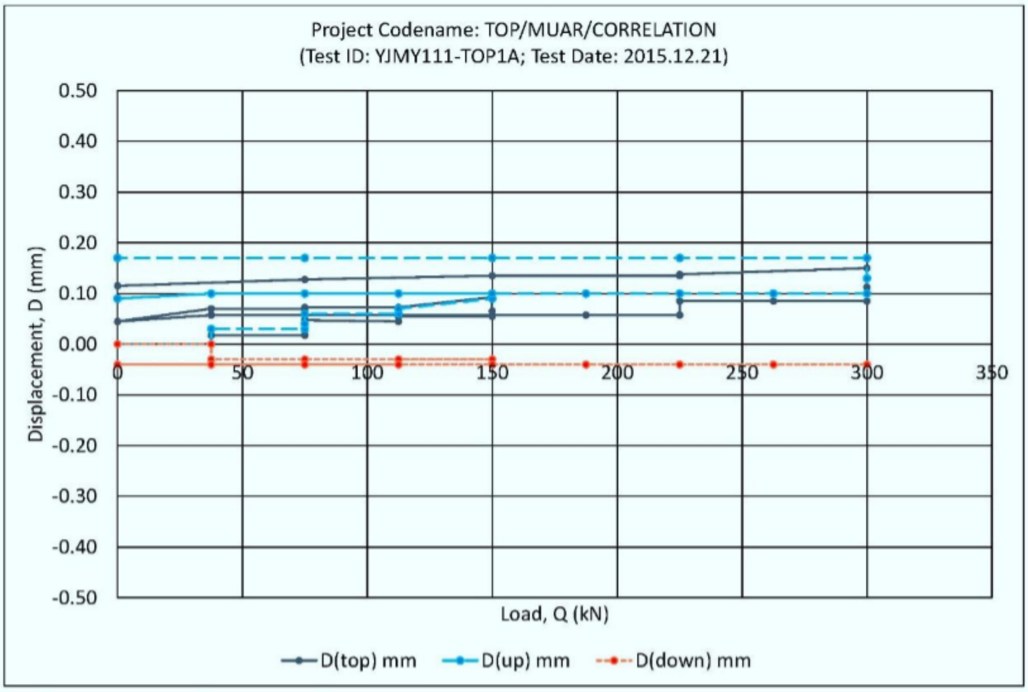


Figure 5.5: YJACK bidirectional test result – TOP1A

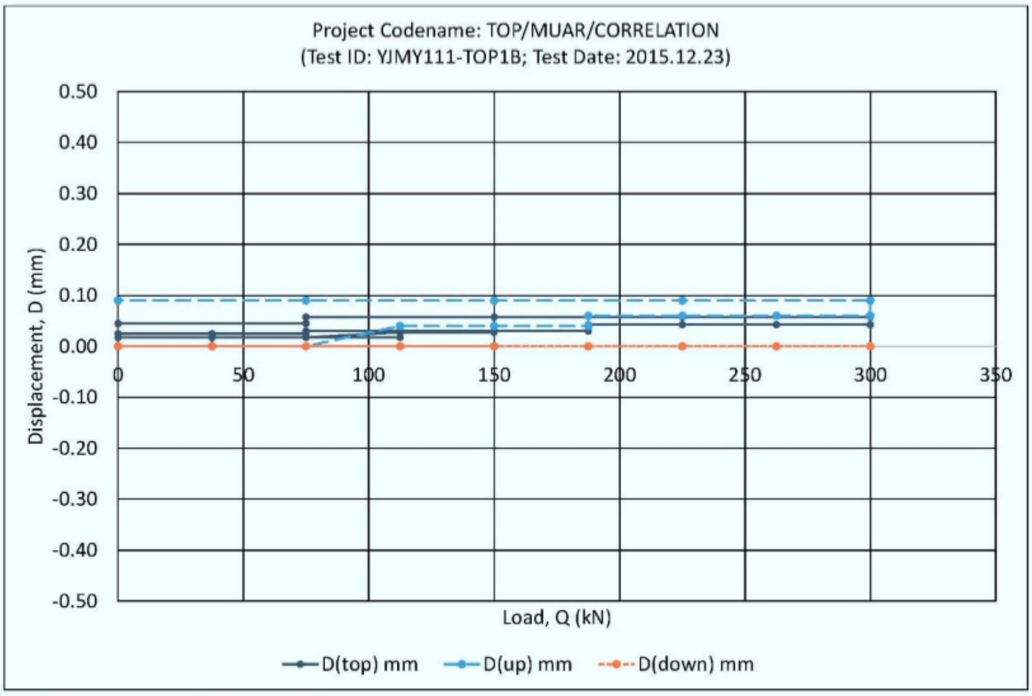


Figure 5.6: YJACK bidirectional test result – TOP1B

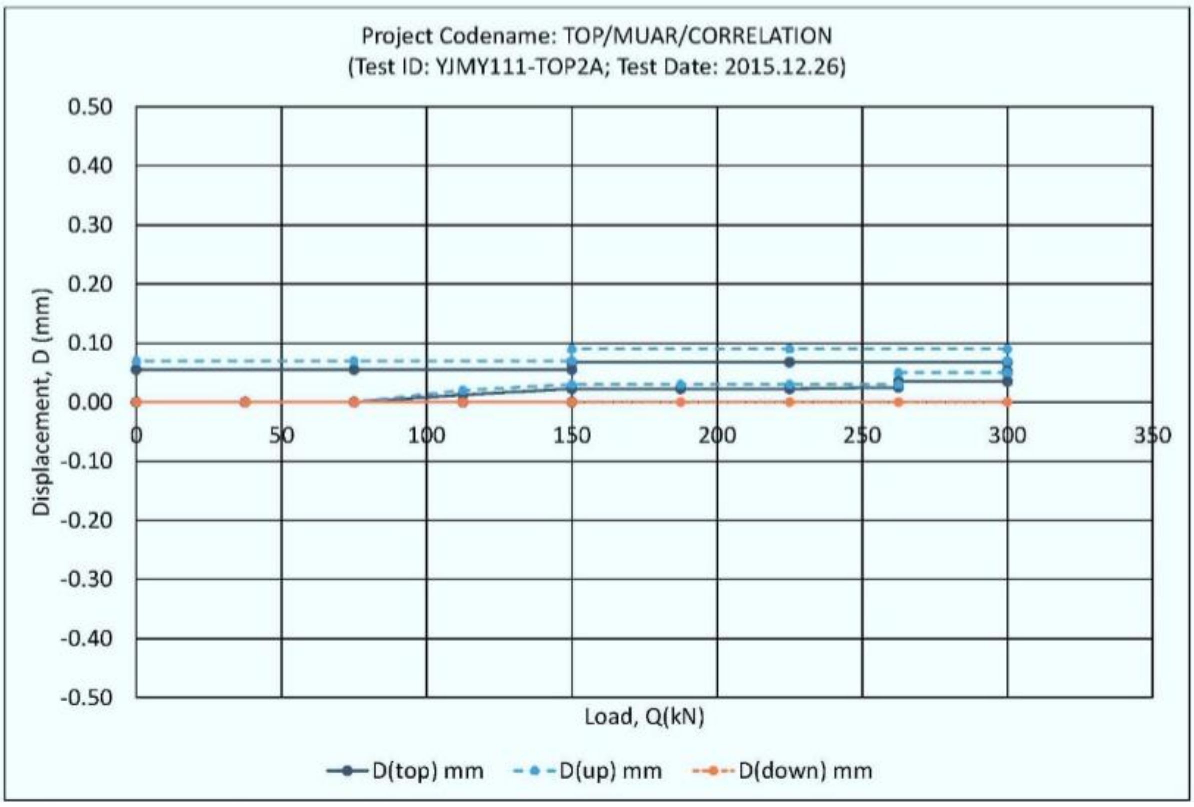


Figure 5.7: YJACK bidirectional test result – TOP2A

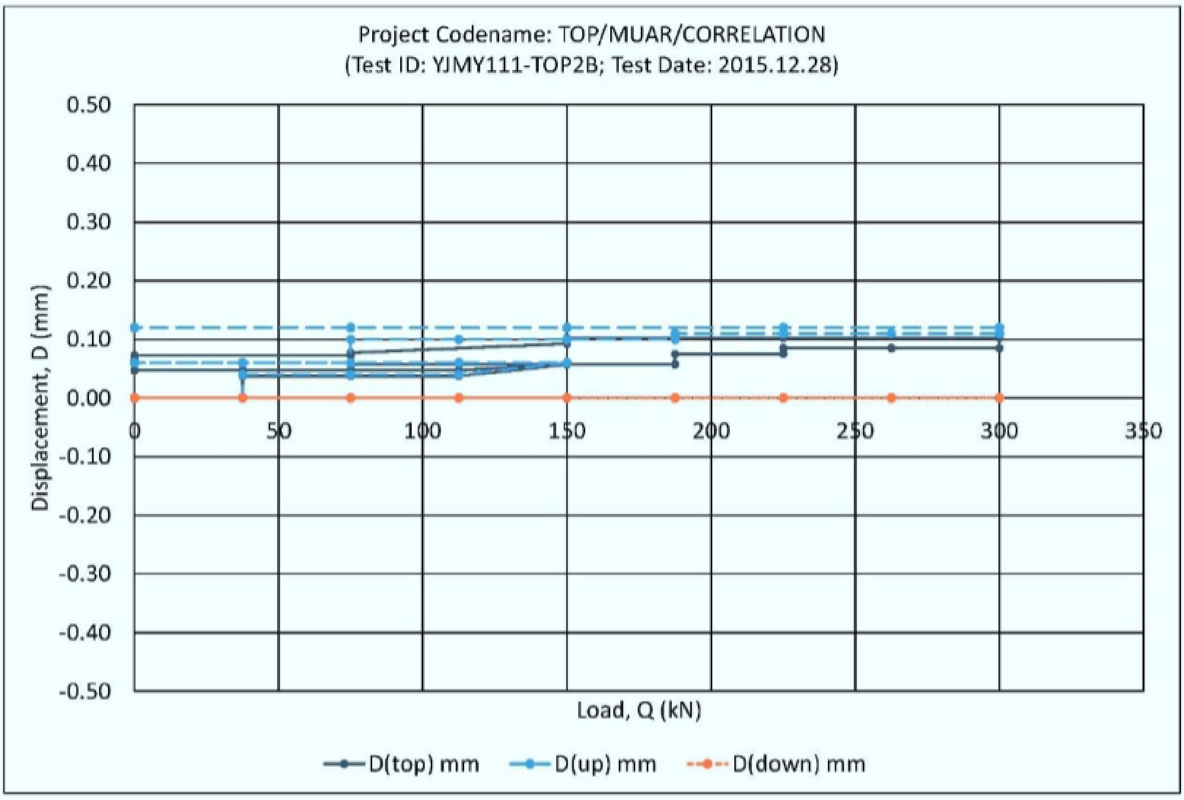


Figure 5.8: YJACK bidirectional test result – TOP2B

5.4.2 Comparison with MLT Result

For comparison purpose, MLTs using kentledge were carried out after the YJACK tests. The comparisons between the MLT and interpreted YJACK test results are shown in Figure 5.9 to Figure 5.12. To note, the conversion of YJACK test results from Section 5.4.1 to Section 5.4.2 is not demonstrated and detailed in the validation report submitted by the Applicant.

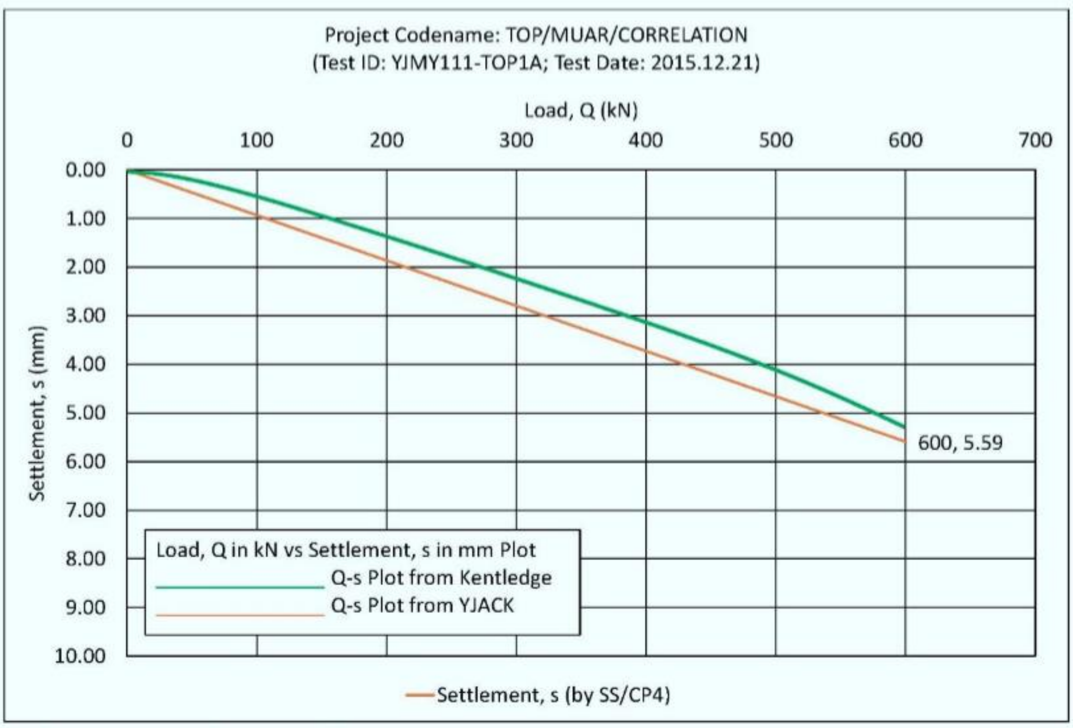


Figure 5.9: Comparison between MLT result and interpreted YJACK test result – TOP1A

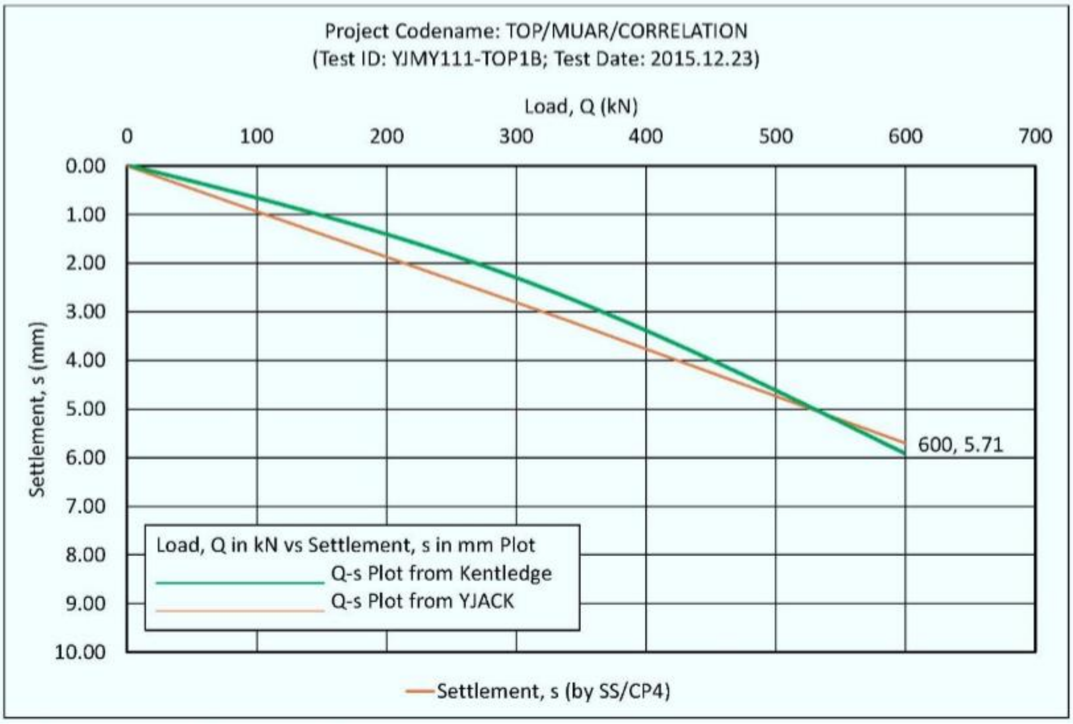


Figure 5.10: Comparison between MLT result and interpreted YJACK test result – TOP1B

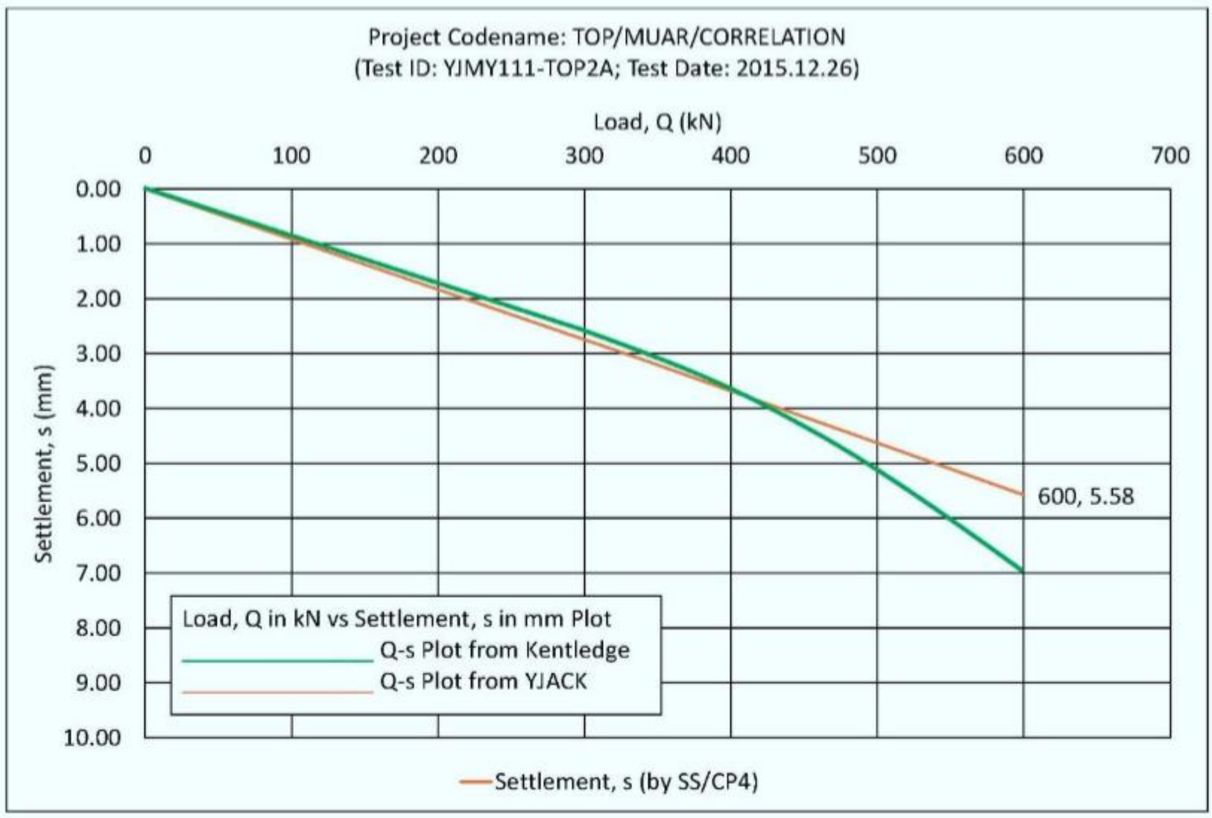


Figure 5.11: Comparison between MLT result and interpreted YJACK test result – TOP2A

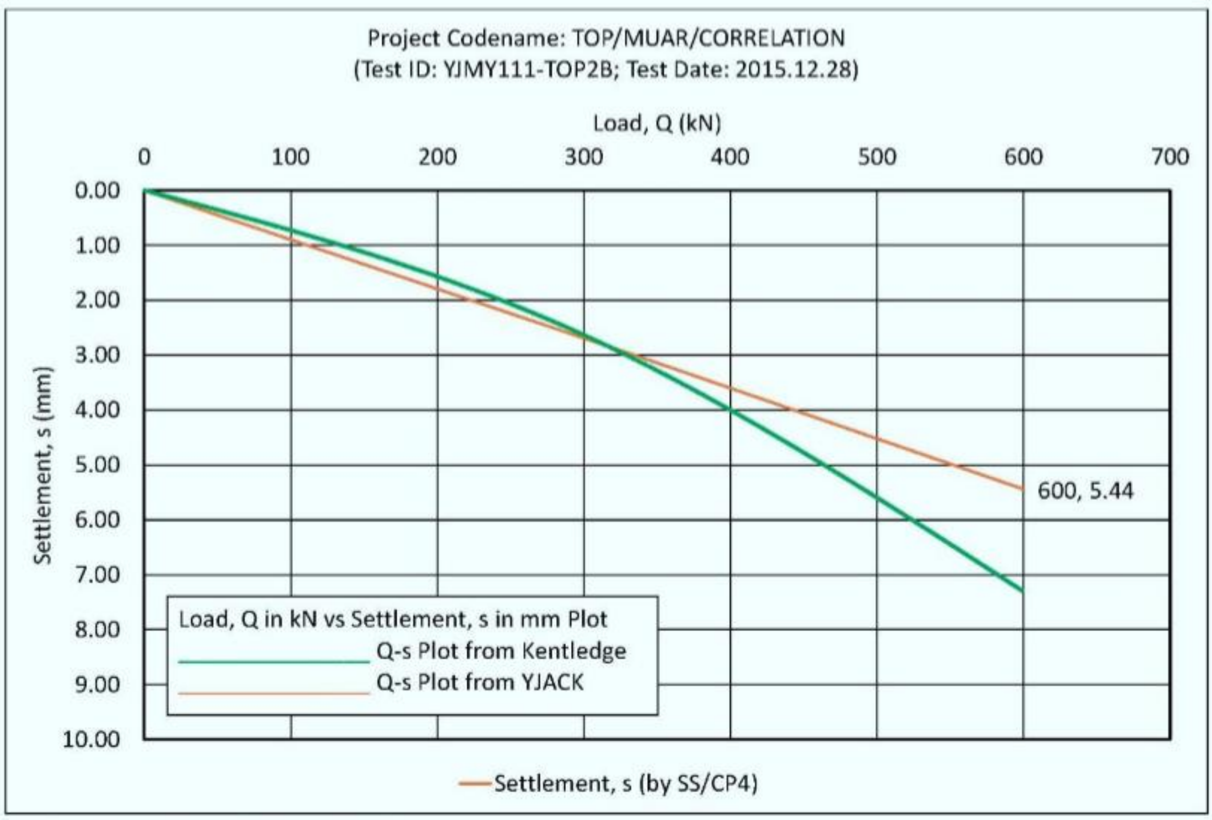


Figure 5.12: Comparison between MLT result and interpreted YJACK test result – TOP2B

6.0 QUALITY ASSURANCE / QUALITY CONTROL

6.1 QA/QC Plan

The information on QA/QC is not available at the time of writing this report. Users may contact the Applicant for further details on QA/QC.

7.0 VALIDITY OF OPINION

7.1 Condition

The Technical Opinion Report given herein is based on several rounds of discussion with the Applicant together with documents and product information made available by the Applicant to the Technical Expert Panel.

This Technical Opinion report is valid for the product specification submitted for evaluation by YJACK Technology Sdn. Bhd. It is the responsibility of the Applicant to notify CIDB of any changes in the product specification mentioned in this report.

7.2 Recommendations from Technical Expert Panel

In the opinion of the Technical Expert Panel, the product has a potential to be used in the local construction industry. However, more justifications are required for the validation test report submitted by the Applicant.

To the Technical Expert Panel's point of view, there are some uncertainties with regard to the validation test reports submitted by the Applicant, in particular:

i. The procedures in taking measurements;
ii. The interpretation of YJACK test results;
iii. The theoretical background of the interpretations

7.3 Term of Validity

This Technical Opinion Report shall become invalid and irrelevant in the event the product does not comply with relevant International Standards or any approved equivalent Standards currently in use. CIDB has the right to publicly announce any withdrawal related to this report subject to the terms above. This report is valid for three (3) years from the date of issuance.

8.0 APPROVED OPINION ABSTRACT

The Technical Expert Panel concludes that this product has a potential to be used in Malaysian construction industry. However, further research and development of the product performance in the local environment are encouraged.

Dr. Foo Chee Hung
Chairman
Technical Expert Panel

Ir. Dr. Chan Swee Huat
Technical Expert Panel

HM Dr.Abdul Aziz KM Hanifah
Technical Expert Panel

Prof.Dr. Mohd. Raihan Taha
Technical Expert Panel

Ir. Som Pong Pichan
Technical Expert Panel

Company Overview

YJACK Technology is the world's leading pile test specialist with 25 years' experience. YJACK Technology is the only few worldwide companies competently to test 10 types of pile test methods (static, dynamic, imaging) especially for the new invented pile test method using YJACK bi-directional pile test.

Products & Services

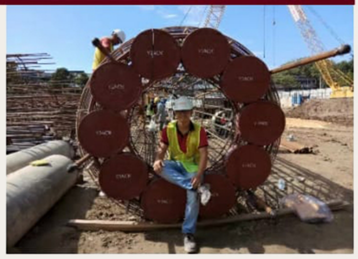
Main Pile Testing: YJACK Pile Testing using bi-directional method on bored piles (Type B) and concrete piles (Type C). General Pile Testing: Dynamic Pile Testing such as high strain HS/PDA, low strain LS/PIT and sonic logging US/CSL

YJACK Pile Testing: Type B for Bored Piles

Bored Pile BP600Ø

Bored Pile BP1200Ø

Bored Pile BP1500Ø



Bored Pile BP2400Ø

End Bearing BP900Ø

Bored Pile BP2200Ø

Bored Pile BP1200Ø

Bored Pile BP1500Ø

YJACK Pile Testing: Type C for Concrete Piles

Driven Pile RC175□

Spun Pile SC300Ø

Driven Pile RC400□

End Bearing SC600Ø

End Bearing SC250Ø

Injection Pile SC300Ø

Driven Pile SC600Ø

Driven Pile SC600Ø

Dynamic Pile Testing

(1) High-Strain Pile Load Test (to determine pile load capacity and pile integrity) [HS]
(2) Low-Strain Pile Integrity Test (to determine pile integrity on bored and concrete piles) [LS]
(3) Ultra-Sonic Pile Integrity Test (to determine pile integrity on bored piles, also diaphragm walls) [US]
(4) Hole-Profiling using Ultra-Sonic Imaging (to determine bored pile inner hole in 2D or 3D images) [HP]

Think YJACK. Think Pile Test.

REPORT # 1

YJACK VALIDATION TEST PROGRAM

STRUCTURAL LABORATORY TESTS

Prepared for:

YJACK TECHNOLOGY SDN BHD

Prepared by:

Issued Date:

2017 APR 01

Table of Contents

BENDING AND COMPRESSION TEST IN LABORATORY

Research Background

YJACK Technology is the world's leading pile test specialist with 25 year experiences. YJACK Technology is the only few worldwide companies competently to test 10 types of pile test methods (static, dynamic, imaging) especially for the new invented pile test using YJACK, the bi-directional pile test – a static pile load test method. It is an alternative and economical method to conventional maintained load test using Kentledge blocks or reaction piles methods.

This invention is by far the best compared to conventional method. The YJACK solves problems by:

a. cost saving;
b. time saving (from 10 days to 1 day in preparation);
c. eco-friendly green and safe;
d. suitable for all types of piles as well as offshore piles using autoYJACK.

[refer to Appendix A: A Glance of YJACK Brochure for details, www.YJACKpiletest.com]

There are four (4) types of YJACK series in design, i.e.:

(1) YJACK Type C for driven closed ended piles (+ H-piles), International World Patented
(2) YJACK Type O for driven open ended piles (+ offshore), International World Patented
(3) YJACK Type B for cast in-situ bored piles, application since 1980; and
(4) YJACK Type M for cast in-situ API-micro piles, application since 2014

The YJACK Type C and O are newly world patented technology in 2014, to conduct bi-directional pile load test on driven piles (and injection piles). Due to new technology, laboratory structural tests shall be conducted to ascertain the capabilities and performances of the YJACKs to function like a normal pile body during the pile installations.

Test Objectives

The YJACK is a component to be connected in spliced joint (in between to pile sections) which will be installed by pile driving hammer like a normal pile driving pile in to the ground.

In pile driving industry, assumed majority of 95% of the driven pile are land piling with closed ended design, hence YJACK Type C is selected to subject indoor laboratory compression and bending tests to comply the local Malaysian Standard for Precast Concrete Piles: MS/1314 (2004) and JKR Standard Specifications for Building Works: JKR/20800-0183 (2014).

The validation objectives are to ascertain:

- The YJACK is stronger than the land piling concrete piles in terms of compressive strength
- The YJACK is stronger than the land piling concrete piles in terms of bending strength
- The YJACK is stronger than the land piling concrete piles in terms of pile joint strength

Test Introduction

Pile sizes 300 and 400 mm diameter Spun Concrete, Grade 80, Class B piles were selected and subjected to compression and bending tests. The testing was carried out at the Heavy Structures Lab, Faculty of Civil Engineering, Universiti Teknologi MARA (University Technology MARA, UiTM), Shah Alam, Malaysia.

For compression tests, pile body SC300Ø (spun concrete pile body with 300mm diameter) were tested. The same compression tests were also carried out for pile connector YJ300Ø (YJACK, as pile connector to be connected at the pile joint).

Due to limitation of the laboratory facilities (in Malaysia) that unable to test high loading capacity, compression tests on SC400Ø and YJ400Ø were aborted, but the test replaced by the finite element modeling (FEM) analysis, and the results are presented in Test Report # 2.

[refer to Appendix B1: AutoCAD Drawings for Compression Test for details]

For bending tests, four (4) specimens were tested; 1st pair with pile size SC300Ø and YJ300Ø; 2nd pair with pile size SC400Ø and YJ400Ø. All piles were 6.0 m long. The test bending was conducted in accordance to Malaysian Standard for Precast Concrete Piles: MS/1314 (2004) and JKR Standard Specifications for Building Works: JKR/20800-0183 (2014).

[refer to Appendix B2: AutoCAD Drawings for Bending Test for details]

The piles (body) were manufactured by Industrial Concrete Product (ICP), with following material design:

- pile type: spun concrete (pile production by spinning process)
- pile design: Grade 80, Class B

The YJACK pile connectors were designed, fabricated and supplied by YJACK Technology Sdn Bhd. The steel plates material used are mile steel Grade 43.

The following sections will illustrate the laboratory test setups and test results.

Test Setup

Compression Test

The objective of the testing was to ensure that the compression capacity of the connectors is higher than the body of the piles.

Both piles and connectors were compression loaded using 2,000kN Universal Testing Machine (UTM). The schematic diagram of the test is illustrated in Figure 1(a). The specimen or sample length is 250mm.

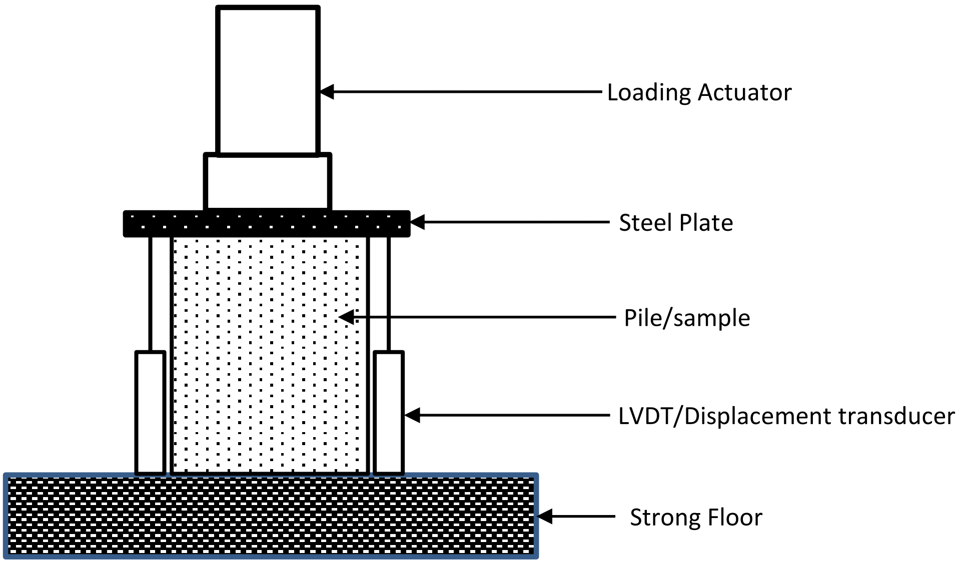


Figure 1(a)
Experimental Setup for Compression Test.

Prior to the compression tests, specimens were loaded up to 5kN and unloaded. This loading and unloading were repeated for five (5) times. This is to ensure that the specimens are completely sitting firmly in the test setup and to remove the initial softening material that is present prior to any structural testing. These load cycles are generally not considered as part of the tests. The specimens were then subjected to compression loading up to failure. Two (2) linear variable displacement transducers (LVDTs) were used to measure the vertical displacement of the specimens.

Figure 1(b) and Figure 1(c) show the pile body and pile connector (i.e. YJACK) respectively, mounted on the UTM machine prior to compression tests.

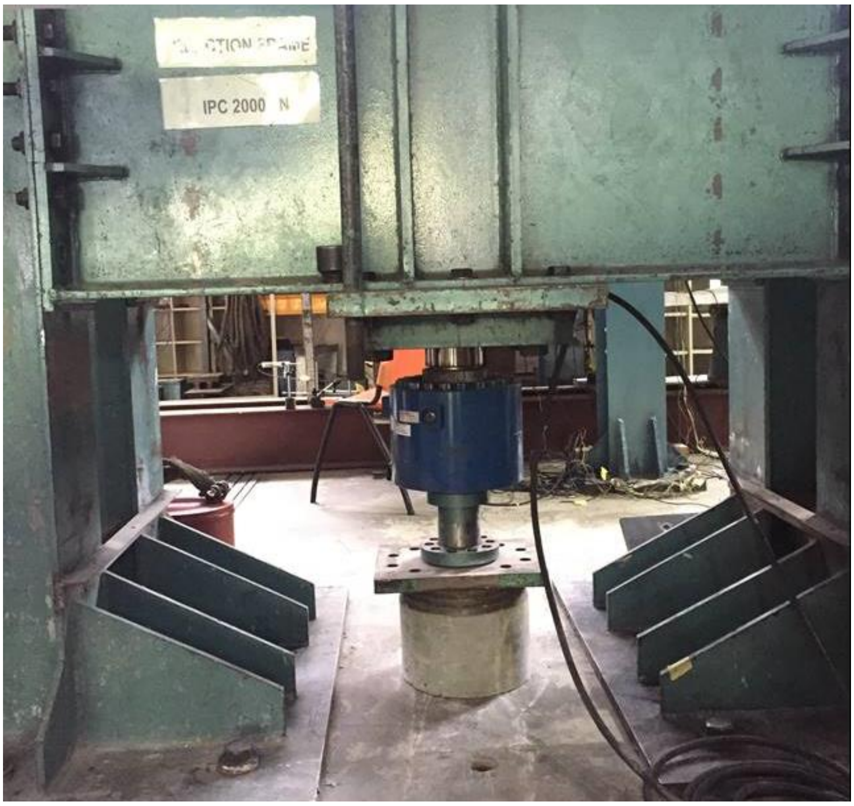


Figure 1(b)
Pile Body mounted on the UTM Machine prior to Compression Test

Figure 1(c)
Pile Connector mounted on the UTM Machine prior to Compression Test

Bending Test

The specimens were tested in 4 points bending in accordance to the specification given in Malaysian Standard for Precast Concrete Piles: MS/1314 (2004) and JKR Standard Specifications for Building Works: JKR/20800-0183 (2014).

Figure 2(a) shows the bending test setup. The 2 load points were at 1.2m apart and the reactions were at 3.6m apart.

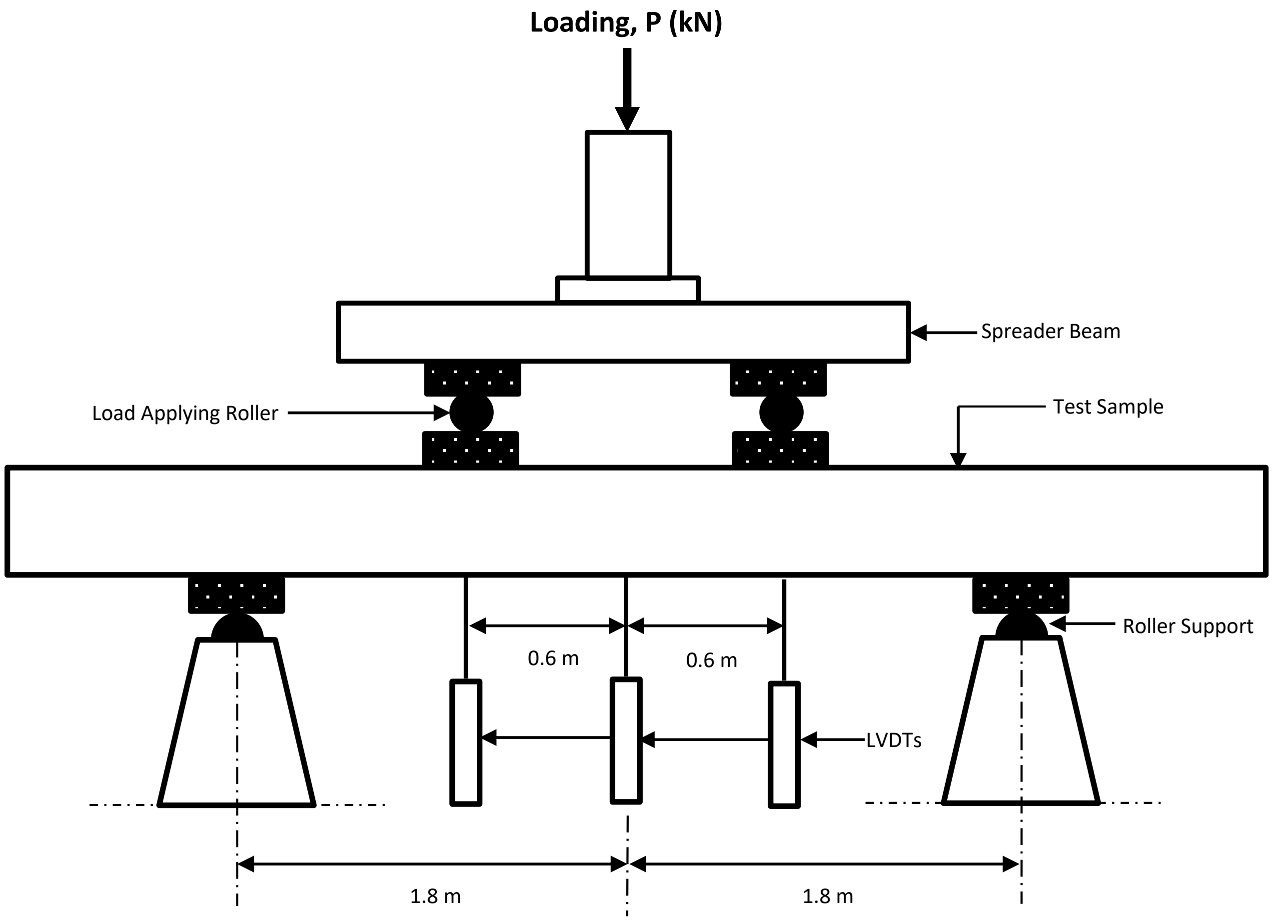


Figure 2(a)
Experimental Setup for Bending Test.

Figure 2B and Figure 2C show the pile body and connected pile (with pile connector) respectively, mounted on the roller supports prior to bending test.

Figure 2(b)
Pile Body mounted on the Roller Supports prior to Bending Test.

Figure 2(c)
YJACK Connected to Pile mounted on the Roller Supports prior to Bending Test.

Similar to the compression tests, specimens were loaded up to 5kN and unloaded for five (5) times to eliminate setting errors. The piles were then subjected to the failure load (P_{max}). During testing, close observations were made at cracking load, (P_c) and at minimum ultimate load (P_{min-u}). The crack width was measured using optical crack meter. In accordance to the standard, the (P_{max}) should not be less than (P_{min-u}).

The cracking load, P_c can be calculated from:

$$M_c = \frac{1}{40}WL + \frac{P_c}{4}\left(\frac{3L}{5} - 1\right)$$

where:

M_c is the applied bending moment (kNm)

W is the weight of the pile (kN)

L is the length of the pile (m)

Pc is the applied load with minimum crack width observed (kN)

$P_{(min-u)}$ is the minimum bending strength obtained by multiplying Mc by factor "*f*"

f is the Mc multiplying factor stated in MS1314 or determined by pile manufacturer

For pile type Spun Concrete, Grade 80, Class B:

- minimum crack width = 0.05 mm (Table C3 in JKR Specifications 2014)

Test Criteria

Compression Test

The ultimate load for compression tests for YJACK (the pile connector) shall be higher than the pile (body) with the following test criteria:

ICP SC Grade 80, Class B Pile Body*	Axial Working Load (kN)	Ultimate Compression Load (kN)
Spun Concrete SC300Ø	844 (= 86tn)	1,688 (=2X Working Load)
Spun Concrete SC400Ø	1501 (= 153tn)	3,002 (= 2X Working Load)

Manufactured by Industries Concrete Products (ICP), Spun Concrete, Grade 80, Class B

[refer to Appendix C: ICP Spun Concrete Pile Catalog for details]

Bending Test

The ultimate load for bending tests for YJACK (the pile connector) shall be higher than the pile (body) with the following test criteria:

ICP SC Grade 80, Class B Pile Body*	Crack Moment, Mc (kNm)	Equivalent Crack Load, Pc (kN)
Spun Concrete SC300Ø	23	34 (use L = 6m specimen)
Spun Concrete SC400Ø	54	80 (use L = 6m specimen)

Manufactured by Industries Concrete Products (ICP), Spun Concrete, Grade 80, Class B

[refer to Appendix C: ICP Spun Concrete Pile Catalog for details]

Joint Test

The strength of the joint shall be 10% higher than the bending test results.

Test Results

Compression Test

Figure 3(a) shows the load versus displacement (average value) for the SC300Ø. The ultimate load for the pile was found to be 1,588kN, which is slightly less than ultimate structural capacity as stated in the pile manufacturer catalog (2 x 844 = 1,688kN).

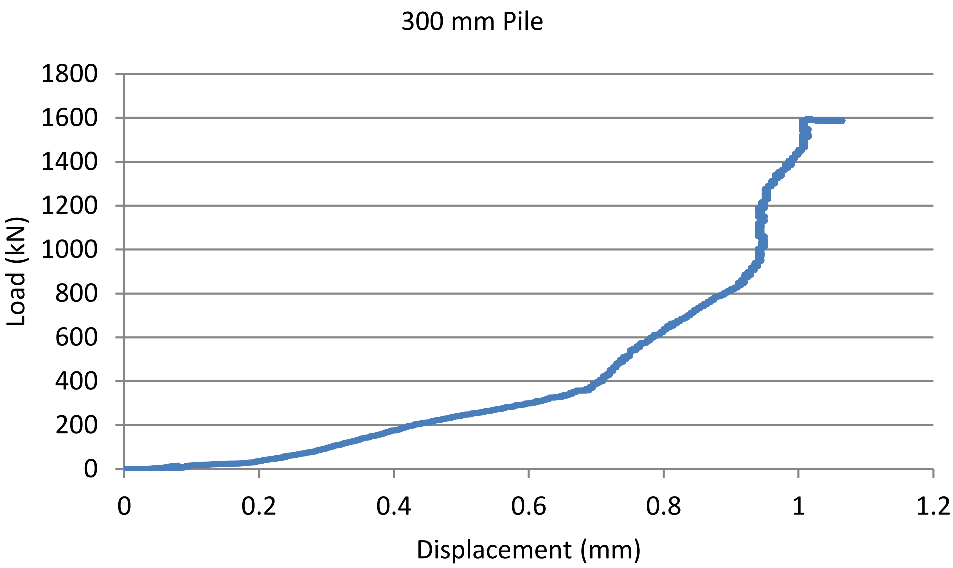


Figure 3(a)
Load-Displacement relationship for SC300Ø (300mm diameter spun pile body)
(Note: The graph is not a stress-strain plot, it is a normal compression load test plot)

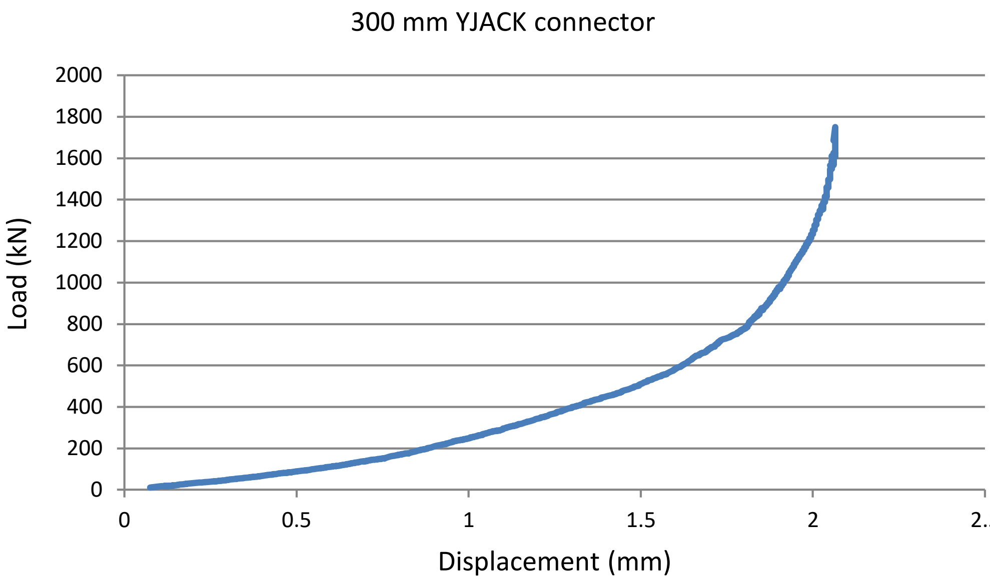


Figure 3(b)
Load-Displacement relationship for YJ300Ø (300mm diameter YJACK connector)
(Note: The graph is not 1 stress-strain plot, it is a normal compression load test plot)

Figure 3(b) shows the load versus displacement (average value) for the YJ300Ø. The ultimate load for the connector was found to be higher than 1,750kN. However, due to the limitation of the UiTM machine capacity, the testing was terminated. It should be noted that at this maximum load point, the specimen was observed to be intact and structurally sound.

The summary of the compression test results is tabulated in Table 1.

Table 1
Test Results for Ultimate Compression Load for Pile Body and YJACK Connector

Specimens	Technical Data Published by ICP Piles	Experimental Test Results
	Ultimate Compression Load (kN)	Ultimate Compression Load (kN)
SC300Ø (Spun Pile Body)	1,688	1,588*
YJ300Ø (YJACK Connector)	N/A	1,750 (3.7%)
SC400Ø (Spun Pile Body)	3,002	Not tested due to lab limitations (performed by FEM analysis)
YJ400Ø (YJACK Connector)	N/A	

* The test result is slightly lower to the technical data published in the catalog.
() The values in the bracket denote the variances of the experimental results

The percentage variance will be computed based on the following expression:

%variance = (#experimental data - #published data) / #published data * 100%

<u>Compression Test Summary</u>

From the test results, it is confirmed that the capacity of the YJ300Ø connector is 3.7% higher than the SC300Ø pile body. Hence, the YJACK connector satisfies the compressive load requirement, i.e. the ultimate compressive load for the connector is higher than the ultimate compressive load for the pile body.

Due to limitation of the laboratory facilities (in Malaysia) that unable to test high loading capacity, compression tests on SC400Ø and YJ400Ø were aborted, but the test replaced by the finite element modeling (FEM) analysis, as described in the FEM Sections in Report # 2.

Bending Test

SC300Ø (pile body)

Test result of load-displacement (to failure) for SC300Ø is shown in Figure 3(a); whilst Figure 3(b) shows the failure test mod for the specimen.

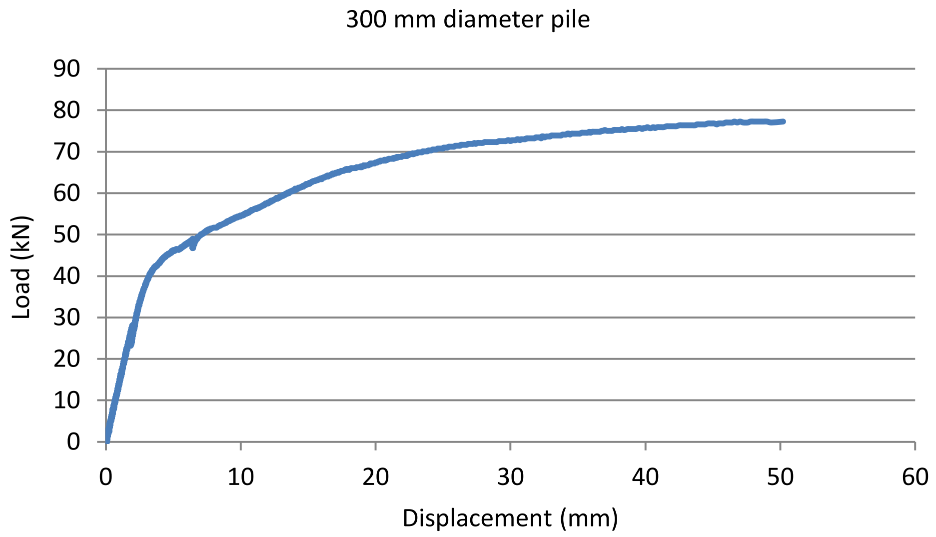


Figure 3(a)
Load-Displacement under Bending Test for SC300Ø (pile body)

Figure 3(b)
Failure Test Mod under Bending Test for SC300 Ø (pile body)

YJ300Ø (YJACK connector)

Test result of load-displacement (to failure) for YJ300Ø is shown in Figure 4(a); whilst Figure 4(b) shows the failure test mod for the specimen.

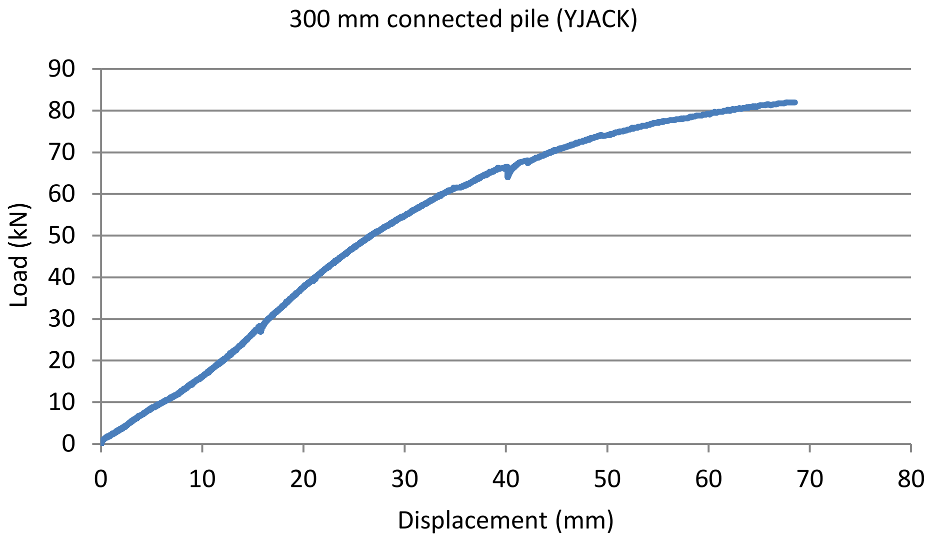


Figure 4(a)
Load-Displacement under Bending Test for YJ300Ø (YJACK Connector)

Figure 4(b)
Failure Test Mod under Bending Test for YJ300 Ø (YJACK Connector), failure occurred at concrete

SC400Ø (pile body)

Test result of load-displacement (to failure) for SC400Ø is shown in Figure 5(a); whilst Figure 5(b) shows the failure test mod for the specimen.

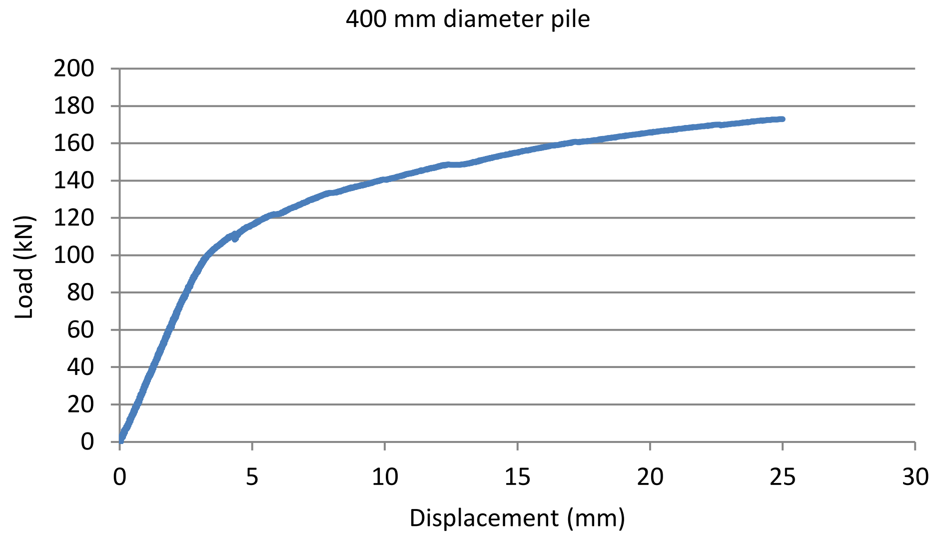


Figure 5(a)
Load-Displacement under Bending Test for SC400Ø (pile body)

Figure 5(b)
Failure Test Mod under Bending Test for SC400 Ø (pile body)

YJ400Ø (YJACK connector)

Test result of load-displacement (to failure) for YJ400Ø is shown in Figure 6(a); whilst Figure 6(b) shows the failure test mod for the specimen.

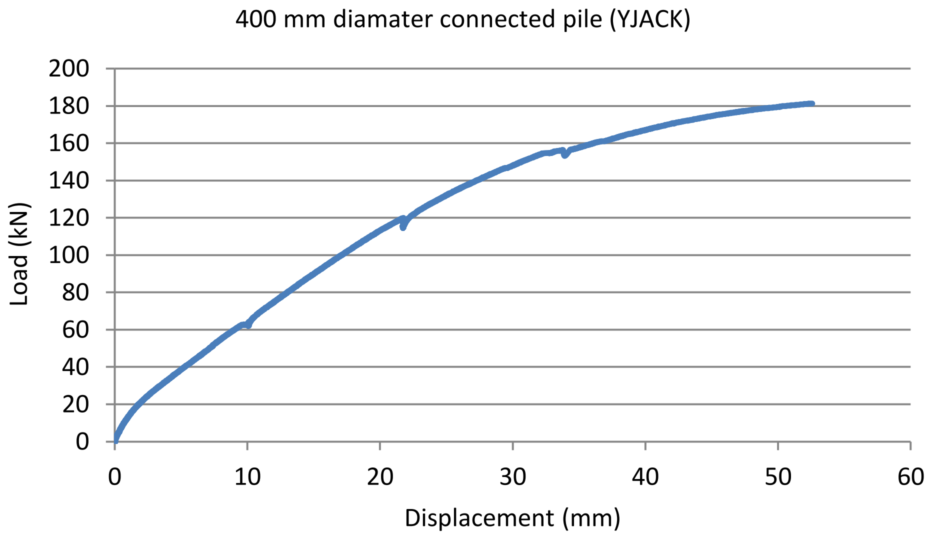


Figure 6(a)
Load-Displacement under Bending Test for YJ400Ø (YJACK Connector)

Figure 6(b)
Failure Test Mod under Bending Test for YJ400 Ø (YJACK Connector), failure occurred at concrete

The summary of the bending test results is tabulated in Table 2.

Table 2
Test Results for Ultimate Bending Load for Pile Body and YJACK Connector

Specimens	Technical Data Published by ICP Piles			Experimental Test Results	
	Crack Moment, M_c (kN)	Equivalent Crack Load, P_c (kN)	Ultimate Load, P_{max} (kN)	Crack Load, P_c (kN)	Ultimate Load, P_{max} (kN)
SC300Ø (Spun Pile Body)	23	34	61	41	77
YJ300Ø (YJACK Connector)	N/A	N/A	N/A	64 (88%)	81 (33%)
SC400Ø (Spun Pile Body)	54	80	140	107	172
YJ400Ø (YJACK Connector)	N/A	N/A	N/A	116 (45%)	181 (29%)

() The values in the bracket denote the variances of the experimental results

The percentage variance will be computed based on the following expression:

%variance = (#experimental data - #published data) / #published data * 100%

<u>Bending Test Summary</u>

All the experimental test results indicated that the pile bodies for SC300Ø and SC400Ø have greater values compared to the published data.

All the experimental test results indicated that the YJACK connectors for YJ300Ø and YJ400Ø have greater values compared to the pile bodies (either published or experimental data), and satisfies the pile bending requirements.

<u>Joint Test Summary</u>

The bending tests indicated all the experimental results have 10% greater values than the published data. Hence the YJACK connector satisfies the pile joint requirements.

Conclusion

SC300Ø and SC400Ø ICP piles with and without connector were subjected to compression and bending test. For piles tested to bending, close observation was made at cracking load, minimum ultimate load and failure load.

For pile under compression load, SC300Ø ICP pile was found failed at 1,588kN (compared to published data of 1,688kN).

YJ300Ø YJACK connecter was not tested up to the failure load (due to the limitations of the compressive machines), but it is confirmed that the ultimate load should be higher than the maximum test load of 1,750kN, and higher than the pile compressive strength.

Both SC300Ø and SC400Ø pile body and YJ300Ø and YJ400Ø pile with YJACK connector, under the bending tests, all experimental values for cracking and ultimate loads were found higher than both required by local standards and those published by pile manufacturer.

The bending tests indicated all the experimental results have 10% greater values than the published data. Hence the YJACK connector satisfies the pile joint requirements.

<u>Conclusion Summary</u>

YJ300Ø (YJACK connector):

- The YJACK is stronger than the land piling concrete piles in terms of compressive strength
- The YJACK is stronger than the land piling concrete piles in terms of bending strength
- The YJACK is stronger than the land piling concrete piles in terms of pile joint strength

YJ400Ø (YJACK connector):

- The YJACK is stronger than the land piling concrete piles in terms of compressive strength*
- The YJACK is stronger than the land piling concrete piles in terms of bending strength
- The YJACK is stronger than the land piling concrete piles in terms of pile joint strength

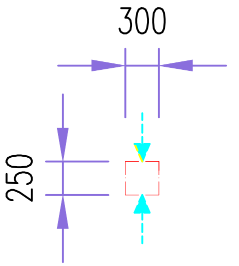
  (* refer to finite element modeling (FEM) analysis results presented in Test Report # 2)

References

1. BS-EN/12390-3 (2009): Testing Hardened Concrete for Compressive Strength
2. MS/1314 (2004): Malaysian Standard for Precast Concrete Piles
3. JKR/20800-0183 (2014): JKR Standard Specifications for Building Works
4. ICP/Catalog (2016): High Performance Pretension Spun Concrete Piles

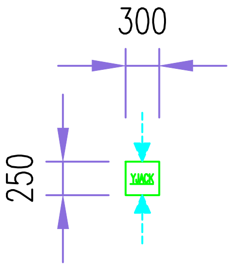
APPENDIX A

APPENDIX B



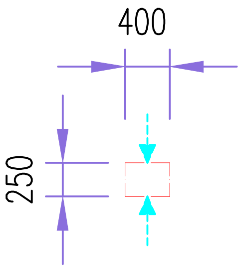
PILE MATERIAL : 300MM DIAM. SPUN PILE GRADE 80 CLASS B

TEST : COMPRESSION ON PILE MATERIAL



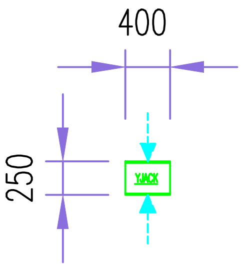
JACK MATERIAL : 400MM DIAM. MILD STEEL GRADE 43

TEST : COMPRESSION TEST ON YJACK MATERIAL



PILE MATERIAL : 400MM DIAM. SPUN PILE GRADE 80 CLASS B

TEST : COMPRESSION ON PILE MATERIAL



JACK MATERIAL : 400MM DIAM. MILD STEEL GRADE 43

TEST : COMPRESSION TEST ON YJACK MATERIAL

PROJECT TITLE:

FABRICATION AND DELIVERY OF YJACK 300MM & 400MM DIAMETER AND SPUN PILE 300MM & 400MM DIAMETER, FOR PURPOSE OF COMPRESSIVE AND BENDING LAB TEST TO COMPLY TO JKR SPECIFICATION 2014

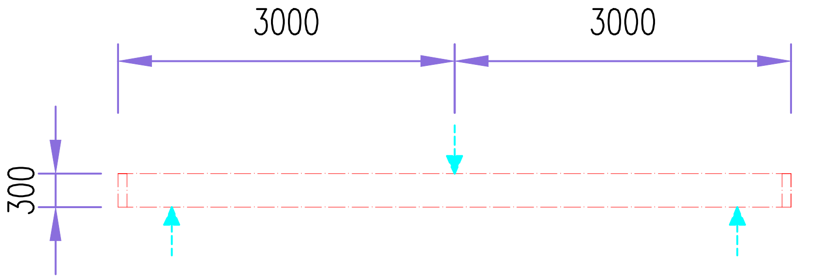
DATE	DESCRIPTION	REV.

DRAWING TITLE:

COMPRESSIVE TEST ON PILE MATERIAL VS. YJACK MATERIAL

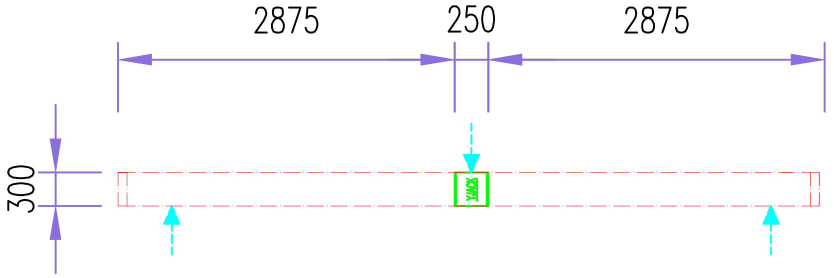
DRAWN BY: YAU KIM WEI	25 MAY 2016
CHECKED BY: WAI YEKONG	31 MAY 2016

REF: YJACK/2016/UTHM/02/REV.1



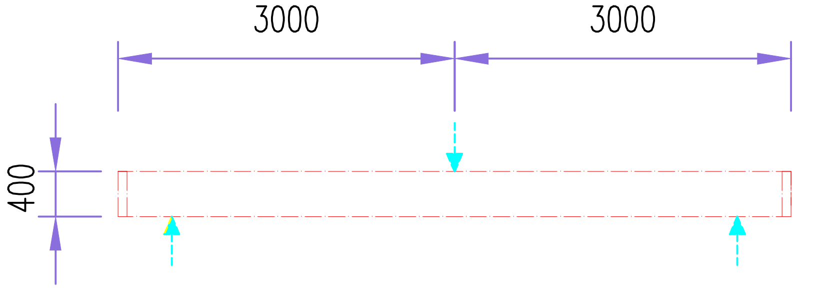
PILE MATERIAL : 300MM DIAM. SPUN PILE GRADE 80 CLASS B

TEST : BENDING TEST ON PILE MATERIAL



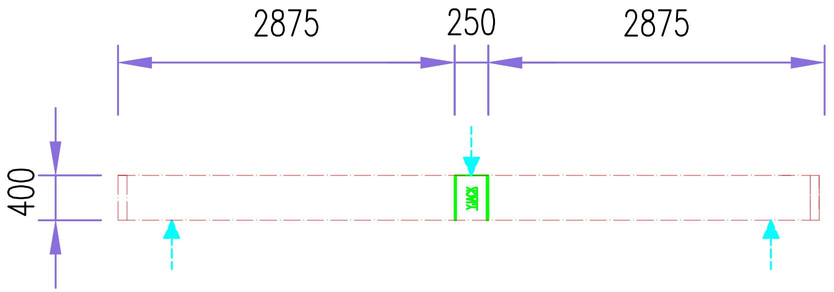
PILE MATERIAL : 300MM DIAM. SPUN PILE GRADE 80 CLASS B

TEST : BENDING TEST ON YJACK MATERIAL



PILE MATERIAL : 400MM DIAM. SPUN PILE GRADE 80 CLASS B

TEST : BENDING TEST ON PILE MATERIAL



PILE MATERIAL : 400MM DIAM. SPUN PILE GRADE 80 CLASS B

TEST : BENDING TEST ON YJACK MATERIAL

PROJECT TITLE:

FABRICATION AND DELIVERY OF YJACK 300MM & 400MM DIAMETER AND SPUN PILE 300MM & 400MM DIAMETER, FOR PURPOSE OF COMPRESSIVE AND BENDING LAB TEST TO COMPLY TO JKR SPECIFICATION 2014

DATE	DESCRIPTION	REV.

DRAWING TITLE:

BENDING TEST ON PILE MATERIAL VS. YJACK MATERIAL

DRAWN BY: YAU KIM WEI	25 MAY 2016
CHECKED BY: WAI YEKONG	31 MAY 2016

REF: YJACK/2016/UTHM/01/REV.1

APPENDIX C

ICP PILES

PROPERTIES OF ICP PILES

GRADE 80 PILES

CLASS A (EFFECTIVE PRESTRESS ≥ 4.0 N/mm²)

Nominal Diameter	Nominal Thickness	Length	Nominal Weight	Prestressing Bar 7.1mm	Prestressing Bar 9.0mm	Prestressing Bar 10.7mm	Area of Concrete	Section Modulus	Bending Moment Cracking	Bending Moment Ultimate	Recommended Max Structural Axial Working Load (For a short strut)	Effective Prestress
mm	mm	m	kg/m	no.	no.	no.	mm²	x1000 mm³	kNm	kNm	ton	N/mm²
300	60	6-12	118	6	-	-	45,239	2,373	21.3	34.8	87	4.9
350	60	6-12	142	8	-	-	54,664	3,533	32.9	54.1	104	5.3
400	65	6-12	178	8	-	-	68,408	5,106	42.7	61.8	132	4.3
450	70	6-12	217	10	-	-	83,566	7,113	60.4	86.9	161	4.5
500	80	6-12	274	12	-	-	105,558	9,888	82.3	115.9	204	4.3
600	90	6-12	375	-	12	-	144,199	16,586	148.8	222.5	276	5.0

CLASS B (EFFECTIVE PRESTRESS ≥ 5.0 N/mm²)

Nominal Diameter	Nominal Thickness	Length	Nominal Weight	Prestressing Bar 7.1mm	Prestressing Bar 9.0mm	Prestressing Bar 10.7mm	Area of Concrete	Section Modulus	Bending Moment Cracking	Bending Moment Ultimate	Recommended Max Structural Axial Working Load (For a short strut)	Effective Prestress
mm	mm	m	kg/m	no.	no.	no.	mm²	x1000 mm³	kNm	kNm	ton	N/mm²
250	55	6-12	88	6	-	-	33,694	1,435	14.9	29.0	63	6.4
300	60	6-12	118	7	-	-	45,239	2,383	22.9	40.6	86	5.6
350	70	6-12	160	9	-	-	61,575	3,778	35.6	60.8	117	5.4
400	80	6-15	209	12	-	-	80,425	5,643	53.7	92.7	153	5.5
450	80	6-15	242	-	8	-	92,991	7,624	70.0	111.2	177	5.2
500	90	6-15	301	-	10	-	115,925	10,518	95.9	154.5	221	5.1
600	100	6-15	408	-	14	-	157,080	17,546	163.1	259.6	299	5.3
700	110	6-18	530	-	20	-	203,889	27,131	265.1	432.6	386	5.8
800	120	6-18	667	-	24	-	256,354	39,455	376.8	593.3	487	5.5
900	130	6-18	818	-	28	-	314,473	54,942	510.3	778.7	599	5.3
1000	140	6-18	983	-	-	24	378,248	74,056	688.9	1042.8	720	5.3
1200	150	6-18	1286	-	-	36	494,801	120,188	1198.5	1877.1	934	6.0

CLASS C (EFFECTIVE PRESTRESS ≥ 7.0 N/mm²)

Nominal Diameter	Nominal Thickness	Length	Nominal Weight	Prestressing Bar 7.1mm	Prestressing Bar 9.0mm	Prestressing Bar 10.7mm	Prestressing Bar 12.6mm	Area of Concrete	Section Modulus	Bending Moment Cracking	Bending Moment Ultimate	Recommended Max Structural Axial Working Load (For a short strut)	Effective Prestress
mm	mm	m	kg/m	no.	no.	no.	no.	mm²	x1000 mm³	kNm	kNm	ton	N/mm²
250	55	6-12	88	7	-	-	-	33,694	1,443	16.2	33.8	63	7.2
300	60	6-12	118	10	-	-	-	45,239	2,416	28.0	57.9	84	7.6
350	70	6-15	160	-	8	-	-	61,575	3,826	43.0	86.5	114	7.2
400	80	6-15	209	-	12	-	-	80,425	5,748	69.7	148.3	147	8.1
450	80	6-15	242	-	12	-	-	92,991	7,734	86.9	166.9	173	7.2
500	90	6-18	301	-	15	-	-	115,925	10,670	120.3	231.7	215	7.3
600	100	6-30	408	-	-	14	-	157,080	17,761	196.4	365.0	292	7.0
700	110	6-46	530	-	-	20	-	203,889	27,498	320.6	608.3	376	7.6
800	120	6-46	667	-	-	24	-	256,354	39,966	454.7	834.3	475	7.4
900	130	6-46	818	-	-	28	-	314,473	55,622	617.7	1095.0	584	7.1
1000	140	6-46	983	-	-	36	-	378,248	75,188	864.5	1564.3	699	7.5
1200	150	6-36	1286	-	-	46	-	494,801	121,361	1378.6	2398.6	916	7.3
1000	140	6-46	983	-	-	-	34	378,248	76,247	961.1	2051.9	688	8.6
1200	150	6-36	1286	-	-	-	46	494,801	123,457	1583.1	3331.3	898	8.8

GRADE 90 PILES

CLASS A (EFFECTIVE PRESTRESS ≥ 4.0 N/mm²)

Nominal Diameter	Nominal Thickness	Length	Nominal Weight	Prestressing Bar 7.1mm	Prestressing Bar 9.0mm	Prestressing Bar 10.7mm	Area of Concrete	Section Modulus	Bending Moment Cracking	Bending Moment Ultimate	Recommended Max Structural Axial Working Load (For a short strut)	Effective Prestress
mm	mm	m	kg/m	no.	no.	no.	mm²	x1000 mm³	kNm	kNm	ton	N/mm²
300	60	6-12	118	6	-	-	45,239	2,373	21.9	34.8	98	4.9
350	60	6-12	142	8	-	-	54,664	3,533	33.8	54.1	118	5.3
400	65	6-12	178	8	-	-	68,408	5,106	43.9	61.8	149	4.3
450	70	6-12	217	10	-	-	83,566	7,113	62.2	86.9	182	4.5
500	80	6-12	274	12	-	-	105,558	9,888	84.8	115.9	231	4.3
600	90	6-12	375	-	12	-	144,199	16,586	152.9	222.5	313	5.0

CLASS B (EFFECTIVE PRESTRESS ≥ 5.0 N/mm²)

Nominal Diameter	Nominal Thickness	Length	Nominal Weight	Prestressing Bar 7.1mm	Prestressing Bar 9.0mm	Prestressing Bar 10.7mm	Area of Concrete	Section Modulus	Bending Moment Cracking	Bending Moment Ultimate	Recommended Max Structural Axial Working Load (For a short strut)	Effective Prestress
mm	mm	m	kg/m	no.	no.	no.	mm²	x1000 mm³	kNm	kNm	ton	N/mm²
250	55	6-12	88	6	-	-	33,694	1,435	15.3	29.0	72	6.4
300	60	6-12	118	7	-	-	45,239	2,383	23.5	40.6	97	5.6
350	70	6-12	160	9	-	-	61,575	3,778	36.5	60.8	133	5.4
400	80	6-15	209	12	-	-	80,425	5,643	55.0	92.7	173	5.5
450	80	6-15	242	-	8	-	92,991	7,624	71.9	111.2	201	5.2
500	90	6-15	301	-	10	-	115,925	10,518	98.5	154.5	251	5.1
600	100	6-15	408	-	14	-	157,080	17,546	167.3	259.6	339	5.3

(Subject to change without prior notice)

FORMULA FOR AXIAL LOAD

Based on BS 8004: 1986, the maximum allowable axial stress that may be applied to a pile acting as a short strut should be one quarter of (specified works cube strength at 28 days less the prestress after losses)

N = f_{ca} x A

= 1/4 (f_{cu} - f_{pe}) x A

Where, N = maximum allowable axial load

A = cross section area of concrete

f_{ca} = permissible compressive strength of concrete

f_{cu} = specified compressive strength of concrete

f_{pe} = effective prestress in concrete

REPORT 2

YJACK VALIDATION TEST PROGRAM

FINITE ELEMENT MODELING

Prepared for:

YJACK TECHNOLOGY SDN BHD

Prepared by:

Issue Date:

2017 APR 01

CONTENTS

SIMULATION AND FINITE ELEMENT ANALYSIS

FEM Objectives

Further to Test Report # 1, the objectives of the FEM are to ascertain:

- The YJACK is stronger than the land piling concrete piles in terms of compressive strength
- The YJACK is stronger than the land piling concrete piles in terms of bending strength

Compression Analysis

YJACK is a newly world patented jack specially designed for bi-directional (BD) static pile load test on driven piles (Patent #: PI2014000539). Professional YJACK adopts capsule sealing technology (Patent #: CN201694784U). That gives a more reasonable product value which avoids too wasteful long life of normal sacrificed test jacks. Meanwhile it offers lower height, larger loading area, lower oil pressure and safer loading results.

YJACK is designed to load low pressure (20-40MPa) onto pile body to ensure the pressure applied on the pile is less than the pile structural capacity (for concrete piles). YJACK comprises by two main components; the cylinder shell (red color) and piston shell (grey color). In this simulation, piston shell was selected to be analyzed up to 1,750kN of force and checked for the displacement and safety. This 1,750kN was the maximum applied load on the YJACK specimen as described in Test Report # 1.

Model Information

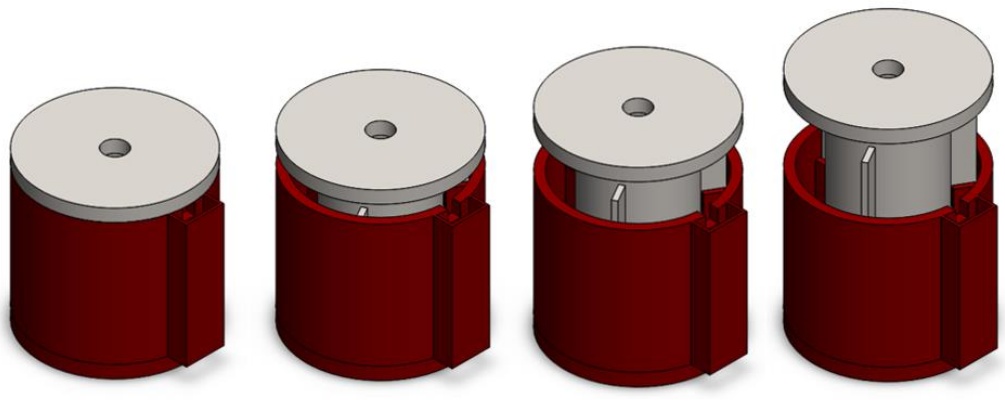


Figure 4: Part Modelling

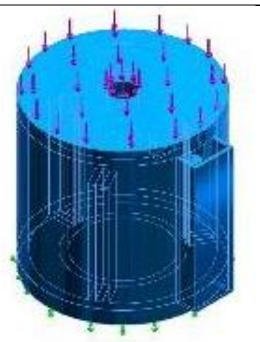
Study Properties

Analysis type	Static
Mesh type	Solid Mesh
Thermal Effect:	On
Thermal option	From thermal study
Zero strain temperature	298 K

Units

Unit system:	SI (MKS)
Length/Displacement	mm
Temperature	Kelvin
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

Material Properties

Model Reference	Properties
	Name: AISI 1020 Model type: Linear Elastic Isotropic Yield strength: $3.51571e^{+008}$ N/m^2 Tensile strength: $4.20507e^{+008}$ N/m^2 Elastic modulus: $2e^{+011}$ N/m^2 Poisson's ratio: 0.29 Mass density: 7900 kg/m^3 Shear modulus: $7.7e^{+010}$ N/m^2 Thermal expansion coefficient: $1.5e^{-005}$ /Kelvin

Fixture and Load

Fixture	Bottom plate
Load	Top plate
Load value [kN]	200, 400, 600, 800, 1000, 1200, 1400, 1600, 1750
Diameter [mm]	300, 400

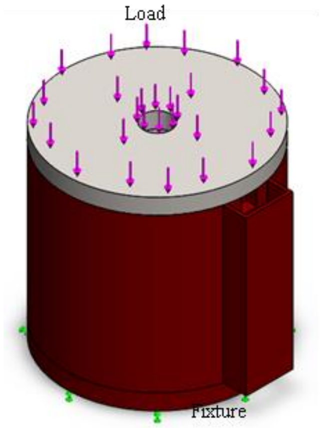


Figure 5: Fixture and load for compression analysis

Mesh Information - Details

Total Nodes	28971
Total Elements	15714
Maximum Aspect Ratio	155.22
% of elements with Aspect Ratio < 3	85.7
% of elements with Aspect Ratio > 10	0.7
% of distorted elements(Jacobian)	0

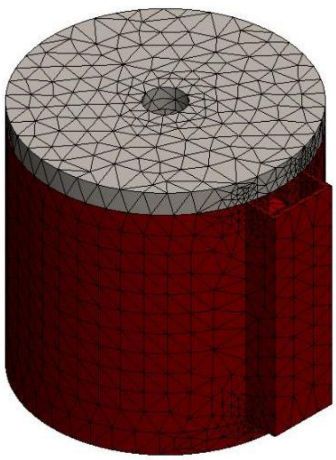


Figure 6: Meshed model for compression analysis

Study Results

Table 1 Static study analysis for 300 mm YJACK

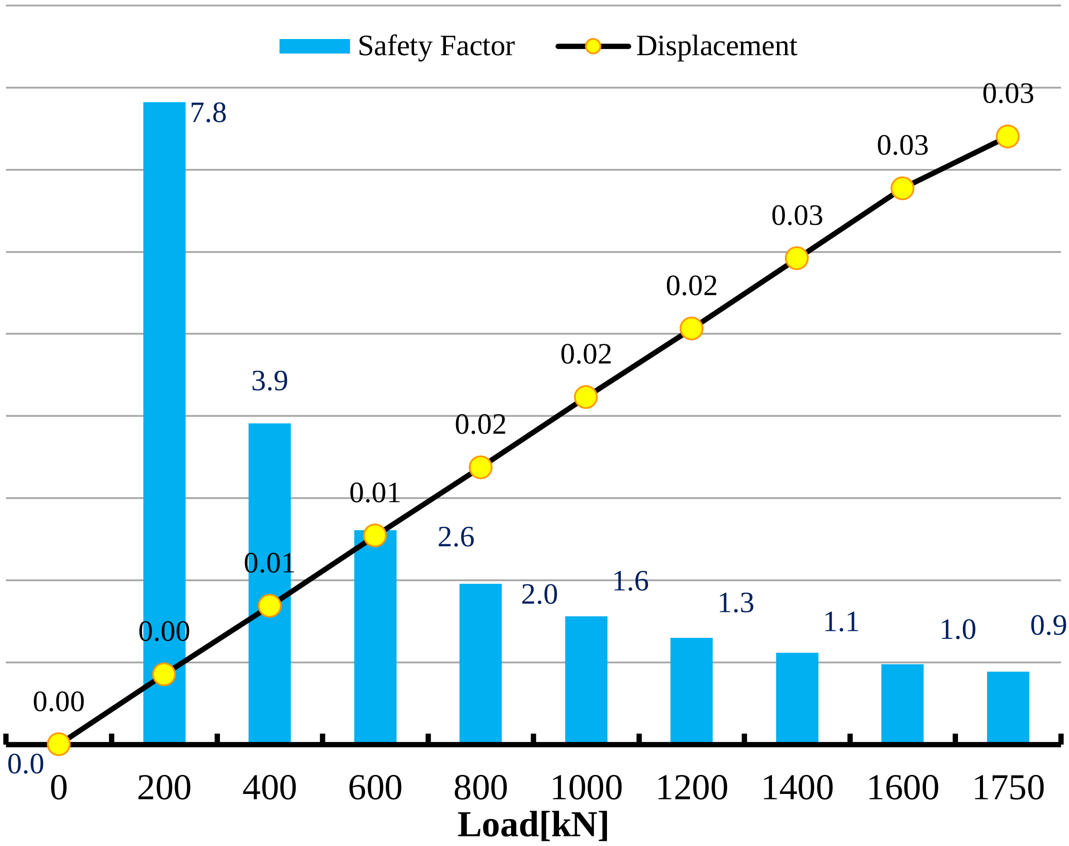
Force	kN	0	200	400	600	800	1000	1200	1400	1600	1750
Displacement	cm	0	0.0038	0.0075	0.0113	0.0150	0.0188	0.0225	0.0263	0.0301	0.0329
Stress	MPa	0	44.9	89.9	134.8	179.8	224.7	269.6	314.6	359.5	393.2
Minimum Factor of Safety		0	7.82	3.91	2.61	1.96	1.56	1.3	1.12	0.98	0.89

Table 2 Static study analysis for 400 mm YJACK

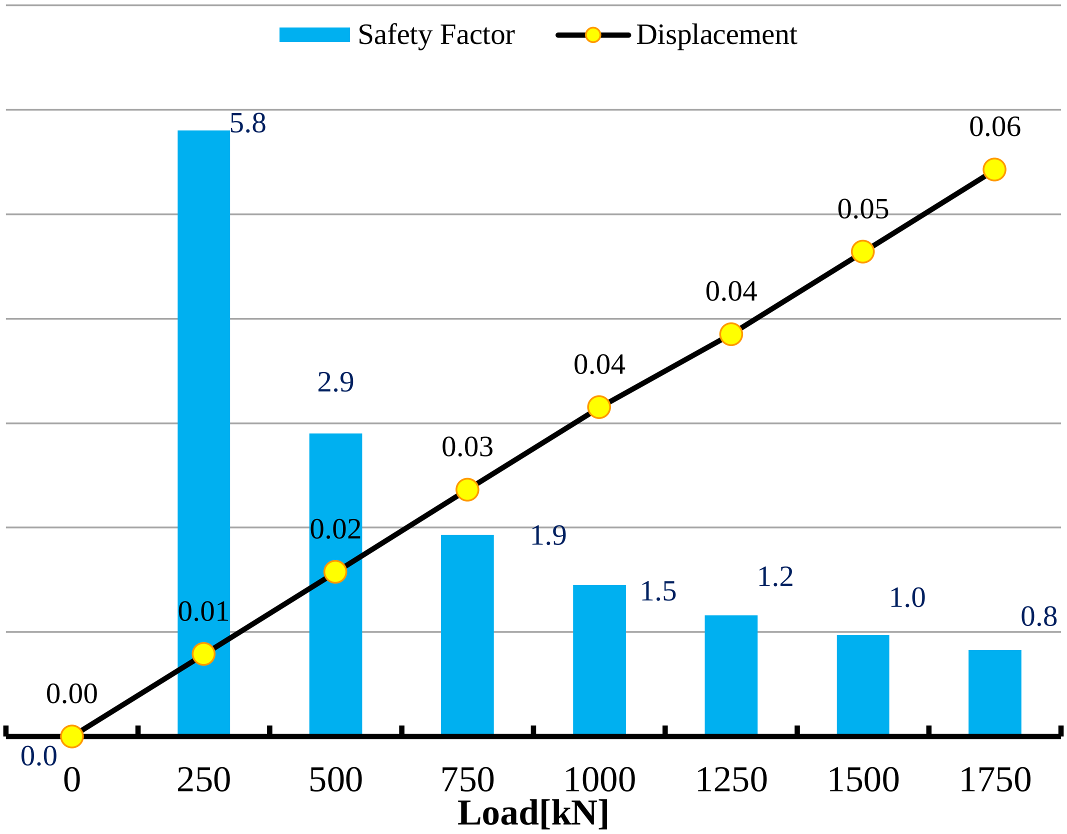
Force	kN	0	250	500	750	1000	1250	1500	1750
Displacement	cm	0	0.009	0.018	0.027	0.036	0.044	0.053	0.062
Stress	MPa	0	60.6	121.2	181.8	242.3	302.9	363.5	424.1
Minimum Factor of Safety		0	5.8	2.9	1.93	1.45	1.16	0.97	0.83

Table 1 and Table 2 show the results of the static study analysis for 300 mm and 400 mm YJACK respectively. Force increments for both cases had been intentionally differentiated to show the slight differences in the results for specified forces. The displacements were increased with the increasing force. Displacement for 400 mm when the force was 1,750 kN was about 1 times higher than that for 300 mm.

Plot for Displacement and Factor of Safety in the case of 300 mm and 400 mm YJACK are shown in Figure 7 (a) and (b) respectively. Factor of Safety indicates the ratio between the yield strength of the materials and allowable stress applied on the materials or the structure. Stress must be lower than the Yield Strength to ensure the safety of the structure. The standard factor of safety will be depended on the condition where the structure is used and typically ranging between 2 to 4 for normal condition and must not too high as it will be led to the over design. The selection of materials and design for specific structure is very much important for the determination of safety factor. Based on the results obtained from the static analysis, the minimum factors of safety were ranging between 1.12 to 7.82 when the forces were lower than 1,400 kN. However, it decreased to 0.89 when the force was increased up to 1,750 kN. The factor of safety decreased in the case of 400 mm compared to that of 300 mm. The location of the minimum factor of safety is shown in Figure 9. It was at the inner side of the YJACK. This is expected to be improved in the actual condition where the inner part of the YJACK will be fully filled up with concrete and this could support the affected area and able to avoid the part from failure.

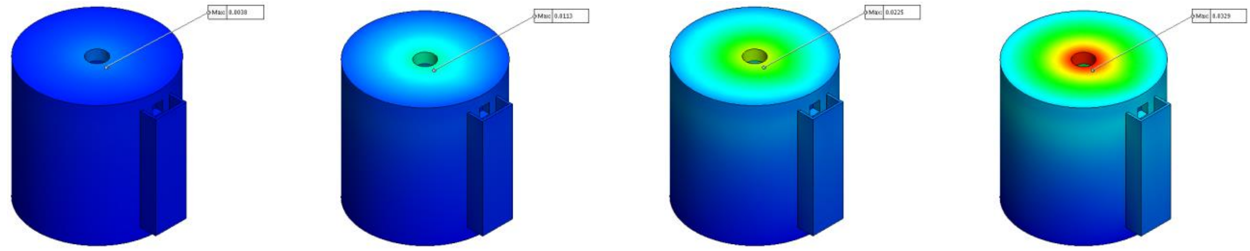


(a)



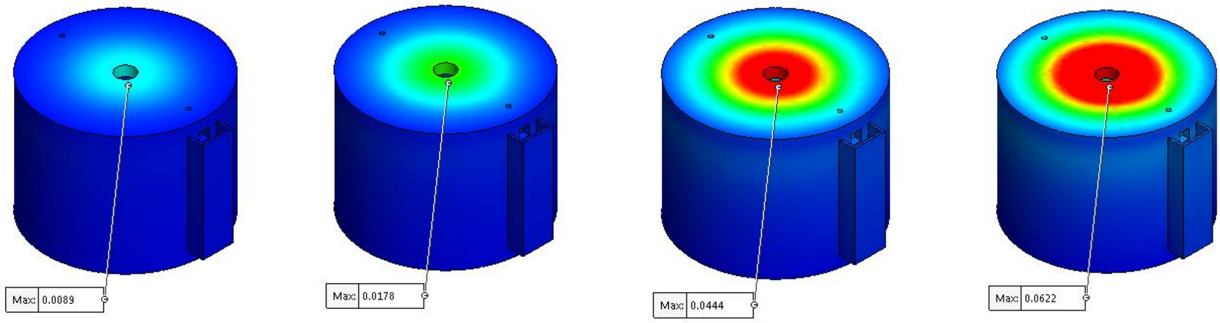
(b)

Figure 7: Safety factor and displacement for each applied load; (a) 300 mm, (b) 400 mm.



(a) 200 kN (b) 600 kN (c) 1,200kN (d) 1,750 kN

(i) 300 mm YJACK

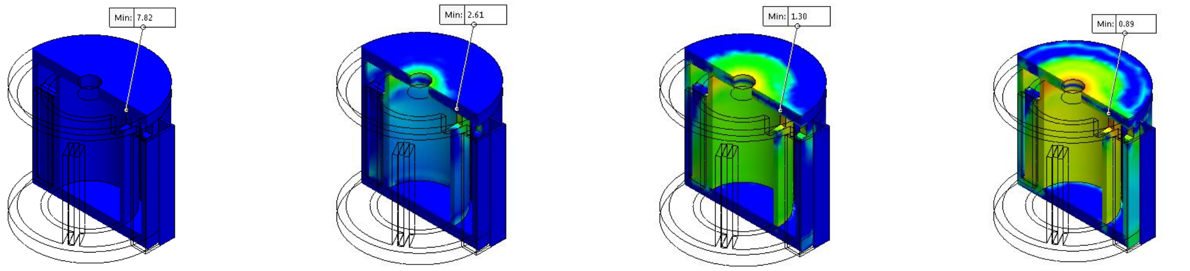


(a) 250 kN (b) 500 kN (c) 1,250kN (d) 1,750 kN

(ii) 400 mm YJACK

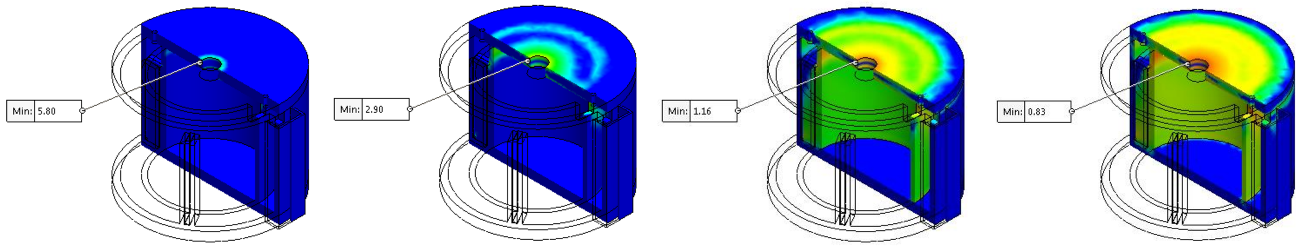
Figure 8: Changes of displacement with increasing loads.

Figure 8 shows the changes of displacement with changing loads. The maximum displacement was recorded at the area near to the hole. The displacement for 400 mm YJACK was higher than that for 300 mm. However, the displacement is expected to decrease in the actual condition due to the insertion of concrete inside the YJACK during on-site installation. The concrete will supports and prevent the YJACK from any notable displacement.



(a) 200 kN (b) 600 kN (c) 1,200kN (d) 1,750 kN

(i) 300 mm YJACK



(a) 250 kN (b) 500 kN (c) 1,250kN (d) 1,750 kN

(ii) 400 mm YJACK

Figure 9: Changes of safety factors with increasing loads.

Figure 9 shows the cross section of the YJACK during compression for 300 mm and 400 mm YJACK. The most critical point is the point labelled with “Min”. The safety factor for 1,750 kN load were very low. The safety factor for 400 mm YJACK was slightly lower than that for 300 mm. If the YJACK is used as in the simulation, it is expected to fail due to excessive stress applied on it. But, since the actual application of YJACK is by fully filling the empty space inside YJACK with concrete, the safety factor might significantly increase and able to prevent the failure.

Bending Analysis

Figure 10(a) shows a schematic diagram of four points bending moment of YJACK. The piles are roller-supported at both ends and the forces are applied at a distance of 0.6 m measured from the middle plane. While Figure 10(b) reveals finite element model of YJACK/Pile configuration. In this work, static linear finite element analysis is used to simulate the problem.

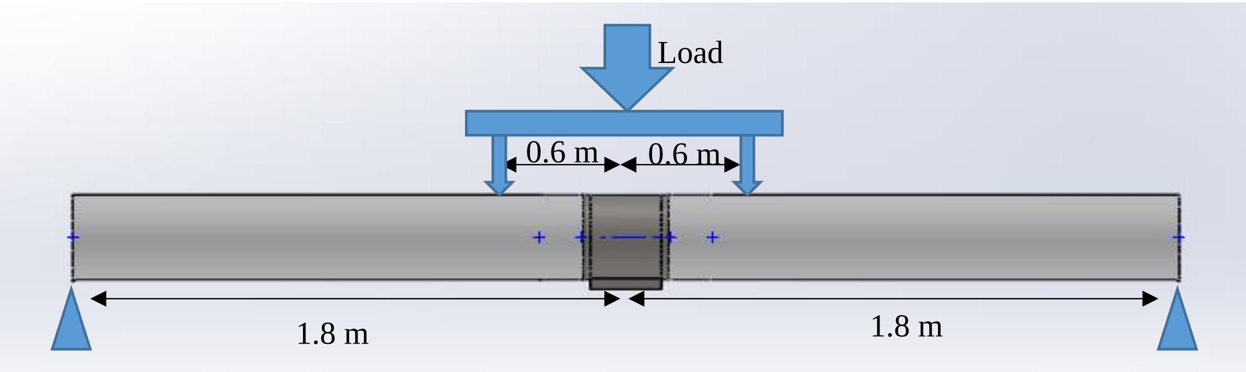


Figure 10 (a) Schematic diagram of YJACK/Piles configuration

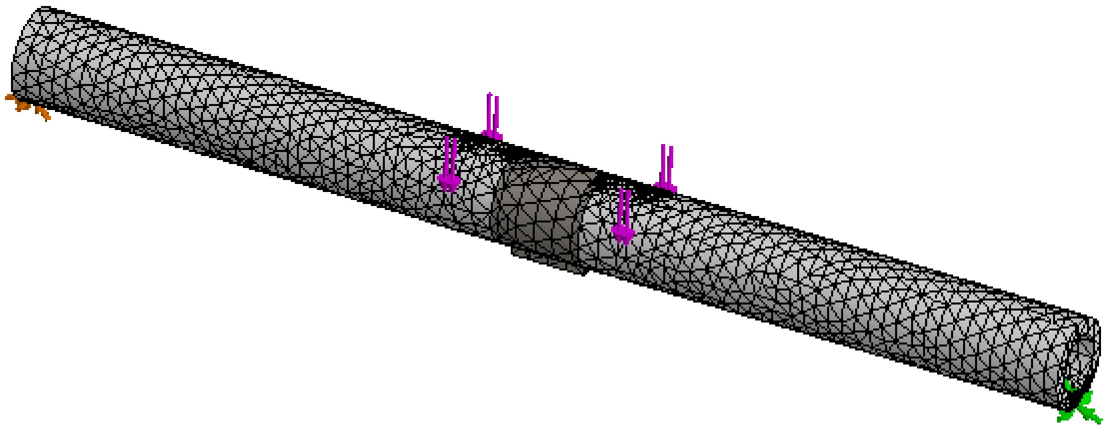


Figure 10 (b) Corresponding finite element model.

After the problem is solved, the result is shown in Figure 11. It is revealed that most of the damages occurred at the region of connections between piles and YJACK. The weak region can be observed at the bottom side of YJACK/Piles since concrete is weakened under the action of tension.

According to Figure 11 (as in enlarged figure), the probability of connection between YJACK and pile disintegrated is relatively high especially at the bottom edge.

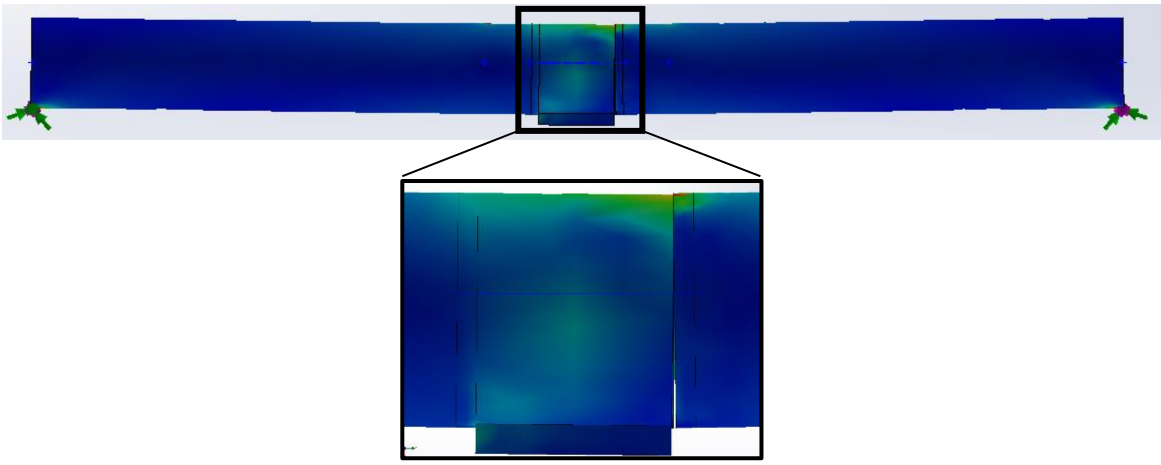
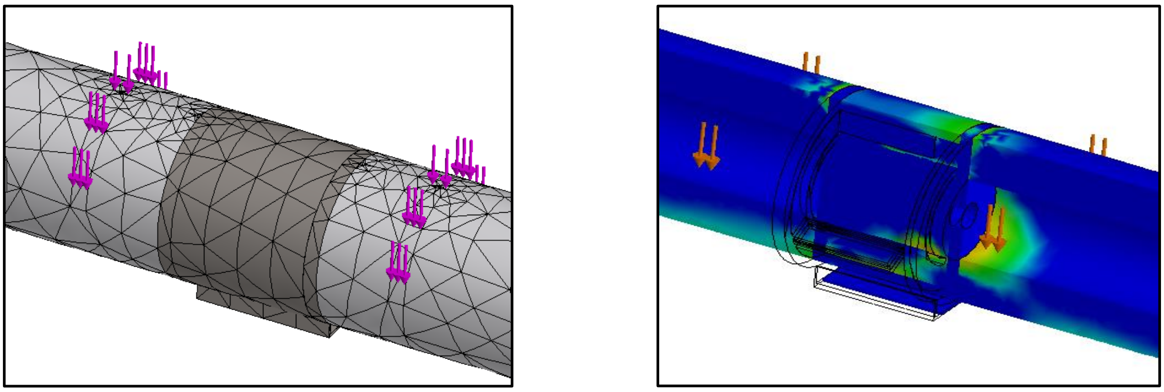


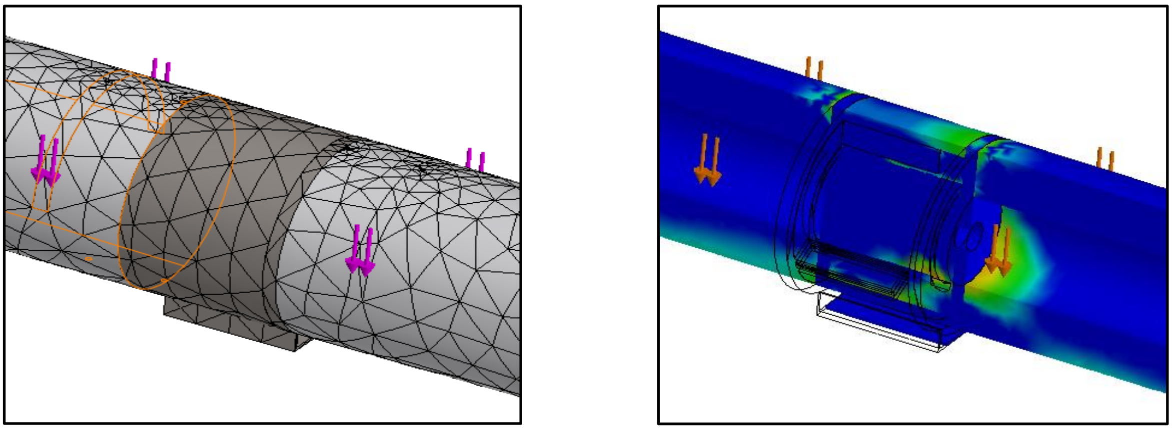
Figure 11: Simulation results of YJACK/Piles configuration

In order to fully understand the role of connection between two different materials, Figure 12 and Figure 13 respectively indicate the variations of safety factors across the YJACK/Piles system for 300 and 400 mm YJACK. Based on the results obtained from finite element analysis, similar behaviour of safety factors can be observed where the minimum values occurred at the junction between YJACK/Pile systems. Minimum safety factors are also observed at the bottom side of piles and it is predicted the disintegrations probably occurs at such locations.



(a) (b)

Figure 12: 300 mm YJACK model (a) finite element model and (b) finite element result



(a) (b)

Figure 13: 400 mm YJACK model (a) finite element model and (b) finite element result

Conclusion

Based on the compression analysis of YJACK, it was found that the YJACK with empty space in it can withstand a load up to 1,400 kN. As the load increased more than 1,400 kN, the safety factor was decreased lower than 1. However, this can be solved by applying a concrete inside the empty space of YJACK as in actual application.

From the bending analysis, similar behavior of safety factors can be observed for diameter 300 and 400 mm of YJACK where the minimum values occurred at the junction between YJACK/Pile systems. Minimum safety factors are also observed at the bottom side of piles and it is predicted the disintegrations probably occurs at such locations.

In conclusion, the finite element modeling (FEM) analysis revealed that YJACK 300 and 400 mm are functionally and durable well to resist pile compression and bending during pile driving.

CORRELATION REPORT

BI-DIRECTIONAL PILE LOAD TESTING OF PILES

Validation Test of YJACK Bi-Directional Pile Load Test as the Alternative Pile Load Test Method Compared to Conventional Kentledge Method on Driven & Injection Concrete Piles.

Project Case Study: Kangsar, 2*YJACK Pile Tests (2*MLT)
Pile Driving System: Driven Piles on 2*Spun Concrete Pile 600mm, SC600Ø
CCGF Research Grant Milestone: Product Testing and Validating

PREPARED FOR:

RESEARCH GRANT:
Concept to Commercialization Gap Fund (CCGF)
High Impact Program 2 (HIP2)

GRANT MANAGER:
Agensi Inovasi Malaysia (AIM)
SME Corporation Malaysia (SME Corp)
PlaTCOM Ventures Sdn Bhd (PlaTCOM)

RESEARH COLLABORATOR:
Universiti Tun Hussein Onn Malaysia (UTHM)
UTHM Commercial Sdn Bhd (UTHMC)

VALIDATION INSTITUTION:
Construction Research Institute Malaysia (CREAM)
Technical Opinion Program (TOP)

Prepared by:

Report Serial	Report No	Revision No	Issued Date
BDPLT-YJMY111	2	1	2017/APR/01

TABLE OF CONTENTS

EXECUTIVE SUMMAY

The objectives of the tests were to validate the newly invented YJACK on driven concrete piles compared to conventional kentledge pile load test system in terms of:

(1) the functionality, and
(2) the accuracy

This YJACK validation correlation tests were performed at Project Case Study at Kangsar on 2016/JUN/02-08 with 2*NOS YJACK pile tests as following:

- Validation: maintained load tests (MLT) on Test Pile # FG-19(5) & G-21(5) to test load 4,000kN

The following is the summary of the correlation results obtained from Correlation Study.

<u>Correlation Method # 1</u>

The following is the correlation using load test settlement at working and test loads as the correlation base data:

Pile ID	FG-19(5)	G-21(5)
Loading Procedure	MLT	MLT
Average Accuracy	86.3%	92.8%
Accuracy Level *	High	High
Average Accuracy	89.6%	

* High if Accuracy ≥ 80%; Moderate if 50% > Accuracy < 80%; Low if Accuracy ≤ 50%

<u>Correlation Method # 2</u>

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Pile ID	FG-19(5)	G-21(5)
Loading Procedure	MLT	MLT
Average Accuracy	96.3%	98.1%
Accuracy Level *	High	High
Average Accuracy	97.2%	

* High if Accuracy ≥ 80%; Moderate if 50% > Accuracy < 80%; Low if Accuracy ≤ 50%

The following is the validation conclusions for functionality and accuracy of the newly invented YJACK.

(1) Validation for the functionality: the YJACKs are fully performed well in terms of functionality in installation and testing.
(2) Validation for the accuracy: the YJACKs are fully performed well in terms of accuracy in terms of ultimate (i.e. the load) and serviceability (i.e. settlement) design considerations.

VALIDATION BACKGROUND

PlaTCOM Ventures Sdn Bhd is the national technology commercialization platform of Malaysia. It is a wholly-owned subsidiary company of Agensi Inovasi Malaysia (AIM) formed in collaboration with SME Corporation Malaysia (SME Corp) under one of its six High Impact Programmes (HIPs) in SME Master Plan 2012-2020.

PlaTCOM Ventures has a mission: to turn the creative ideas of our inventors and entrepreneurs into successful products and services that change the world.

The model addresses the innovation gaps through a holistic and 'market-driven' approach in supporting innovation and industrial competitiveness. It is designed to remove market and financing barriers to innovation.

The program provides necessary support from 'concept to commercialization'. This is done through the provision of access to technical assistance, market intelligence, incubation facilities, testing facilities and other relevant services - all in a single platform.

VALIDATION PRODUCT – YJACK

The validation product is YJACK. It is a static pile load test method based on bi-directional principle. It is an alternative and economical method to conventional maintained load test using kentledge blocks or reaction piles methods.
This invention is by far the best compared to conventional method. The YJACK solves problems by:

a. cost saving;
b. time saving (from 10 days to 1 day in preparation);
c. eco-friendly green and safe;
d. suitable for all types of piles and test loads as well as offshore piles using autoYJACK.

VALIDATION OBJECTIVE

The objectives of the tests were to validate the newly invented YJACK on driven concrete piles compared to conventional kentledge pile load test system in terms of:

(1) the functionality, and

(2) the accuracy

This YJACK validation correlation tests were performed at Project Case Study at Kangsar on 2016/JUN/02-08 with 2*NOS YJACK pile tests as following:

- Validation: maintained load tests (MLT) on Test Pile # FG-19(5) & G-21(5) to test load 4,000kN

PILE DESIGN

The Test Piles have the following pile design information based on piling record:

Pile ID	FG-19(5)	G-21(5)
Pile Type	Spun Concrete	Spun Concrete
Pile Grade	Grade 80/Class B	Grade 80/Class B
Pile Size (mm)	600Ø	600Ø
Pile Area (cm2)	1571	1571
Pile Make-Up	0.3Y+9E+6E	0.3Y+9E+6E
Pile Length (m)	15.3	15.3
Working Load (kN)	2,000	2,000
Test Load (kN)	4,000	4,000

YJACK MODEL

Based on the pile design, the following YJACK selected:

Pile ID	FG-19(5)	G-21(5)
YCELL Model	3GYJ3D300	3GYJ3D300
YCELL Capacity (kN)	4,000	4,000
YCELL Area (mm2)	67,500	67,500
YCELL Quantity (nos)	1	1
YJACK Capacity (kN)	4,000	4,000
YJACK Size (mm)	600	600
YJACK Stroke (mm)	80	80

YCELL: the single hydraulic unit prior to fabricate the YJACK

TERMINATION CRITERIA

All the Test Piles were installed by driving hammer with pile termination criteria "pile to set" (refer to pile driving criteria from the piling contractor).

PILE INSTALLATION

The design pile make-up was 0.3YJACK+9E+6E = 15.3m (toe to top), YJACK end bearing design. The base of the pile toe was installed with YJACK during the pile driving process.

The following were the site photos to illustrate the YJACK installation:

Step (1)

Step (2)

Step (3)

Step (4)

Step (1): Spliced the YJACK at the end bearing (i.e. 0m from pile toe)
Step (2): Pile positioning, check verticality and then continue driving
Step (3): Hydraulic hoses and telltales attached out and fixed along the pile body
Step (2): End of pile driving and completion of the YJACK installation

The details of the pile installations were shown in the piling record as shown in Appendix A1 (Pile Installation Record).

INSTALLATION TERMINATION

All the Test Piles were installed pile to set as following:

Pile ID	FG-19(5)	G-21(5)
Date Installed	2016/JUN/02	2016/JUN/08
Pile Depth (m)	14.8	14.8
Pile Set (mm/10b)	Driven Pile to Set	Driven Pile to Set

Subsequently, pile tests were carried out as described in YJACK TEST Section.

INSTALLATION BEHAVIOR

The pile installation using driving hammer on the Test Piles has similar pile installation behavior like those working piles without YJACK. No abnormality installation behavior observed. This means that the YJACK has a good impedance so that the compressive forces can transmit from pile top to pile toe and effectively past thru the YJACK location without losses of the compressive forces.

The pile installation of Test Piles did not change the mode of piling practices. The Test Piles was installed like a normal pile (without YJACK). However, there were minor interruptions of pile installation for fixing the casing pipe outside the pile for every 1.0 – 1.5m pile penetration intervals.

In summary, the Test Piles have the followings installation behavior:

- No different in installation, just install the pile like a test pile without YJACK
- Minor interruptions in pile installation due to fixing of casing pipe
- The YJACK able to resist pile bending during installation
- The YJACK able to transmit compressive forces and has enough pile impedance

YJACK TEST

After waiting period of more than 2 months (without delay the contractor piling work plan), the Test Piles were subjected to static load pile test based on YJACK bi-directional method using a maintained load test loading procedure (MLT).

The pressure increment and loading schedule presented in Appendix B (YJACK Bi-Directional Pile Load Test Loading Schedule).

The displacements of the telltales were measured in every loading steps by using manual data recording on the field sheets.

The following were the site photos to illustrate the YJACK testing using bi-directional principle:


Step 1


Step 2


Step 3

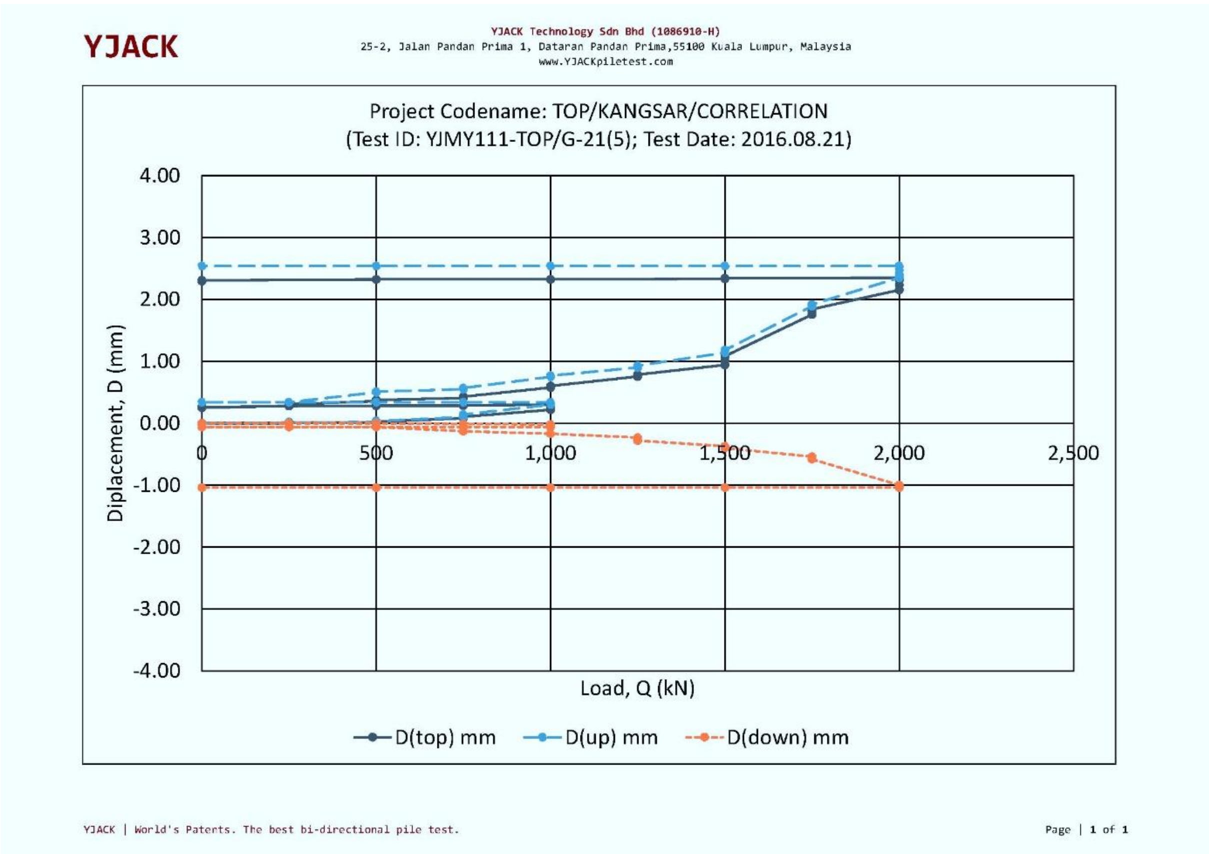
Step 1: Reference beams setup (follow the conventional load test procedure)

Step 2: Load test setup ready, 4*dial gauges at pile top and 2*dial gauges for YJACK up/down

Step 3: Auto data recording using data logger (follow the conventional load test procedure)

YJACK VALIDATION RESULTS

The YJACK test results using static maintained load test (MLT) method were presented in Appendix C (YJACK Bi-Directional Pile Load Test Results using MLT).



The following is the summary test results based on YJACK MLT Method:

Pile ID	FG-19(5)	G-21(5)
Skin Friction at Top Section (kN) *	2,000	2,000
Skin friction at Bottom Section + Base Bearing (kN) #	2,000	2,000
Total Pile Load Capacity in Full Section (kN)	4,000	4,000
Gap Opening after Removal Working Load 2000kN (mm)	0.40	0.34
Gap Opening after Removal Test Load 4000kN (mm)	2.80	2.54

* top skin friction not failure with applied load well maintained in 24 hours loading
# base bearing not failure with permanent displacement < 30mm (= assumed 5% of pile diameter)

The following is the determination of the pile ultimate load by consideration of the tension over compression factor:

Pile ID	FG-19(5)	G-21(5)
Corrected Skin Friction at Top Section (kN) *	2,000/γ	2,000/γ
Corrected Skin Friction at Top Section (kN)	2,500	2,500
Corrected Total Pile Load Capacity in Full Section (kN)	4,500	4,500
Pile Weight at Top Section (kN) #	60	60
Ultimate Pile Load Capacity in Full Section (kN)	4,440	4,440
Accepted Ultimate Capacity in Full Section (kN)	> 4,000 (OK!)	> 4,000 (OK!)

* use tension over compression factor, γ = 0.8 for cohesive material
# pile weight at pile top section = pile area x pile length at top section x pile density = about 60kN

The following is the summary test results based on top loaded Q-s Plot in accordance to Singapore Standard SS/CP4:

Pile ID	FG-19(5)	G-21(5)
Top-Loaded Pile Load Capacity (kN)	4,000	4,000
Top-Loaded Settlement at Working Load 300kN (mm)	2.9	2.0
Top-Loaded Settlement at Test Load 600kN (mm)	7.5	7.3

The following is the test acceptance in accordance to Malaysian JKR Specifications JKR/20800 (2014):

Pile ID	FG-19(5)	G-21(5)
Accepted Top-Loaded Pile Load Capacity (kN)	> 4,000 (OK!)	> 4,000 (OK!)
Accepted Top-Loaded Settlement at Working Load (mm)	< 12.5 (OK!)	< 12.5 (OK!)
Accepted Top-Loaded Settlement at Test Load (mm)	< 38.0 (OK!)	< 38.0 (OK!)
Accepted Residual Settlement *	< 6.5 (OK!)	< 6.5 (OK!)

* Pile-soil interaction of residual settlement assumed to be similar to gap opening after removal working load.

Test Comments:

- the YJACK gap opening after removal of the working load is very small, this small gap opening equivalent to residual settlement in conventional maintained load test with the pile head almost fully rebound
- the ultimate load of 4,440kN is deemed to be conservative
- it is recommended to do pile restrike to close the such a small gap opening of 2.54 – 2.80mm, to utilize the test piles as working piles

YJACK VALIDATION CORRELATIONS

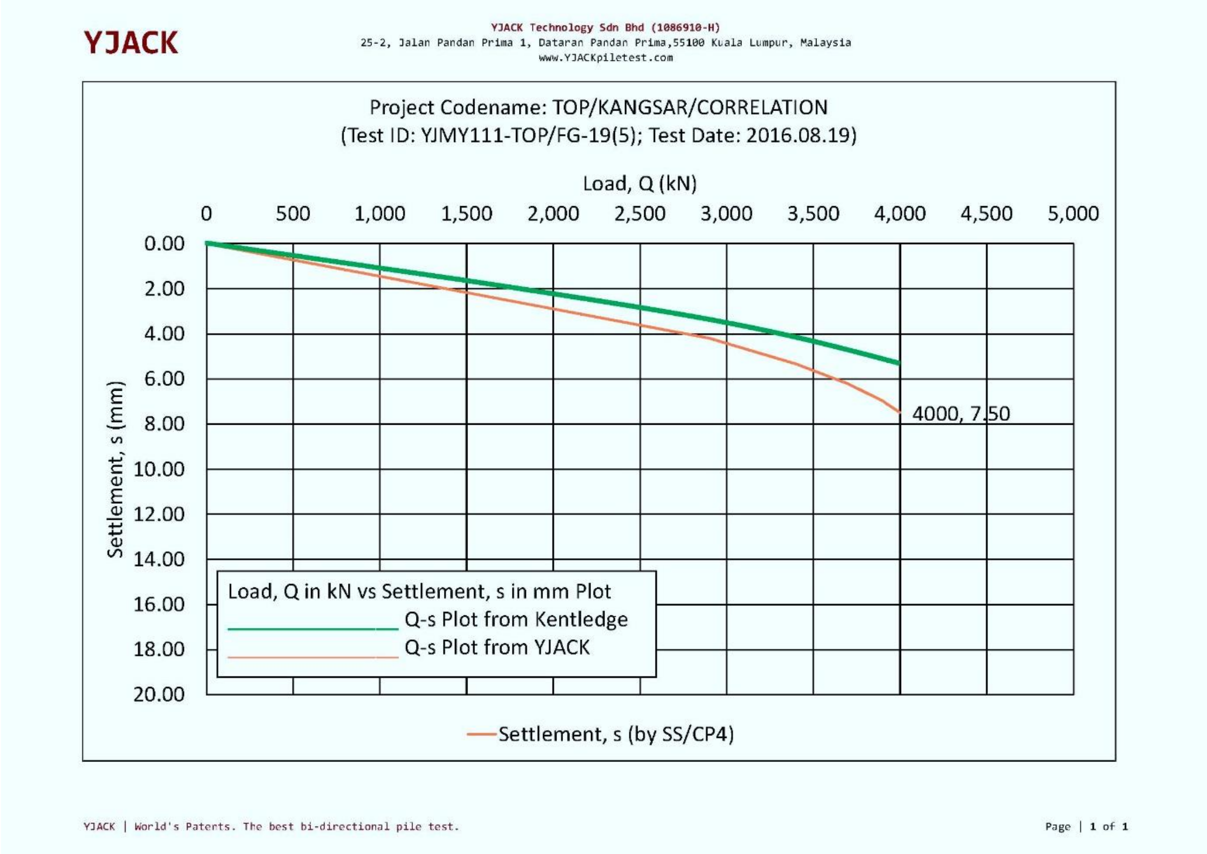
All the Test Piles were tested by using kentledge method and YJACK method based on maintained load test (MLT) procedure.

The MLT load tests were carried out by kentledge followed by YJACK method on the same piles as follows:

Pile ID	FG-19(5)	G-21(5)
Kentledge Test	2016/JUN/08	2016/JUN/15
YJACK Test	2016/AUG/19	2016/AUG/21

The kentledge load tests were performed by using the conventional concrete blocks as the reaction system.

The correlation results are shown in following pages.



Correlation Method # 1

The following is the correlation using MLT settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement At 2,000kN	Test Load *	Settlement At 4,000kN
Kentledge Method	2,000	2.2	4,000	5.2
YJACK Method	2,000	2.9	4,000	7.5
Percentage Error #	0.0%	24.1%	0.0%	30.7%
Average Accuracy	86.3%			

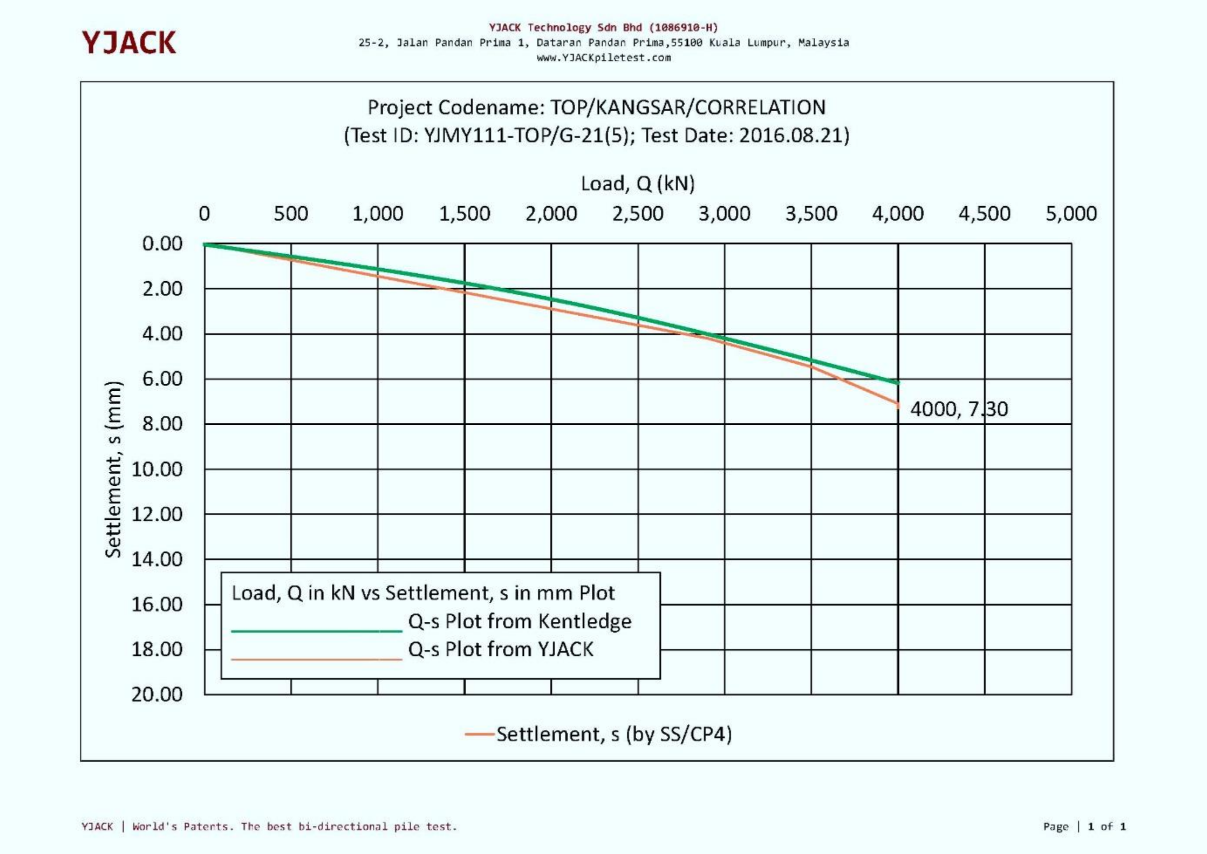
* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

Correlation Method # 2

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement Limit 12.5	Test Load *	Settlement Limit 38.0
Kentledge Method	2,000	10.3	4,000	32.8
YJACK Method	2,000	9.6	4,000	30.5
Percentage Error #	0.0%	7.3%	0.0%	7.5%
Average Accuracy	96.3%			

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values



Correlation Method # 1

The following is the correlation using MLT settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement At 2,000kN	Test Load *	Settlement At 4,000kN
Kentledge Method	2,000	2.5	4,000	6.2
YJACK Method	2,000	2.9	4,000	7.3
Percentage Error #	0.0%	13.8%	0.0%	15.1%
Average Accuracy	92.8%			

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

Correlation Method # 1

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement Limit 12.5	Test Load *	Settlement Limit 38.0
Kentledge Method	2,000	10.0	4,000	31.8
YJACK Method	2,000	9.6	4,000	30.7
Percentage Error #	0.0%	4.2%	0.0%	3.6%
Average Accuracy	98.1%			

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

CORRELARION SUMMARY

The following is the summary of the correlation results obtained from Correlation Phase 1 and Phase 2.

Correlation Method # 1

The following is the correlation using load test settlement at working and test loads as the correlation base data:

Pile ID	FG-19(5)	G-21(5)
Loading Procedure	MLT	MLT
Average Accuracy	86.3%	92.8%
Accuracy Level *	High	High
Average Accuracy	89.6%	

* High if Accuracy ≥ 80%; Moderate if 50% > Accuracy < 80%; Low if Accuracy ≤ 50%

Correlation Method # 2

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Pile ID	FG-19(5)	G-21(5)
Loading Procedure	MLT	MLT
Average Accuracy	96.3%	98.1%
Accuracy Level *	High	High
Average Accuracy	97.2%	

* High if Accuracy ≥ 80%; Moderate if 50% > Accuracy < 80%; Low if Accuracy ≤ 50%

VALIDATION CONCLUSION

The following is the validation conclusions for functionality and accuracy of the newly invented YJACK.

(1) Validation for the functionality of the YJACK

The pile installation using driving hammer on the 2*NOS Test Piles has similar pile installation behavior like those working piles without YJACK. No abnormality installation behavior observed with the followings installation behavior:

- No different in installation, just install the pile like a test pile without YJACK
- Minor interruptions in pile installation due to fixing of casing pipe
- The YJACK able to resist pile bending during installation
- The YJACK able to transmit compressive forces and has enough pile impedance

The pile testing also demonstrated the YJACK can perform well under load pressurizations from 0 to 2,000 (working load) to 4,000 (test load). No any hydraulic jack interlocking observed during loading and unloading procedures.

In conclusion, the YJACKs are fully performed well in terms of functionality in installation and testing.

(2) Validation for the accuracy of the YJACK

The correlation summary on 2*NOS YJACK pile tests indicated high accuracy more than 85% with the following correlation studies:

- Validation: maintained load tests (MLT) on Test Pile # FG-19(5) & G-21(5) to test load 4,000kN

YJACK is a hydraulic jack system, the same to conventional load test which also using hydraulic jack in pressure loading measurements. Hence, both YJACK and kentledge loads were measured by the same pressure systems with same loading accuracies, i.e. 100%.

In the load-settlement behavior plots for kentledge and YJACK, both indicated similar patterns with accuracy range higher than 80%, in which this is deemed to be high level accuracy in correlation studies.

In conclusion, the YJACKs are fully performed well in terms of accuracy of ultimate (i.e. the load) and serviceability (i.e. settlement) design considerations.

APPENDIX A1

CYLONIX GEOTECHNICS SDN BHD (1113599-M)
No. 20-1, Jalan 1/18D Batu 5½
Off Jalan Ipoh, Taman Mastiara,
51200 Kuala Lumpur.
Tel : 03 6179 3113
Fax : 03 6250 0691

HAMMER DRIVEN PILING RECORD

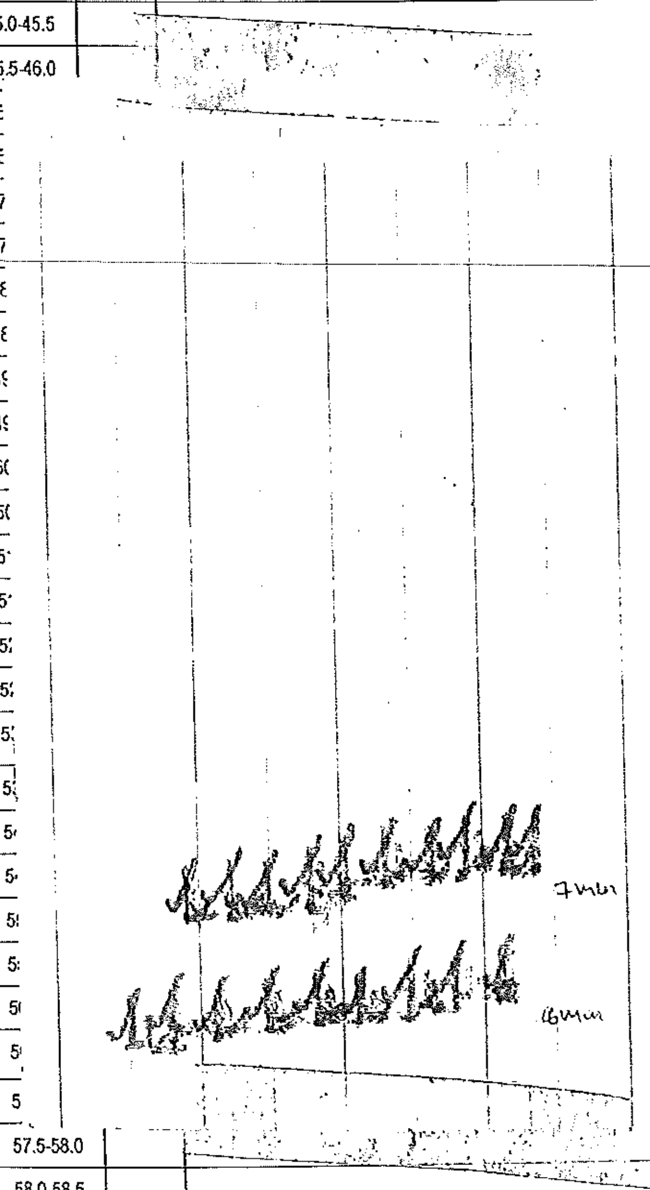
PROJECT: Mydin K. Kangsar

DATE: 2-6-16

Size of Pile : 600mm	Hammer Type : 9 ton	Hammer Drop Height : 800 mm
Pile Group : F-6/19	Supplied Pile Length : 9s + 6E	Pile Combination :
Pile No : (5)	Penetration : 14.8m	Final Set : 7mm
Pile Frame :		No. of Pile Joints :

Penetration (M)	No. of Blow	Penetration (M)	No. of Blow	Penetration (M)	No. of Blow	Penetration (M)	No. of Blow
0.0-0.5	6	15.0-15.5		30.0-30.5		45.0-45.5	
0.5-1.0	7	15.5-16.0		30.5-31.0		45.5-46.0	
1.0-1.5	10	16.0-16.5		31.0-31.5		46…	
1.5-2.0	10	16.5-17.0		31.5-32.0		46…	
2.0-2.5	11	17.0-17.5		32.0-32.5		47…	
2.5-3.0	10	17.5-18.0		32.5-33.0		47…	
3.0-3.5	12	18.0-18.5		33.0-33.5		48…	
3.5-4.0	12	18.5-19.0		33.5-34.0		48…	
4.0-4.5	12	19.0-19.5		34.0-34.5		49…	
4.5-5.0	14	19.5-20.0		34.5-35.0		49…	
5.0-5.5	15	20.0-20.5		35.0-35.5		50…	
5.5-6.0	17	20.5-21.0		35.5-36.0		50…	
6.0-6.5	19	21.0-21.5		36.0-36.5		5…	
6.5-7.0	19	21.5-22.0		36.5-37.0		5…	
7.0-7.5	18	22.0-22.5		37.0-37.5		5…	
7.5-8.0	18	22.5-23.0		37.5-38.0		5…	
8.0-8.5	20	23.0-23.5		38.0-38.5		5…	
8.5-9.0	20	23.5-24.0		38.5-39.0		5…	
9.0-9.5	22	24.0-24.5		39.0-39.5		5…	
9.5-10.0	22	24.5-25.0		39.5-40.0		5…	
10.0-10.5	23	25.0-25.5		40.0-40.5		5…	
10.5-11.0	26	25.5-26.0		40.5-41.0		5…	
11.0-11.5	26	26.0-26.5		41.0-41.5		5…	
11.5-12.0	75	26.5-27.0		41.5-42.0		5…	
12.0-12.5	75	27.0-27.5		42.0-42.5		5…	
12.5-13.0	78	27.5-28.0		42.5-43.0		57.5-58.0	
13.0-13.5	78	28.0-28.5		43.0-43.5		58.0-58.5	
13.5-14.0	80	28.5-29.0		43.5-44.0		58.5-59.0	
14.0-14.5	90	29.0-29.5		44.0-44.5		59.0-59.5	
14.5-15.0	95	29.5-30.0		44.5-45.0		59.5-60.0	

REMARKS



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Set.

Cylonix

CYLONIX GEOTECHNICS SDN BHD (1113599-M)
No. 20-1, Jalan 1/18D Batu 5½,
Off Jalan Ipoh, Taman Mastiara,
51200 Kuala Lumpur.
Tel : 03 6179 3113
Fax : 03 6250 0691

Pile level - 64 -987

HAMMER DRIVEN PILING RECORD

PROJECT: Mydin K. Kangsar

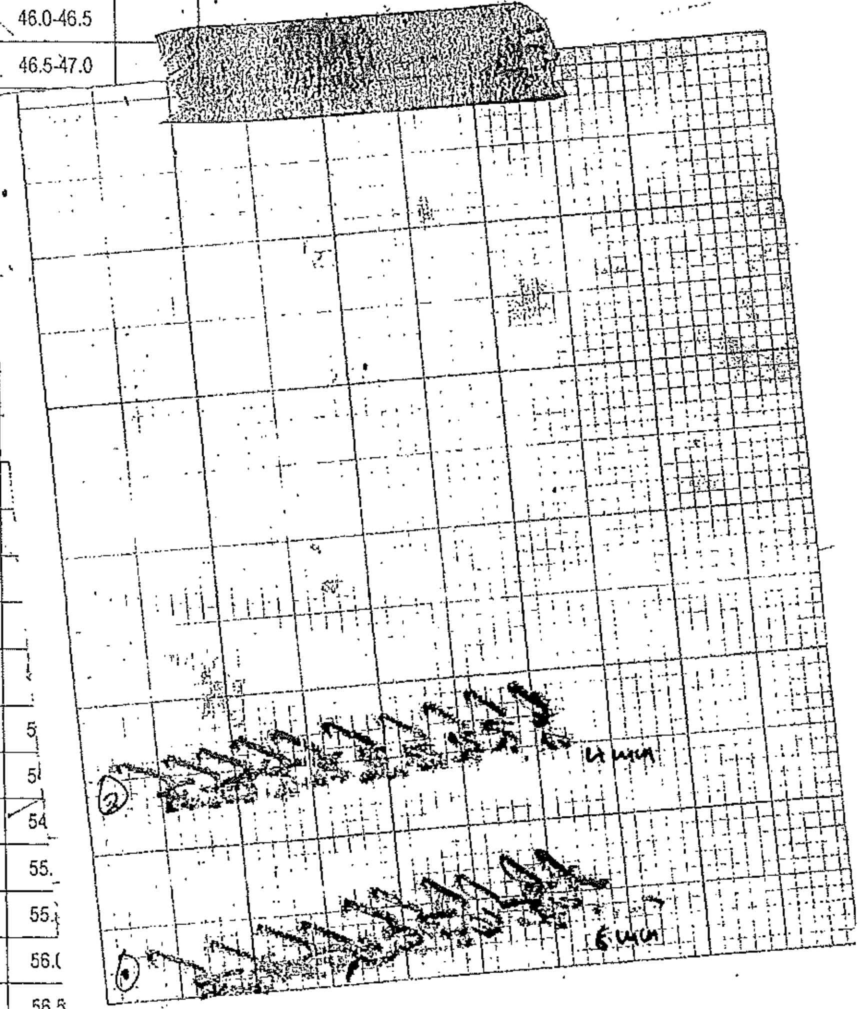
DATE: 8-6-16

Size of Pile : 600 mm	Hammer Type : 9 ton	Hammer Drop Height : 0 mm
Pile Group : 6/21	Supplied Pile Length : 95 + 6E	Pile Combination :
Pile No : (5)	Penetration : 14.8 m	Final Set : 4mm
Pile Frame :		No. of Pile Joints :

Penetration (M)	No. of Blow	Penetration (M)	No. of Blow	Penetration (M)	No. of Blow	Penetration (M)	No. of Blow
0.0-0.5	2	15.0-15.5		30.0-30.5		45.0-45.5	
0.5-1.0	7	15.5-16.0		30.5-31.0		45.5-46.0	
1.0-1.5	11	16.0-16.5		31.0-31.5		46.0-46.5	
1.5-2.0	14	16.5-17.0		31.5-32.0		46.5-47.0	
2.0-2.5	15	17.0-17.5		32.0-32.5			
2.5-3.0	15	17.5-18.0		32.5-33.0			
3.0-3.5	18	18.0-18.5		33.0-33.5			
3.5-4.0	24	18.5-19.0		33.5-34.0			
4.0-4.5	30	19.0-19.5		34.0-34.5			
4.5-5.0	36	19.5-20.0		34.5-35.0			
5.0-5.5	36	20.0-20.5		35.0-35.5			
5.5-6.0	40	20.5-21.0		35.5-36.0			
6.0-6.5	45	21.0-21.5		36.0-36.5			
6.5-7.0	60	21.5-22.0		36.5-37.0			
7.0-7.5	62	22.0-22.5		37.0-37.5			
7.5-8.0	60	22.5-23.0		37.5-38.0			
8.0-8.5	65	23.0-23.5		38.0-38.5			
8.5-9.0	70	23.5-24.0		38.5-39.0		5	
9.0-9.5	71	24.0-24.5		39.0-39.5		5	
9.5-10.0	70	24.5-25.0		39.5-40.0		54	
10.0-10.5	71	25.0-25.5		40.0-40.5		55.	
10.5-11.0	74	25.5-26.0		40.5-41.0		55.	
11.0-11.5	80	26.0-26.5		41.0-41.5		56.(	
11.5-12.0	82	26.5-27.0		41.5-42.0		56.5	
12.0-12.5	86	27.0-27.5		42.0-42.5		57.0-	
12.5-13.0	88	27.5-28.0		42.5-43.0		57.5-	
13.0-13.5	90	28.0-28.5		43.0-43.5		58.0-	
13.5-14.0	92	28.5-29.0		43.5-44.0		58.5-59.0	
14.0-14.5	94	29.0-29.5		44.0-44.5		59.0-59.5	
14.5-15.0	103	29.5-30.0		44.5-45.0		59.5-60.0	

Set

REMARKS



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APPENDIX A2

Bore-Hole Records / SI Report

Thick documents. Will be furnished upon request.

APPENDIX B

YJACK Technology Sdn Bhd (1086910-H)
25-2, Jalan Pandan Prima 1, Dataran Pandan Prima, 55100 Kuala Lumpur, Malaysia
(W)www.YJACKpiletest.com

Bi-Directional Pile Load Test (BDPLT), Reaction System: YJACK System, Test Procedure: Maintained Load Test (MLT)

Loading Schedule Table Sheet for SC600; Test Load 4,000kN

Project Name: Bi-directional Test at Kangsar

Test Pile Data		YJACK Data	
Pile ID:	YJACK Test Pile (Spun Pile)	YCELL Model:	3GYJ3D300
Pile Size:	600 mm	YCELL Stroke:	80 mm
Work Load in F(BD):	2,000 kN	YCELL Capacity in F(BD):	4,000 kN
Test Load in F(BD):	4,000 kN	YCELL Effective Area:	67,500 mm2
Safety Factor:	2.0 kN	YCELL Quantity:	1 NOS
Applied Working Load in F(1D):	1,000 kN	YJACK Capacity in F(BD):	4,000 kN
Applied Test Load in F(1D):	2,000 kN	YJACK Effective Area:	67,500 mm2

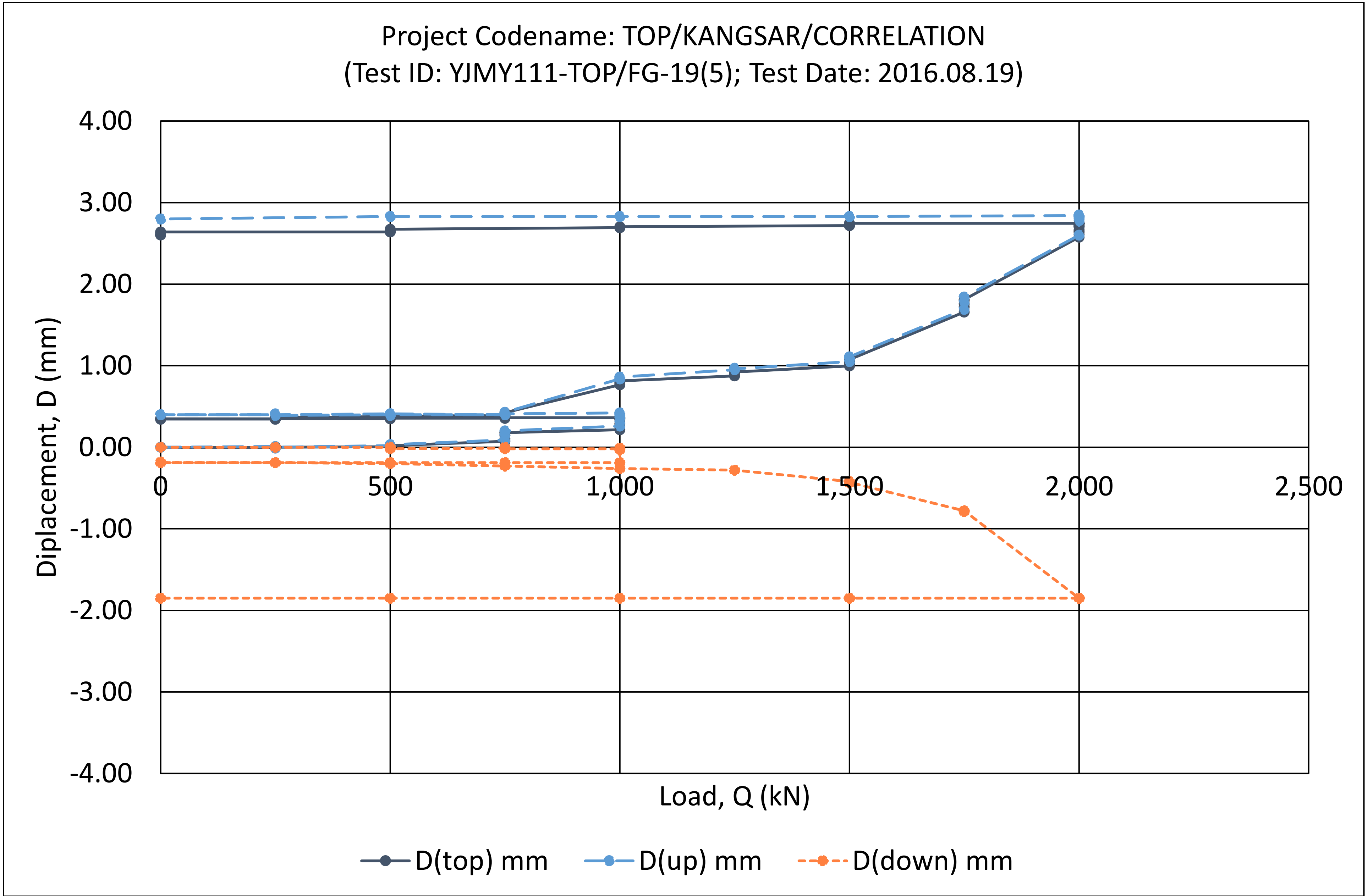
BD: bi-rectional load; 1D: single or uni-directional load

Load Schedule Table for Maintain Load Testing using Bi-Directional Pile Load Test using YJACK

use γ value: 0.8

Working Load (%)	Applied Load F(1D) (kN)	Pressure Reading (N/mm2)	Pressure Reading (BAR)	Holding Time (min)*	Read Time (min)	Test Load F(BD) (kN)	Corrected Load (kN)
25	250.0	3.7	37.0	60	15	500	563
50	500.0	7.4	74.1	60	15	1,000	1,125
75	750.0	11.1	111.1	60	15	1,500	1,688
100	1,000.0	14.8	148.1	360	15 then 60	2,000	2,250
75	750.0	11.1	111.1	60	15	1,500	1,688
50	500.0	7.4	74.1	60	15	1,000	1,125
25	250.0	3.7	37.0	60	15	500	563
0	0.0	0.0	0.0	60	15	0	0
25	250.0	3.7	37.0	60	15	500	563
50	500.0	7.4	74.1	60	15	1,000	1,125
75	750.0	11.1	111.1	60	15	1,500	1,688
100	1,000.0	14.8	148.1	60	15	2,000	2,250
125	1,250.0	18.5	185.2	60	15	2,500	2,813
150	1,500.0	22.2	222.2	60	15	3,000	3,375
175	1,750.0	25.9	259.3	60	15	3,500	3,938
200	2,000.0	29.6	296.3	1440	15 then 60	4,000	4,500
150	1,500.0	22.2	222.2	60	15	3,000	3,375
100	1,000.0	14.8	148.1	60	15	2,000	2,250
50	500.0	7.4	74.1	60	15	1,000	1,125
0	0.0	0.0	0.0	60	15	0	0
* Settlement Rate: < 0.05mm/15mins or Holding Time: min 2 hours achieved				2880	test duration in minutes		
				48	test duration in hours		

APPENDIX C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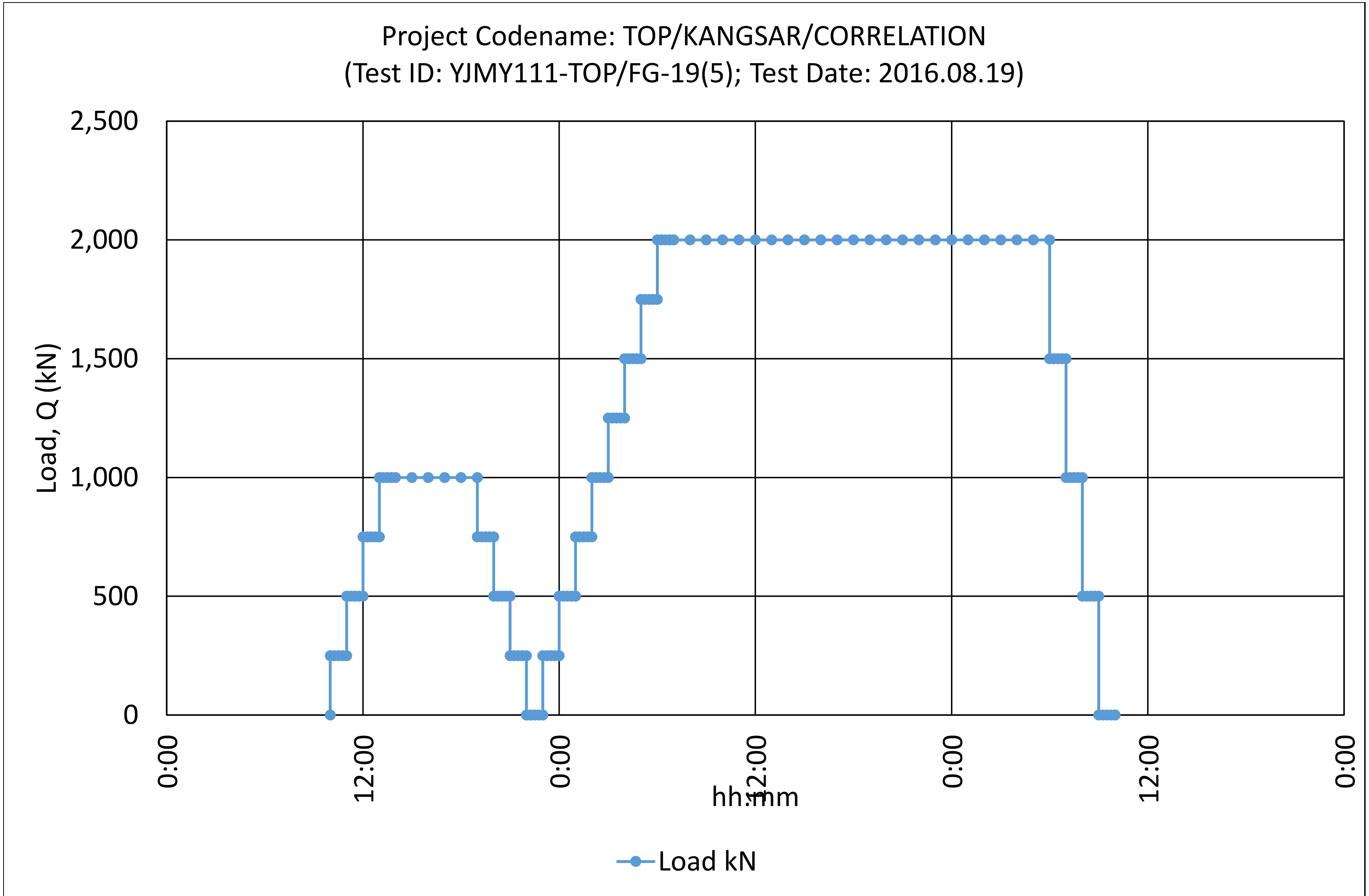
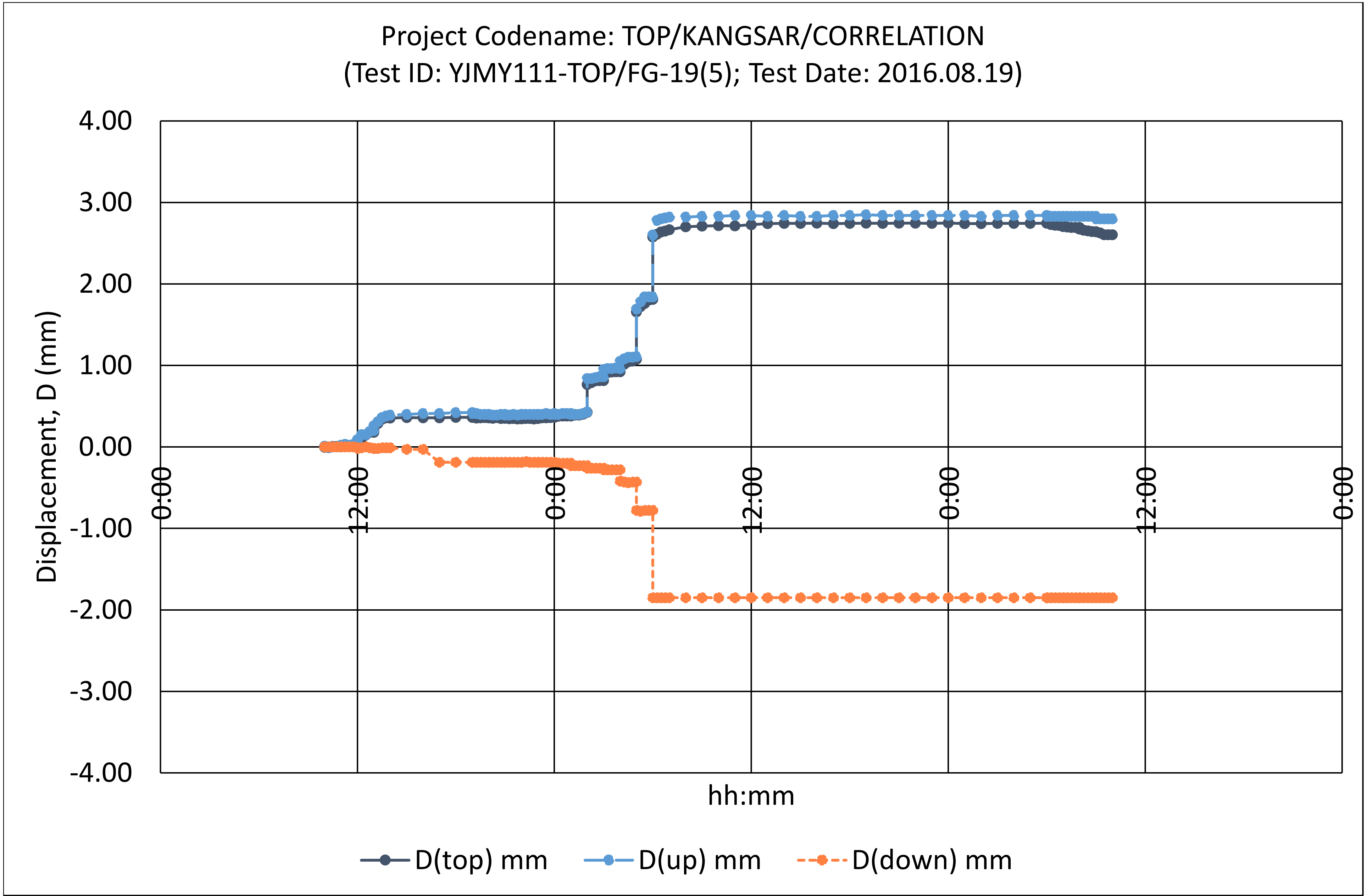
(Test ID: YJMY111-TOP/FG-19(5); Test Date: 2016.08.19)
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
0
500
1,000
1,500
2,000
2,500
Diplacement, D (mm)
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm


Project Codename: TOP/KANGSAR/CORRELATION
(Test ID: YJMY111-TOP/FG-19(5); Test Date: 2016.08.19)
2,500
2,000
1,500
1,000
500
0
Load, Q (kN)
0:00
12:00
0:00
12:00
0:00
12:00
0:00
hh:mm
Load kN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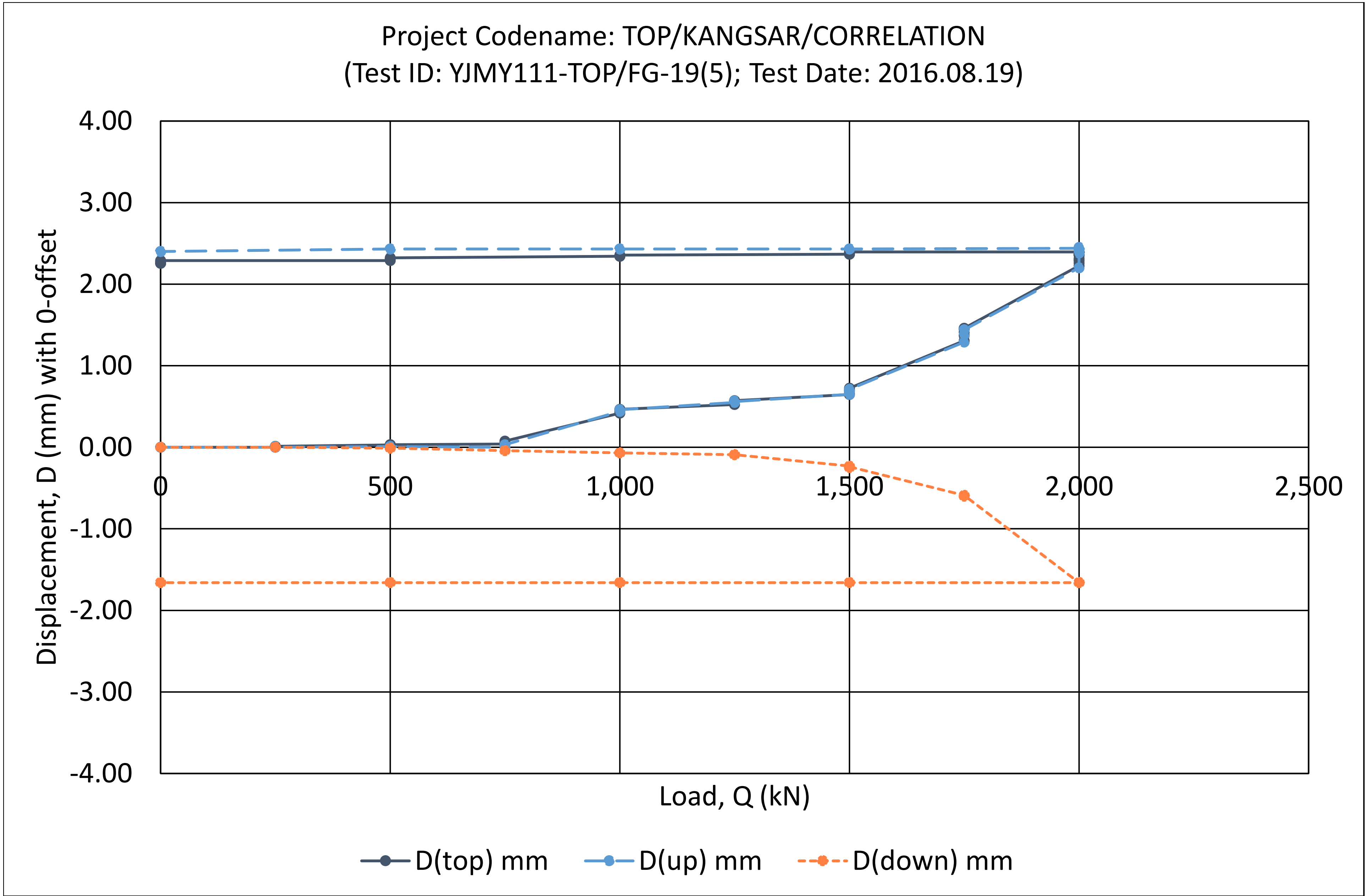
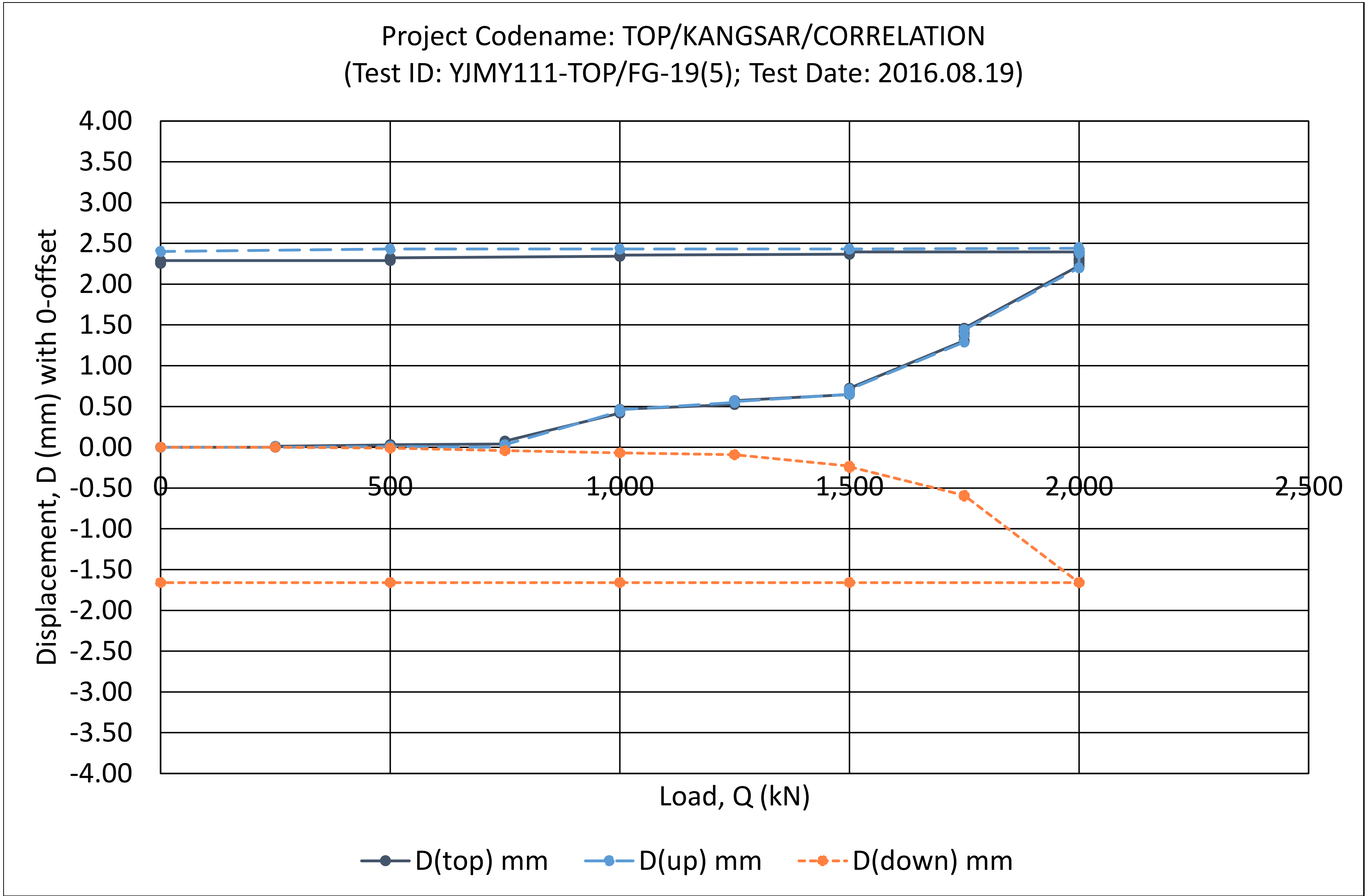
(Test ID: YJMY111-TOP/FG-19(5); Test Date: 2016.08.19)
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
Displacement, D (mm)
0:00
12:00
0:00
12:00
0:00
12:00
0:00
hh:mm
D(top) mm
D(up) mm
D(down) mm


Project Codename: TOP/KANGSAR/CORRELATION
(Test ID: YJMY111-TOP/FG-19(5); Test Date: 2016.08.19)
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
0
500
1,000
1,500
2,000
2,500
Displacement, D (mm) with 0-offset
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm


Project Codename: TOP/KANGSAR/CORRELATION
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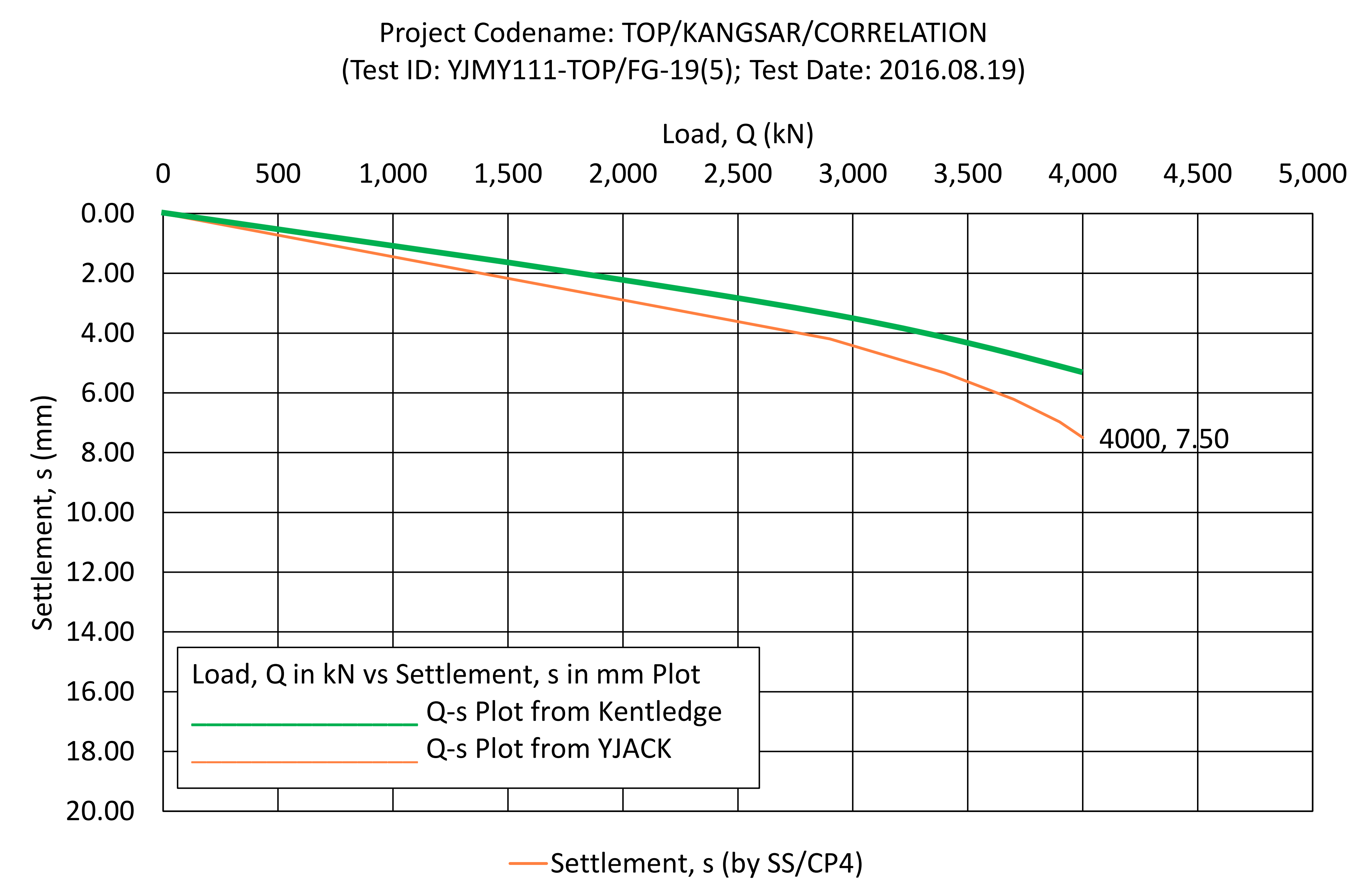
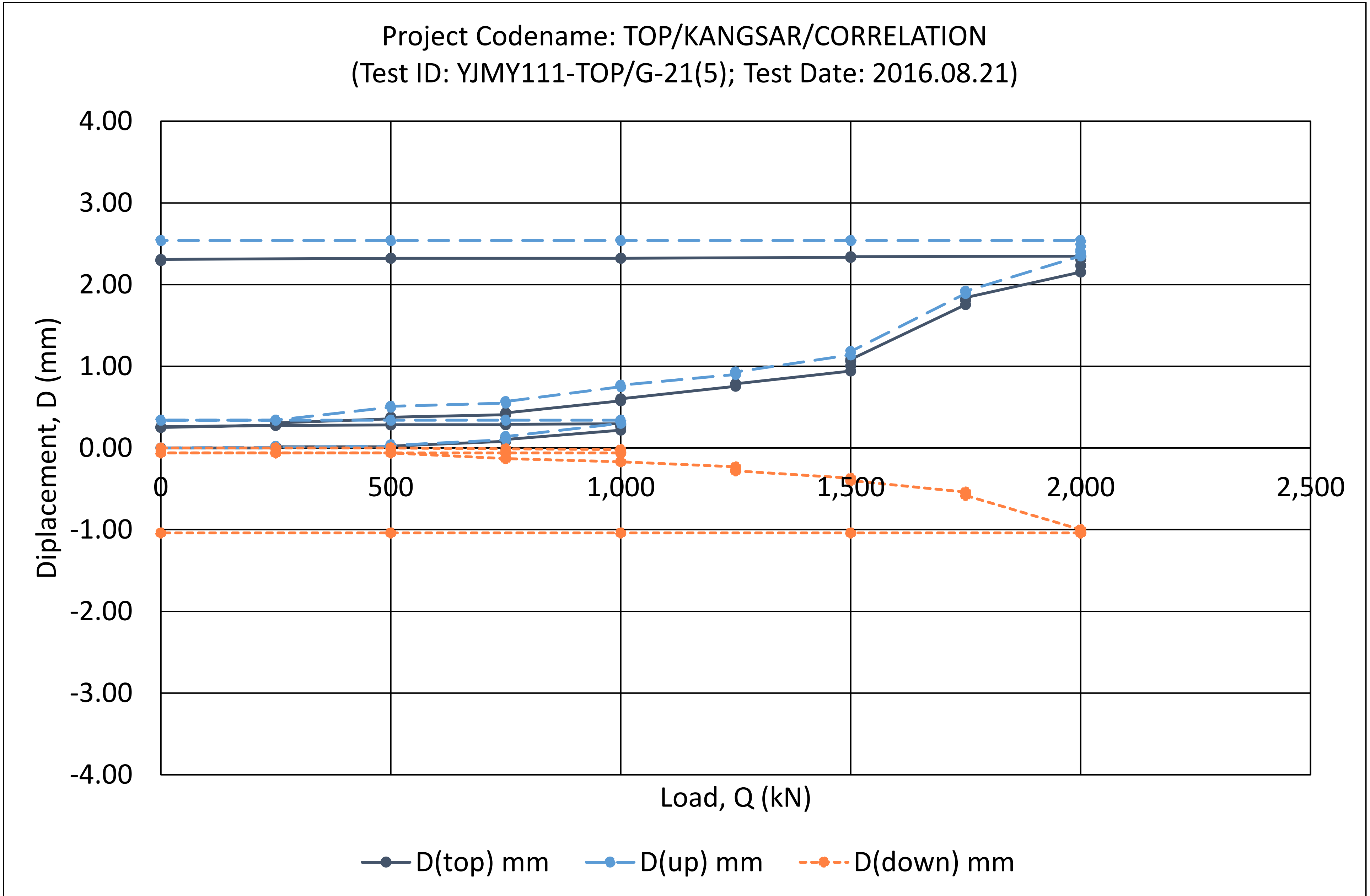
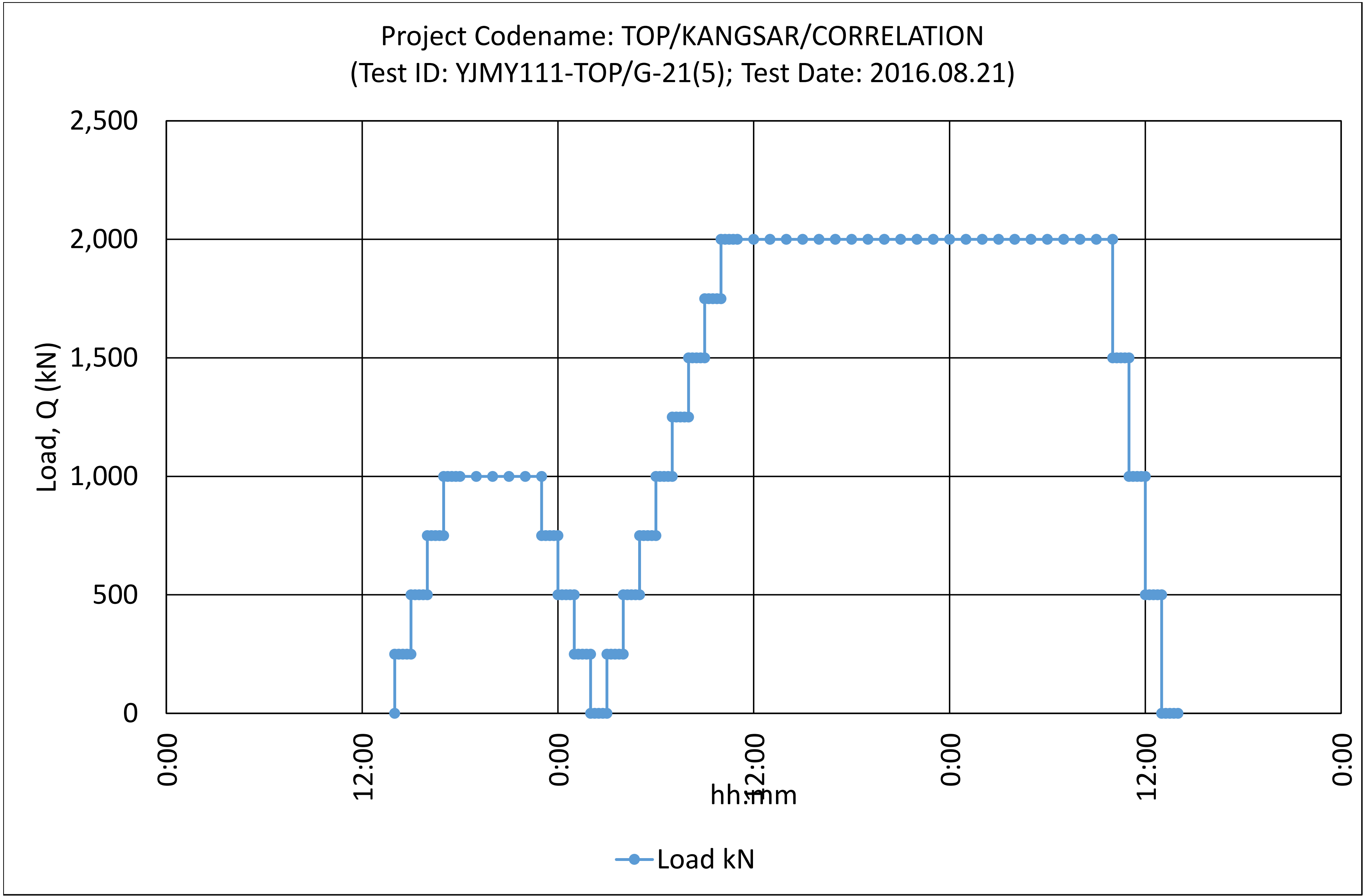
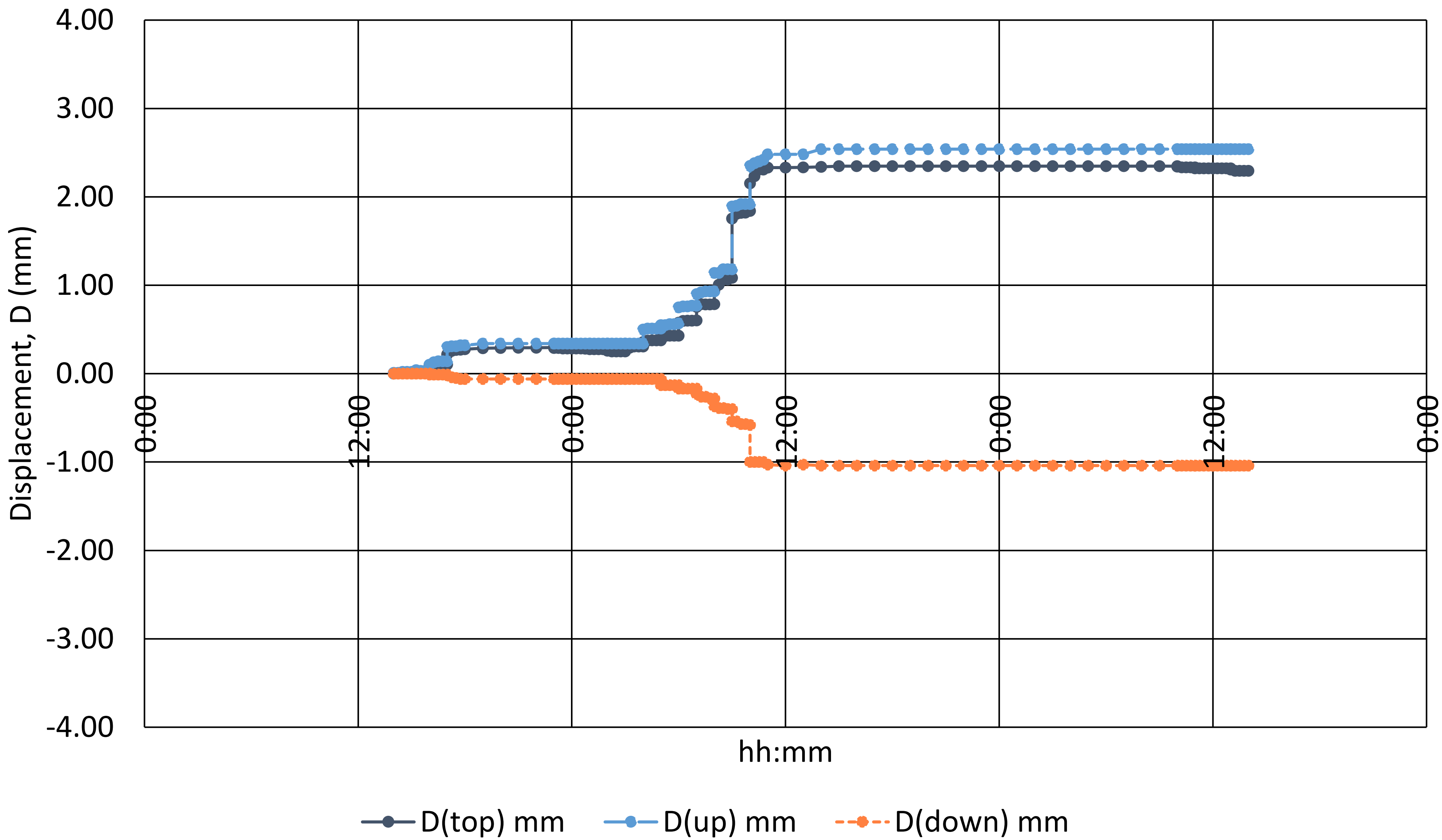
Displacement, D (mm) with 0-offset
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
-4.00
0
500
1,000
1,500
2,000
2,500
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm

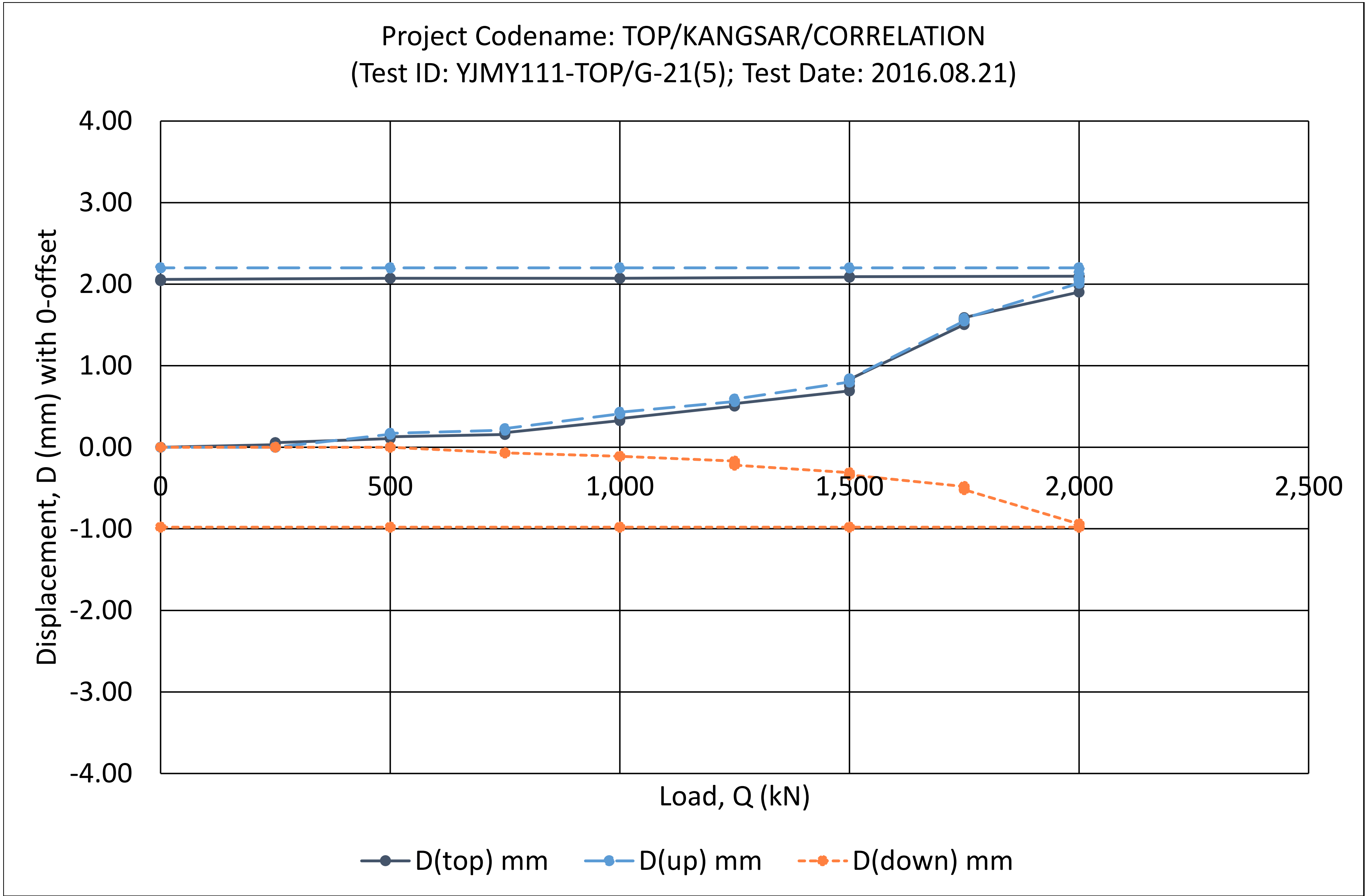

Project Codename: TOP/KANGSAR/CORRELATION
(Test ID: YJMY111-TOP/FG-19(5); Test Date: 2016.08.19)
Load, Q (kN)
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
Settlement, s (mm)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
4000, 7.50
Load, Q in kN vs Settlement, s in mm Plot
Q-s Plot from Kentledge
Q-s Plot from YJACK
Settlement, s (by SS/CP4)

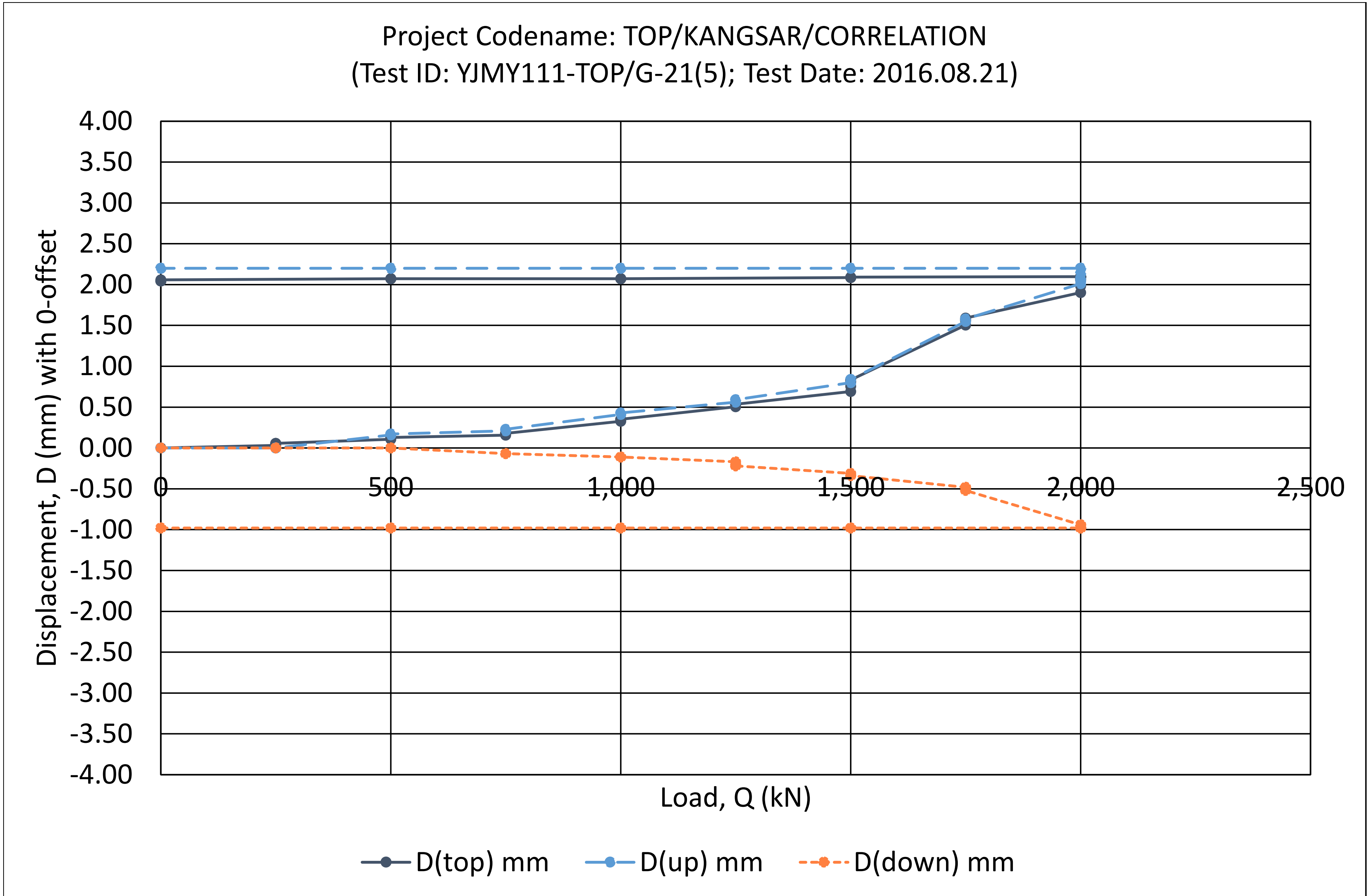

Project Codename: TOP/KANGSAR/CORRELATION
(Test ID: YJMY111-TOP/G-21(5); Test Date: 2016.08.21)
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
Diplacement, D (mm)
0
500
1,000
1,500
2,000
2,500
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm

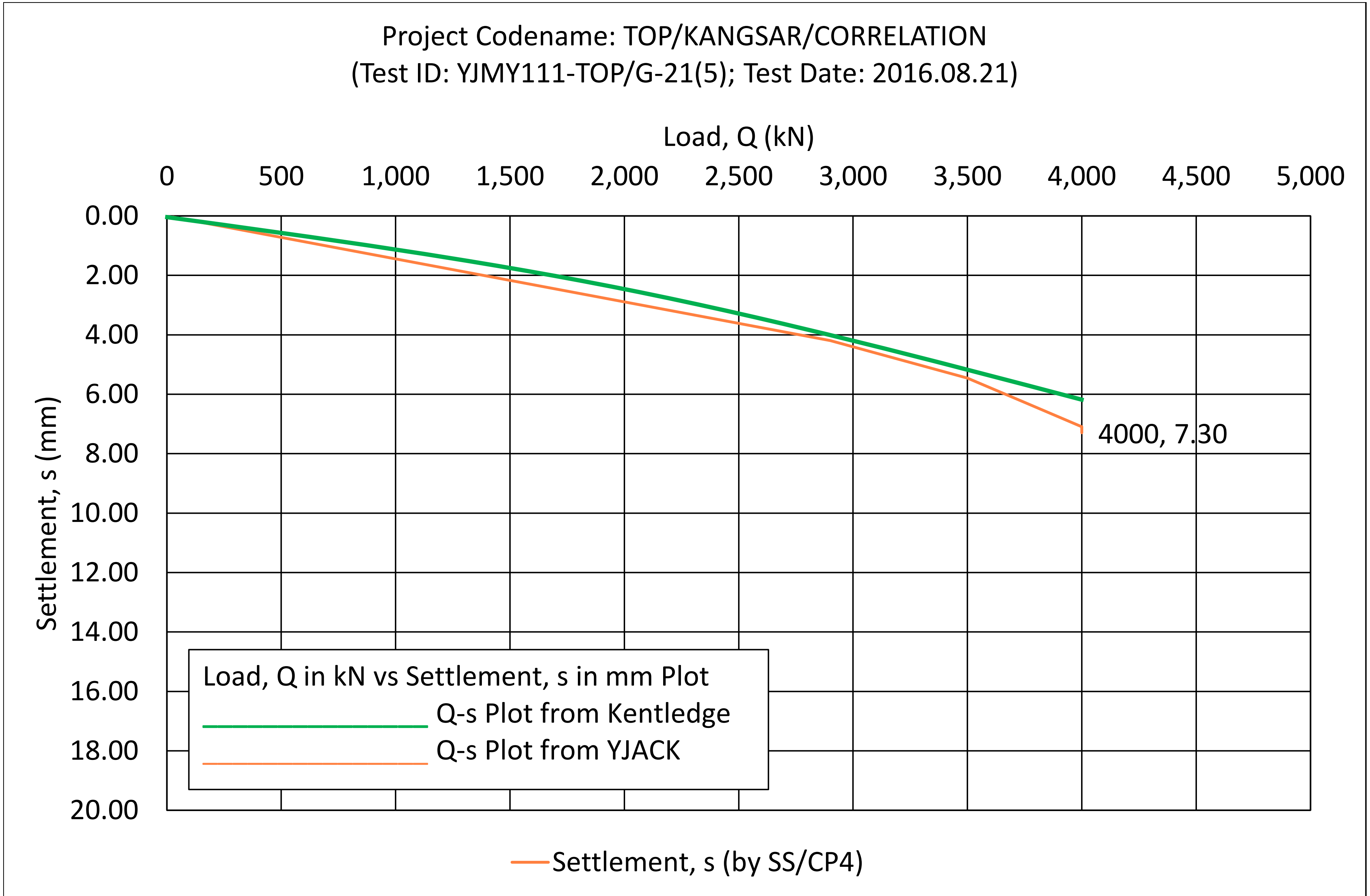

Project Codename: TOP/KANGSAR/CORRELATION
(Test ID: YJMY111-TOP/G-21(5); Test Date: 2016.08.21)
Load, Q (kN)
2,500
2,000
1,500
1,000
500
0
0:00
12:00
0:00
12:00
0:00
12:00
0:00
hh:mm
Load kN

Project Codename: TOP/KANGSAR/CORRELATION
(Test ID: YJMY111-TOP/G-21(5); Test Date: 2016.08.21)




Project Codename: TOP/KANGSAR/CORRELATION
(Test ID: YJMY111-TOP/G-21(5); Test Date: 2016.08.21)
Displacement, D (mm) with 0-offset
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
0
500
1,000
1,500
2,000
2,500
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm


Project Codename: TOP/KANGSAR/CORRELATION
(Test ID: YJMY111-TOP/G-21(5); Test Date: 2016.08.21)
Displacement, D (mm) with 0-offset
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
-4.00
0
500
1,000
1,500
2,000
2,500
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm

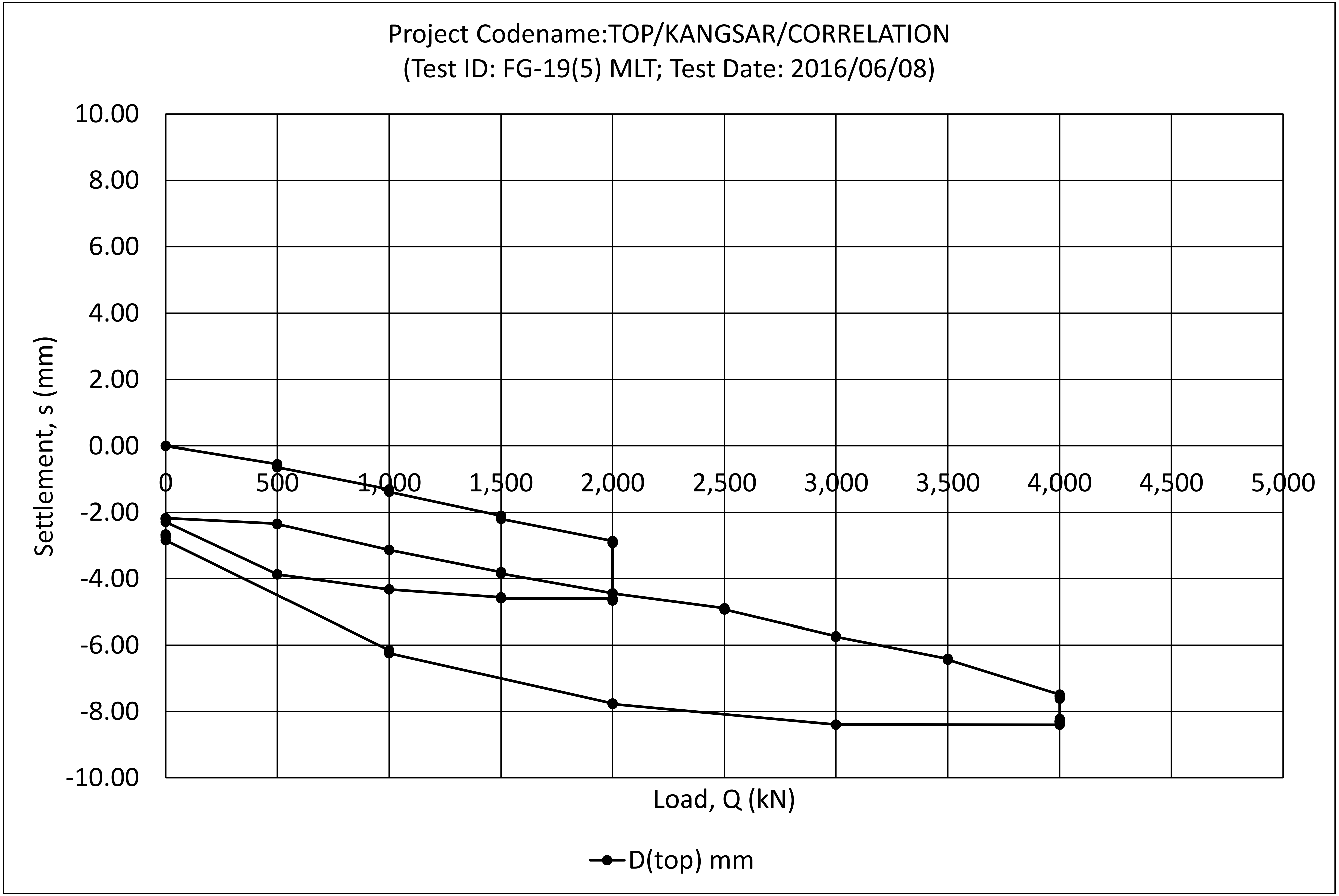

Project Codename: TOP/KANGSAR/CORRELATION
(Test ID: YJMY111-TOP/G-21(5); Test Date: 2016.08.21)
Load, Q (kN)
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
Settlement, s (mm)
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
20.00
4000, 7.30
Load, Q in kN vs Settlement, s in mm Plot
Q-s Plot from Kentledge
Q-s Plot from YJACK
Settlement, s (by SS/CP4)

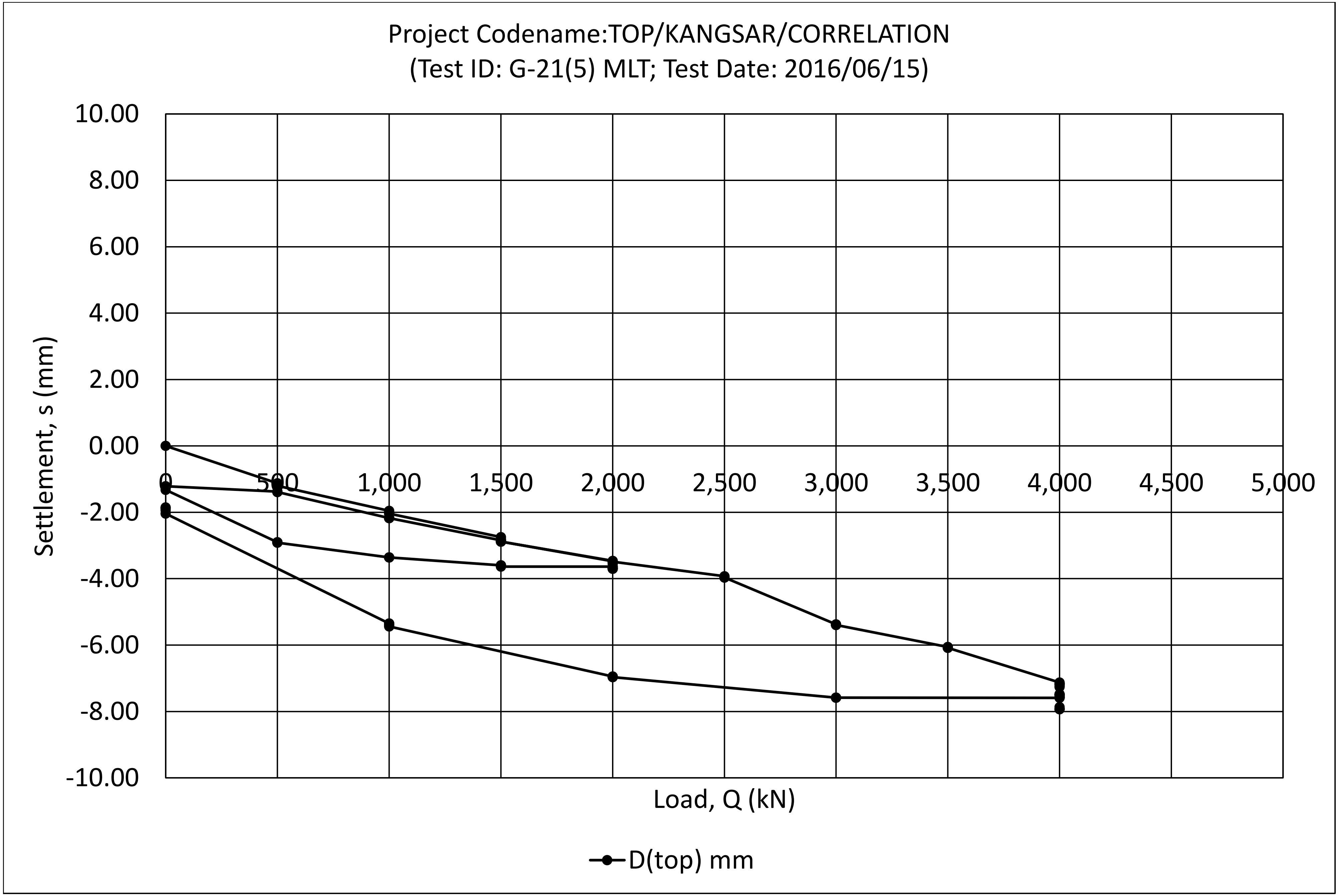
APPENDIX D

Field Sheets

Thick documents. Will be furnished upon request.

APPENDIX E


Project Codename:TOP/KANGSAR/CORRELATION
(Test ID: FG-19(5) MLT; Test Date: 2016/06/08)
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
Settlement, s (mm)
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
Load, Q (kN)
D(top) mm


Project Codename:TOP/KANGSAR/CORRELATION
(Test ID: G-21(5) MLT; Test Date: 2016/06/15)
Settlement, s (mm)
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
-10.00
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
Load, Q (kN)
D(top) mm

ATTACHMENT A

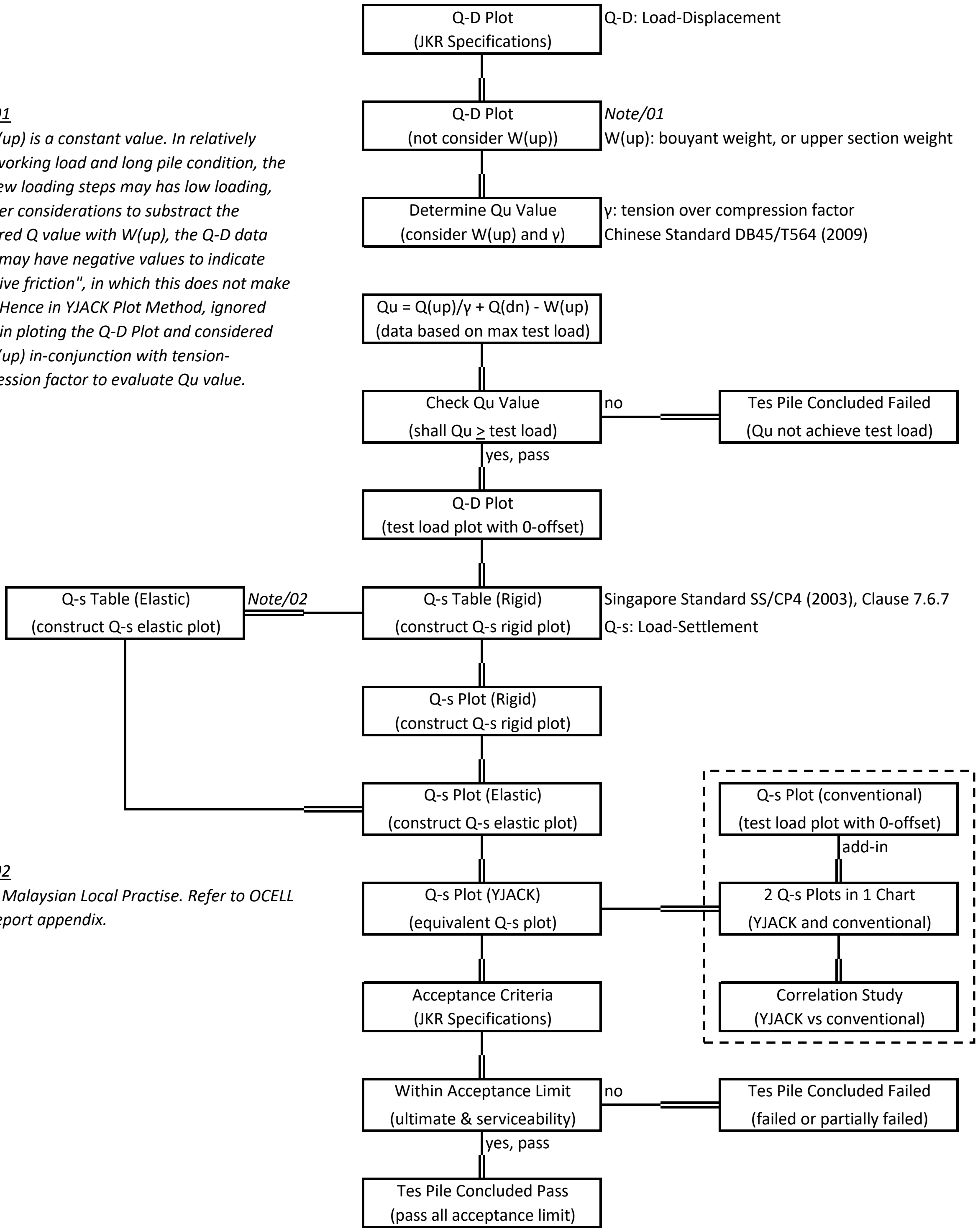
YJACK Technology Sdn Bhd (1086910-H)
25-2, Jalan Pandan Prima 1, Dataran Pandan Prima, 55100 Kuala Lumpur, Malaysia.
(T)+6016-2168129/2158129 (F)+603-92026811 (W)www.YJACKpiletest.com

SOP

Standard Operating Procedure (SOP) for Technical and Project Department
Constructing YJACK Q-s Plot from BD Pile Testing

Note/01

The W(up) is a constant value. In relatively small working load and long pile condition, the early few loading steps may has low loading, but after considerations to substract the measured Q value with W(up), the Q-D data points may have negative values to indicate "negative friction", in which this does not make sense. Hence in YJACK Plot Method, ignored W(up) in ploting the Q-D Plot and considered this W(up) in-conjunction with tension-compression factor to evaluate Qu value.



Note/02

Follow Malaysian Local Practise. Refer to OCELL Test Report appendix.

This SOP shall be deemd as YJACK Plot Method in constructing Q-s Plot from BD Testing (i.e. YPLOT Method).

Authorized By: Chief Executive Officer	Managed By: Chief Technical Officer	Effective Date: 2017/03/08

CONSTRUCTION OF THE EQUIVALENT TOP-LOADED LOAD-SETTLEMENT CURVE FROM THE RESULTS OF BI-DIRECTIONAL LOAD TEST (BDLT)

Introduction:
BDLT can provide a good estimate of a curve showing the load versus settlement of a top-loaded driven or bored pile (drilled shaft) with the following assumptions, which is consider good sense and usually conservative:

1. The end bearing load-movement curve in a top-loaded shaft has the same loads for a given movement as the net (subtract buoyant weight of pile above hydraulic jack) end bearing load-movement curve developed by the bottom of the hydraulic jack when placed at or near the bottom of the shaft.

2. The side shear load-movement curve in a top-loaded shaft has the same net shear, multiplied by an adjustment factor 'F' for a given downward movement as occurred in the BDLT for that same movement at the top of the jack in the upward direction. The same applies to the upward movement in a top-loaded tension test. Unless noted otherwise, a factor F=0.95 for compression in cohesionless soils and F=0.80 for tension tests in all soils is used.

3. The pile behaves as a rigid body, but includes the elastic compressions that are part of the movement data obtained from a bidirectional load test (BDLT). Procedure 1 interprets an equivalent top-load test (TLT) movement curve and procedure 2 corrects the effects of the additional elastic compressions in a TLT.

4. The part of the shaft below the hydraulic jack (one or multi level) has the same load-movement behavior as when top-loading the entire shaft. The subsequent 'end bearing movement curve' refers to the movement of the entire length of shaft below the jack.

Procedure 1:
Figure A shows BDLT results and Figure B shows the construction of equivalent top loaded settlement curve. Each of the curves shown has points numbered from 1 to 12 such that the same point number on each curve has the same movement magnitude.

With the above assumptions, the equivalent curve can be constructed as follows:
Select an arbitrary movement such as the 0.40 inches to give point 4 on the shaft side shear load movement curve in Figure A and record the load of 2,090 tons in shear at that movement. With the initial assumption of a rigid pile, the top of pile moves downward the same as the bottom. Therefore, find point 4 with 0.40 inches of upward movement on the end bearing load movement curve and record the corresponding load of 1,060 tons.

Adding these two loads will give the total load of 3,150 tons due to side shear plus end bearing at the same movement and thus gives point 4 on the Figure B load settlement curve for an equivalent top-loaded test. Procedure 1 can be used to obtain all the points in Figure B up to the component that moved the least at the end of the test, in this case point 5 in side shear.

Suitable hyperbolic curve fitting technique can be used for extrapolation of the side shear curve to produce end bearing movement data up to 12. Some judgment is required for deciding on the maximum number of data points to provide good fit with high correlation coefficient, r^2. Using the same movement matching procedure described earlier, the equivalent curve to points 6 to 12 can be extended. The dashed line shown in Figure B, signify that this part of the equivalent curve depends partly on extrapolated data.

If the data warrants, the extrapolations of both side shear and end bearing to extend the equivalent curve to a greater movement than the maximum measured (point 12) will be used. An appendix in this report gives the details of the extrapolation(s) used with the present BDLT and shows the fit with the actual data.

Procedure 2:
The elastic compression in the equivalent top load test always exceeds that in the BDLT. It produces more top movement and also additional side shear movement, which then generate more side shear, more compression, etc. An exact solution of this load transfer problem requires knowing the side shear vs. vertical movement (t-y) curves for a large number of pile length increments and solving the resulting set of simultaneous equations or using finite element or finite difference simulations to obtain an approximate solution for these equations.

The attached analysis P.6 gives the equations for the elastic compressions that occur in the BDLT with one or two levels of hydraulic jacks. Analysis P.7 gives the equations for the elastic compressions that occur in the equivalent TLT. Both sets of equations do not include the elastic compression below the hydraulic jack because the same compression takes place in both the BDLT and the TLT. This is equivalent to taking $I_3 = 0$. Subtracting the BDLT from the TLT compression gives the desired additional elastic compression at the top of the TLT. The additional elastic compression is then added to the 'rigid' equivalent curve obtained from Part 1 to obtain the final, corrected equivalent load-settlement curve for the TLT on the same pile as the actual BDLT.

Note that the above p.6 and p.7 give equations for each of three assumed patterns of developed side shear stress along the pile. The pattern shown in the center of the three is applicable to any approximate determined side shear distribution. Experience has shown the initial solution for the additional elastic compression, as described above, gives an adequate and slightly conservative (high) estimate of the additional compression versus more sophisticated load-transfer analyses as described in the first paragraph of this Part II.

The analysis p.8 provides an example of calculated results in English units on a hypothetical 1-stage, single level BDLT using the simplified method in Part II with the centroid of the side shear distribution 44.1% above the base of the hydraulic jack. Figure C compares the corrected with the rigid curve of Figure B. Page 9 contains an example equivalent to that above in SI units.

The final analysis p.10 provides an example of calculated results in English units on a hypothetical 3-stage, multi level BDSLT using the simplified method in Part II with the centroid of the combined upper and middle side shear distribution 44.1% above the base of the bottom hydraulic jack. The individual centroids of the upper and middle side shear distribution lie 39.6% and 57.9% above and below the middle hydraulic jack, respectively. Figure E compares the corrected with the rigid curve. Page II contains an example equivalent to that above in SI units.

Other Tests: The example illustrated in Figure A has the maximum component movement in end bearing. The procedures remain the same if the maximum test movement occurred in side shear. Then we would have extrapolated end bearing to produce the dashed-line part of the reconstructed top-load settlement curve.

The example illustrated also assumes a pile top-loaded in compression. For a pile top-loaded in tension we would, based on Assumptions 2 and 3, use the upward side shear load curve in Figure A, multiplied by the F = 0.80 noted in Assumption 2, for the equivalent top-loaded displacement curve.

Expected Accuracy: There are only five series of tests that provide the data needed to make a direct comparison between actual, full scale, top-loaded pile movement behaviour and the equivalent behaviour obtained from a BDLT by the method described herein. These involved three sites in Japan and one in Singapore, in a variety of soils, with three compression tests on bored piles (drilled shafts), one compression test on a driven pile and one tension test on a bored pile. The largest bored pile had a 1.2 m diameter and a 37 m length. The driven pile had a 1-m increment modular construction and a 9 m length. The largest top loading = 28 MN (3,150 tons).

The following references detail the aforementioned Japanese tests and the results therefore:

> Kishida H. et al., 1992, "Pile Loading Tests at Osaka Amenity Park Project", Paper by Mitsubishi Co., also briefly described in Schmertmann (1993, see bibliography). Compares one drilled shaft in tension and another in compression.
>
> Ogura, H. et al., 1995, "Application of Pile Toe Load Test to Cast-in-place Concrete Pile and Precast Pile", special volume 'Tsuchi-to-Kiso' on Pile Loading Test, Japanese Geotechnical Society, Vol. 3, No. 5, Ser. No. 448. Original in Japanese. Translated by M.B. Karkee, GEOTOP Corporation. Compares one drilled shaft and one driven pile, both in compression.

We compared the predicted equivalent and measured top load at three top movements in each of the above four Japanese comparisons. The top movements ranged from ¼ inch (6 mm) to 40 mm, depending on the data available.

The (equiv./meas.) ratios of the top load averaged 1.03 in the 15 comparisons with a coefficient of variation of less than 10%. These available comparisons help support the practical validity of the equivalent top load method described herein.

L.S. Peng, A.M. Koon, R. Page and C. W. Lee report the results of a class-A prediction by others of the TLT curve from a BDLT on a 1.2 m diameter, 37.2 m long bored pile in Singapore, compared to an adjacent pile with the same dimensions actually top-loaded by kentledge. They report about a 4% difference in ultimate capacity and less than 8% difference in settlements over the 1.0 to 1.5 times working load range – comparable to the accuracy noted above. Their paper was published in March 1999 in the Proceedings of the International Conference on Rail Transit, held in Singapore and published by the Association of Consulting Engineers Singapore.

B.H. Fellenius has made several finite element method (FEM) studies of a BDLT in which he adjusted the parameters to produce good load-deflection matches with the BDLT up and down load-deflection curve. He then used the same parameters to predict the TLT deflection curve. We compared the FEM-predicted curve with the equivalent load-deflection predicted by the previously described Part I and II procedures, with the results again comparable to the accuracy noted above. A paper by Fellenius et. al. titled "BDLT and FE Analysis of a 28 m Deep Barrette in Manila, Philippines", awaiting publication in the ASCE Journal of Geotechnical and Environmental Engineering, details one of the comparisons.

Limitations: The engineer using these results should judge the conservatism of the aforementioned assumptions and extrapolation(s) before utilizing the results for design purposes. For example, brittle failure behaviour may produce movement curves with abrupt changes in curvature (not hyperbolic). However, the hyperbolic fit method and the assumptions used usually produce reasonable equivalent top load settlement curves.

Example of the Construction of an Equivalent Top-Loaded Settlement Curve (Figure B) From BDLT Results (Figure A)

Figure A

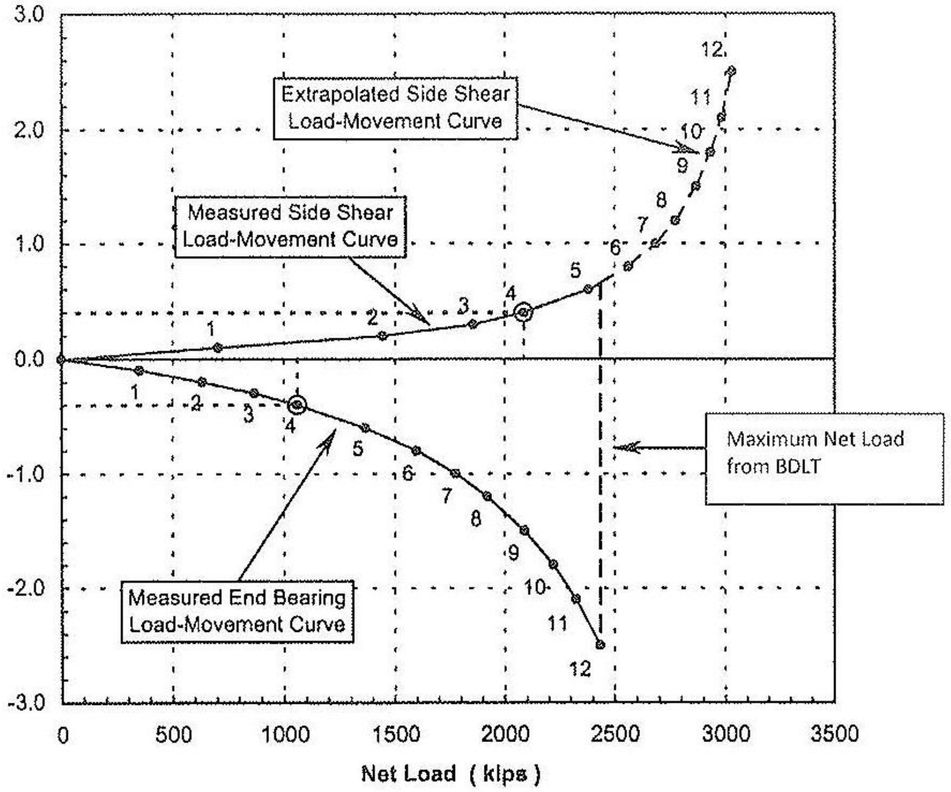
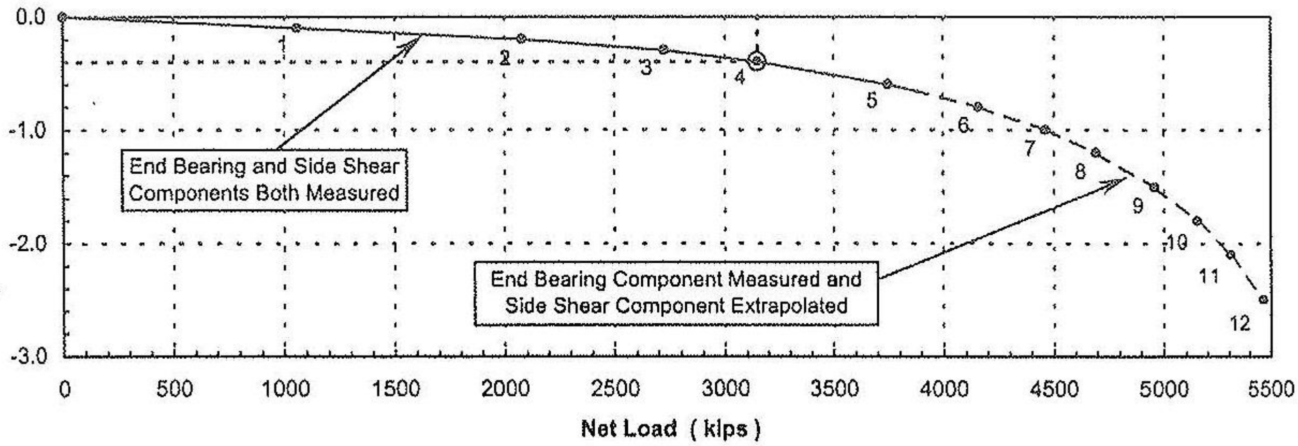
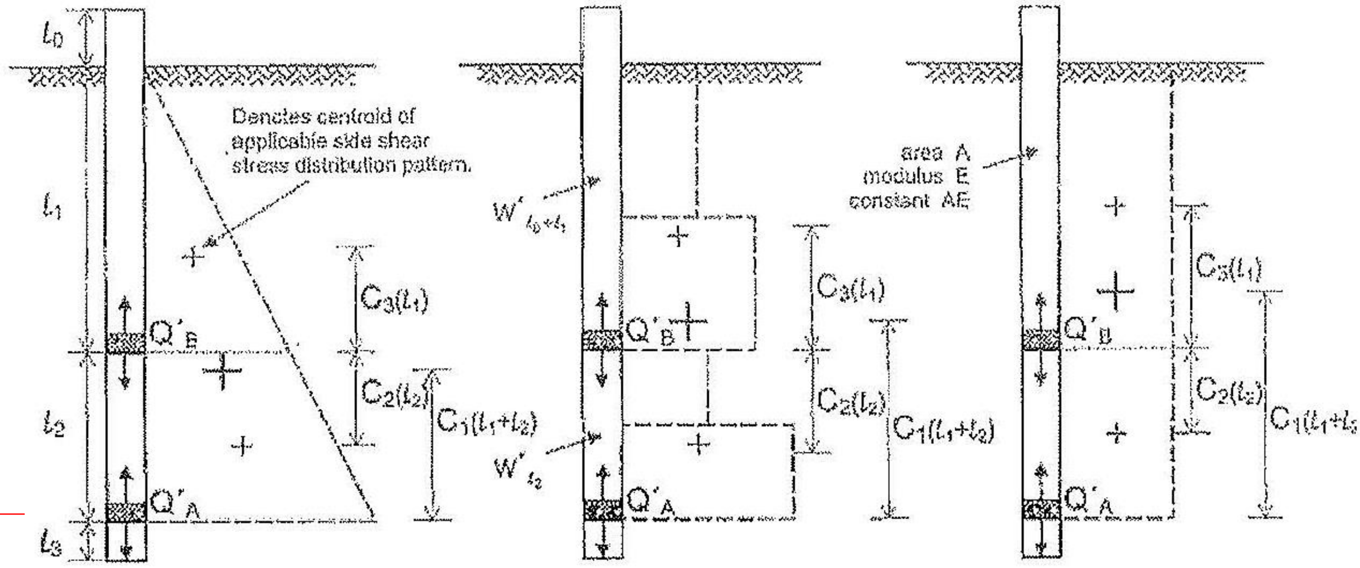


Figure B



Theoretical Elastic Compression in BDLT
Based on Pattern of Development Side Shear Stress



1-Stage Single Level Test (Q'_A only):

$\delta_{BDLT} = \delta_{\uparrow e1} + \delta_{\downarrow e2}$

$C_1 = \frac{1}{3}$	Centroid Factor = C_1	$C_1 = \frac{1}{2}$
$\delta_{\uparrow(\ell_1+\ell_2)} = \frac{1}{3}\frac{Q'_{\uparrow A}(\ell_1+\ell_2)}{AE}$	$\delta_{\uparrow(\ell_1+\ell_2)} = C_1\frac{Q'_{\uparrow A}(\ell_1+\ell_2)}{AE}$	$\delta_{\uparrow(\ell_1+\ell_2)} = \frac{1}{2}\frac{Q'_{\uparrow A}(\ell_1+\ell_2)}{AE}$

3-Stage Multi Level Test (Q'_A and Q'_B):

$\delta_{BDLT} = \delta_{\uparrow e1} + \delta_{\downarrow e2}$

$C_3 = \frac{1}{3}$	Centroid Factor = C_3	$C_3 = \frac{1}{2}$
$\delta_{\uparrow\ell_1} = \frac{1}{3}\frac{Q'_{\uparrow B}\ell_1}{AE}$	$\delta_{\uparrow\ell_1} = C_3\frac{Q'_{\uparrow B}\ell_1}{AE}$	$\delta_{\uparrow\ell_1} = \frac{1}{3}\frac{Q'_{\uparrow B}\ell_1}{AE}$
$C_2 = \frac{1}{3}\left(\frac{3\ell_1+2\ell_2}{2\ell_1+\ell_2}\right)$	Centroid Factor = C_2	$C_2 = \frac{1}{2}$
$\delta_{\downarrow\ell_2} = \frac{1}{3}\left(\frac{3\ell_1+2\ell_2}{2\ell_1+\ell_2}\right)\frac{Q'_{\downarrow B}\ell_2}{AE}$	$\delta_{\downarrow\ell_2} = C_2\frac{Q'_{\downarrow B}\ell_2}{AE}$	$\delta_{\downarrow\ell_2} = \frac{1}{2}\frac{Q'_{\downarrow B}\ell_2}{AE}$

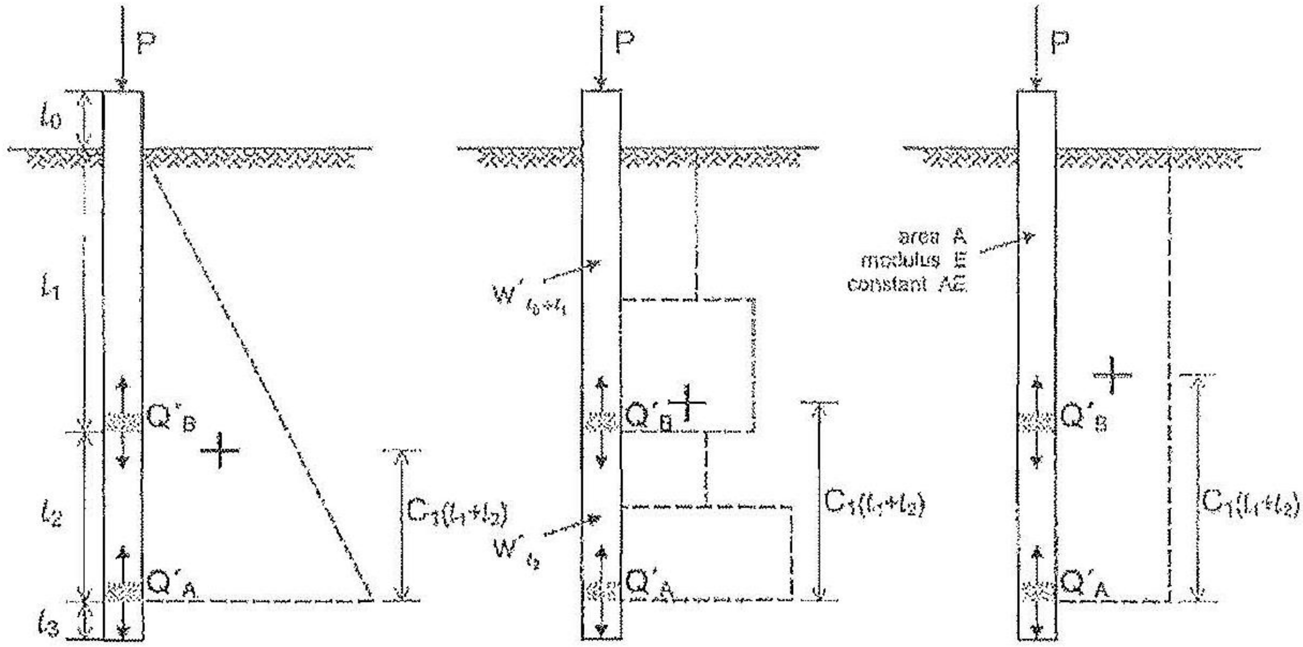
Net Loads:

$Q'_{\uparrow A} = Q_{\uparrow A} - W'_{\ell_0+\ell_1+\ell_2}$ $Q'_{\uparrow B} = Q_{\uparrow B} - W'_{\ell_0+\ell_1}$ $Q'_{\downarrow B} = Q_{\downarrow B} + W'_{\ell_2}$

W' = pile weight, bouyant where below water table

Q'_B is the 2nd level BD-JACK.
In YJACK Validation Program, only single level (1) YJACK installed, hence ignored Q'_B level.
Only consider Q'_A level.

Theoretical Elastic Compression in Top Loaded Test
Based on Pattern of Development Side Shear Stress



Top Loaded Test: $\delta_{TLT} = \delta_{\downarrow \ell_0} + \delta_{\downarrow \ell_1+\ell_2}$

$\delta_{\downarrow \ell_0} = \dfrac{P\ell_0}{AE}$	$\delta_{\downarrow \ell_0} = \dfrac{P\ell_0}{AE}$	$\delta_{\downarrow \ell_0} = \dfrac{P\ell_0}{AE}$
$C_1 = \dfrac{1}{3}$	Centroid Factor $= C_1$	$C_1 = \dfrac{1}{2}$
$\delta_{\downarrow \ell_1+\ell_2} = \dfrac{(Q'_{\downarrow A}+2P)}{3}\dfrac{(\ell_2+\ell_2)}{AE}$	$\delta_{\downarrow \ell_1+\ell_2} = \left[(C_1)Q'_{\downarrow A}+(1-C_1)P\right]\dfrac{(\ell_1+\ell_2)}{AE}$	$\delta_{\downarrow \ell_1+\ell_2} = \dfrac{(Q'_{\downarrow A}+P)}{2}\dfrac{(\ell_1+\ell_2)}{AE}$

Net and Equivalent Loads:

$Q'_{\downarrow A} = Q_{\downarrow A} - W'_{\ell_0+\ell_1+\ell_2}$ $\quad P_{single} = Q'_{\downarrow A} + Q'_{\uparrow A}$ $\quad P_{multi} = Q'_{\downarrow A} + Q'_{\uparrow B} + Q'_{\downarrow B}$

Component loads Q selected at the same (±) Δ_{BDSLT}.

ATTACHMENT B

CONTROLLED COPY

Please refer to separate document.

ATTACHMENT C

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STANDARDS MALAYSIA ACCREDITED LABORATORY

MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE : 12 May 2016

CERTIFICATE NO : SST/SA/R/2016E/784

ISSUED BY : **SIRIM Standards Technology Sdn. Bhd.**
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APPROVED SIGNATORIES

Mohd Hashim Bin Effandi

Submitted by : YJack Technology Sdn Bhd
No 25-2, Jalan Pandan Prima1
Dataran Pandan Prima
55100 Kuala Lumpur Malaysia
Attn:Mr. Jimmy Wai

Job No. : SA2016-3049-1
Date Received : 12/05/2016

Instrument : Displacement Transducer
Manufacturer : RSI

Model No. : PM-52L
Serial No. : 20141

Instrument Condition When Received :
Physically in good condition

Instrument Condition When Returned :
1.Calibrated and test serviceable
2.Calibration due date requested by customer
3.The user should be aware that there are a number of factors that may caused this instrument to drift out of calibration before the specified calibration interval has expired.

Environmental Condition:-
Average Temperature : (20 ± 1) °C
Average Relative Humidity : (58 ± 1) %RH
Calibration Date : 12 May 2016
Requested Cal.Due Date : 12 May 2017

Calibration Method :
This instrument was calibrated using the calibration procedures No. MSD/0010 Rev 5.0

Calibration Standard(s) Used :

Instrument Type :	Serial No. :	Cal. Due Date :	Cal. Cert. No.:	Traceability :
Gauge Block	183102	18/02/2017	SST/SA/IR/2016B/25	SST(SA)/NML(M'SIA)

The standard instruments used in this calibration are traceable to either the National Standards maintained at the National Metrology Laboratory, SIRIM Berhad or other recognised International Standard Laboratories

Calibration Sticker No.: SA-05-784
Measurement Uncertainty : ± 0.05 mm
The uncertainty calculation is based on the ISO guide to the expression of uncertainty in measurement.
Coverage Factor k : 2

Approved Signatory
Mohd Hashim Bin Effandi

The uncertainties are for a confidence probability of approximately 95%

SIRIM SST

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STANDARDS MALAYSIA ACCREDITED LABORATORY

MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE: 12 May 2016 **CERTIFICATE NUMBER:** SST/SA/R/2016E/784

Instrument : Displacement Tranducer **Serial No.** : 20141

CALIBRATION RESULTS

Nominal Value (mm)	Calibrated Value (mm)	Tolerance (mm)
0.0	0.00	N/A
10.0	9.90	N/A
20.0	19.92	N/A
30.0	30.91	N/A
40.0	40.90	N/A
50.0	49.90	N/A

Note: Tolerance not provided by user

Calibrated by:

Mohd Amri Abd Aziz

The uncertainties are for a confidence probability of approximately 95%

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MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE : 12 May 2016 **CERTIFICATE NO** : SST/SA/R/2016E/785

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55100 Kuala Lumpur Malaysia
Attn:Mr. Jimmy Wai

Job No. : SA2016-3049-2
Date Received : 12/05/2016

Instrument : Displacement Transducer
Manufacturer : RSI

Model No. : PM-52L
Serial No. : 20142

Instrument Condition When Received :
Physically in good condition

Instrument Condition When Returned :
1.Calibrated and test serviceable
2.Calibration due date requested by customer
3.The user should be aware that there are a number of factors that may caused this instrument to drift out of calibration before the specified calibration interval has expired.

Environmental Condition:-
Average Temperature : (20 ± 1) °C Average Relative Humidity : (58 ± 1) %RH
Calibration Date : 12 May 2016 **Requested Cal.Due Date** : 12 May 2017

Calibration Method :
This instrument was calibrated using the calibration procedures No. MSD/0010 Rev 5.0

Calibration Standard(s) Used :

Instrument Type :	Serial No. :	Cal. Due Date :	Cal. Cert. No.:	Traceability :
Gauge Block	183102	18/02/2017	SST/SA/IR/2016B/25	SST(SA)/NML(M'SIA)

The standard instruments used in this calibration are traceable to either the National Standards maintained at the National Metrology Laboratory, SIRIM Berhad or other recognised International Standard Laboratories

Calibration Sticker No.: SA-05-785
Measurement Uncertainty : ± 0.05 mm
The uncertainty calculation is based on the ISO guide to the expression of uncertainty in measurement.
Coverage Factor k : 2

Approved Signatory
Mohd Hashim Bin Effandi

The uncertainties are for a confidence probability of approximately 95%

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MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE: 12 May 2016 **CERTIFICATE NUMBER:** SST/SA/R/2016E/785

Instrument : Displacement Tranducer **Serial No.** : 20142

CALIBRATION RESULTS

Nominal Value (mm)	Calibrated Value (mm)	Tolerance (mm)
0.0	0.00	N/A
10.0	9.95	N/A
20.0	19.89	N/A
30.0	30.04	N/A
40.0	39.98	N/A
50.0	50.02	N/A

Note: Tolerance not provided by user

Calibrated by:

Mohd Amri Abd Aziz

The uncertainties are for a confidence probability of approximately 95%

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MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE : 12 May 2016

CERTIFICATE NO : SST/SA/R/2016E/786

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No 25-2, Jalan Pandan Prima1
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55100 Kuala Lumpur Malaysia
Attn:Mr. Jimmy Wai

Job No. : SA2016-3049-3
Date Received : 12/05/2016

Instrument : Displacement Transducer
Manufacturer : RSI

Model No. : PM-52L
Serial No. : 20143

Instrument Condition When Received :
Physically in good condition

Instrument Condition When Returned :
1.Calibrated and test serviceable
2.Calibration due date requested by customer
3.The user should be aware that there are a number of factors that may caused this instrument to drift out of calibration before the specified calibration interval has expired.

Environmental Condition:-
Average Temperature : (20 ± 1) °C
Average Relative Humidity : (58 ± 1) %RH
Calibration Date : 12 May 2016
Requested Cal.Due Date : 12 May 2017

Calibration Method :
This instrument was calibrated using the calibration procedures No. MSD/0010 Rev 5.0

Calibration Standard(s) Used :

Instrument Type :	Serial No. :	Cal. Due Date :	Cal. Cert. No.:	Traceability :
Gauge Block	183102	18/02/2017	SST/SA/IR/2016B/25	SST(SA)/NML(M'SIA)

The standard instruments used in this calibration are traceable to either the National Standards maintained at the National Metrology Laboratory, SIRIM Berhad or other recognised International Standard Laboratories

Calibration Sticker No.: SA-05-786
Measurement Uncertainty : ± 0.05 mm
The uncertainty calculation is based on the ISO guide to the expression of uncertainty in measurement.
Coverage Factor k : 2

Approved Signatory
Mohd Hashim Bin Effandi

The uncertainties are for a confidence probability of approximately 95%

CERTIFICATE OF CALIBRATION

MS ISO/IEC 17025 CALIBRATION SAMM NO. 088

DATE OF ISSUE: 12 May 2016 **CERTIFICATE NUMBER:** SST/SA/R/2016E/786

Instrument : Displacement Tranducer **Serial No.** : 20143

CALIBRATION RESULTS

Nominal Value (mm)	Calibrated Value (mm)	Tolerance (mm)
0.0	0.00	N/A
10.0	10.02	N/A
20.0	20.04	N/A
30.0	30.05	N/A
40.0	40.06	N/A
50.0	49.93	N/A

Note: Tolerance not provided by user

Calibrated by:

Mohd Amri Abd Aziz

The uncertainties are for a confidence probability of approximately 95%

CERTIFICATE OF CALIBRATION

DATE OF ISSUE : 12 May 2016

CERTIFICATE NO : SST/SA/R/2016E/787

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55100 Kuala Lumpur Malaysia
Attn:Mr. Jimmy Wai

Job No. : SA2016-3049-4
Date Received : 12/05/2016

Instrument : Displacement Transducer
Manufacturer : RSI

Model No. : PM-52L
Serial No. : 20144

Instrument Condition When Received :
Physically in good condition

Instrument Condition When Returned :
1.Calibrated and test serviceable
2.Calibration due date requested by customer
3.The user should be aware that there are a number of factors that may caused this instrument to drift out of calibration before the specified calibration interval has expired.

Environmental Condition:-
Average Temperature : (20 ± 1) °C
Average Relative Humidity : (58 ± 1) %RH
Calibration Date : 12 May 2016
Requested Cal.Due Date : 12 May 2017

Calibration Method :
This instrument was calibrated using the calibration procedures No. MSD/0010 Rev 5.0

Calibration Standard(s) Used :

Instrument Type :	Serial No. :	Cal. Due Date :	Cal. Cert. No.:	Traceability :
Gauge Block	183102	18/02/2017	SST/SA/IR/2016B/25	SST(SA)/NML(M'SIA)

The standard instruments used in this calibration are traceable to either the National Standards maintained at the National Metrology Laboratory, SIRIM Berhad or other recognised International Standard Laboratories

Calibration Sticker No.: SA-05-787

Measurement Uncertainty : Refer to calibration results

The uncertainty calculation is based on the ISO guide to the expression of uncertainty in measurement.

Coverage Factor k : 2

Approved Signatory
Mohd Hashim Bin Effandi

The uncertainties are for a confidence probability of approximately 95%

MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE: 12 May 2016 **CERTIFICATE NUMBER:** SST/SA/R/2016E/787

Instrument : Displacement Tranducer **Serial No.** : 20144

CALIBRATION RESULTS

Nominal Value (mm)	Calibrated Value (mm)	Tolerance (mm)
0.0	0.00	N/A
10.0	9.88	N/A
20.0	19.89	N/A
30.0	30.04	N/A
40.0	40.01	N/A
50.0	49.98	N/A

Note: Tolerance not provided by user

Calibrated by:

Mohd Amri Abd Aziz

The uncertainties are for a confidence probability of approximately 95%

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CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE : 12 May 2016

CERTIFICATE NO : SST/SA/R/2016E/788

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Submitted by : YJack Technology Sdn Bhd
No 25-2, Jalan Pandan Prima1
Dataran Pandan Prima
55100 Kuala Lumpur Malaysia
Attn:Mr. Jimmy Wai

Job No. : SA2016-3049-5
Date Received : 12/05/2016

Instrument : Displacement Transducer
Manufacturer : RSI

Model No. : PM-52L
Serial No. : 20147

Instrument Condition When Received :
Physically in good condition

Instrument Condition When Returned :
1.Calibrated and test serviceable
2.Calibration due date requested by customer
3.The user should be aware that there are a number of factors that may caused this instrument to drift out of calibration before the specified calibration interval has expired.

Environmental Condition:-
Average Temperature : (20 ± 1) °C
Average Relative Humidity : (58 ±) %RH
Calibration Date : 12 May 2016
Requested Cal.Due Date : 12 May 2017

Calibration Method :
This instrument was calibrated using the calibration procedures No. MSD/0010 Rev 5.0

Calibration Standard(s) Used :

Instrument Type :	Serial No. :	Cal. Due Date :	Cal. Cert. No.:	Traceability :
Gauge Block	183102	18/02/2017	SST/SA/IR/2016B/25	SST(SA)/NML(M'SIA)

The standard instruments used in this calibration are traceable to either the National Standards maintained at the National Metrology Laboratory, SIRIM Berhad or other recognised International Standard Laboratories

Calibration Sticker No.: SA-05-788
Measurement Uncertainty : ± 0.05 mm
The uncertainty calculation is based on the ISO guide to the expression of uncertainty in measurement.
Coverage Factor k : 2

Approved Signatory
Mohd Hashim Bin Effandi

The uncertainties are for a confidence probability of approximately 95%

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MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE: 12 May 2016 **CERTIFICATE NUMBER:** SST/SA/R/2016E/788

Instrument : Displacement Tranducer **Serial No.** : 20147

CALIBRATION RESULTS

Nominal Value (mm)	Calibrated Value (mm)	Tolerance (mm)
0.0	0.00	N/A
10.0	10.06	N/A
20.0	20.07	N/A
30.0	30.09	N/A
40.0	40.04	N/A
50.0	50.02	N/A

Note: Tolerance not provided by user

Calibrated by:

Mohd Amri Abd Aziz

The uncertainties are for a confidence probability of approximately 95%

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MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE : 12 May 2016

CERTIFICATE NO : SST/SA/R/2016E/789

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Mohd Hashim Bin Effandi

Submitted by : YJack Technology Sdn Bhd
No 25-2, Jalan Pandan Prima1
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55100 Kuala Lumpur Malaysia
Attn:Mr. Jimmy Wai

Job No. : SA2016-3049-6
Date Received : 12/05/2016

Instrument : Displacement Transducer
Manufacturer : RSI
Model No. : PM-52L
Serial No. : 20148

Instrument Condition When Received :
Physically in good condition

Instrument Condition When Returned :
1.Calibrated and test serviceable
2.Calibration due date requested by customer
3.The user should be aware that there are a number of factors that may caused this instrument to drift out of calibration before the specified calibration interval has expired.

Environmental Condition:-
Average Temperature : (20 ± 1) °C
Average Relative Humidity : (58 ± 1) %RH
Calibration Date : 12 May 2016
Requested Cal.Due Date : 12 May 2017

Calibration Method :
This instrument was calibrated using the calibration procedures No. MSD/0010 Rev 5.0

Calibration Standard(s) Used :

Instrument Type :	Serial No. :	Cal. Due Date :	Cal. Cert. No.:	Traceability :
Gauge Block	183102	18/02/2017	SST/SA/IR/2016B/25	SST(SA)/NML(M'SIA)

The standard instruments used in this calibration are traceable to either the National Standards maintained at the National Metrology Laboratory, SIRIM Berhad or other recognised International Standard Laboratories

Calibration Sticker No.: SA-05-789
Measurement Uncertainty : ± 0.05 mm
The uncertainty calculation is based on the ISO guide to the expression of uncertainty in measurement.
Coverage Factor k : 2

Approved Signatory
Mohd Hashim Bin Effandi

The uncertainties are for a confidence probability of approximately 95%

SIRIM SST

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STANDARDS MALAYSIA ACCREDITED LABORATORY

MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE: 12 May 2016 **CERTIFICATE NUMBER:** SST/SA/R/2016E/789

Instrument : Displacement Tranducer **Serial No.** : 20148

CALIBRATION RESULTS

Nominal Value (mm)	Calibrated Value (mm)	Tolerance (mm)
0.0	0.00	N/A
10.0	10.02	N/A
20.0	20.04	N/A
30.0	30.07	N/A
40.0	40.02	N/A
50.0	49.98	N/A

Note: Tolerance not provided by user

Calibrated by:

Mohd Amri Abd Aziz

The uncertainties are for a confidence probability of approximately 95%

CERTIFICATE OF CALIBRATION

MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

DATE OF ISSUE : 12 May 2016

CERTIFICATE NO : SST/SA/R/2016E/805

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Abdul Latip Bin Alias

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55100 Kuala Lumpur Malaysia
Attn:Mr. Jimmy Wai

Job No. : SA2016-3049-8
Date Received : 12/05/2016

Instrument : Pressure Transducer (Force)
Manufacturer : Shanghai Shendi Sensor & Technology

Model No. : PT124B-210-M20
Serial No. : 150131097

Instrument Condition When Received :
Physically in good condition

Instrument Condition When Returned :
1.Calibrated and test serviceable
2.Calibration due date requested by customer
3.The user should be aware that there are a number of factors that may caused this instrument to drift out of calibration before the specified calibration interval has expired.

Environmental Condition:-
Average Temperature : (23 ± 1) °C
Average Relative Humidity : (54 ± 1) %RH
Calibration Date : 12 May 2016
Requested Cal.Due Date : 12 May 2017

Calibration Method :
This instrument was calibrated using the calibration procedures No.MSP/0011 Rev.8.0

Calibration Standard(s) Used :

Instrument Type :	Serial No. :	Cal. Due Date :	Cal. Cert. No.:	Traceability :
Digital Test Gauge	963071	12/02/2017	SST/SA/IR/2016B/22	SST(SA)/NML(M'SIA)
Budenberg Comparator	580/29944	-	-	-

The standard instruments used in this calibration are traceable to either the National Standards maintained at the National Metrology Laboratory, SIRIM Berhad or other recognised International Standard Laboratories

Calibration Sticker No.: SA-05-805
Measurement Uncertainty : ± 2 kN
The uncertainty calculation is based on the ISO guide to the expression of uncertainty in measurement.
Coverage Factor k : 2

Approved Signatory
Abdul Latip Bin Alias

The uncertainties are for a confidence probability of approximately 95%

SIRIM SST

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MS ISO/IEC 17025
CALIBRATION
SAMM NO. 088

CERTIFICATE OF CALIBRATION

DATE OF ISSUE: 12 May 2016 **CERTIFICATE NUMBER:** SST/SA/R/2016E/805

Instrument : Pressure Transducer (Force) **Serial No.** : 150131097

CALIBRATION RESULTS

Range : 2000 kN **Graduation** : 1 kN

Standard Applied (kN)	Actual Equipment Reading (kN)				Limits
	Increase		Decrease		
	Before Adjustment	After Adjustment	Before Adjustment	After Adjustment	
0	0	N/A	0	N/A	N/A
200	198	N/A	198	N/A	N/A
400	398	N/A	398	N/A	N/A
600	597	N/A	597	N/A	N/A
800	794	N/A	794	N/A	N/A
1000	993	N/A	993	N/A	N/A
1200	1192	N/A	1192	N/A	N/A
1600	1590	N/A	1590	N/A	N/A
2000	1985	N/A	-	-	N/A

Note *: No adjustment done.*
: Limits not available (N/A)
: Inner diameter = 300 mm

Calibrated By :

Muhamad Ghulwani Ab Ghalib

The uncertainties are for a confidence probability of approximately 95%

CORRELATION REPORT

BI-DIRECTIONAL PILE LOAD TESTING OF PILES

Validation Test of YJACK Bi-Directional Pile Load Test as the Alternative Pile Load Test Method Compared to Conventional Kentledge Method on Driven & Injection Concrete Piles.

Project Case Study: Muar, 6*YJACK Pile Tests (Stage 1: 4*MLT + Stage 2: 2*QLT)
Pile Driving System: Injection Piles on 4*Spun Concrete Pile 300mm, SC300Ø
CCGF Research Grant Milestone: Product Proof of Concept

PREPARED FOR:

RESEARCH GRANT:
Concept to Commercialization Gap Fund (CCGF)
High Impact Program 2 (HIP2)

GRANT MANAGER:
Agensi Inovasi Malaysia (AIM)
SME Corporation Malaysia (SME Corp)
PlaTCOM Ventures Sdn Bhd (PlaTCOM)

RESEARH COLLABORATOR:
Universiti Tun Hussein Onn Malaysia (UTHM)
UTHM Commercial Sdn Bhd (UTHMC)

VALIDATION INSTITUTION:
Construction Research Institute Malaysia (CREAM)
Technical Opinion Program (TOP)

Prepared by:

Report Serial	Report No	Revision No	Issued Date
BDPLT-YJMY111	1	1	2017/APR/01

TABLE OF CONTENTS

EXECUTIVE SUMMAY

The objectives of the tests were to validate the newly invented YJACK on driven concrete piles compared to conventional kentledge pile load test system in terms of:

(1) the functionality, and

(2) the accuracy

This YJACK validation correlation tests were performed at Project Case Study at Muar on 2015/OCT/10-12 with 6*NOS YJACK pile tests as following:

- Validation Phase 1: maintained load tests (MLT) on Test Pile # TOP1A & 1B, TOP2A & 2B to test load 600kN
- Validation Phase 2: quick load tests (QLT) on Test Pile # TOP1A & 1B to test load 900kN

The following is the summary of the correlation results obtained from Correlation Phase 1 and Phase 2.

Correlation Method # 1

The following is the correlation using load test settlement at working and test loads as the correlation base data:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B	TOP1A	TOP1B
Loading Procedure	MLT	MLT	MLT	MLT	QLT	QLT
Average Accuracy	94.2%	94.7%	93.3%	91.2%	87.4%	83.1%
Accuracy Level *	High	High	High	High	High	High
Average Accuracy	90.7%					

* High if Accuracy ≥ 80%; Moderate if 50% > Accuracy < 80%; Low if Accuracy ≤ 50%

Correlation Method # 2

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B	TOP1A	TOP1B
Loading Procedure	MLT	MLT	MLT	MLT	QLT	QLT
Average Accuracy	98.5%	98.6%	98.8%	98.6%	96.6%	96.9%
Accuracy Level *	High	High	High	High	High	High
Average Accuracy	98.0%					

* High if Accuracy ≥ 80%; Moderate if 50% > Accuracy < 80%; Low if Accuracy ≤ 50%

The following is the validation conclusions for functionality and accuracy of the newly invented YJACK.

(1) Validation for the functionality: the YJACKs are fully performed well in terms of functionality in installation and testing.

(2) Validation for the accuracy: the YJACKs are fully performed well in terms of accuracy in terms of ultimate (i.e. the load) and serviceability (i.e. settlement) design considerations.

VALIDATION BACKGROUND

PlaTCOM Ventures Sdn Bhd is the national technology commercialization platform of Malaysia. It is a wholly-owned subsidiary company of Agensi Inovasi Malaysia (AIM) formed in collaboration with SME Corporation Malaysia (SME Corp) under one of its six High Impact Programmes (HIPs) in SME Master Plan 2012-2020.

PlaTCOM Ventures has a mission: to turn the creative ideas of our inventors and entrepreneurs into successful products and services that change the world.

The model addresses the innovation gaps through a holistic and 'market-driven' approach in supporting innovation and industrial competitiveness. It is designed to remove market and financing barriers to innovation.

The program provides necessary support from 'concept to commercialization'. This is done through the provision of access to technical assistance, market intelligence, incubation facilities, testing facilities and other relevant services - all in a single platform.

VALIDATION PRODUCT – YJACK

The validation product is YJACK. It is a static pile load test method based on bi-directional principle. It is an alternative and economical method to conventional maintained load test using kentledge blocks or reaction piles methods.
This invention is by far the best compared to conventional method. The YJACK solves problems by:

a. cost saving;
b. time saving (from 10 days to 1 day in preparation);
c. eco-friendly green and safe;
d. suitable for all types of piles and test loads as well as offshore piles using autoYJACK.

VALIDATION OBJECTIVE

The objectives of the tests were to validate the newly invented YJACK on driven concrete piles compared to conventional kentledge pile load test system in terms of:

(1) the functionality, and

(2) the accuracy

This YJACK Test Report presents the 4*NOS test piles installed at Project Case at Muar on 2015/OCT/10-12 with 6*NOS YJACK pile tests as following:

- Validation Phase 1: maintained load tests (MLT) on Test Pile # TOP1A & 1B, TOP2A & 2B to test load 600kN
- Validation Phase 2: quick load tests (QLT) on Test Pile # TOP1A & 1B to test load 900kN

PILE DESIGN

The Test Piles have the following pile design information based on piling record:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Pile Type	Spun Concrete	Spun Concrete	Spun Concrete	Spun Concrete
Pile Grade	Grade 80/Class B	Grade 80/Class B	Grade 80/Class B	Grade 80/Class B
Pile Size (mm)	300Ø	300Ø	300Ø	300Ø
Pile Area (cm2)	452	452	452	452
Pile Make-Up	6S+0.3Y+12E+12E	6S+0.3Y+12E+12E	6S+0.3Y+12E+12E	6S+0.3Y+12E+12E
Pile Length (m)	30.3	30.3	30.3	30.3
Working Load (kN)	300	300	300	300
Test Load (kN)	600	600	600	600
Failure Load (kN)	900	900	Not Tested	Not Tested

YJACK MODEL

Based on the pile design, the following YJACK selected:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
YCELL Model	3GYJZD150	3GYJZD150	3GYJZD150	3GYJZD150
YCELL Capacity (kN)	800	800	800	800
YCELL Area (mm2)	11,304	11,304	11,304	11,304
YCELL Quantity (nos)	1	1	1	1
YJACK Capacity (kN)	800	800	800	800
YJACK Size (mm)	300	300	300	300
YJACK Stroke (mm)	80	80	80	80

YCELL: the single hydraulic unit prior to fabricate the YJACK

TERMINATION CRITERIA

All the Test Piles were installed by injection hammer with pile termination criteria “pile to set” (refer to pile driving criteria from the piling contractor).

PILE INSTALLATION

The design pile make-up was 6S+0.3YJACK+12E+12E = 30.3m (toe to top). The 1st pile joint from pile toe was installed with YJACK during the pile driving process.

The following were the site photos to illustrate the YJACK installation:

Step (1)

Step (2)

Step (3)

Step (1): Prefabricated YJACK arrive on site and wait for installation
Step (2): Spliced the YJACK at the 1st pile joint from pile toe (i.e. 6m from pile toe)
Step (3): Joint-welded YJACK with 12m extension pile and then continue driving

The details of the pile installations were shown in the piling record as shown in Appendix A1 (Pile Installation Record).

PILE LOCATION

All the Test Piles were installed at same location with “same” soil properties conditions as shown in the site photos below with bore-hole records as shown in Appendix A2 (Bore Hole Records).

INSTALLATION TERMINATION

All the Test Piles were installed pile to set as following:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Date Installed	2015/OCT/12	2015/OCT/12	2015/OCT/13	2015/OCT/13
Pile Depth (m)	27.3	27.7	27.2	26.8
Pile Set (mm/10b)	Injection Pile to Set	Injection Pile to Set	Injection Pile to Set	Injection Pile to Set

Subsequently, pile tests were carried out as described in YJACK TEST Section.

INSTALLATION BEHAVIOR

The pile installation using injection hammer on the Test Piles has similar pile installation behavior like those working piles without YJACK. No abnormality installation behavior observed. This means that the YJACK has a good impedance so that the compressive forces can transmit from pile top to pile toe and effectively past thru the YJACK location without losses of the compressive forces.

The pile installation of Test Piles did not change the mode of piling practices. The Test Piles was installed like a normal pile (without YJACK). However, there were minor interruptions of pile installation for fixing the casing pipe outside the pile for every 1.0 – 1.5m pile penetration intervals.

In summary, the Test Piles have the followings installation behavior:

- No different in installation, just install the pile like a test pile without YJACK
- Minor interruptions in pile installation due to fixing of casing pipe
- The YJACK able to resist pile bending during installation
- The YJACK able to transmit compressive forces and has enough pile impedance

YJACK TEST

After waiting period of approximately 2 months, the Test Piles were subjected to static load pile test based on YJACK bi-directional method using a maintained load test loading procedure (MLT).

The pressure increment and loading schedule presented in Appendix B (YJACK Bi-Directional Pile Load Test Loading Schedule).

The displacements of the telltales were measured in every loading steps by using manual data recording on the field sheets.

The following were the site photos to illustrate the YJACK testing using bi-directional principle:

Step 1

Step 2

Step 3

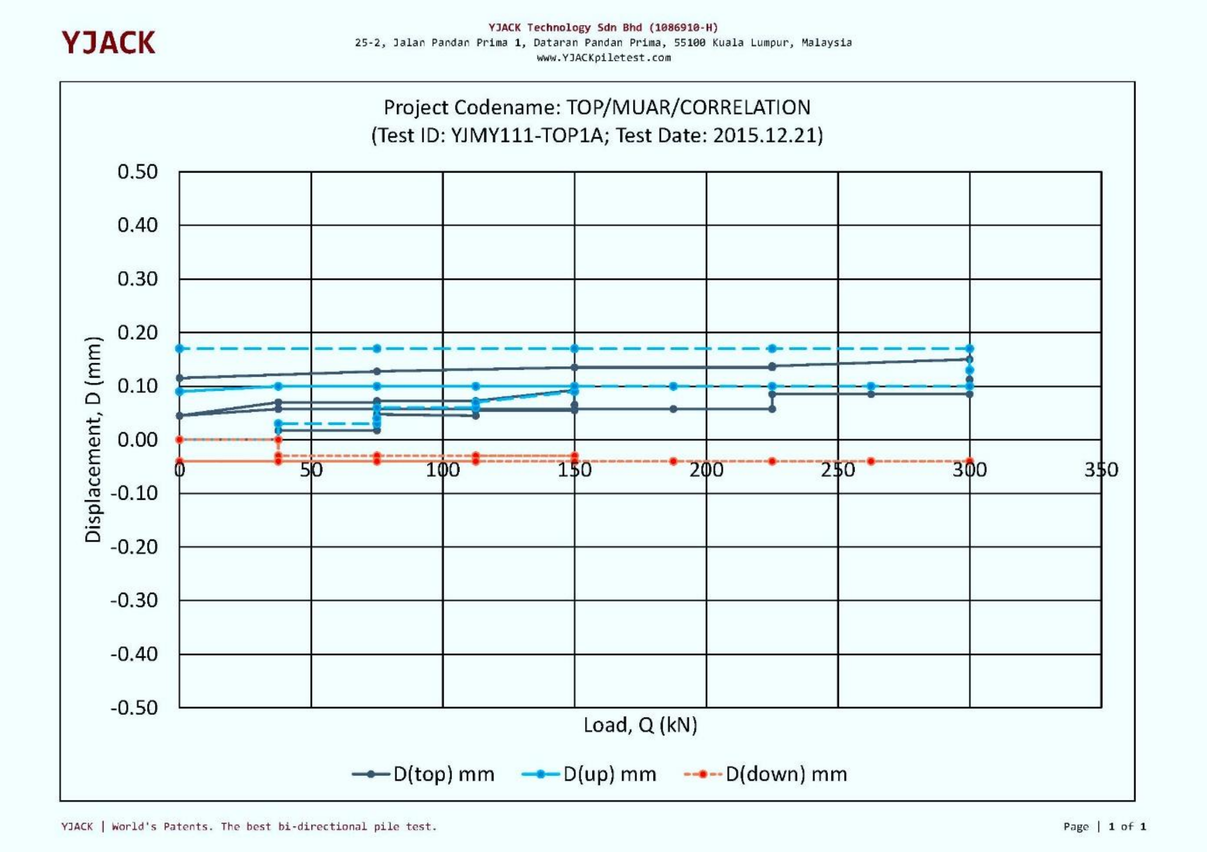
Step 1: Reference beams setup (follow the conventional load test procedure)

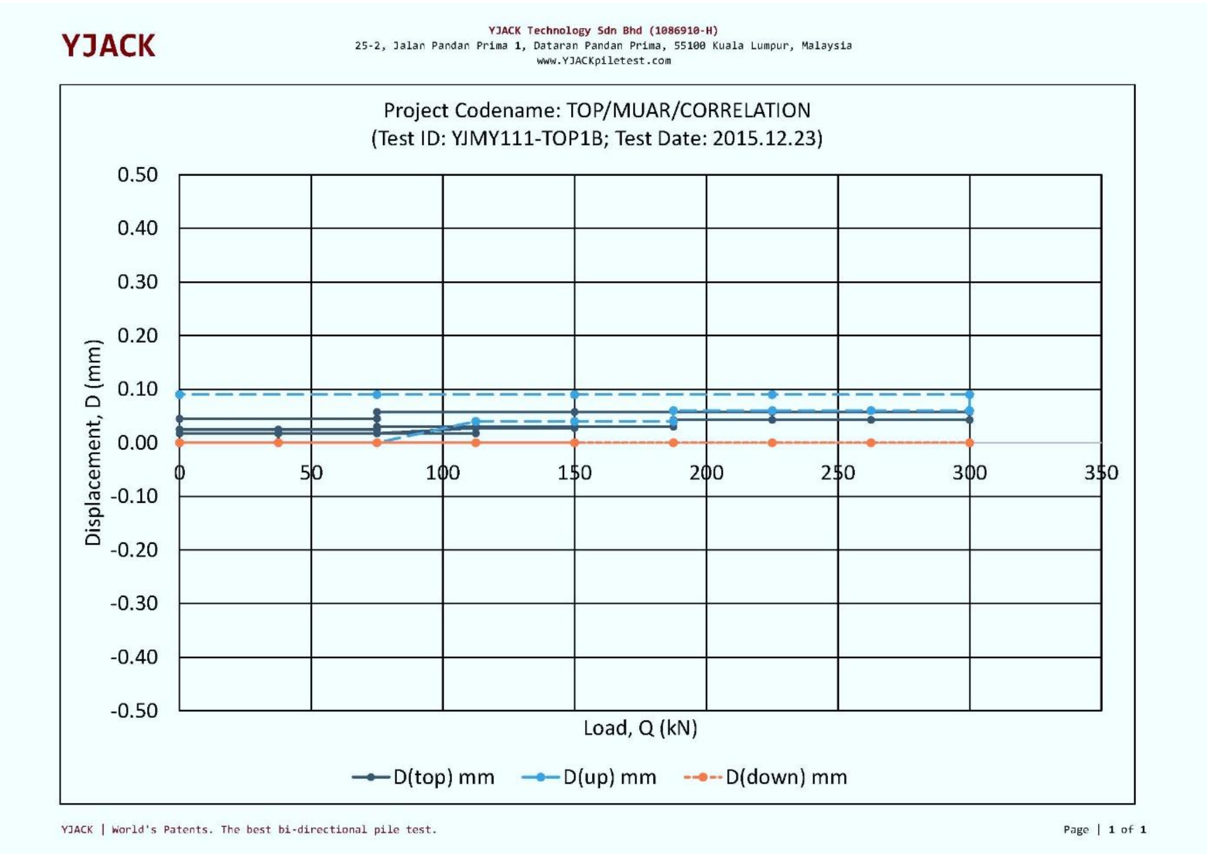
Step 2: Load test setup ready, 4*dial gauges at pile top and 2*dial gauges for YJACK up/down

Step 3: Manual data recording (follow the conventional load test procedure)

PHASE 1: YJACK VALIDATION RESULTS

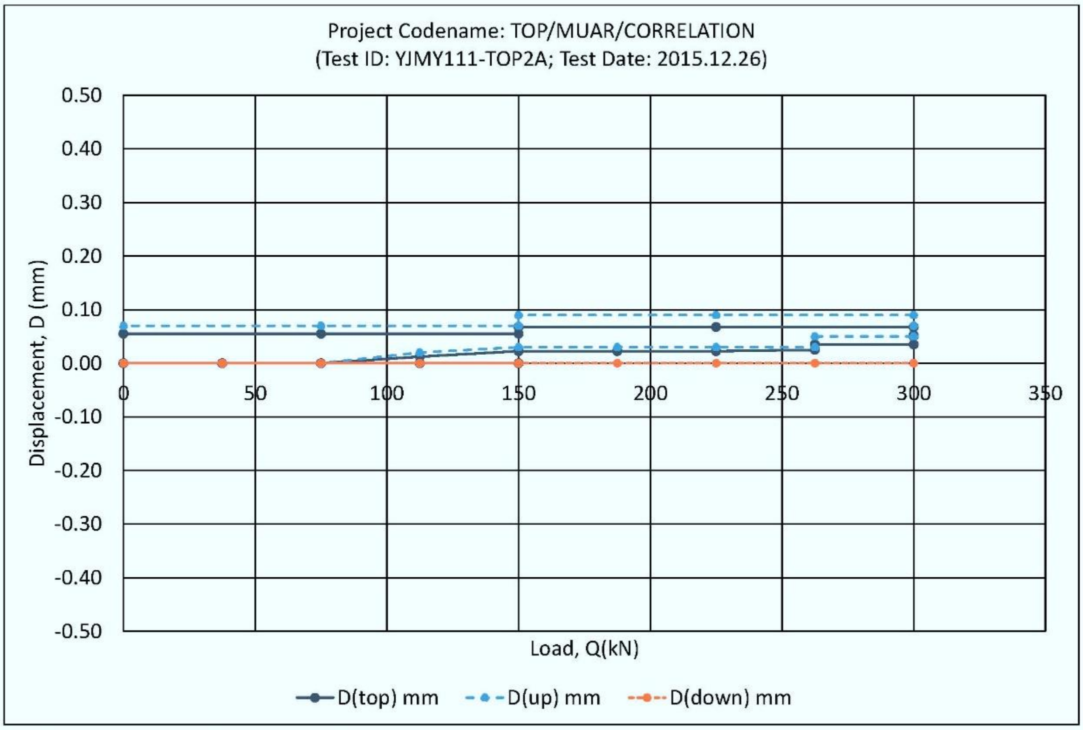
The YJACK test results using static maintained load test (MLT) method were presented in Appendix C1 (YJACK Bi-Directional Pile Load Test Results using MLT).





YJACK

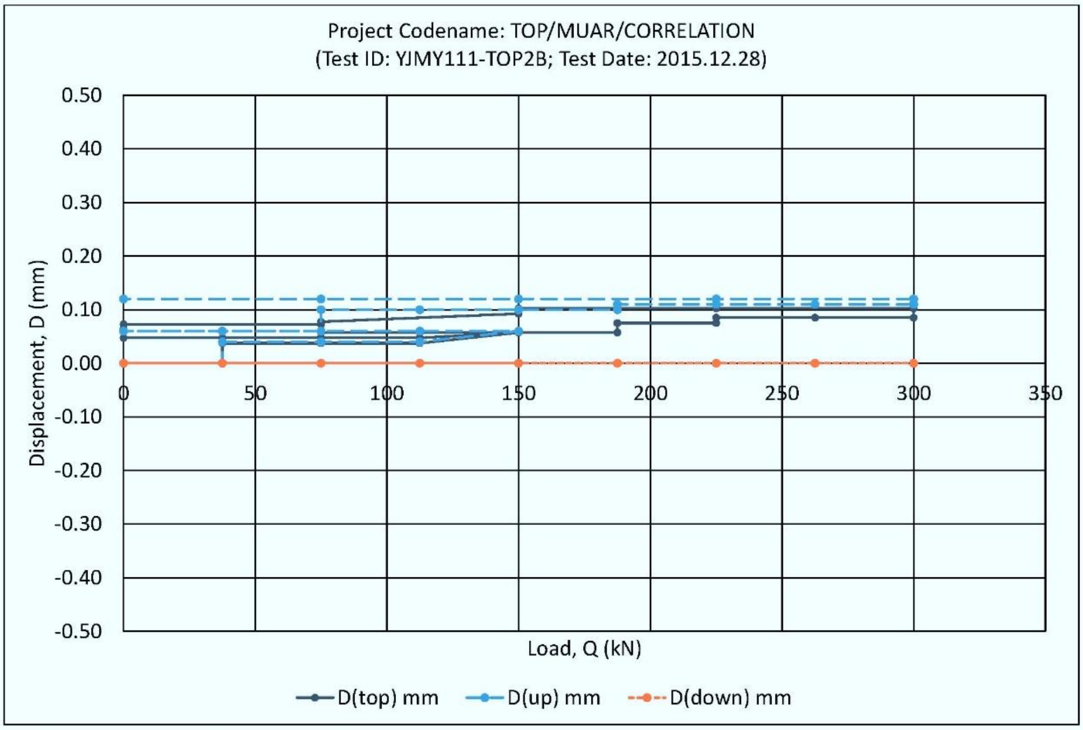
YJACK Technology Sdn Bhd (1086910-H)
25-2, Jalan Pandan Prima 1, Dataran Pandan Prima, 55100 Kuala Lumpur, Malaysia
www.YJACKpiletest.com



YJACK | World's Patents. The best bi-directional pile test. Page | 1 of 1

YJACK

YJACK Technology Sdn Bhd (1086910-H)
25-2, Jalan Pandan Prima 1, Dataran Pandan Prima, 55100 Kuala Lumpur, Malaysia
www.YJACKpiletest.com



YJACK | World's Patents. The best bi-directional pile test. Page | 1 of 1

The following is the summary test results based on YJACK MLT Method:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Skin Friction at Top Section (kN) *	300	300	300	300
Skin friction at Bottom Section + Base Bearing (kN) #	300	300	300	300
Total Pile Load Capacity in Full Section (kN)	600	600	600	600
Gap Opening after Removal Working Load 300kN (mm)	0.13	0.02	0.01	0.06
Gap Opening after Removal Test Load 600kN (mm)	0.21	0.09	0.07	0.12

* top skin friction not failure with applied load well maintained in 24 hours loading
# base bearing not failure with permanent displacement < 15mm (= assumed 5% of pile diameter)

The following is the determination of the pile ultimate load by consideration of the tension over compression factor:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Corrected Skin Friction at Top Section (kN) *	300/γ	300/γ	300/γ	300/γ
Corrected Skin Friction at Top Section (kN)	375	375	375	375
Corrected Total Pile Load Capacity in Full Section (kN)	675	675	675	675
Pile Weight at Top Section (kN) #	25	25	25	25
Ultimate Pile Load Capacity in Full Section (kN)	650	650	650	650
Accepted Ultimate Capacity in Full Section (kN)	> 600 (OK!)	> 600 (OK!)	> 600 (OK!)	> 600 (OK!)

* use tension over compression factor, γ = 0.8 for cohesive material
# pile weight at pile top section = pile area x pile length at top section x pile density = about 25kN

The following is the summary test results based on top loaded Q-s Plot in accordance to Singapore Standard SS/CP4:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Top-Loaded Pile Load Capacity (kN)	600	600	600	600
Top-Loaded Settlement at Working Load 300kN (mm)	2.8	2.8	2.7	2.6
Top-Loaded Settlement at Test Load 600kN (mm)	5.6	5.7	5.6	5.4

The following is the test acceptance in accordance to Malaysian JKR Specifications JKR/20800 (2014):

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Accepted Top-Loaded Pile Load Capacity (kN)	> 600 (OK!)	> 600 (OK!)	> 600 (OK!)	> 600 (OK!)
Accepted Top-Loaded Settlement at Working Load (mm)	< 12.5 (OK!)	< 12.5 (OK!)	< 12.5 (OK!)	< 12.5 (OK!)
Accepted Top-Loaded Settlement at Test Load (mm)	< 38.0 (OK!)	< 38.0 (OK!)	< 38.0 (OK!)	< 38.0 (OK!)
Accepted Residual Settlement *	< 6.5 (OK!)	< 6.5 (OK!)	< 6.5 (OK!)	< 6.5 (OK!)

* Pile-soil interaction of residual settlement assumed to be similar to gap opening after removal working load.

Test Comments:

- the YJACK gap opening after removal of the working load is very small, this small gap opening equivalent to residual settlement in conventional maintained load test with the pile head almost fully rebound.
- the ultimate load of 650kN is deemed to be conservative and there is no requirement to do pile restrike to close the such a small gap opening of 0.2mm, hence the test piles can be further to be designed as working piles.

PHASE 1: YJACK VALIDATION CORRELATIONS

All the Test Piles were tested by using kentledge method and YJACK method based on maintained load test (MLT) procedure.

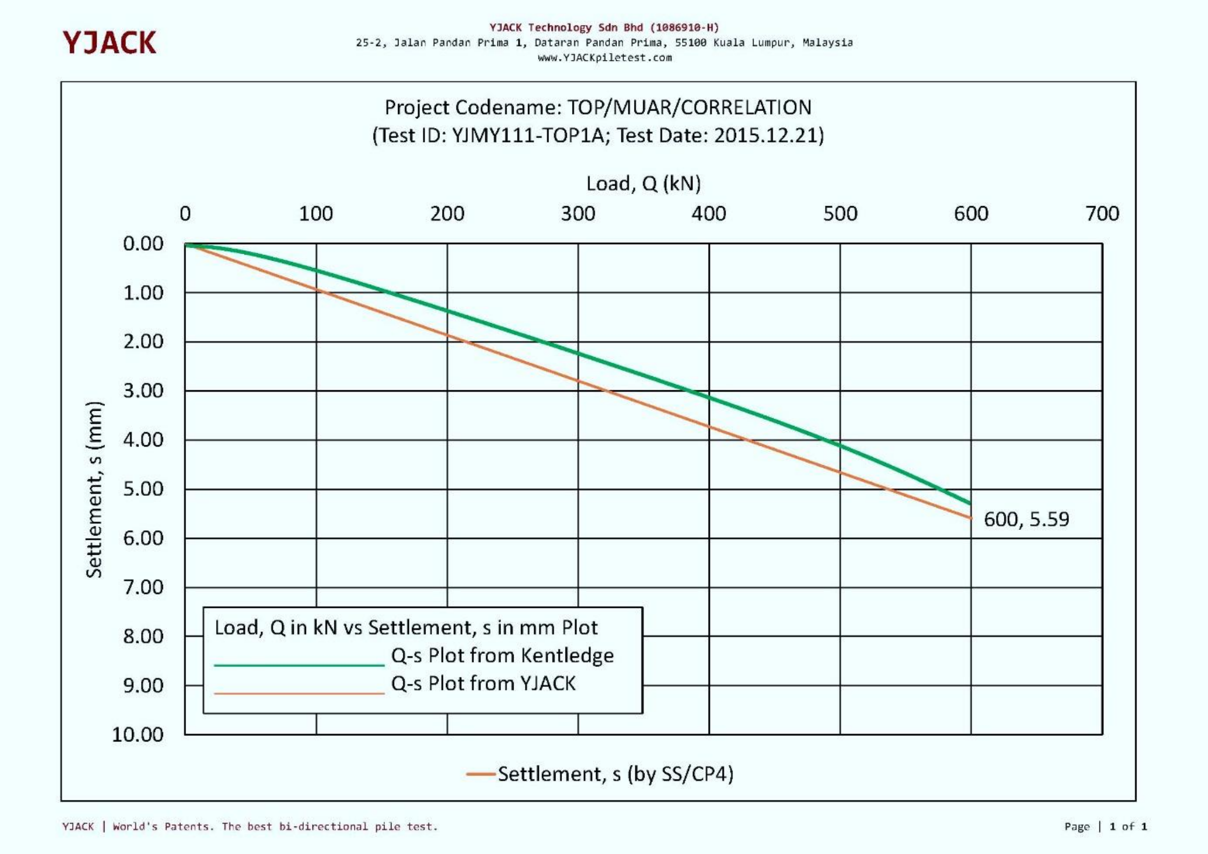
The MLT load tests were carried out by kentledge followed by YJACK method on the same piles as follows:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Kentledge Test	2015/DEC/16	2015/DEC/18	2015/DEC/23	2015/DEC/25
YJACK Test	2015/DEC/21	2015/DEC/23	2015/DEC/26	2015/DEC/28

The kentledge load tests were performed by using the injection machines as the reaction system.

The following site photos to show the load test setup comparisons:

The correlation results are shown in following pages.



Correlation Method # 1

The following is the correlation using MLT settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement At 300kN	Test Load *	Settlement At 600kN
Kentledge Method	300	2.3	600	5.3
YJACK Method	300	2.8	600	5.6
Percentage Error #	0.0%	17.9%	0.0%	5.4%
Average Accuracy	94.2%			

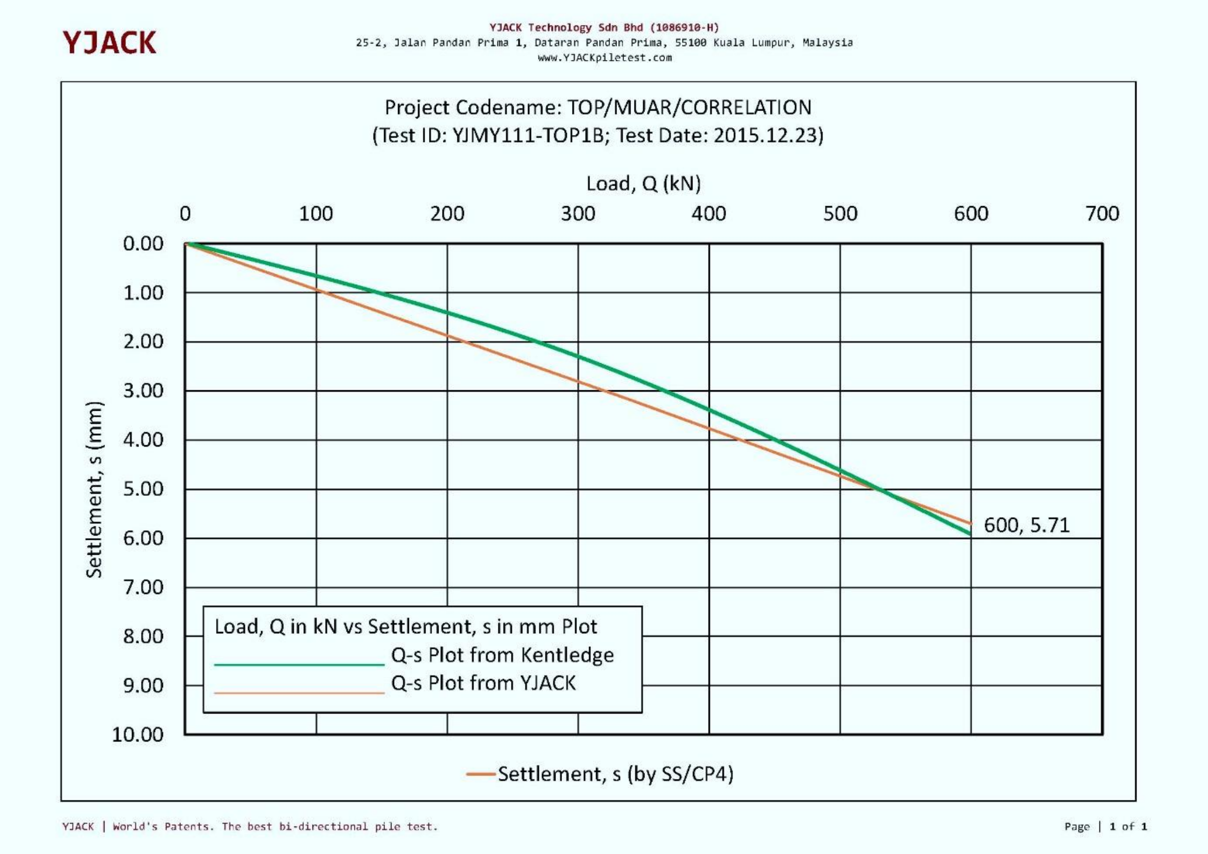
* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

Correlation Method # 2

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement Limit 12.5	Test Load *	Settlement Limit 38.0
Kentledge Method	300	10.2	600	32.7
YJACK Method	300	9.7	600	32.4
Percentage Error #	0.0%	5.2%	0.0%	0.9%
Average Accuracy	98.5%			

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values



Correlation Method # 1

The following is the correlation using MLT settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement At 300kN	Test Load *	Settlement At 600kN
Kentledge Method	300	2.3	600	5.9
YJACK Method	300	2.8	600	5.7
Percentage Error #	0.0%	17.9%	0.0%	3.5%
Average Accuracy	94.7%			

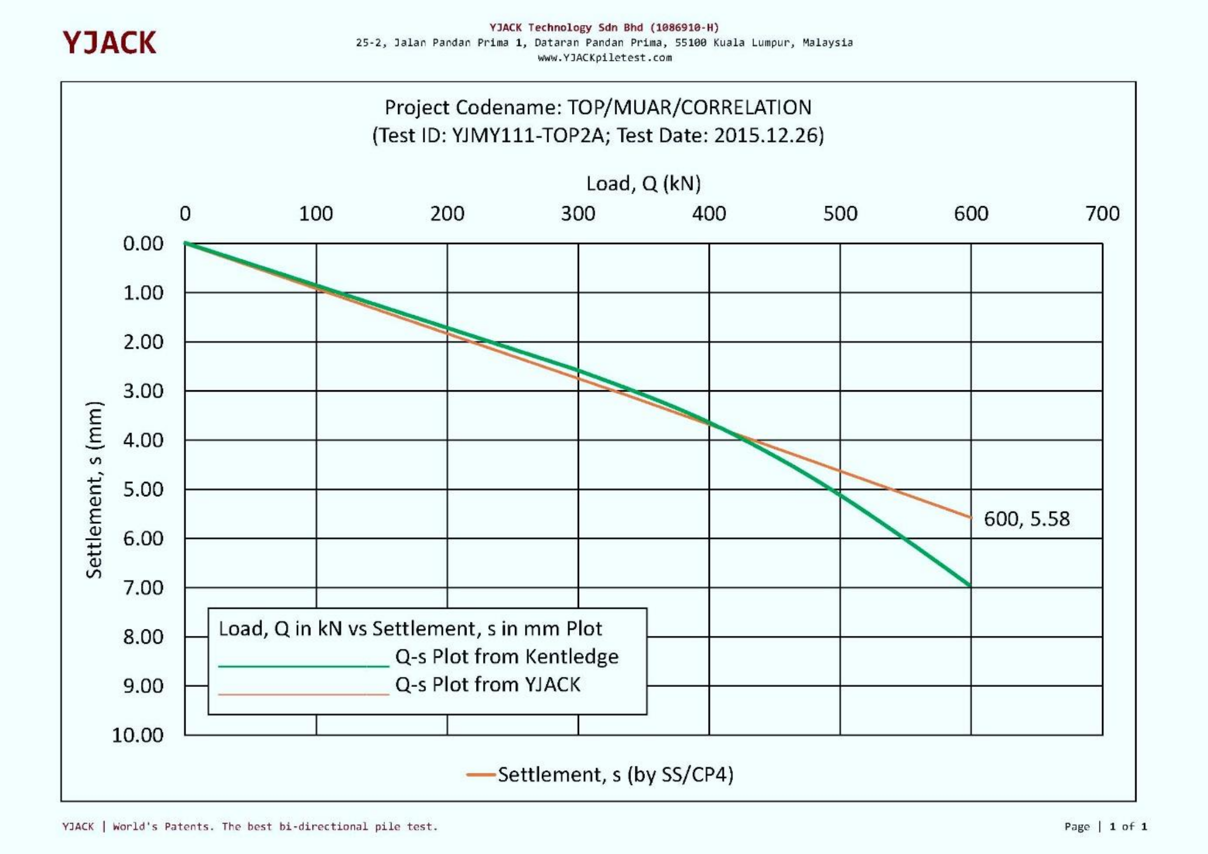
* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

Correlation Method # 1

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement Limit 12.5	Test Load *	Settlement Limit 38.0
Kentledge Method	300	10.2	600	32.1
YJACK Method	300	9.7	600	32.3
Percentage Error #	0.0%	5.2%	0.0%	0.6%
Average Accuracy	98.6%			

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values



Correlation Method # 1

The following is the correlation using MLT settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement At 300kN	Test Load *	Settlement At 600kN
Kentledge Method	300	2.6	600	6.9
YJACK Method	300	2.7	600	5.6
Percentage Error #	0.0%	3.7%	0.0%	23.2%
Average Accuracy	93.3%			

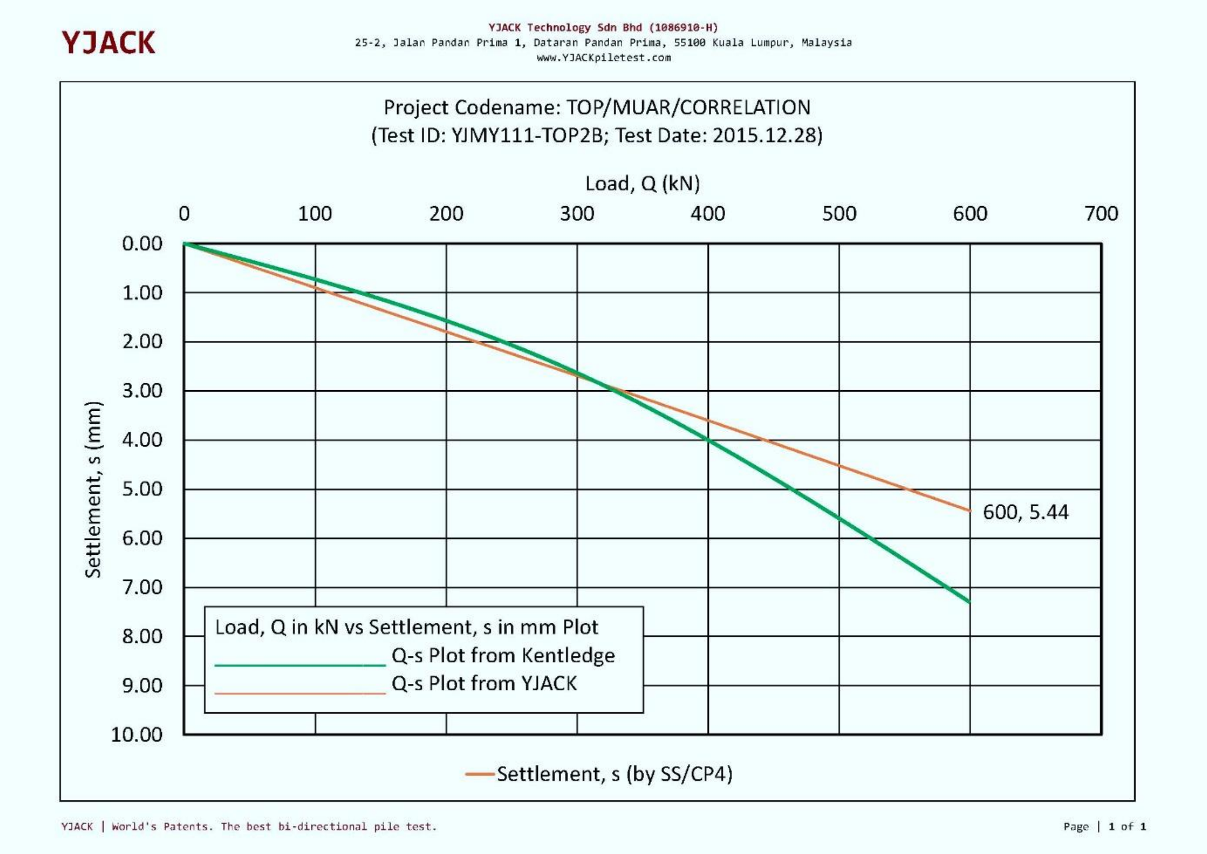
* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

Correlation Method # 2

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement Limit 12.5	Test Load *	Settlement Limit 38.0
Kentledge Method	300	9.9	600	31.1
YJACK Method	300	9.8	600	32.4
Percentage Error #	0.0%	1.0%	0.0%	4.0%
Average Accuracy	98.8%			

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values



Correlation Method # 1

The following is the correlation using MLT settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement At 300kN	Test Load *	Settlement At 600kN
Kentledge Method	300	2.6	600	7.3
YJACK Method	300	2.6	600	5.4
Percentage Error #	0.0%	0.0%	0.0%	35.2%
Average Accuracy	91.2%			

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

Correlation Method # 2

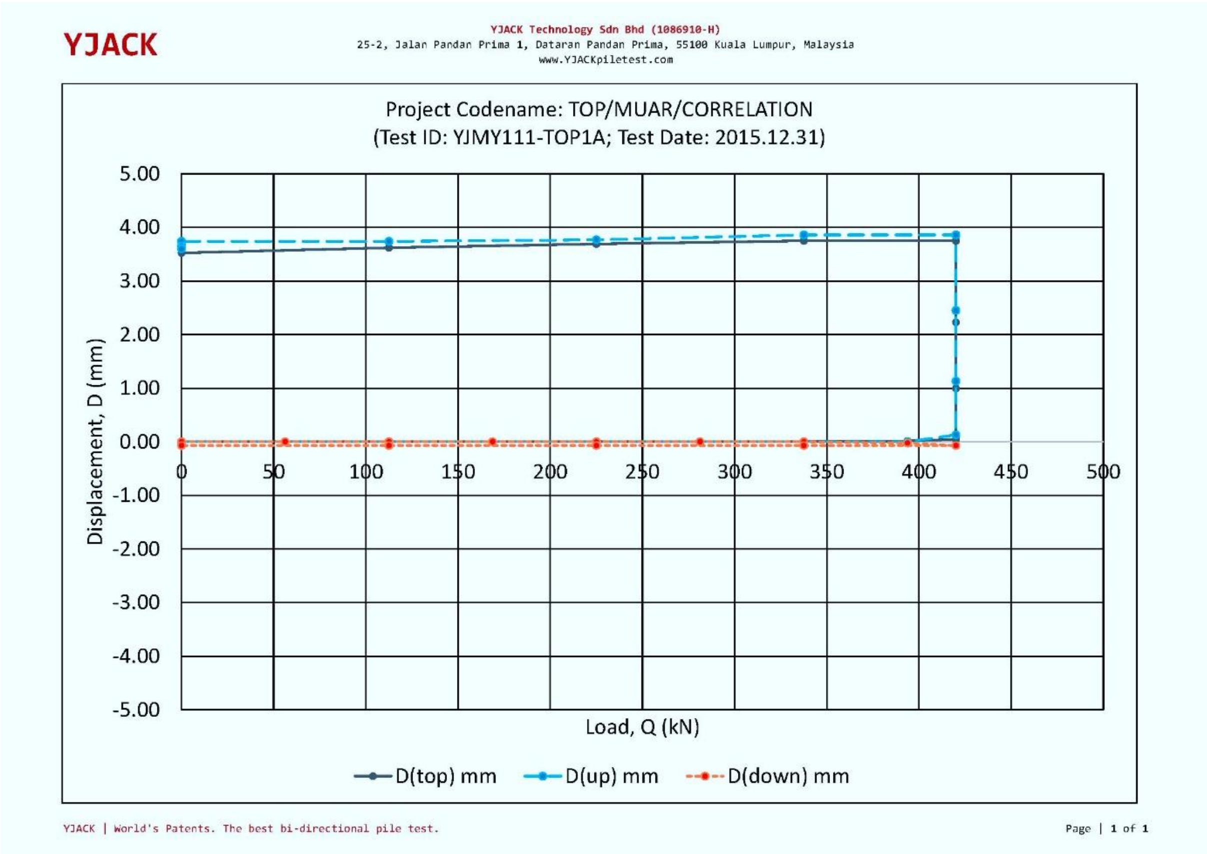
The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

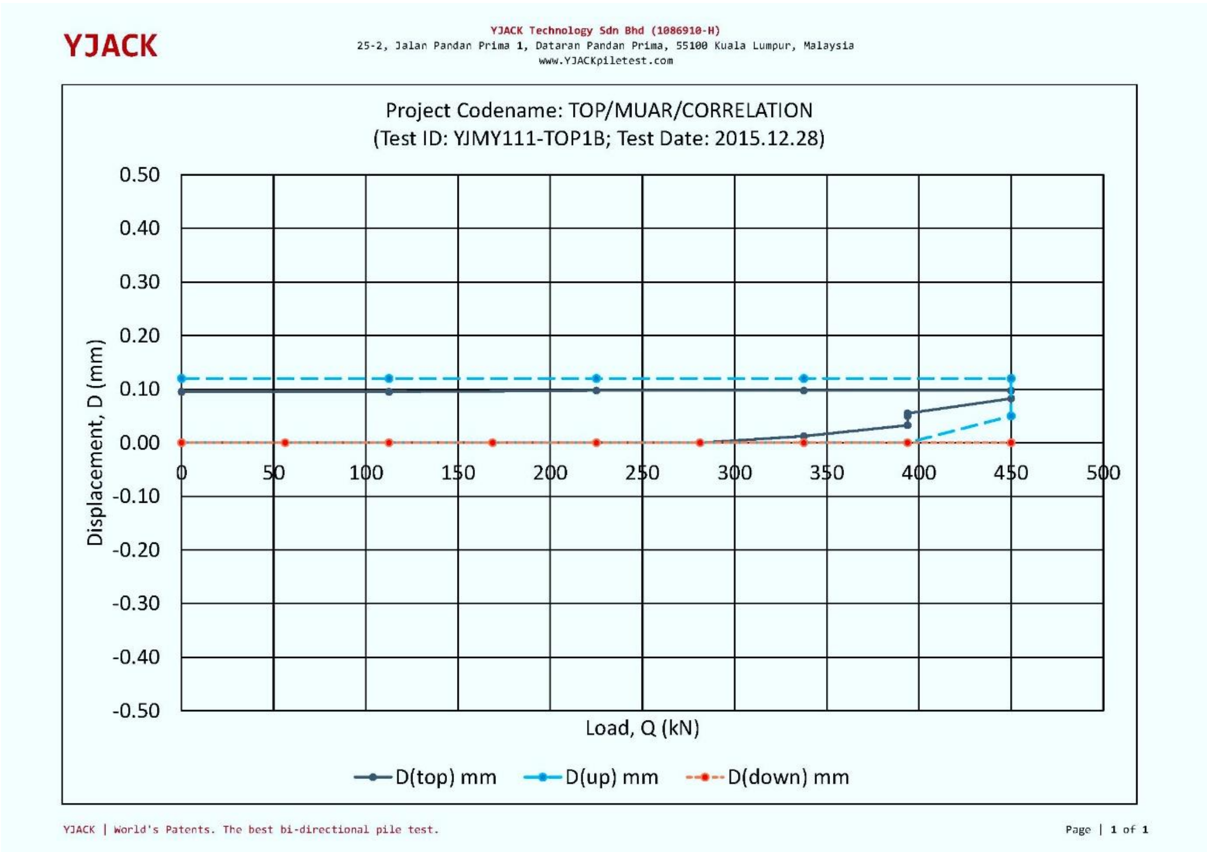
Correlation Data Point	Working Load *	Settlement Limit 12.5	Test Load *	Settlement Limit 38.0
Kentledge Method	300	9.9	600	30.7
YJACK Method	300	9.9	600	32.6
Percentage Error #	0.0%	0.0%	0.0%	5.8%
Average Accuracy	98.6%			

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

PHASE 2: YJACK VALIDATION RESULTS

In addition to MLT static pile load test, subsequent load tests were carried out on TOP1A and TOP1B using quick load test (QLT) and the results were presented in Appendix C2 (YJACK Bi-Directional Pile Load Test Results using QLT).





The following is the summary test results based on YJACK QLT Method:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Skin Friction at Top Section (kN) *	420	450	Not Tested	Not Tested
Skin friction at Bottom Section + Base Bearing (kN) #	450	450	Not Tested	Not Tested
Total Pile Load Capacity in Full Section (kN)	870	900	Not Tested	Not Tested

* top skin friction failure with load unable maintained
# base bearing not failure with permanent displacement < 15mm (= assumed 5% of pile diameter)

The following is the determination of the pile ultimate load by consideration of the tension over compression factor:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Corrected Skin Friction at Top Section (kN) *	420/γ	450/γ	Not Tested	Not Tested
Corrected Skin Friction at Top Section (kN)	525	560	Not Tested	Not Tested
Extrapolated Pile Capacity at Bottom Section (kN)	30	0	Not Tested	Not Tested
Corrected Total Pile Load Capacity in Full Section (kN)	1005	1010	Not Tested	Not Tested
Pile Weight at Top Section (kN) #	25	25	Not Tested	Not Tested
Ultimate Pile Load Capacity in Full Section (kN)	980	985	Not Tested	Not Tested
Accepted Ultimate Capacity in Full Section (kN)	> 900 (OK!)	> 900 (OK!)	Not Tested	Not Tested

* use tension over compression factor, γ = 0.8 for cohesive material
* pile weight at pile top section = pile area x pile length at top section x pile density = approx. 25kN

The following is the summary test results based on top loaded Q-s Plot in accordance to Singapore Standard SS/CP4:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Top-Loaded Pile Load Capacity (kN)	900	900	Not Tested	Not Tested
Top-Loaded Settlement at Working Load 300kN (mm)	2.9	2.9	Not Tested	Not Tested
Top-Loaded Settlement at Test Load 600kN (mm)	5.5	5.6	Not Tested	Not Tested
Top-Loaded Settlement at Test Load 900kN (mm)	9.8	8.5	Not Tested	Not Tested

The following is the test acceptance in accordance to Malaysian JKR Specifications JKR/20800 (2014):

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Accepted Top-Loaded Pile Load Capacity (kN)	> 900 (OK!)	> 900 (OK!)	Not Tested	Not Tested
Accepted Top-Loaded Settlement at Working Load (mm)	< 12.5 (OK!)	< 12.5 (OK!)	Not Tested	Not Tested
Accepted Top-Loaded Settlement at Test Load (mm)	< 38.0 (OK!)	< 38.0 (OK!)	Not Tested	Not Tested
Accepted Top-Loaded Settlement at Failure Load (mm)	< 76.0 (OK!)	< 76.0 (OK!)	Not Tested	Not Tested

* Assumed acceptable settlement at 3X Working Load = 76mm (3 inch).

Test Comments:

- the residual settlements were not considered due to quick load test procedure with 1 cycle loading up to failure load of 900kN (= 3X working load).
- the top section of the Test Pile # TOP1A only achieve ultimate load of 420kN and unable to achieve test load of 450, however the pile capacity bottom section deems to be conservative with very small displacement, hence by extrapolated the bottom section from 450 to 480kN, to construct the equivalent Q-s Plot to obtain 4900kN (= 420 + 480).

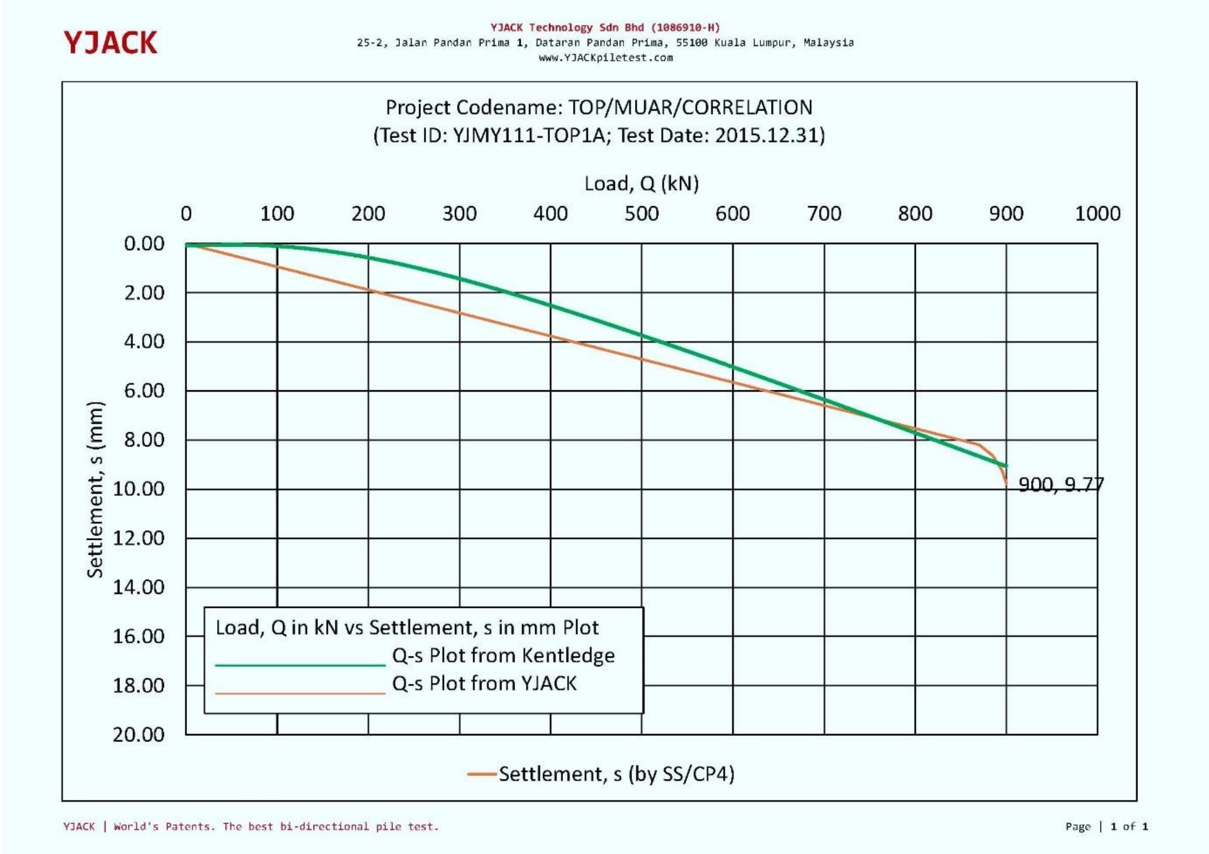
PHASE 2: YJACK VALIDATION CORRELATIONS

In additional to Phase 1 Correlations, subsequent load tests were carried out on Test Piles # TOP1A and TOP1B for failure load tests based on quick load test (QLT) procedure.

The QLT load tests were carried out by kentledge followed by YJACK Method on the same piles as follows:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B
Kentledge Failure	2015/DEC/25	2015/DEC/26	No Tested	No Tested
YJACK Failure	2015/DEC/31	2015/DEC/28	No Tested	No Tested

The correlation results are shown in following pages.



Correlation Method # 1

The following is the correlation using MLT settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement At 300kN	Test Load *	Settlement At 600kN	Failure Load *	Settlement At 900kN
Kentledge Method	300	1.2	600	5.0	900	9.0
YJACK Method	300	2.9	600	5.5	900	9.8
Percentage Error #	0.0%	58.6%	0.0%	9.1%	0.0%	8.2%
Average Accuracy	87.4%					

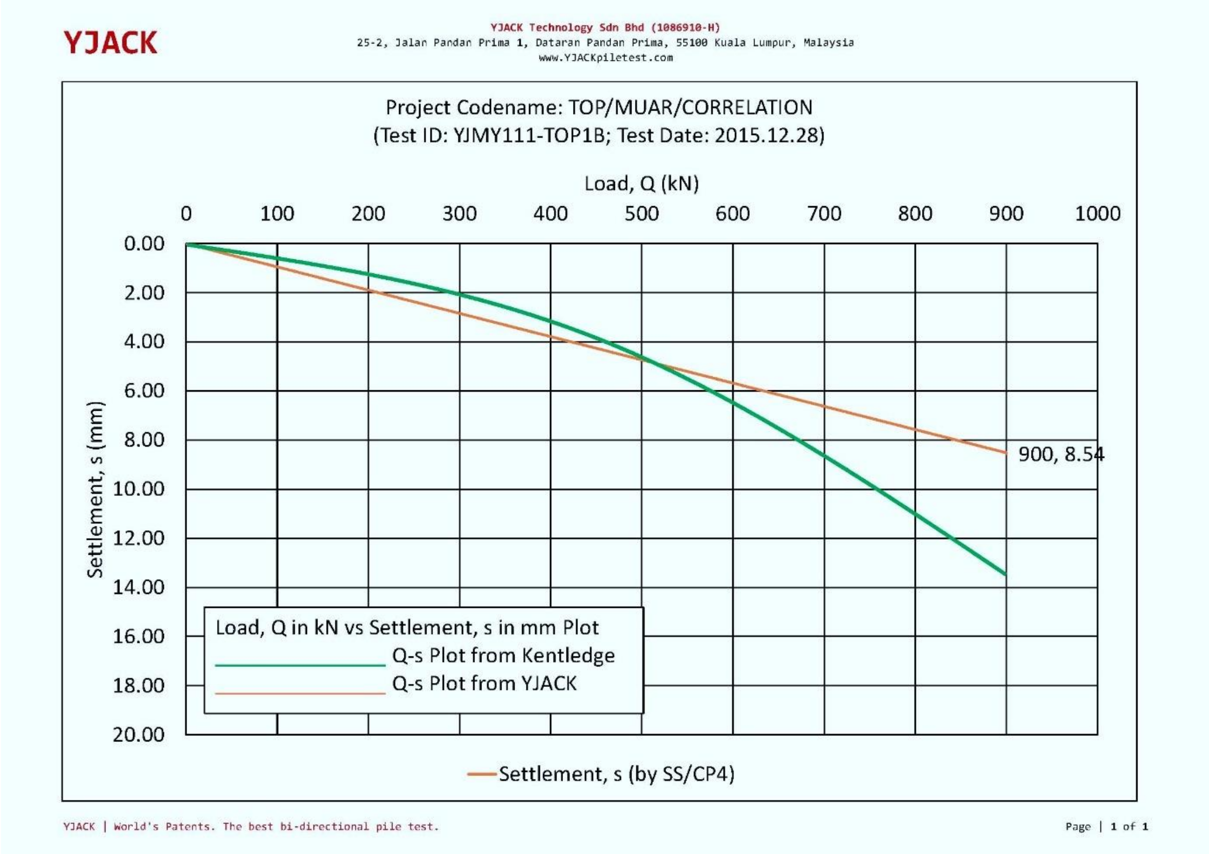
* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

Correlation Method # 2

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement Limit 12.5	Test Load *	Settlement Limit 38.0	Failure Load *	Settlement Limit 76.0
Kentledge Method	300	11.3	600	33.0	900	67.0
YJACK Method	300	9.6	600	32.5	900	66.2
Percentage Error #	0.0%	17.7%	0.0%	1.5%	0.0%	1.2%
Average Accuracy	96.6%					

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values



Correlation Method # 1

The following is the correlation using MLT settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement At 300kN	Test Load *	Settlement At 600kN	Failure Load *	Settlement At 900kN
Kentledge Method	300	2.1	600	6.5	900	13.4
YJACK Method	300	2.9	600	5.6	900	8.5
Percentage Error #	0.0%	27.6%	0.0%	16.1%	0.0%	57.6%
Average Accuracy	83.1%					

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

Correlation Method # 2

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Correlation Data Point	Working Load *	Settlement Limit 12.5	Test Load *	Settlement Limit 38.0	Failure Load *	Settlement Limit 76.0
Kentledge Method	300	10.4	600	31.5	900	62.6
YJACK Method	300	9.6	600	32.4	900	67.5
Percentage Error #	0.0%	8.3%	0.0%	2.8%	0.0%	7.3%
Average Accuracy	96.9%					

* The loads were measured by same pressure system. Both system have same loading accuracies.
# Percentage Error = (measured - published) / published, in absolute values

CORRELARION SUMMARY

The following is the summary of the correlation results obtained from Correlation Phase 1 and Phase 2.

Correlation Method # 1

The following is the correlation using load test settlement at working and test loads as the correlation base data:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B	TOP1A	TOP1B
Loading Procedure	MLT	MLT	MLT	MLT	QLT	QLT
Average Accuracy	94.2%	94.7%	93.3%	91.2%	87.4%	83.1%
Accuracy Level *	High	High	High	High	High	High
Average Accuracy	90.7%					

* High if Accuracy > 80%; Moderate if 50% > Accuracy < 80%; Low if Accuracy < 50%

Correlation Method # 2

The following is the correlation using acceptable settlement at working and test loads as the correlation base data:

Pile ID	TOP1A	TOP1B	TOP2A	TOP2B	TOP1A	TOP1B
Loading Procedure	MLT	MLT	MLT	MLT	QLT	QLT
Average Accuracy	98.5%	98.6%	98.8%	98.6%	96.6%	96.9%
Accuracy Level *	High	High	High	High	High	High
Average Accuracy	98.0%					

* High if Accuracy > 80%; Moderate if 50% > Accuracy < 80%; Low if Accuracy < 50%

VALIDATION CONCLUSION

The following is the validation conclusions for functionality and accuracy of the newly invented YJACK.

(1) Validation for the functionality of the YJACK

The pile installation using injection hammer on the 4*NOS Test Piles has similar pile installation behavior like those working piles without YJACK. No abnormality installation behavior observed with the followings installation behavior:

- No different in installation, just install the pile like a test pile without YJACK
- Minor interruptions in pile installation due to fixing of casing pipe
- The YJACK able to resist pile bending during installation
- The YJACK able to transmit compressive forces and has enough pile impedance

The pile testing also demonstrated the YJACK can perform well under load pressurizations from 0 to 300 (working load) to 600 (test load) to 900kN (failure load). No any hydraulic jack interlocking observed during loading and unloading procedures.

In conclusion, the YJACKs are fully performed well in terms of functionality in installation and testing.

(2) Validation for the accuracy of the YJACK

The correlation summary on 6*NOS YJACK pile tests indicated extremely high accuracy more than 95% with the following correlation studies:

- Validation Phase 1: 4*NOS YJACK pile tests based on maintained load test method (MLT) up to 600kN
- Validation Phase 2: 2*NOS YJACK pile tests based on quick load test method (QLT) up to 900kN

YJACK is a hydraulic jack system, the same to conventional load test which also using hydraulic jack in pressure loading measurements. Hence, both YJACK and kentledge loads were measured by the same pressure systems with same loading accuracies, i.e. 100%.

In the load-settlement behavior plots for kentledge and YJACK, both indicated similar patterns with accuracy range higher than 80%, in which this is deemed to be high level accuracy in correlation studies.

In conclusion, the YJACKs are fully performed well in terms of accuracy of ultimate (i.e. the load) and serviceability (i.e. settlement) design considerations.

APPENDIX A1

JABATAN KERJA RAYA MALAYSIA

REKOD PENANAMAN CERUCUK

KONTRAKTOR : ALIAH ENTERPRISE.

SHEET NO: 1

NO. KONTRAK : JKR/PERS/J/M/01/2014

DATE: 13 / 10 / 15

PROJECT: MEMBINA & MENYIAPKAN SEBUAH (1) GELANGGANG SERBAGUNA TERBUKA DLL DI SMK SG.ABONG				
PILE NO./LOCATION: TP-2B				
PILE TYPE: 300X300 m		SIZE:		
PILE PIRCHED LENGTH: ~~6+12+12~~ 6+0.3YJACK+12+12		TOTAL PENETRATION: 26.8 m		
PILE PAID LENGTH		NO. OF JOINTS: 3		
JACK MODEL / RAMP AREA:		FINAL SET:		
CUT OFF PILE HEAD: YES: NO:				
DATE CASTING/REF:				
PILE LENGTH USED:				
JACKED TIME:				

REMARKS	M	Mpa	M	Mpa	M	Mpa	M	Mpa	M	Mpa	M	Mpa
	1	6	7	2	13	3 4 7	19	7 8 7	25	10 11 10	31	
	2		8		14		20	7 0	26	11 12 12	32	
	3		9		15		21		27	13 ~~50~~	33	2-cylinders
	4	1 1	10	2	16		22		28		34	
	5		11	3 3	17	4 5 6	23	8 7 8	29		35	
	6	0	12	3	18	5 6 7	24	9 9 9	30		36	

DISAHKAN OLEH: Tekwi... (WAKIL KONTRAKTOR)

ISMAIL JAUHARI B. MOHD TAPPRIZI
H/P: 012-6389312
ALIAH ENTERPRISE
Penyelia Tapak

(WAKIL JKR)

NOORLIZA ABDULLAH
PEN. JURUTERA JA29
J.K.R. MUAR

Jimmy Wai

JABATAN KERJA RAYA MALAYSIA

REKOD PENANAMAN CERUCUK

KONTRAKTOR : ALIAH ENTERPRISE. SHEET NO: 1

NO. KONTRAK : JKR/PERS/J/M/01/2014 DATE: 13 / 10 / 15

PROJECT: MEMBINA & MENYIAPKAN SEBUAH (1) GELANGGANG SERBAGUNA TERBUKA DLL DI SMK SG.ABONG					
PILE NO./LOCATION: T.P - 2A					
PILE TYPE: 300 X 300 m			SIZE:		
PILE PIRCHED LENGTH: ~~6+12+12~~ 6 to 3 JACK +12 +12.			TOTAL PENETRATION: 27 - 30 m		
PILE PAID LENGTH			NO. OF JOINTS: 3		
JACK MODEL / RAMP AREA:			FINAL SET:		
CUT OFF PILE HEAD:	YES:	NO:			
DATE CASTING/REF:					
PILE LENGTH USED:					
JACKED TIME:					

REMARKS	M	Mpa	M	Mpa	M	Mpa	M	Mpa	M	Mpa	M	Mpa
				2		1		4		7		
	1	0	7	3	13	3	19	5	25	7	31	
				2				4		8		
										9		
	2		8		14		20		26	10	32	
										11		
		0								12.		
	3		9		15		21		27-	13 = 2 →	33	cylinders
										~~30~~		
	4	2	10		16	3	22		28		34	
						3		4				
				2		4		5				
	5		11	3	17	3	23	7	29		35	
				2		4		1				
								7				
	6	0	12		18		24	6	30		36	
		2						1				

DISAHKAN OLEH: ....

(WAKIL KONTRAKTOR) (WAKIL JKR)

ISMAIL JAUHARI B. MOHD TAPPRIZI
H/P: 012-6389312
ALIAH ENTERPRISE
Penyelia Tapak

for
Jimmy Wai

JABATAN KERJA RAYA MALAYSIA

REKOD PENANAMAN CERUCUK

KONTRAKTOR : ALIAH ENTERPRISE.

SHEET NO: 1

NO. KONTRAK : JKR/PERS/J/M/01/2014

DATE: 12 / 10 / 15

PROJECT: MEMBINA & MENYIAPKAN SEBUAH (1) GELANGGANG SERBAGUNA TERBUKA DLL DI SMK SG.ABONG					
PILE NO./LOCATION: TP - 1A					
PILE TYPE: 300X300			SIZE:		
PILE PIRCHED LENGTH: ~~6 + 12 + 12~~ 6+0.35JACK+12			TOTAL PENETRATION: 27.7m		
PILE PAID LENGTH +12			NO. OF JOINTS: 3		
JACK MODEL / RAMP AREA:			FINAL SET:		
CUT OFF PILE HEAD:	YES:	NO:			
DATE CASTING/REF:					
PILE LENGTH USED:					
JACKED TIME:					

REMARKS	M	Mpa	M	Mpa	M	Mpa	M	Mpa	M	Mpa	M	Mpa
	1	2	7	0	13	2 1	19	5 4	25	2 4 2	31	
	2		8		14	0 2	20		26	9 9 8	32	
	3		9	0	15		21	5	27	10 11 12.	33	
	4	0	10		16	3 4	22	1 6 3	28	13 ~~50~~	34 2C [illegible]	
	5		11		17		23	6	29		35	
	6	0	12	9	18	3 4 4	24	7 7	30		36	

DISAHKAN OLEH: Talk/Nd ISMAIL JAUHARI B. MOHD TAPPRIZI H/P: 012-6389312 ALIAH ENTERPRISE *Penyelia Tapak*

(WAKIL KONTRAKTOR)

NOORLIZA ABDULLAH PEN. JURUTERA JA29 J.K.R. MUAR

(WAKIL JKR)

Jimmy Wai

D

JABATAN KERJA RAYA MALAYSIA

REKOD PENANAMAN CERUCUK

KONTRAKTOR : ALIAH ENTERPRISE. SHEET NO: 1

NO. KONTRAK : JKR/PERS/J/M/01/2014 DATE: 12 / 10 / 15

PROJECT: MEMBINA & MENYIAPKAN SEBUAH (1) GELANGGANG SERBAGUNA TERBUKA DLL DI SMK SG.ABONG				
PILE NO./LOCATION: TP 1A				
PILE TYPE: 300ϕ			SIZE:	
PILE PIRCHED LENGTH: ~~6+12+12m~~ 6+0.3X3 JACK +12+12			TOTAL PENETRATION: 27.30M	
PILE PAID LENGTH			NO. OF JOINTS: 3	
JACK MODEL / RAMP AREA:			FINAL SET:	
CUT OFF PILE HEAD:	YES:	NO:		
DATE CASTING/REF:				
PILE LENGTH USED:				
JACKED TIME:				

REMARKS	M	Mpa	M	Mpa	M	Mpa	M	Mpa	M	Mpa	M	Mpa
	1		7	2, 3, 2	13	3	19	5, 7, 6	25	7, 7, 8	31	
	2		8		14		20	5	26	9, 9, 9	32	
	3		9		15	4	21		27	10, 11, 12	33	
	4	2, 2, 3	10	2	16	3, 4, 3	22	7, 7	28	13 Set 2 cylinders	34	
	5	2	11	2, 3, 4	17	4	23	6, 7, 7	29		35	
	6	2	12	3, 4, 4	18	4, 5	24	7, 7, 7	30		36	

DISAHKAN OLEH: Tokwinjay S. ISMAIL JAUHARI B. MOHD TAPPRIZI H/P: 012-6389312 ALIAH ENTERPRISE *Penyelia Tapak* (WAKIL KONTRAKTOR)

Jimmy Wai

NOORLIZA ABDULLAH PEN. JURUTERA JA29 J.K.R. MUAR (WAKIL JKR)

011376/9062

01138

APPENDIX A2

Bore-Hole Records / SI Report

Thick documents. Will be furnished upon request.

APPENDIX B

Cylonix

Project: Maintain Load Test @ Muar

LOADING SEQUENCE FOR WORKING TEST PILE
300mm diam. Spun Pile (WORKING LOAD = 30T)

The Load Test sequence shall generally be in accordance with BS 8004, 1986-British Standard Code of Practice for foundation.

Acting Cylinder = 200 Tonne
Ram Area = 41.22 in^2

The stages of loading shall generally be as follow:

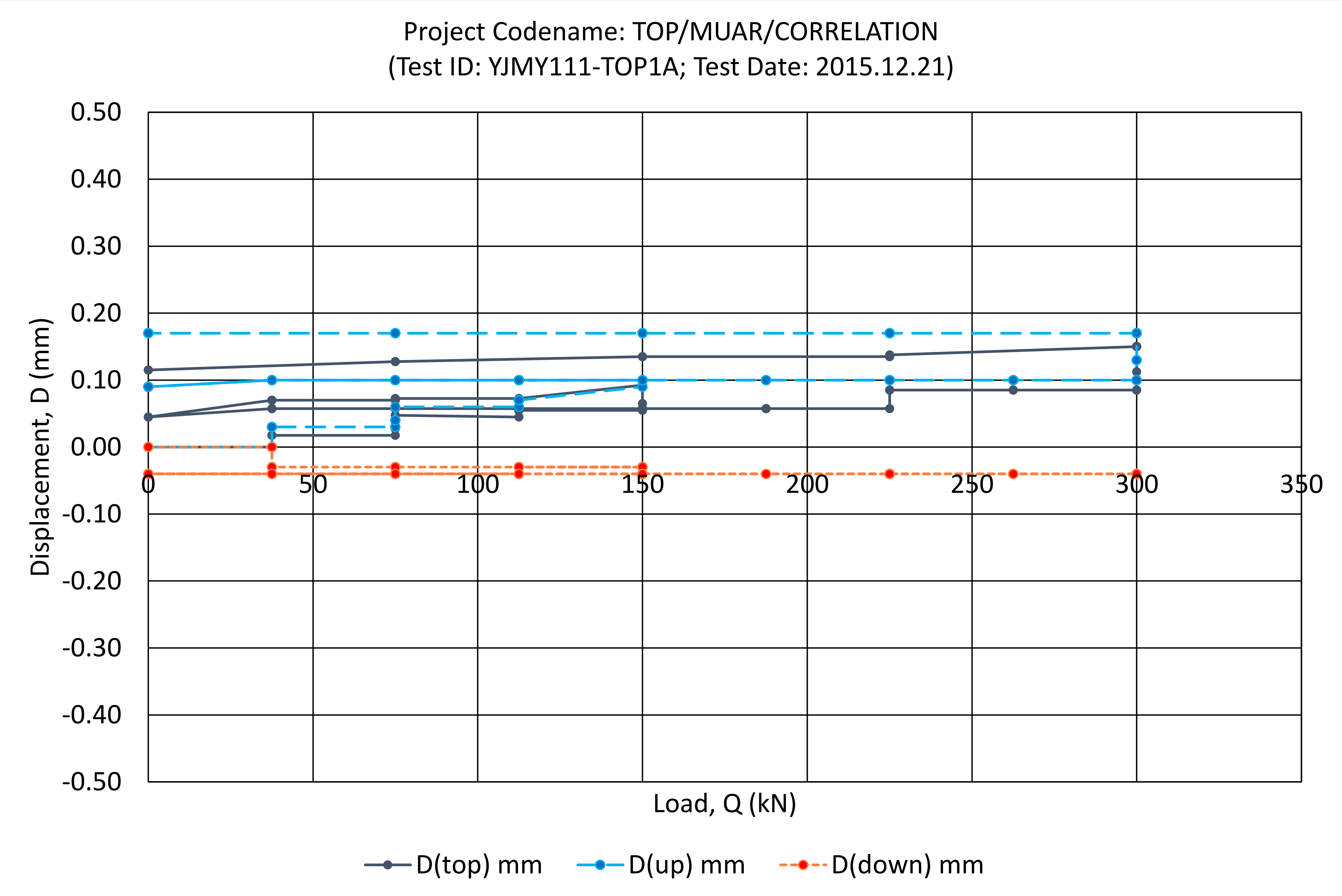
Cycle	Load Percentage (%)	Tons	PSI	Minimum Time of Holding Load
	0	0.0	0	0
1st Cycle	25	7.5	402	1 hr
1st Cycle	50	15.0	803	1 hr
1st Cycle	75	22.5	1204	1 hr
1st Cycle	100	**30.0**	**1605**	6 hr
1st Cycle	75	22.5	1204	1 hr
1st Cycle	50	15.0	803	1 hr
1st Cycle	25	7.5	402	1 hr
	0	0.0	0	1 hr
2nd Cycle	25	7.5	402	1 hr
2nd Cycle	50	15.0	803	1 hr
2nd Cycle	75	22.5	1204	1 hr
2nd Cycle	100	30.0	1605	1 hr
2nd Cycle	125	37.5	2006	1 hr
2nd Cycle	150	45.0	2407	1 hr
2nd Cycle	175	52.5	2808	1 hr
2nd Cycle	200	**60.0**	**3209**	24 hr
2nd Cycle	150	45.0	2407	1 hr
2nd Cycle	100	30.0	1605	1 hr
2nd Cycle	50	15.0	803	1 hr
	0	0.0	0	1 hr
3rd Cycle	50	15.0	803	15min
3rd Cycle	100	30.0	1605	15min
3rd Cycle	150	45.0	2407	15min
3rd Cycle	200	60.0	3209	15min
3rd Cycle	225	67.5	3610	15min
3rd Cycle	250	75.0	4011	15min
3rd Cycle	275	82.5	4412	15min
3rd Cycle	300	**90.0**	**4813**	15min
3rd Cycle	250	75.0	4011	15min
3rd Cycle	200	60.0	3209	15min
3rd Cycle	150	45.0	2407	15min
3rd Cycle	100	30.0	1605	15min
3rd Cycle	50	15.0	803	15min
3rd Cycle	0	0.0	0	15min

Notes:
**Reading to be taken every 5 minutes.*
**For 200% of loading maintained*
- *1st hour of reading to be taken every 15 minutes;*
- *subsequent reading to be taken hourly.*

Example (calculation from ton to psi)
For 200T hydraulic jack, cylinder effective area = 41.22in^2
1T = 2204lb

For 90Tonne, the pressure in PSI = (90*2204)/41.22
= 4813 psi

APPENDIX C1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Displacement, D (mm)
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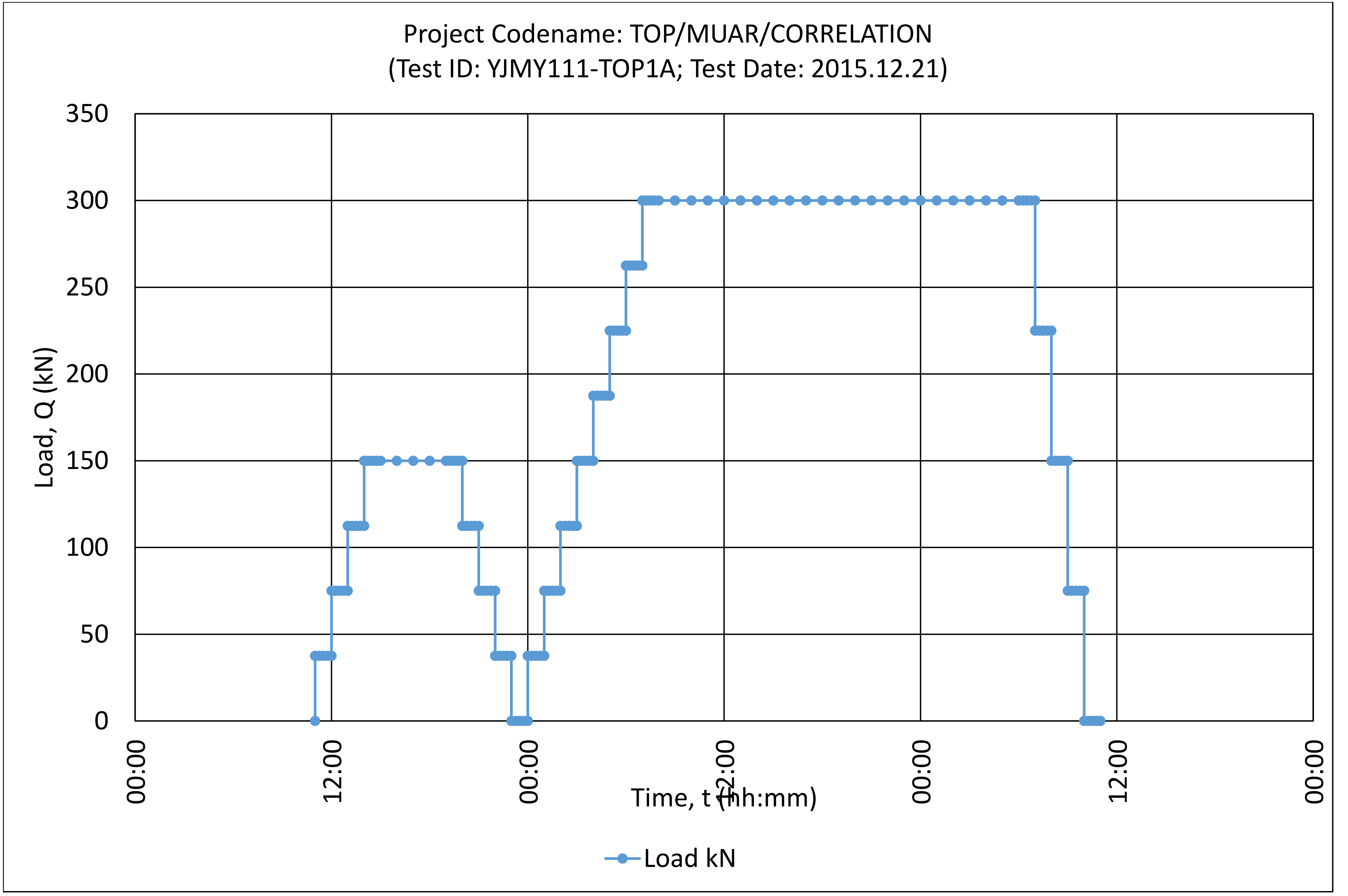
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
0
50
100
150
200
250
300
350
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm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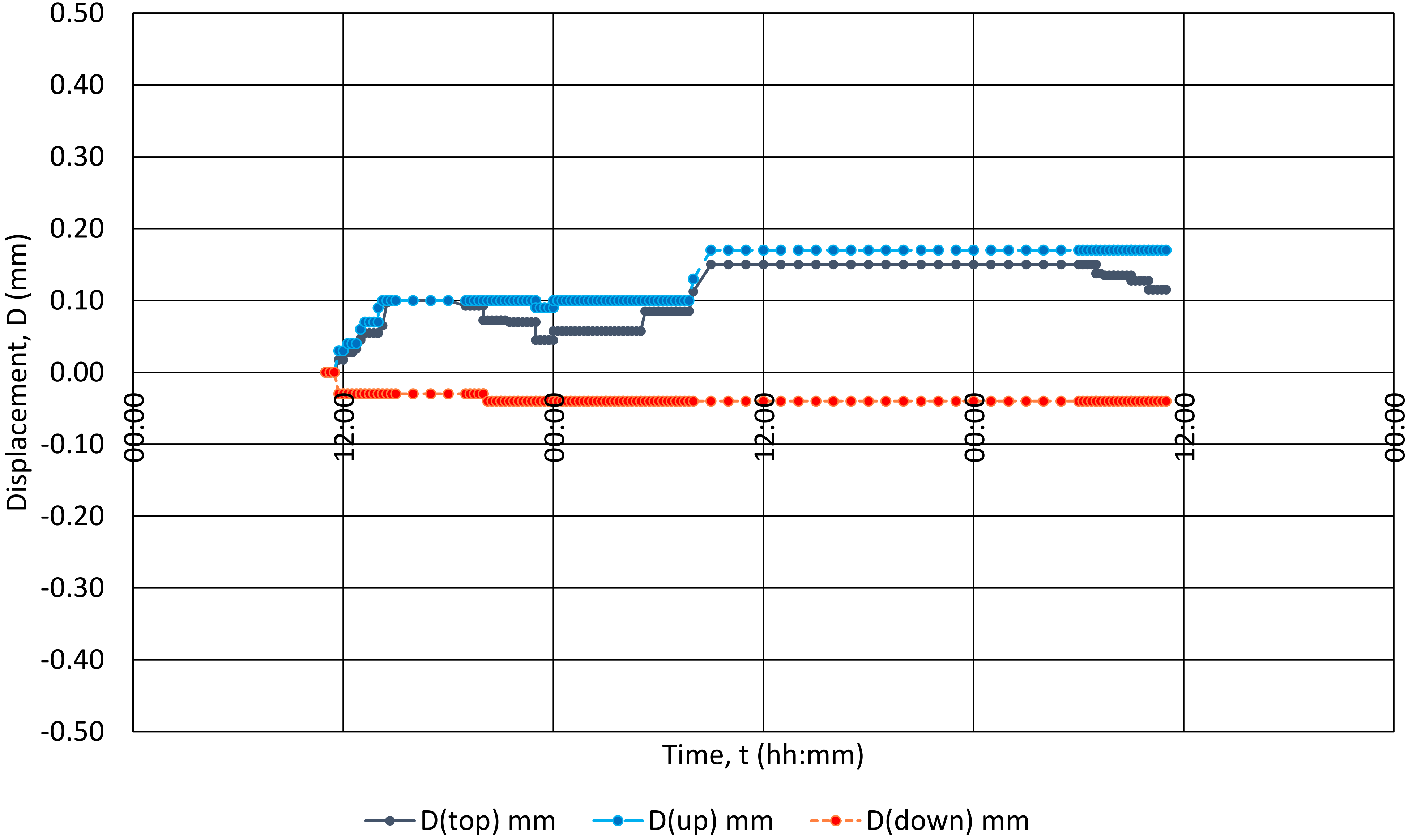
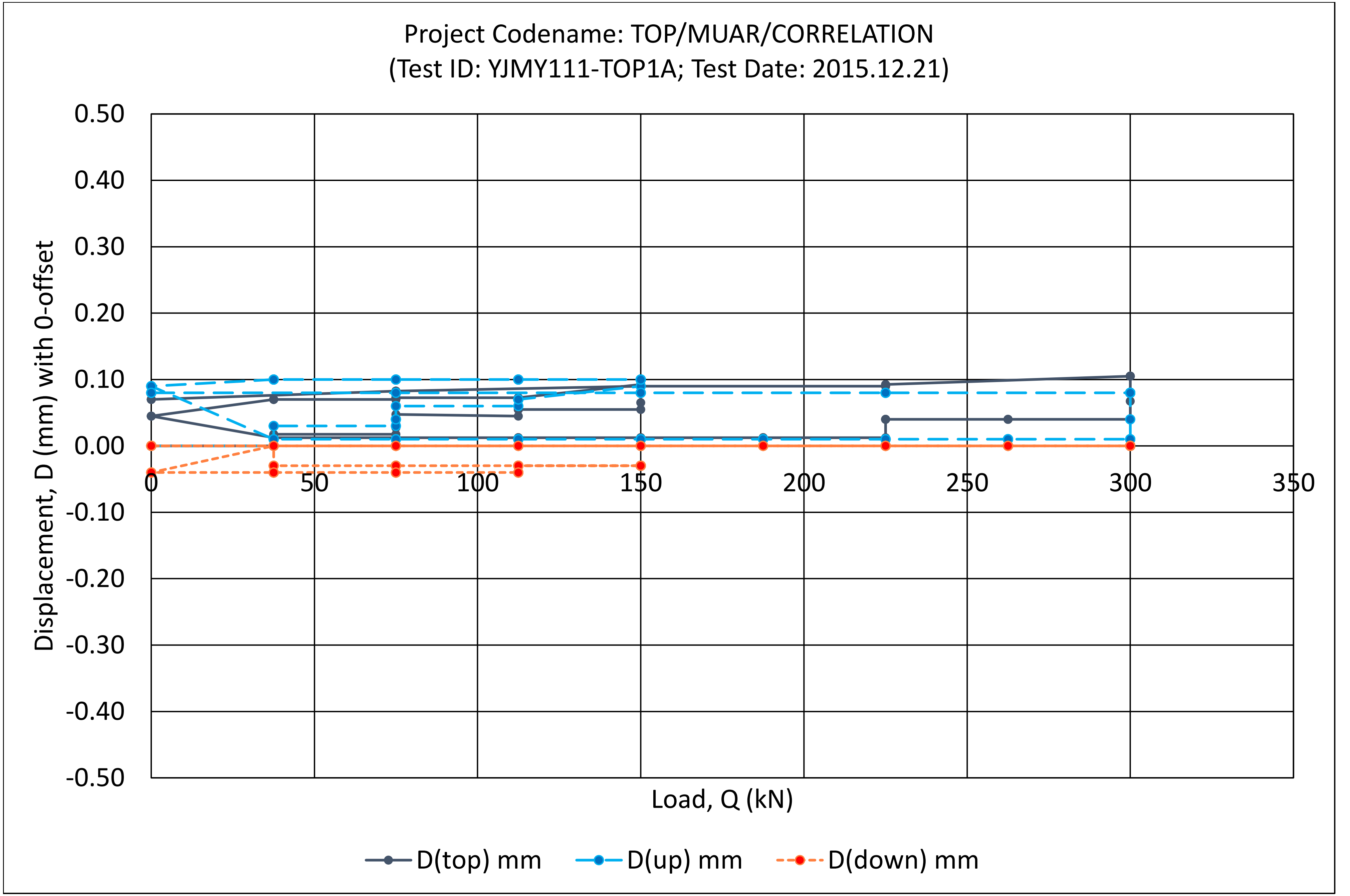
(Test ID: YJMY111-TOP1A; Test Date: 2015.12.21)
Load, Q (kN)
350
300
250
200
150
100
50
0
00:00
12:00
00:00
12:00
00:00
12:00
00:00
Time, t (hh:mm)
Load kN

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1A; Test Date: 2015.12.21)

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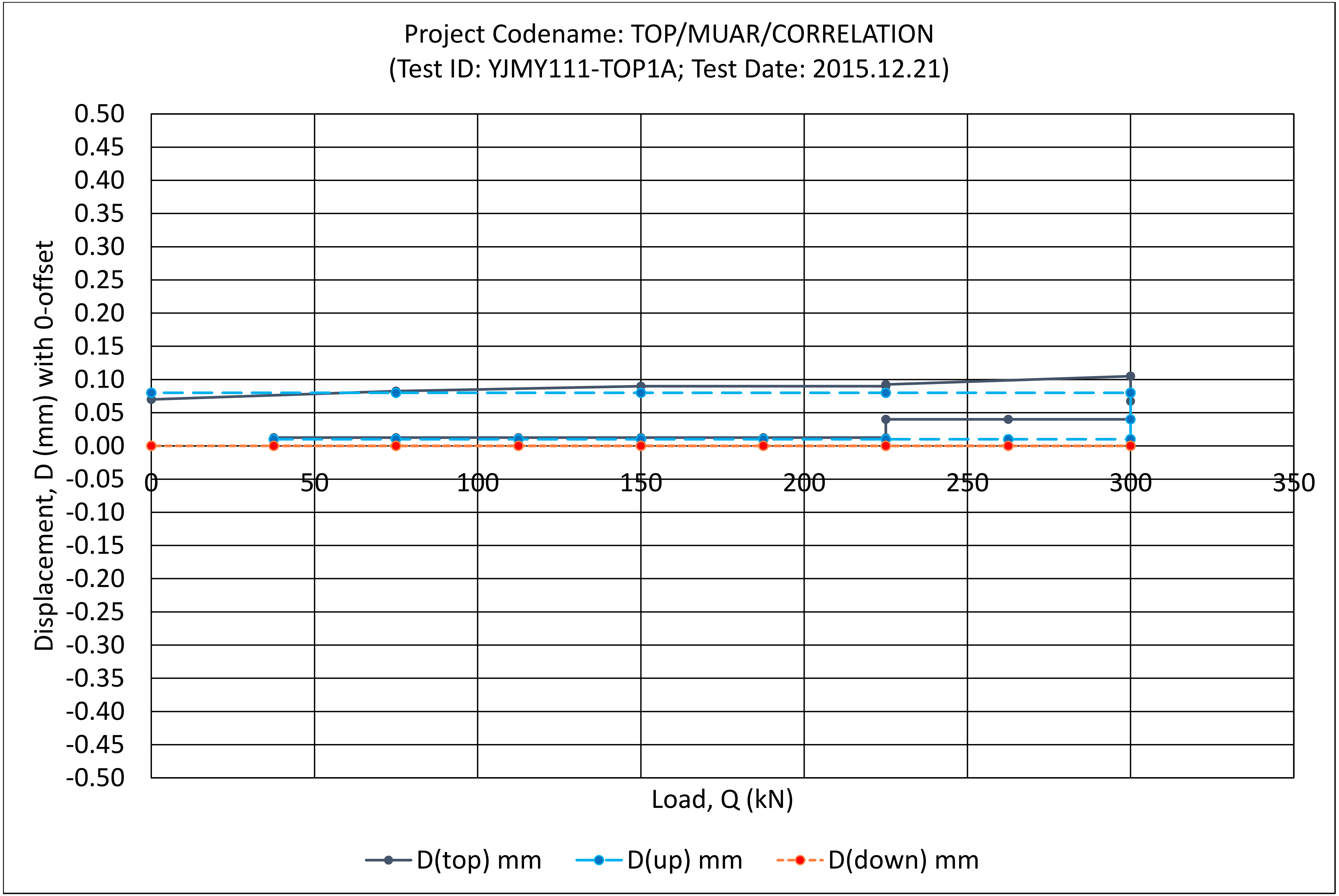
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
Displacement, D (mm) with 0-offset
0
50
100
150
200
250
300
350
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm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(Test ID: YJMY111-TOP1A; Test Date: 2015.12.21)
Displacement, D (mm) with 0-offset
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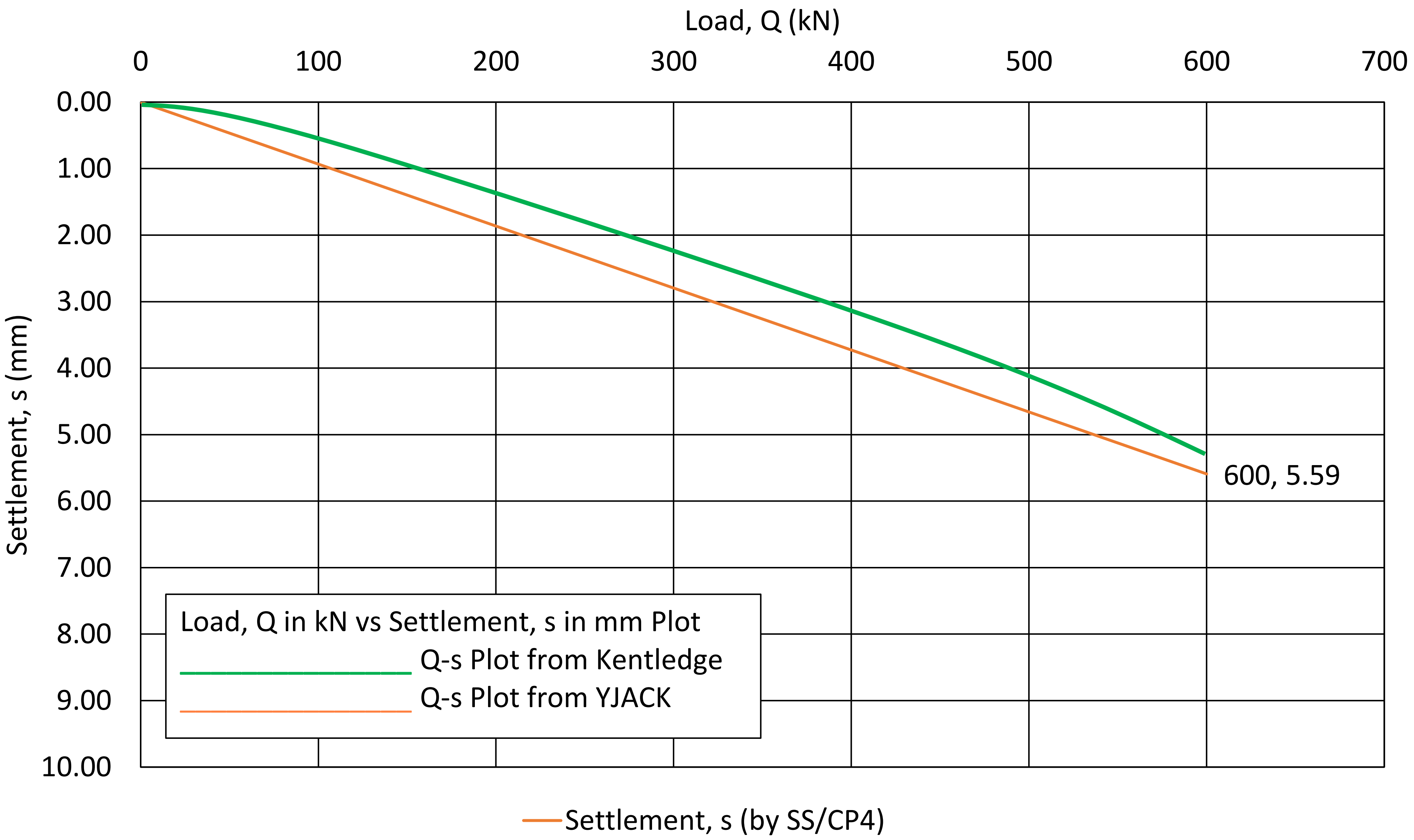
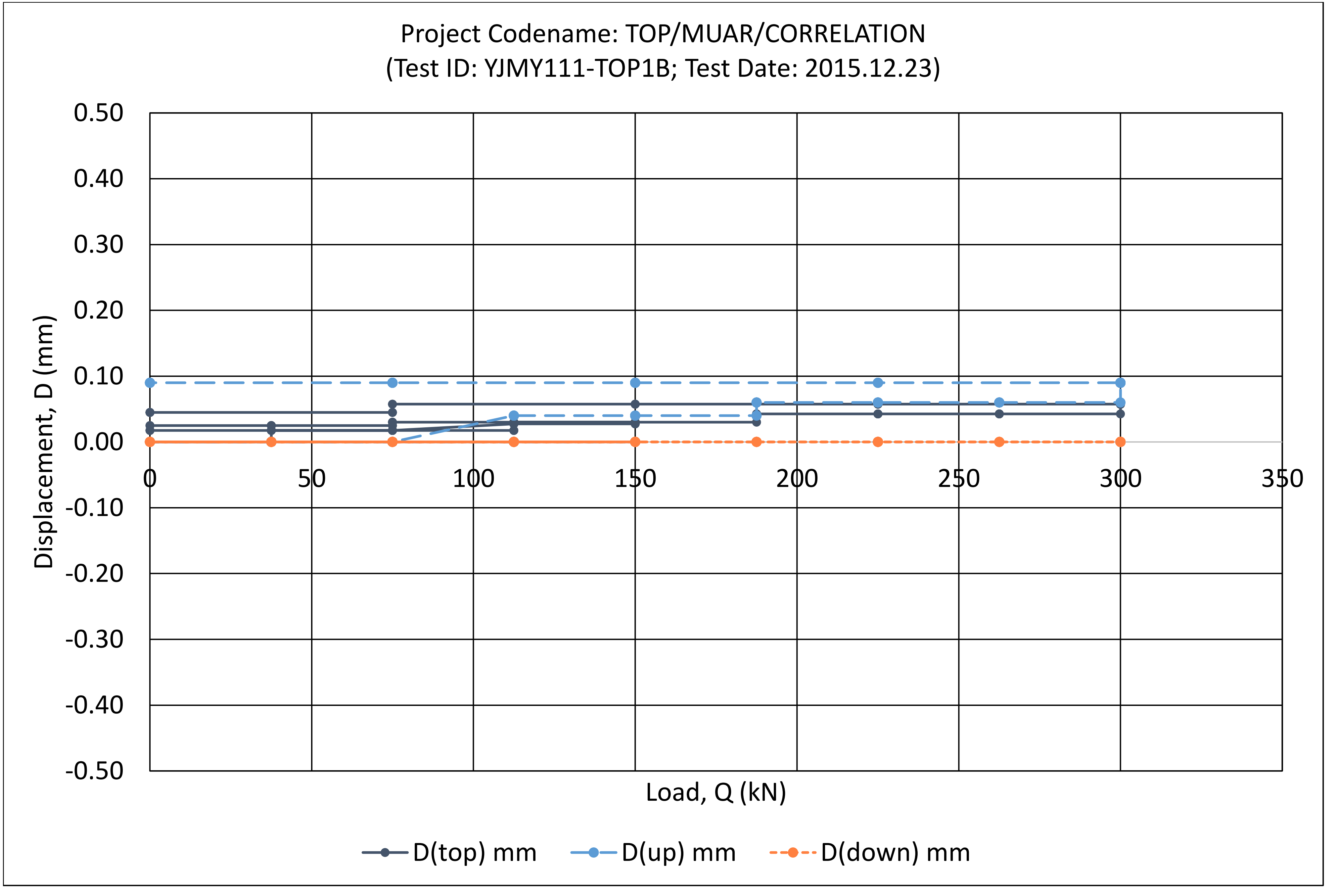
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
-0.45
-0.50
0
50
100
150
200
250
300
350
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1A; Test Date: 2015.12.21)

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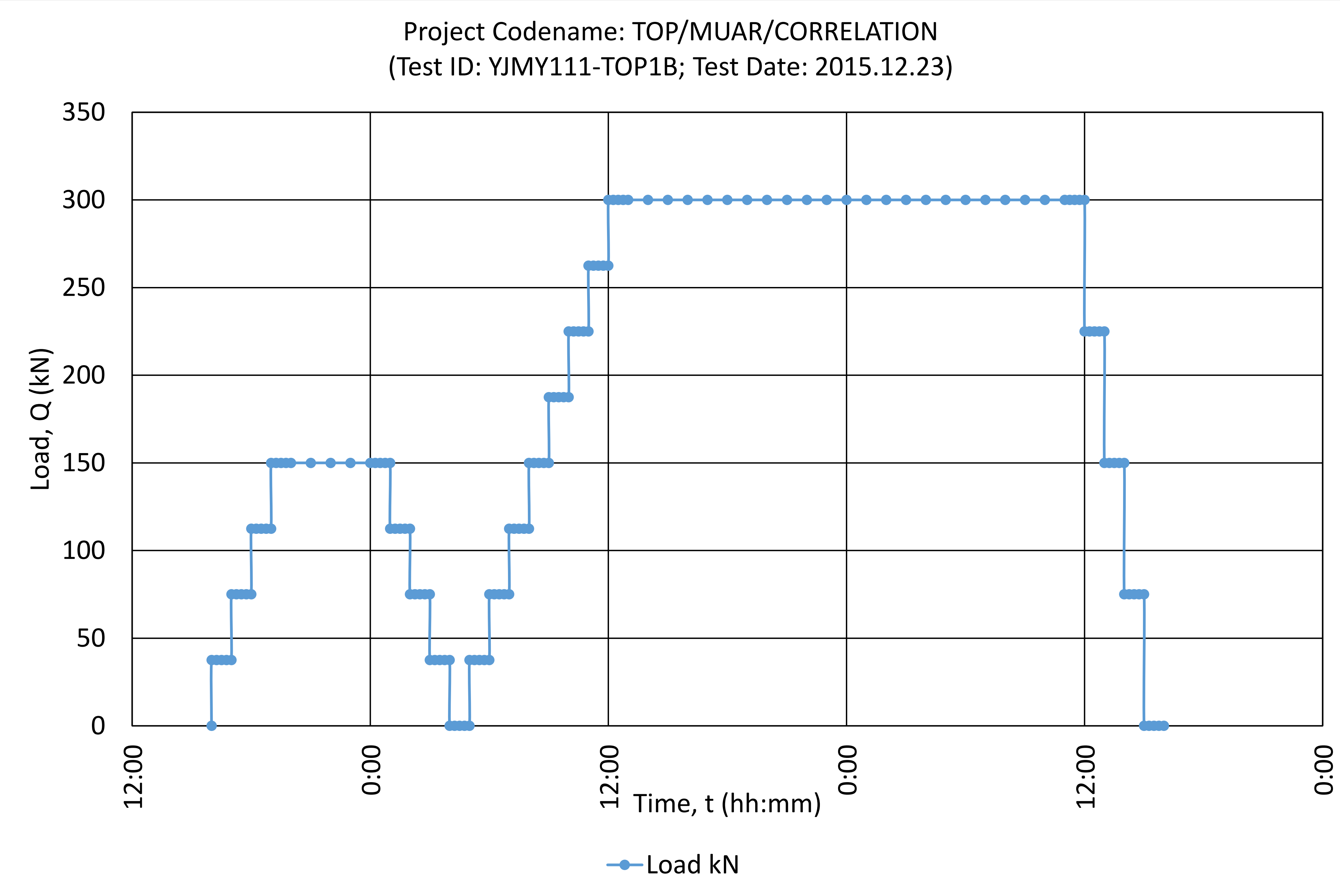
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
Displacement, D (mm)
0
50
100
150
200
250
300
350
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm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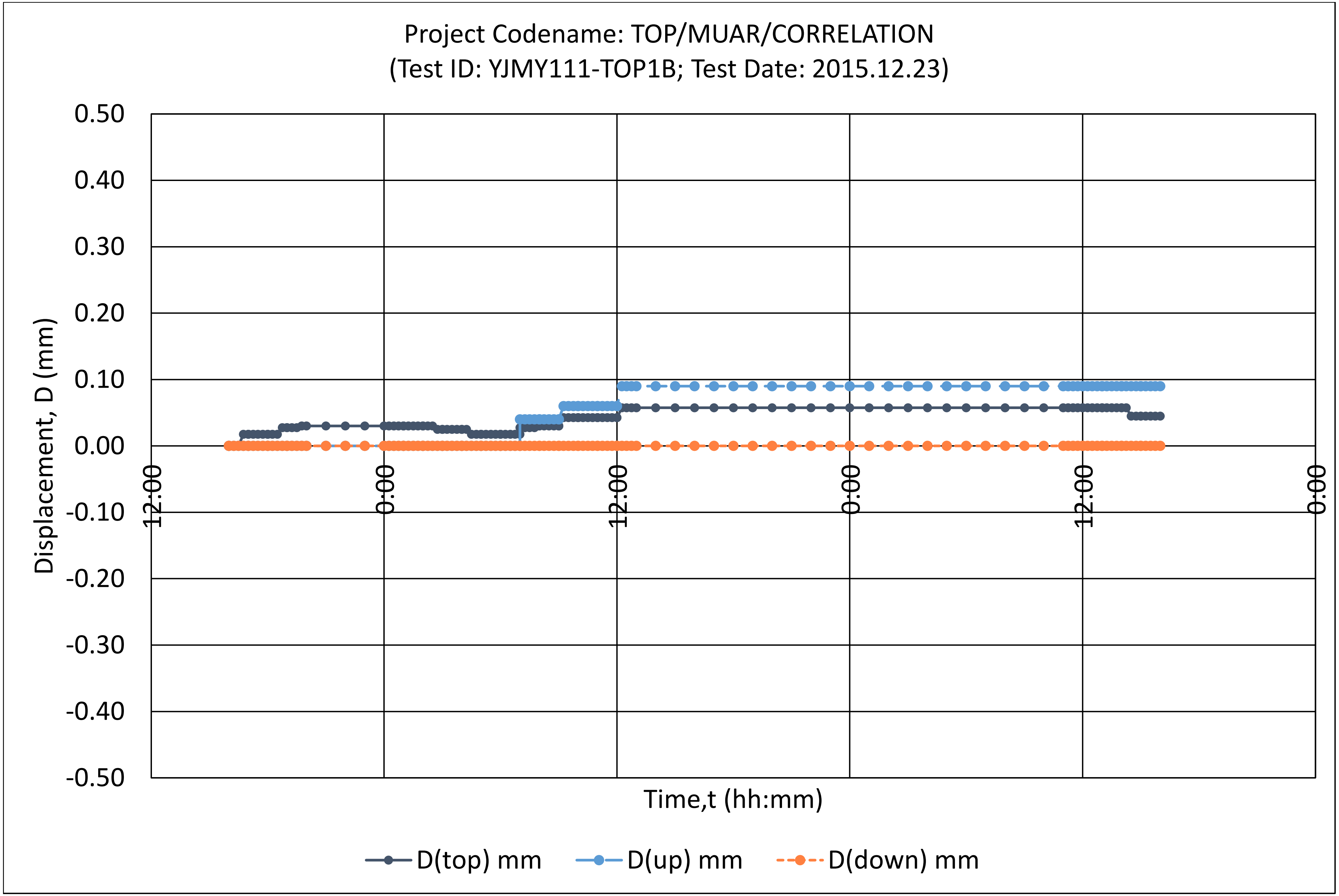
(Test ID: YJMY111-TOP1B; Test Date: 2015.12.23)
Load, Q (kN)
350
300
250
200
150
100
50
0
12:00
0:00
12:00
0:00
12:00
0:00
Time, t (hh:mm)
Load kN



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Displacement, D (mm)
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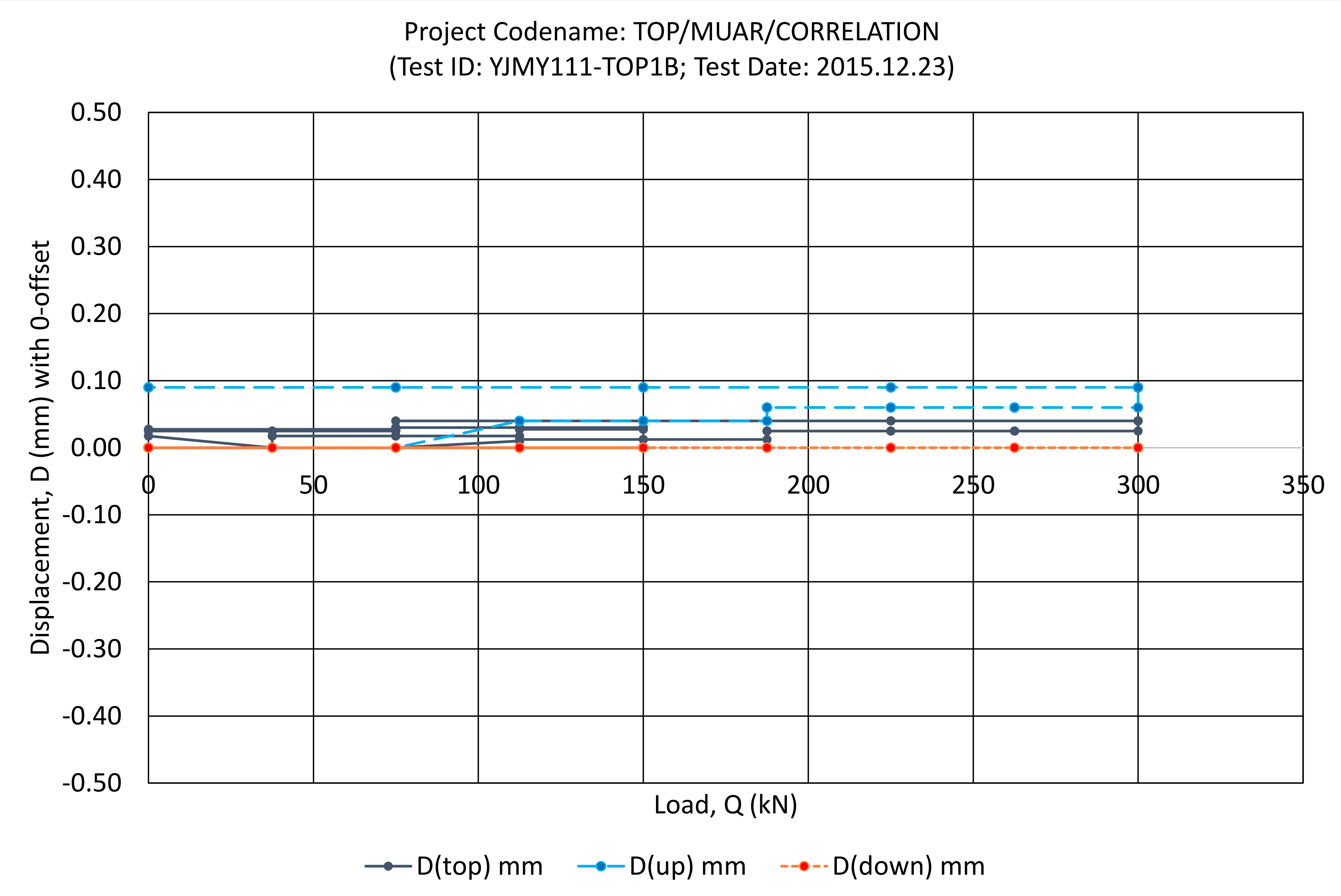
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
12:00
0:00
12:00
0:00
12:00
0:00
Time,t (hh:mm)
D(top) mm
D(up) mm
D(down) mm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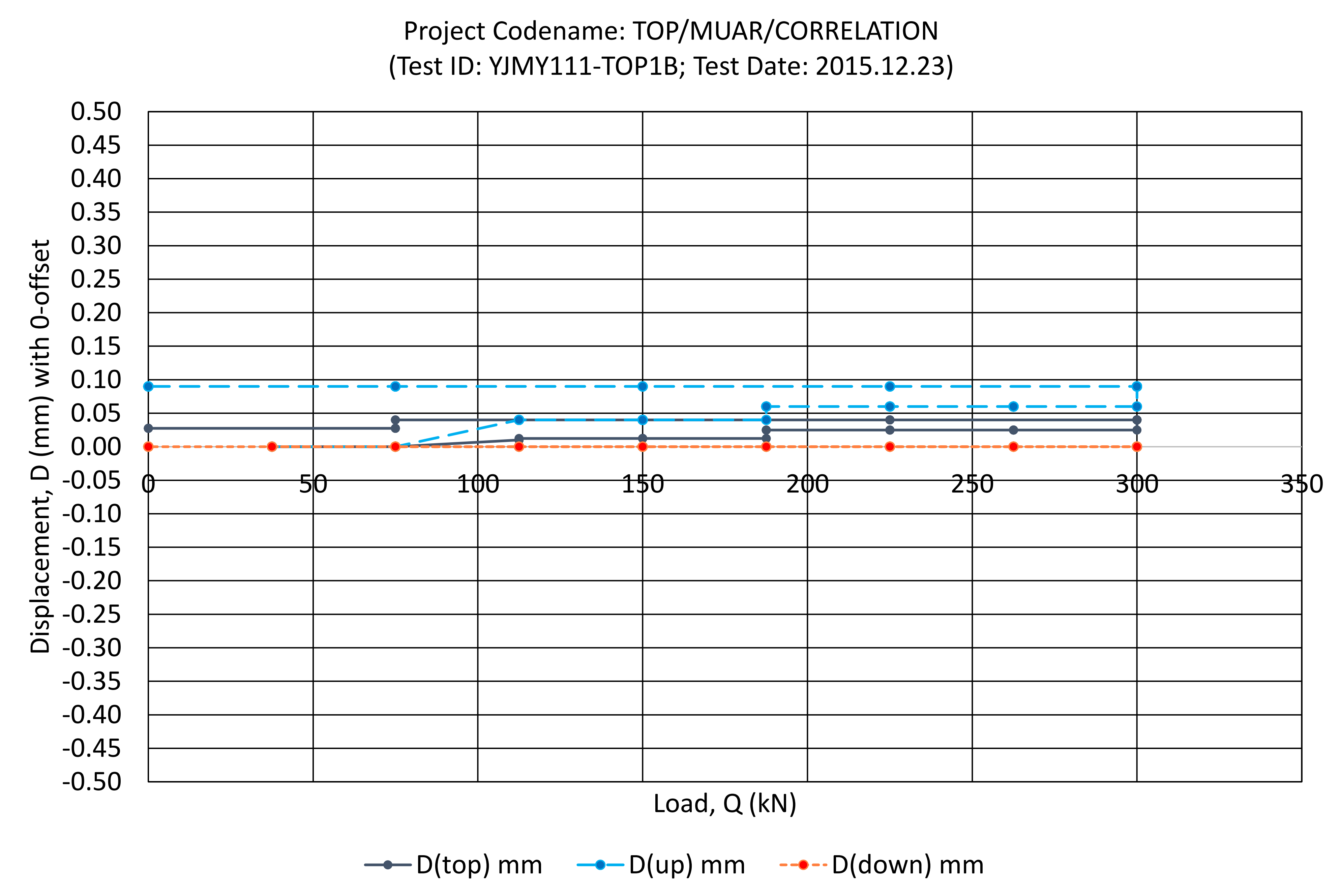
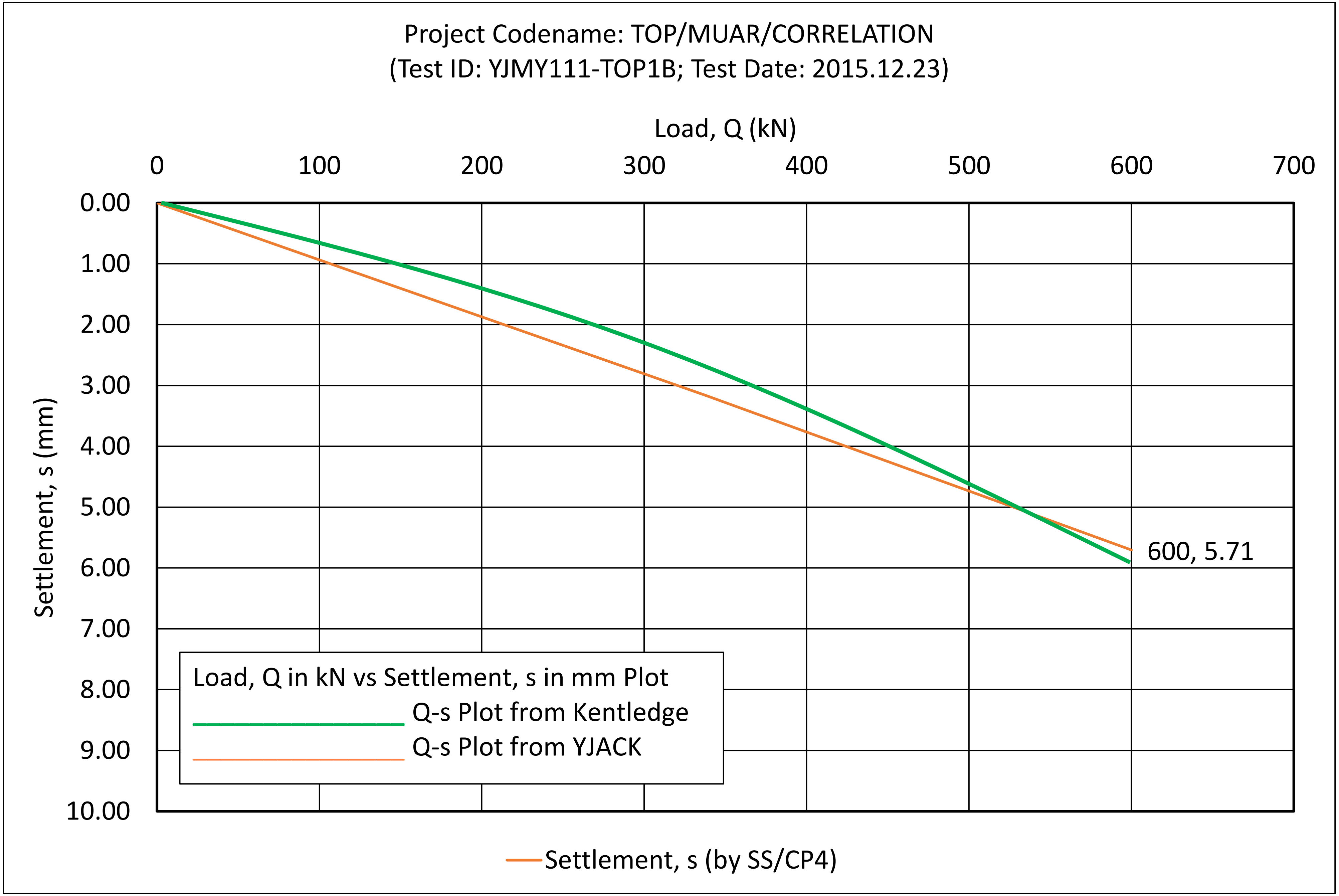
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
0
50
100
150
200
250
300
350
Displacement, D (mm) with 0-offset
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm


Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1B; Test Date: 2015.12.23)
Displacement, D (mm) with 0-offset
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
-0.45
-0.50
0
50
100
150
200
250
300
350
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm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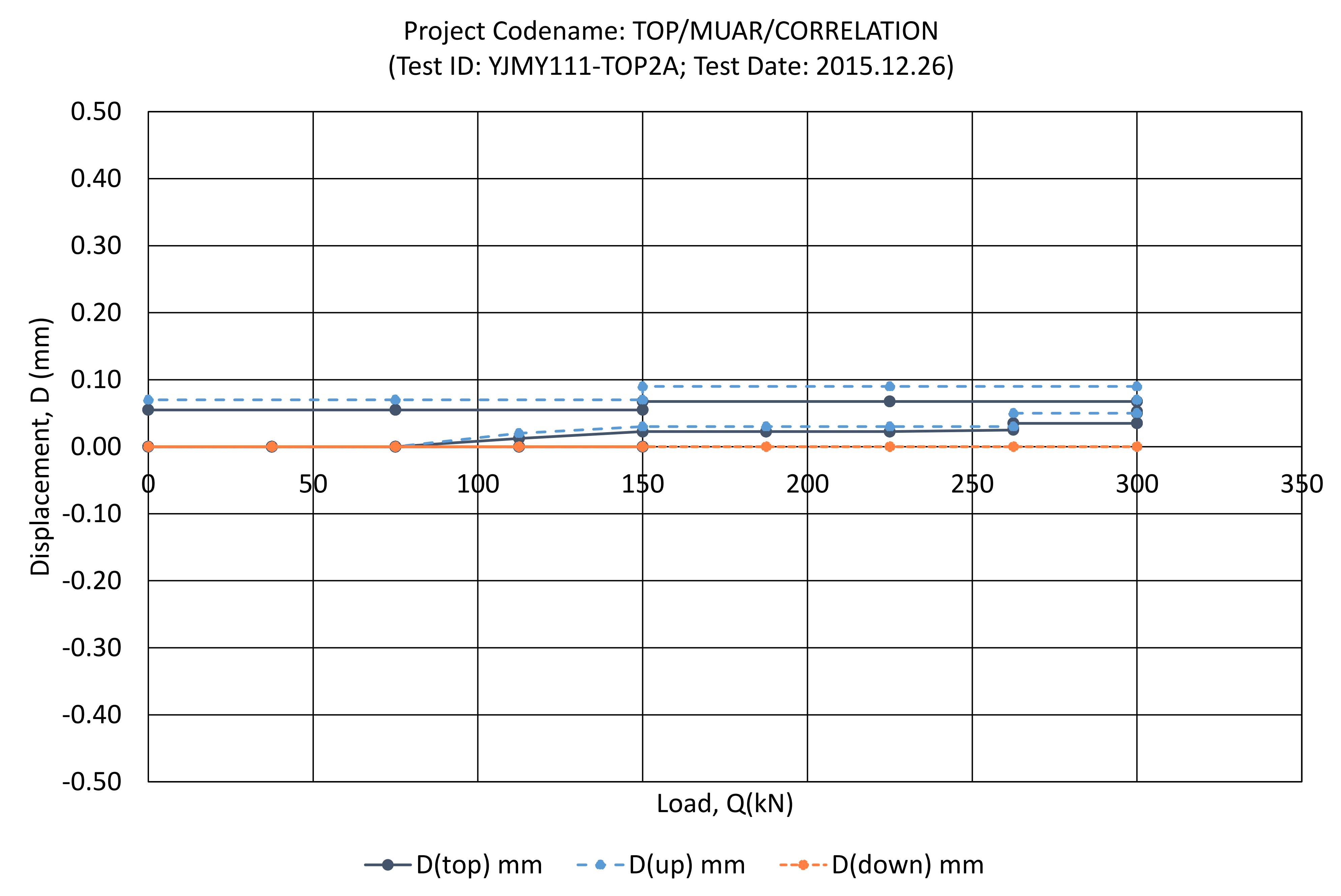
Load, Q (kN)
0
100
200
300
400
500
600
700
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
Settlement, s (mm)
600, 5.71
Load, Q in kN vs Settlement, s in mm Plot
Q-s Plot from Kentledge
Q-s Plot from YJACK
Settlement, s (by SS/CP4)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Displacement, D (mm)
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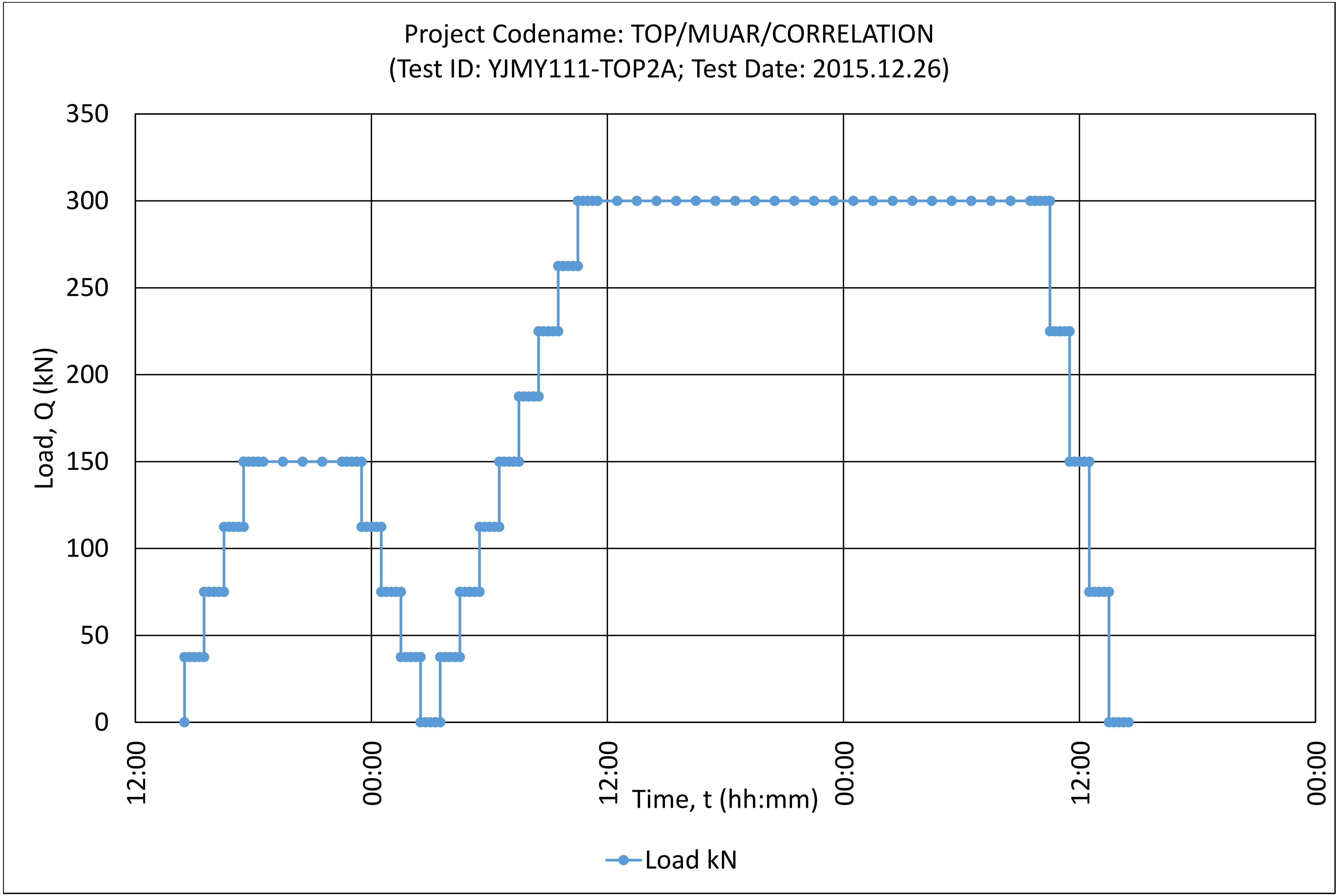
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
0
50
100
150
200
250
300
350
Load, Q(kN)
D(top) mm
D(up) mm
D(down) mm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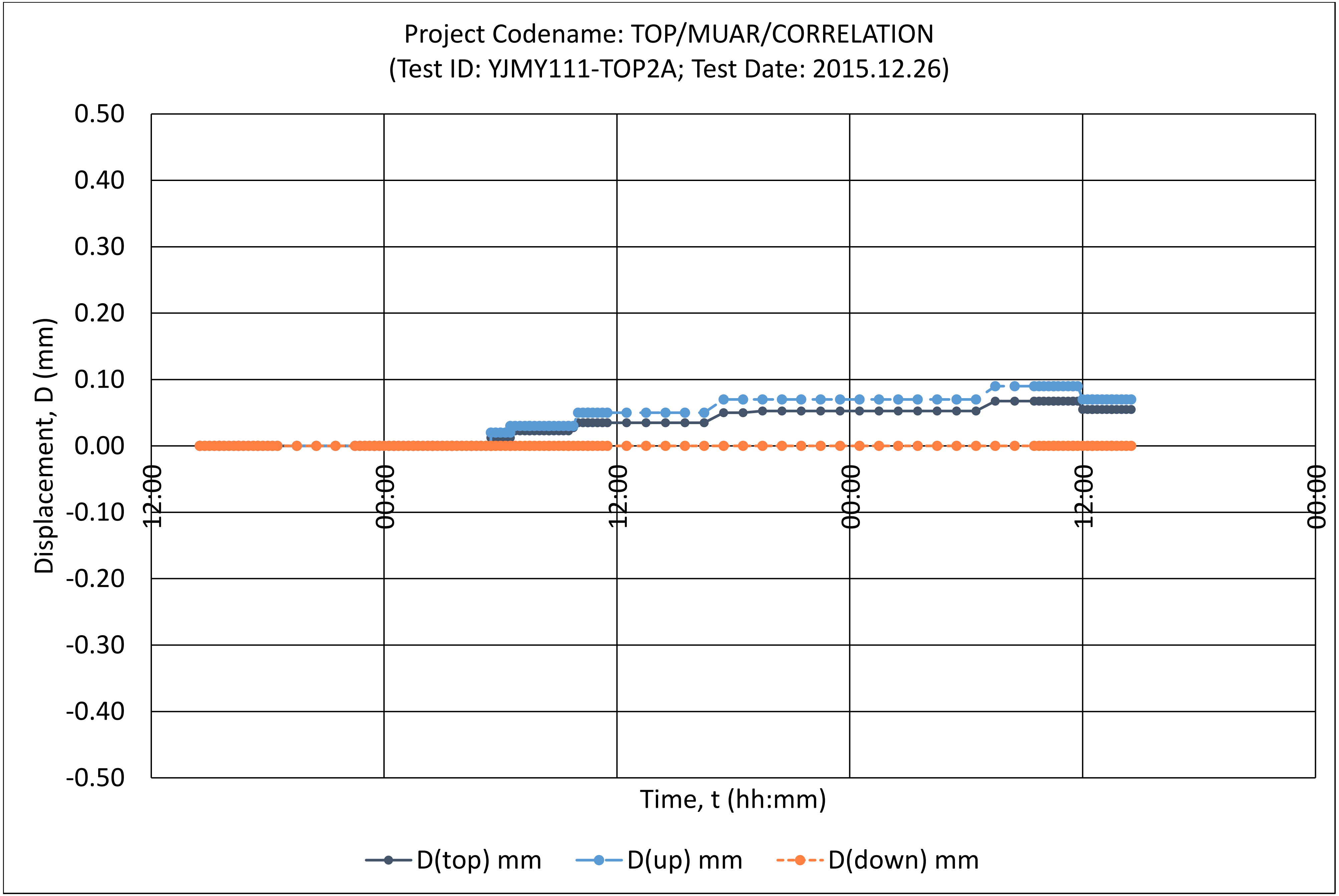
350
300
250
200
150
100
50
0
Load, Q (kN)
12:00
00:00
12:00
00:00
12:00
00:00
Time, t (hh:mm)
Load kN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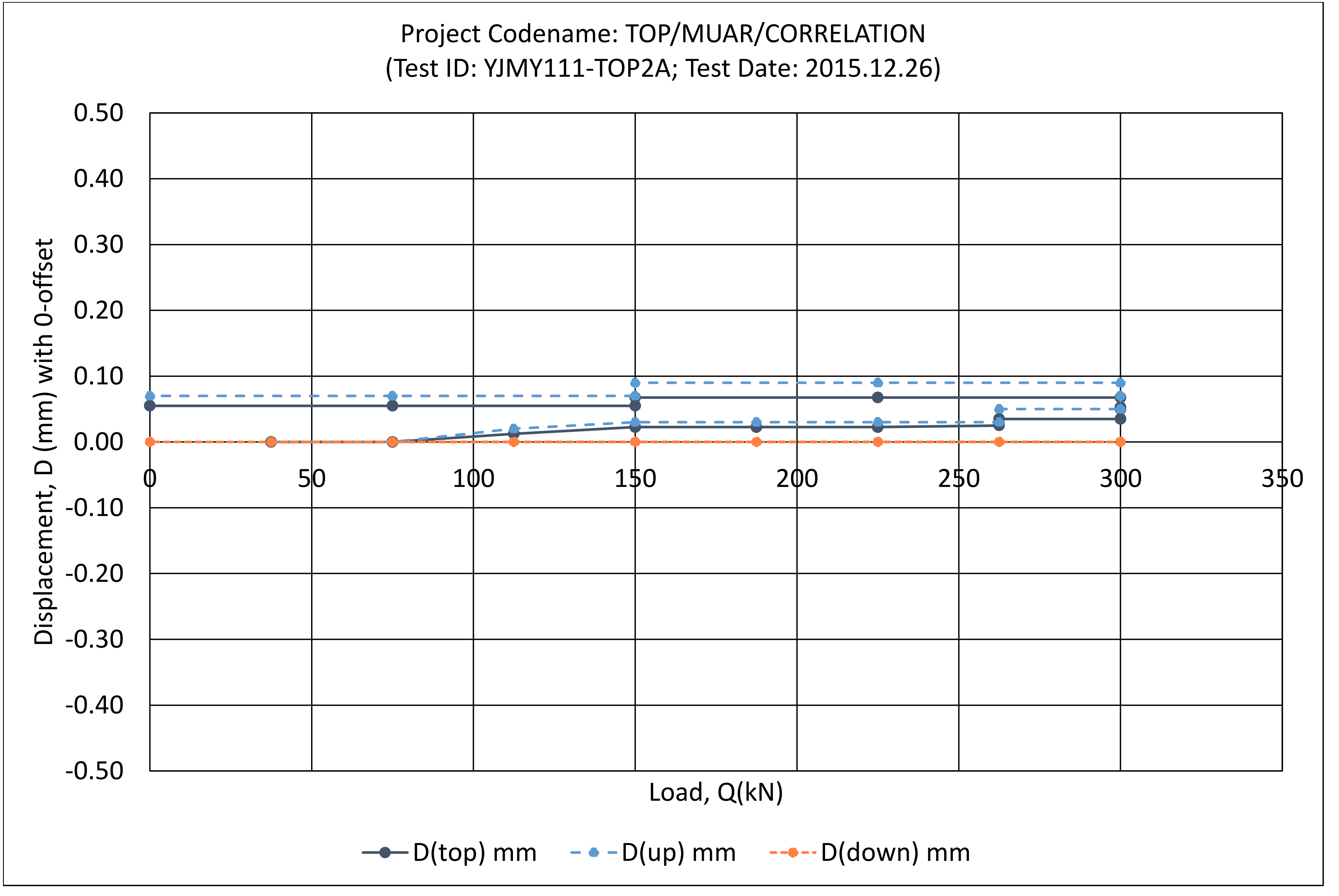
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
Displacement, D (mm)
12:00
00:00
12:00
00:00
12:00
00:00
Time, t (hh:mm)
D(top) mm
D(up) mm
D(down) mm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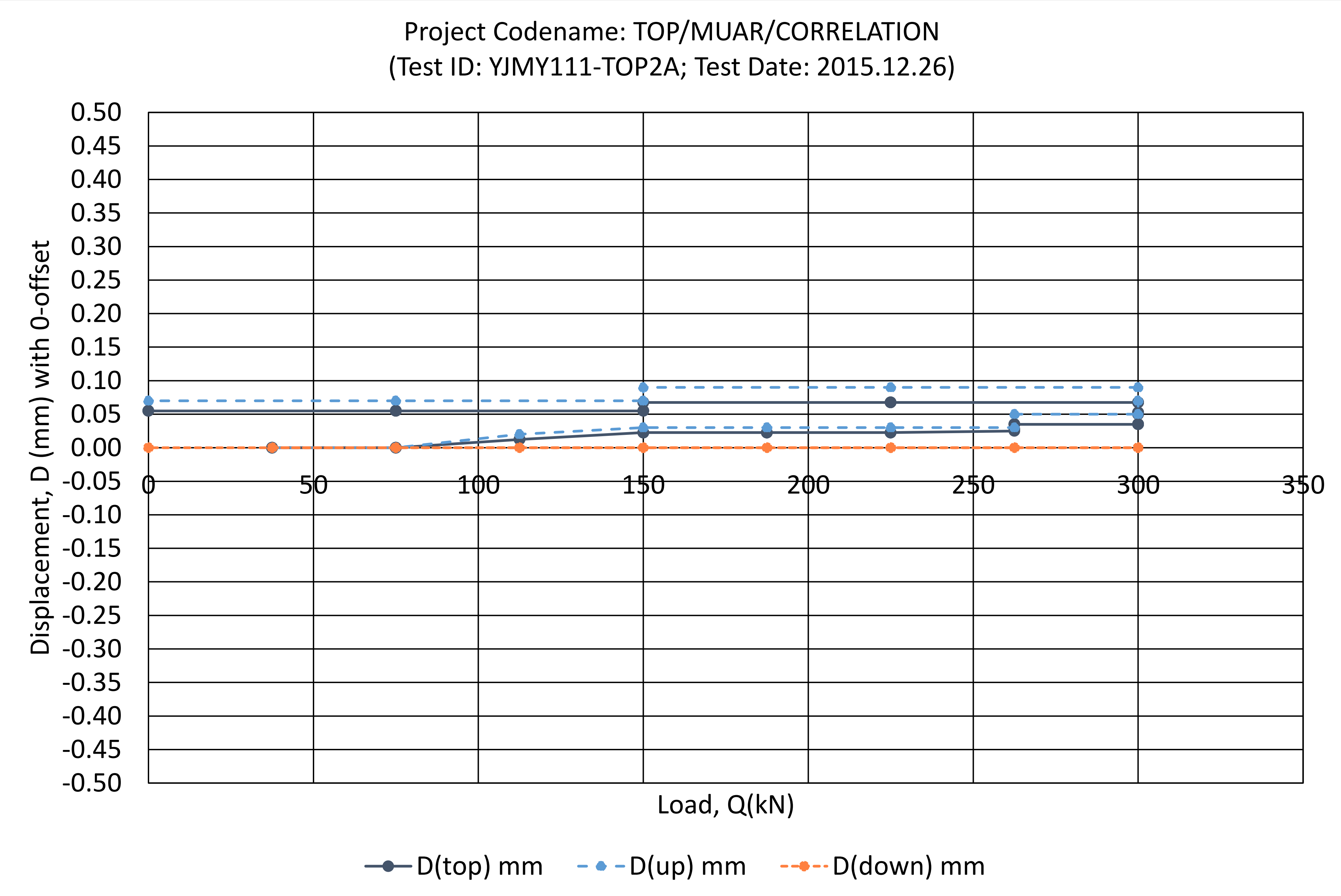
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
0
50
100
150
200
250
300
350
Displacement, D (mm) with 0-offset
Load, Q(kN)
D(top) mm
D(up) mm
D(down) mm


Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP2A; Test Date: 2015.12.26)
Displacement, D (mm) with 0-offset
Load, Q(kN)
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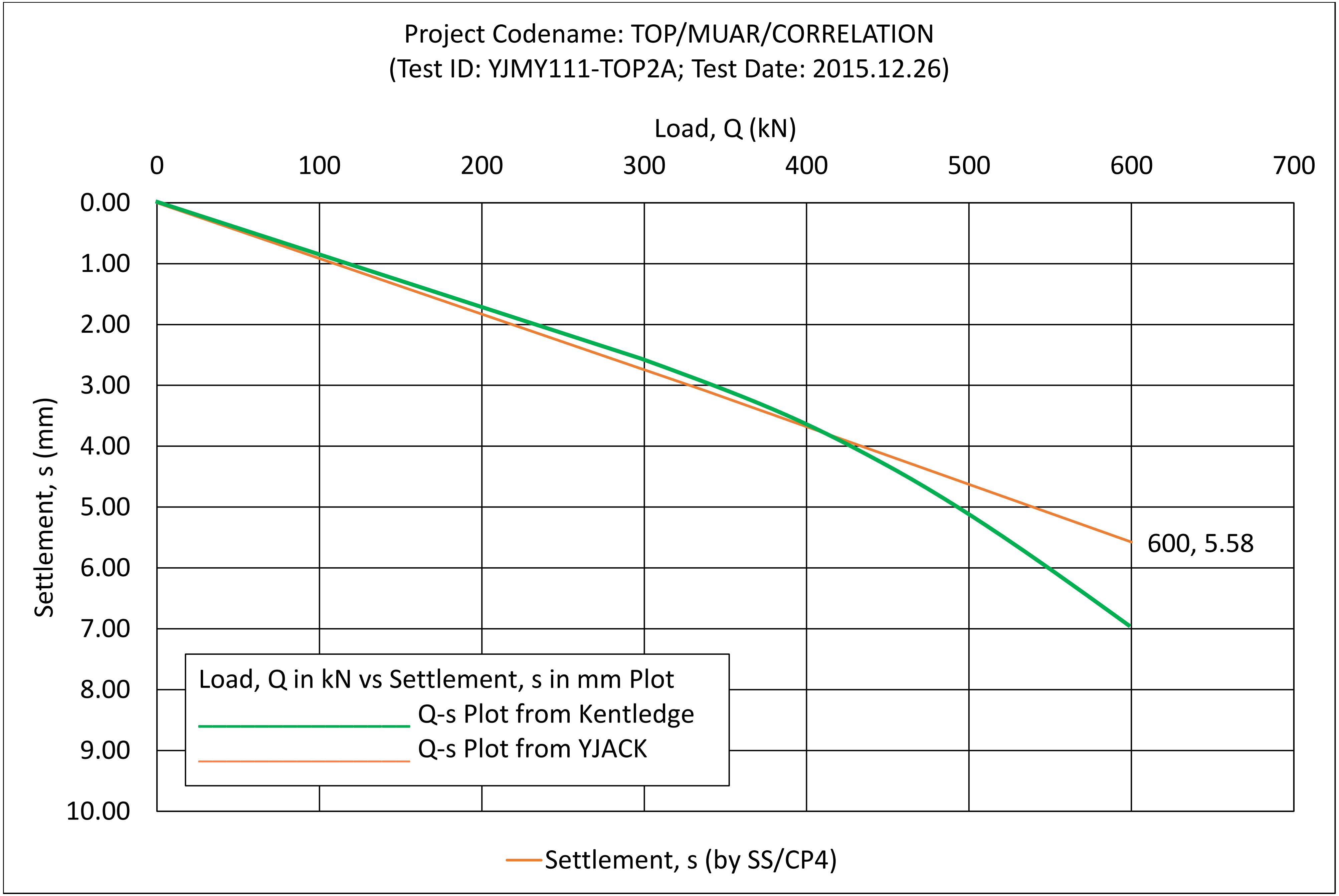
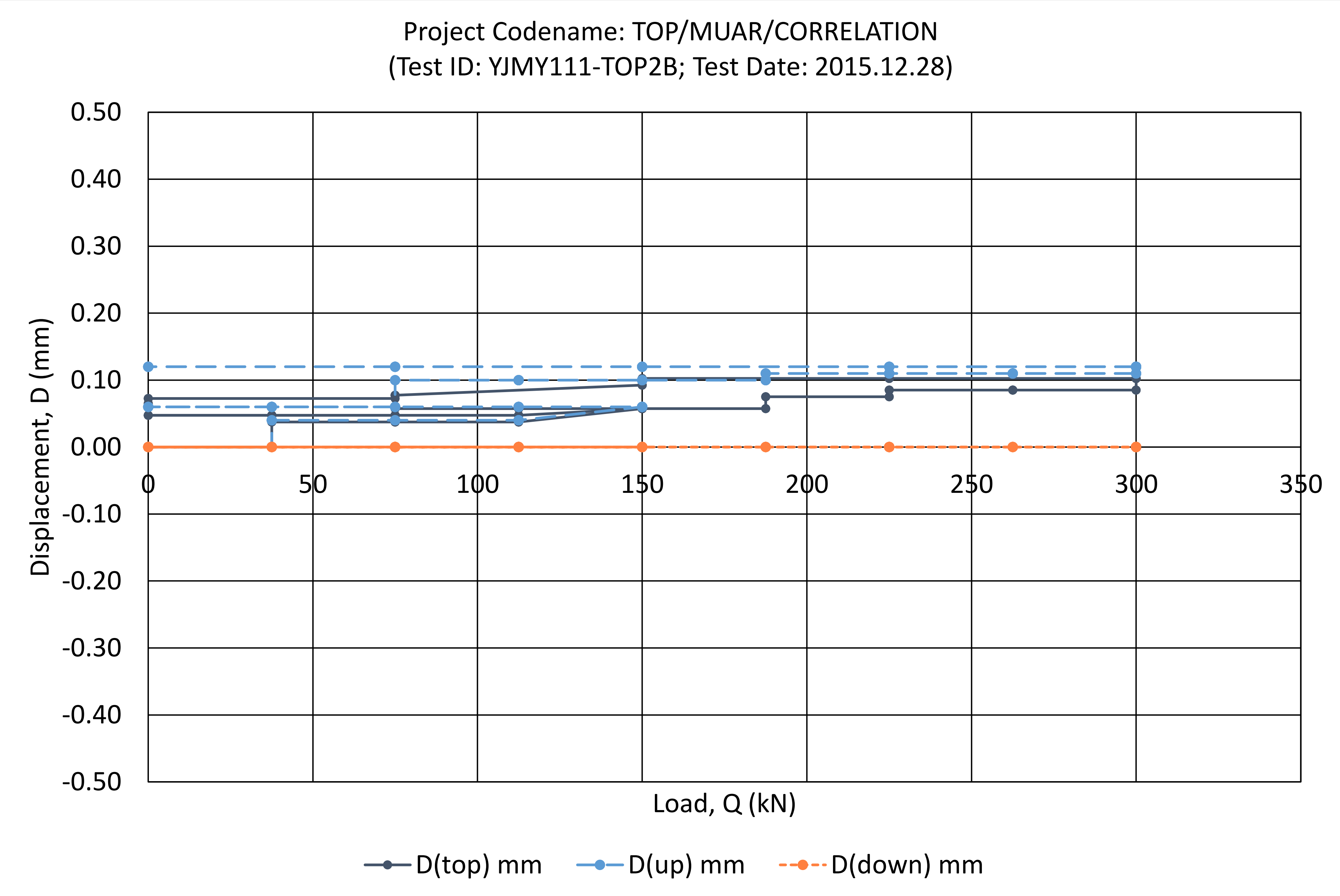
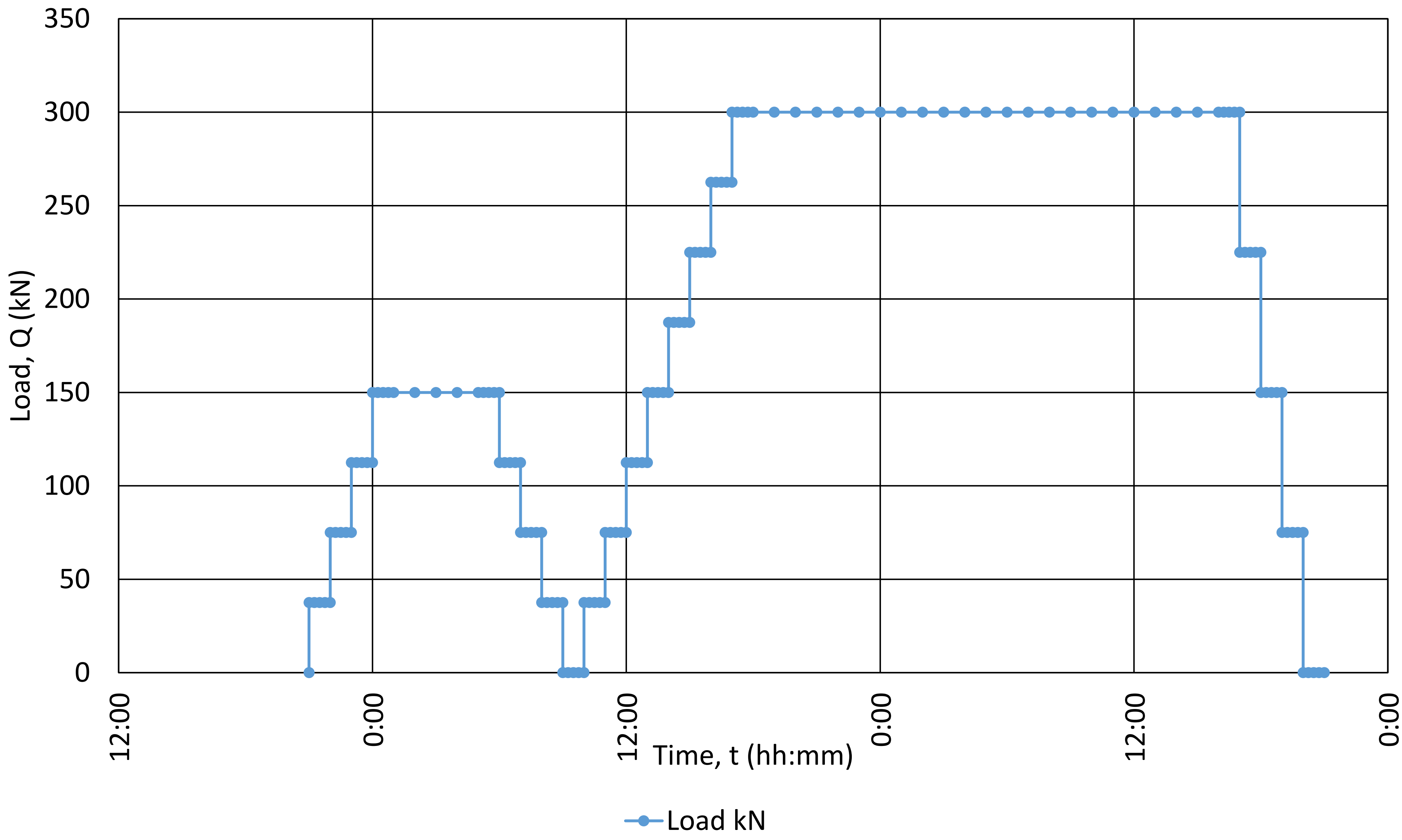
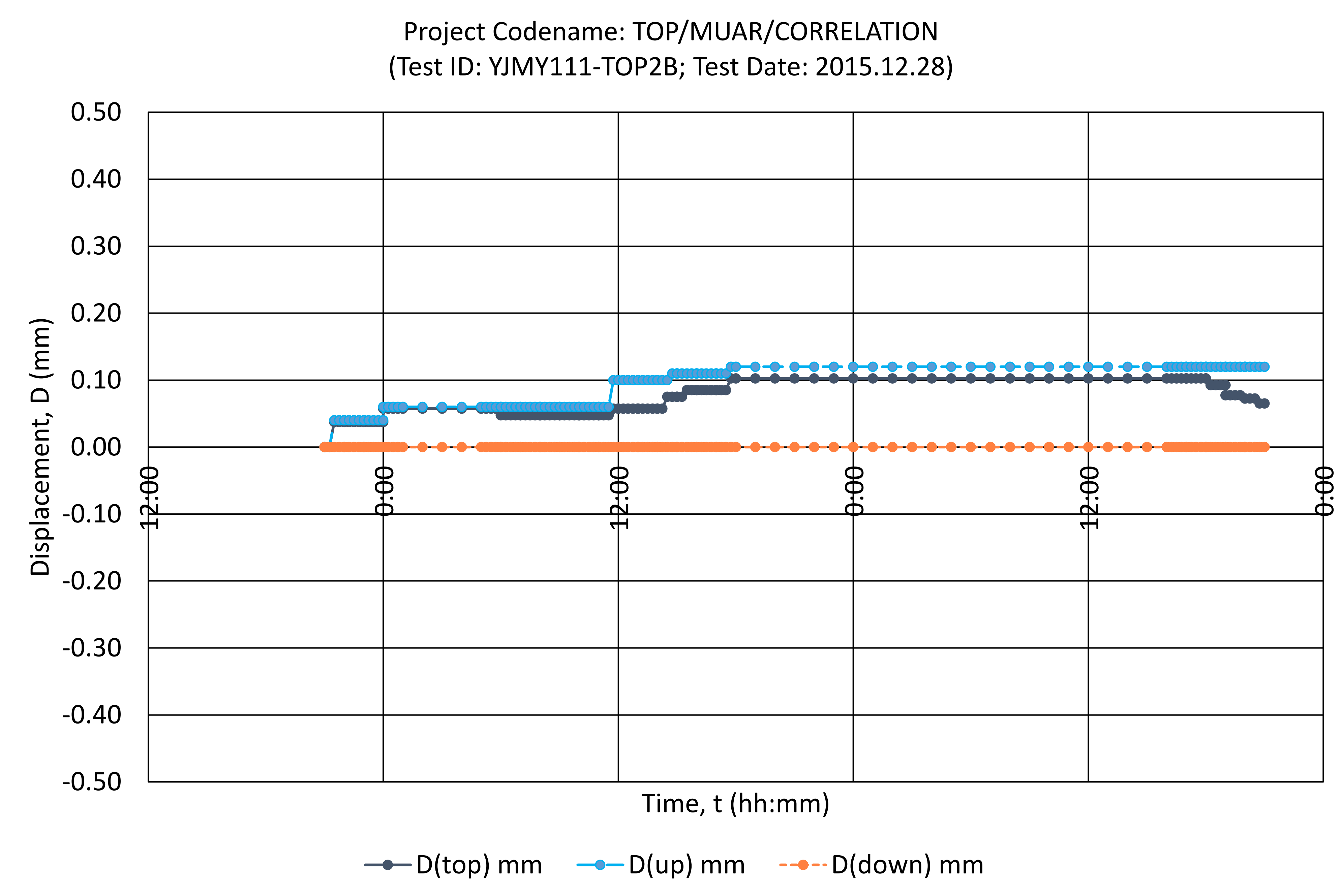
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
-0.45
-0.50
0
50
100
150
200
250
300
350
D(top) mm
D(up) mm
D(down) mm

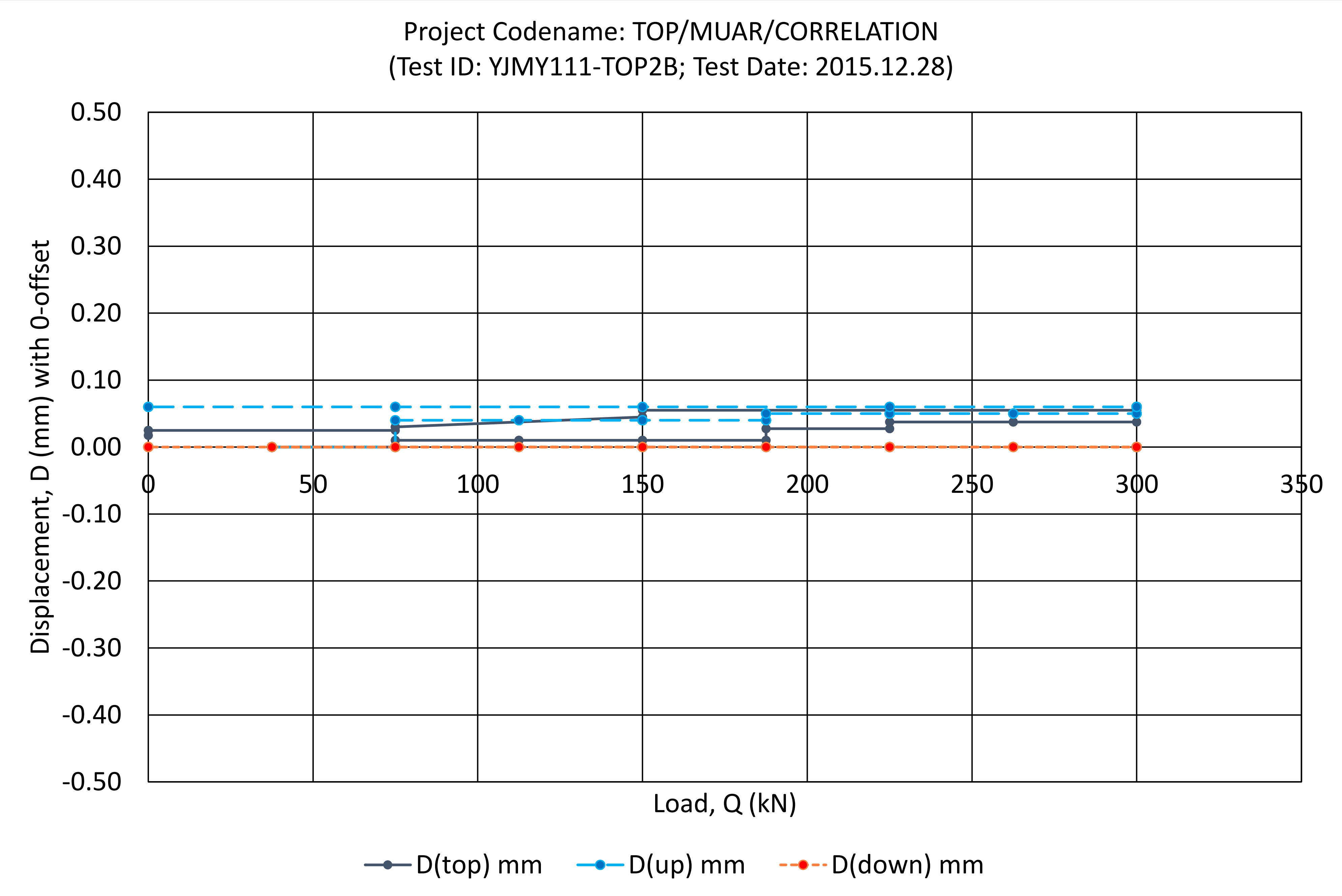

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP2A; Test Date: 2015.12.26)
Load, Q (kN)
0
100
200
300
400
500
600
700
Settlement, s (mm)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
600, 5.58
Load, Q in kN vs Settlement, s in mm Plot
Q-s Plot from Kentledge
Q-s Plot from YJACK
Settlement, s (by SS/CP4)

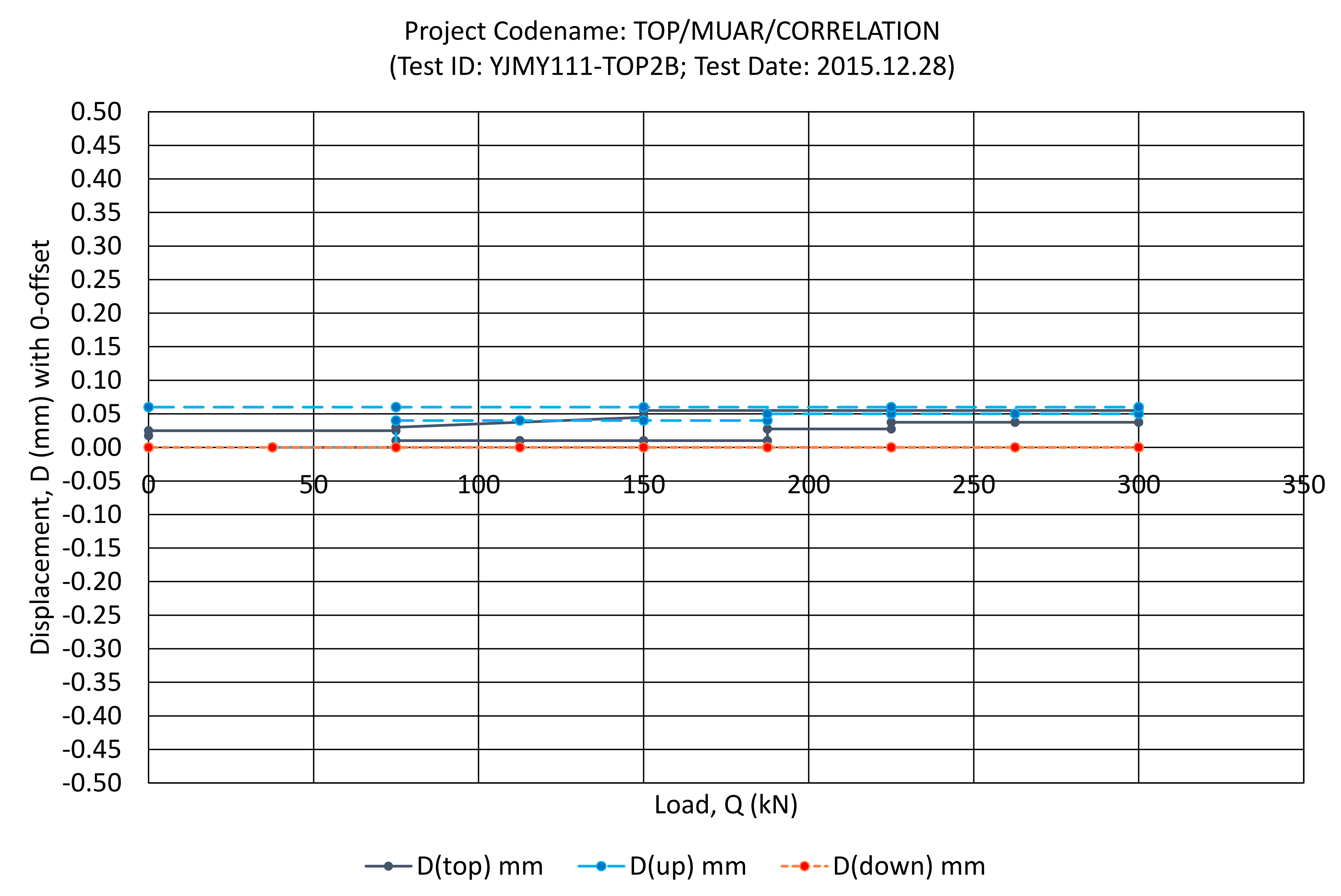

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP2B; Test Date: 2015.12.28)
Displacement, D (mm)
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
0
50
100
150
200
250
300
350
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP2B; Test Date: 2015.12.28)

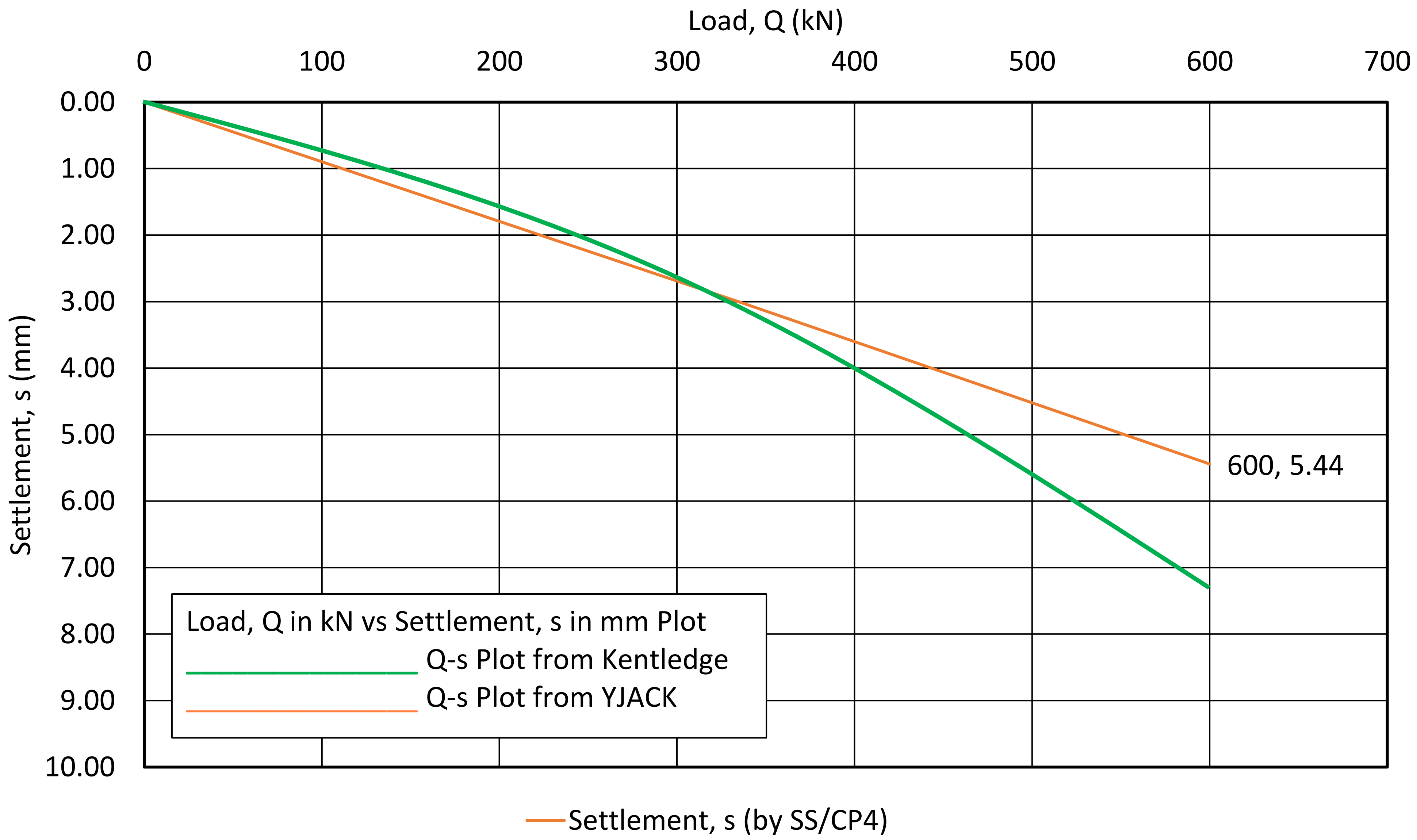



Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP2B; Test Date: 2015.12.28)
Displacement, D (mm)
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
12:00
0:00
12:00
0:00
12:00
0:00
Time, t (hh:mm)
D(top) mm
D(up) mm
D(down) mm

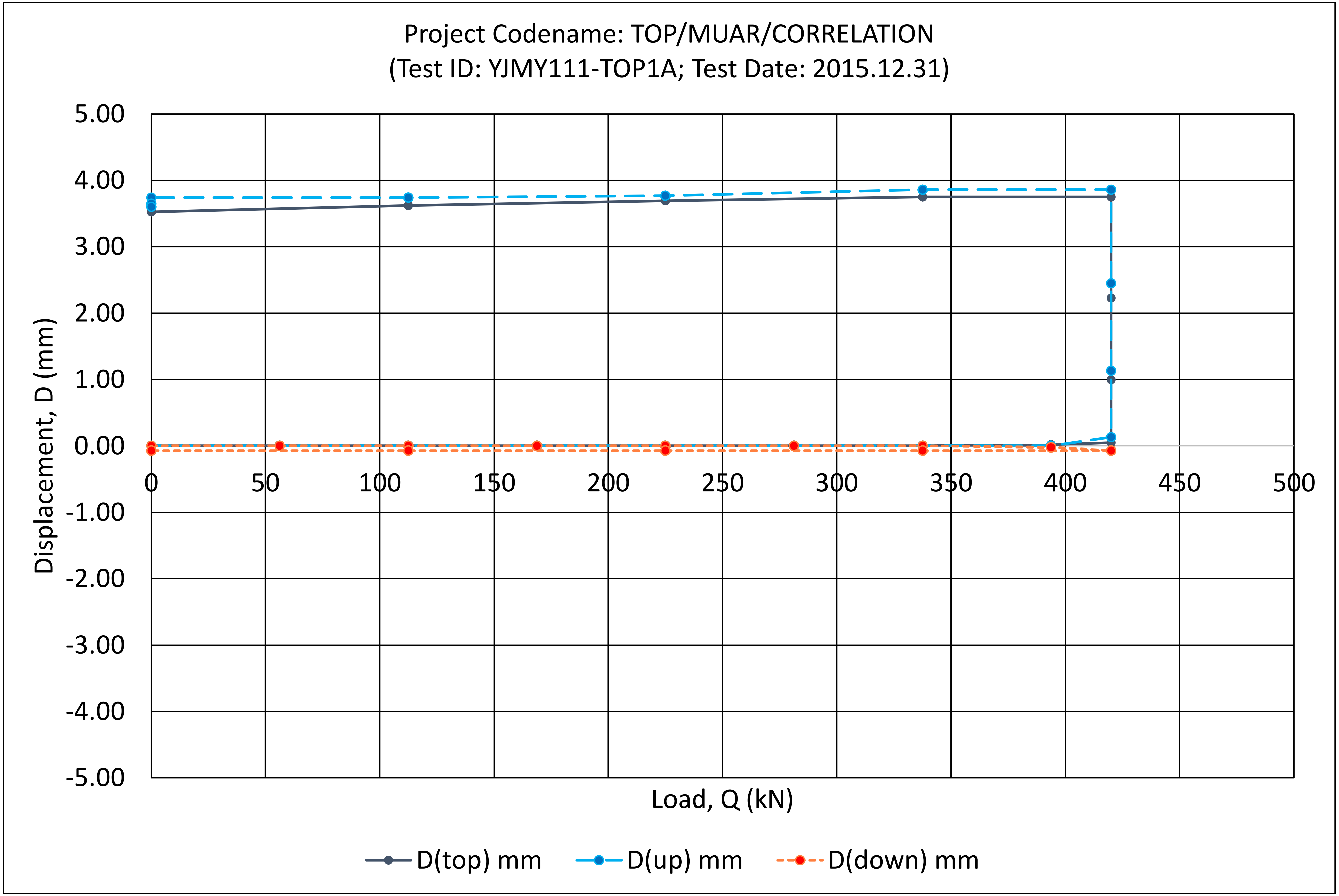

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP2B; Test Date: 2015.12.28)
Displacement, D (mm) with 0-offset
Load, Q (kN)
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
0
50
100
150
200
250
300
350
D(top) mm
D(up) mm
D(down) mm

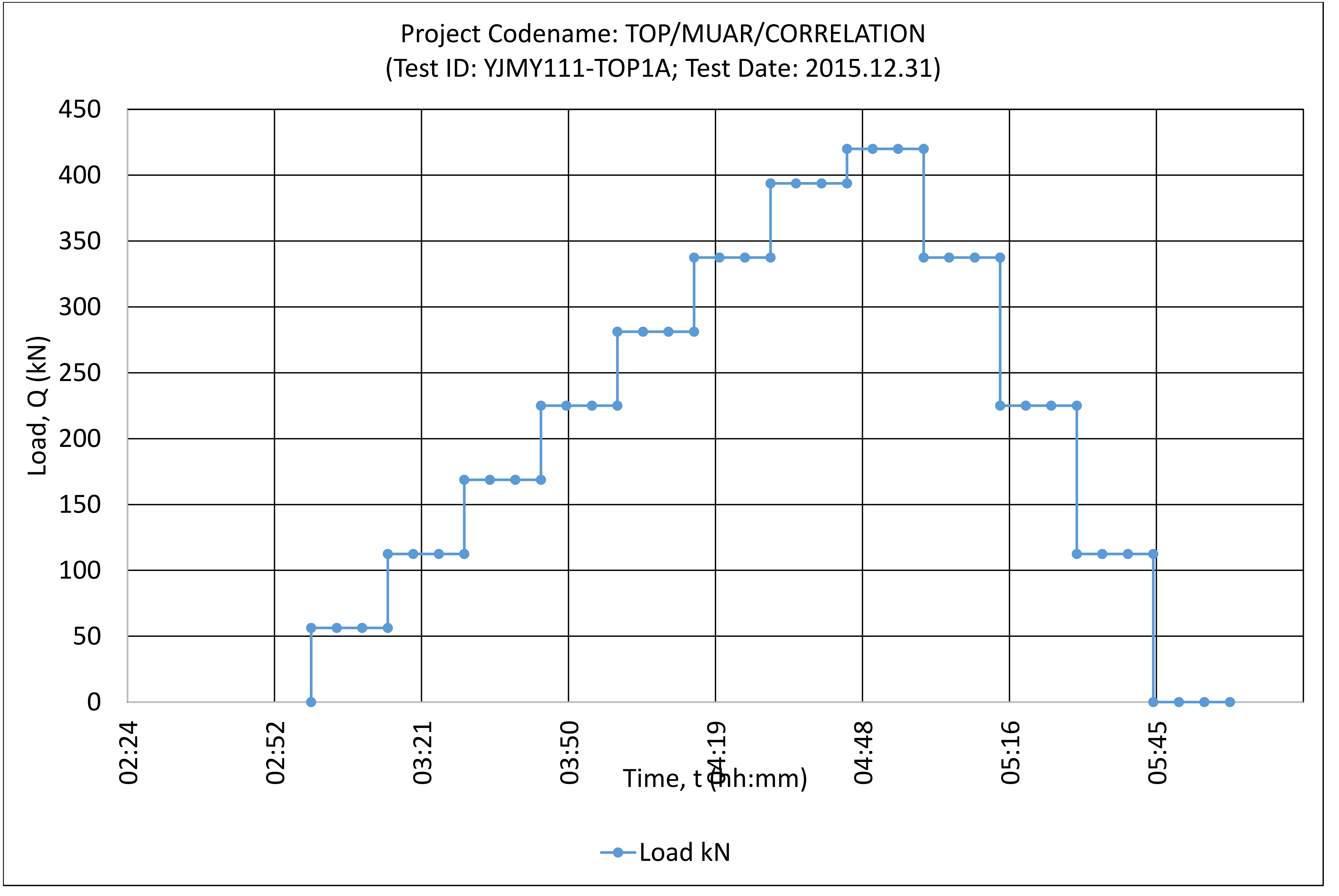

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP2B; Test Date: 2015.12.28)
Displacement, D (mm) with 0-offset
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
-0.45
-0.50
0
50
100
150
200
250
300
350
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm

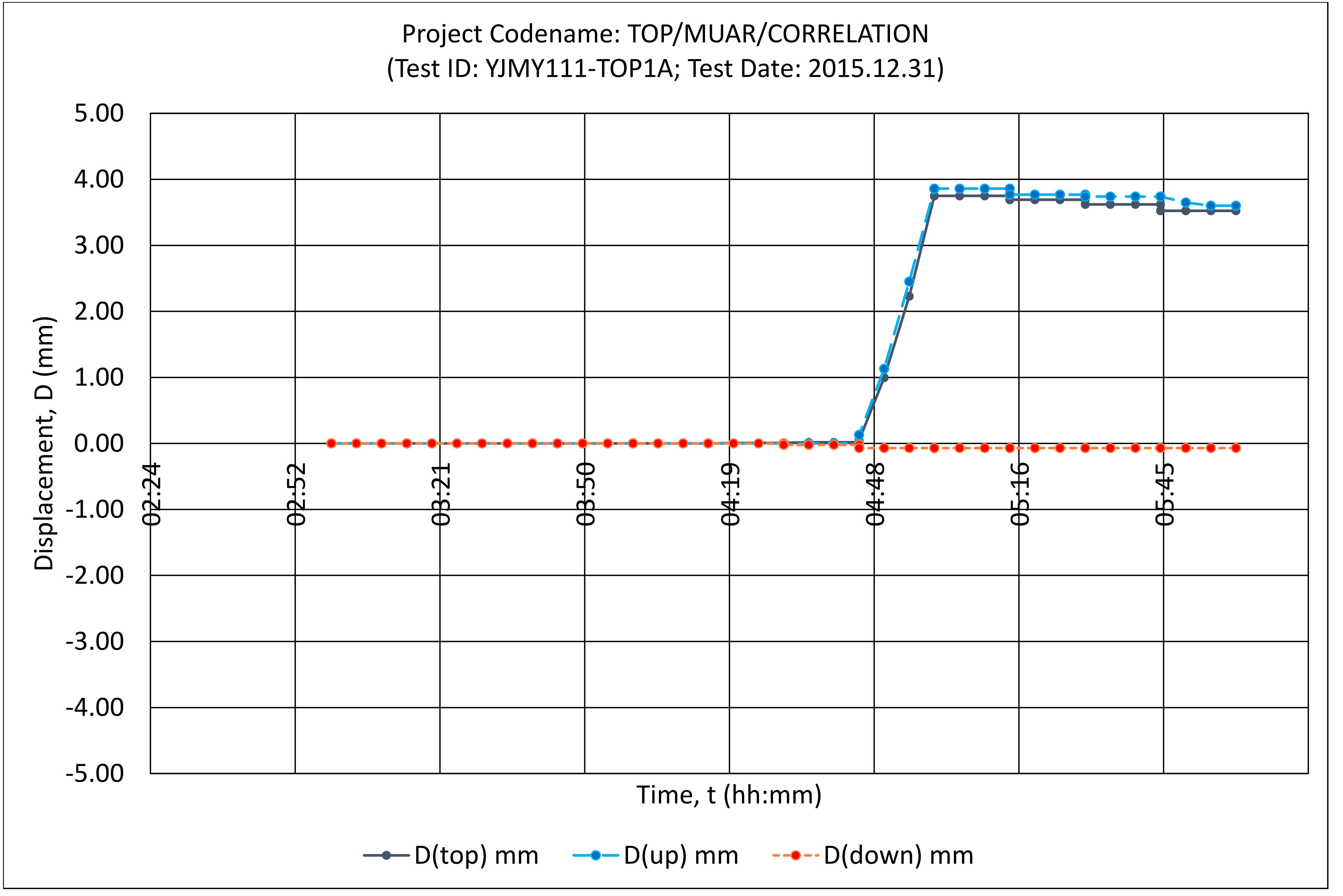
Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP2B; Test Date: 2015.12.28)

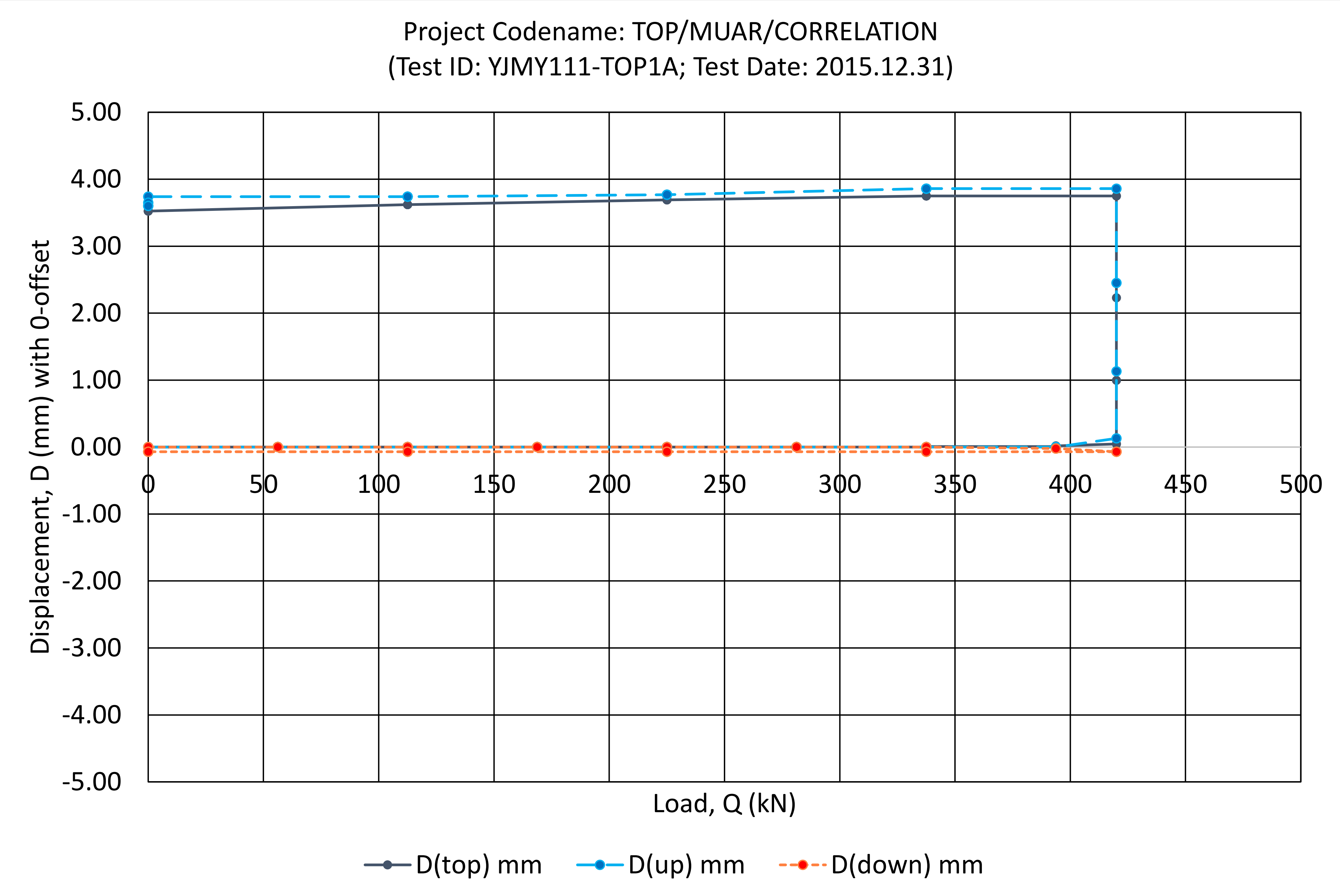


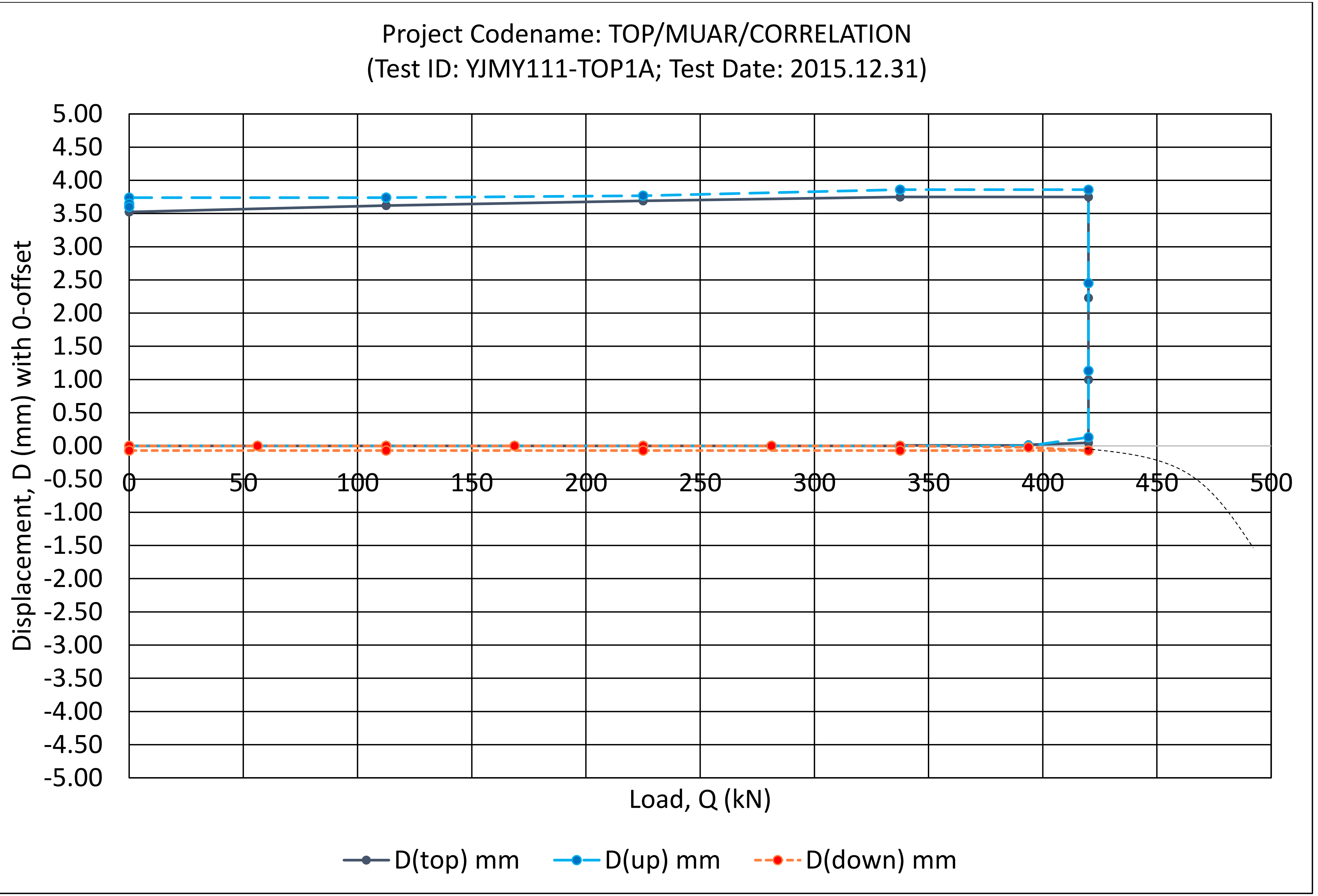
APPENDIX C2


Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1A; Test Date: 2015.12.31)
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
Displacement, D (mm)
0
50
100
150
200
250
300
350
400
450
500
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm

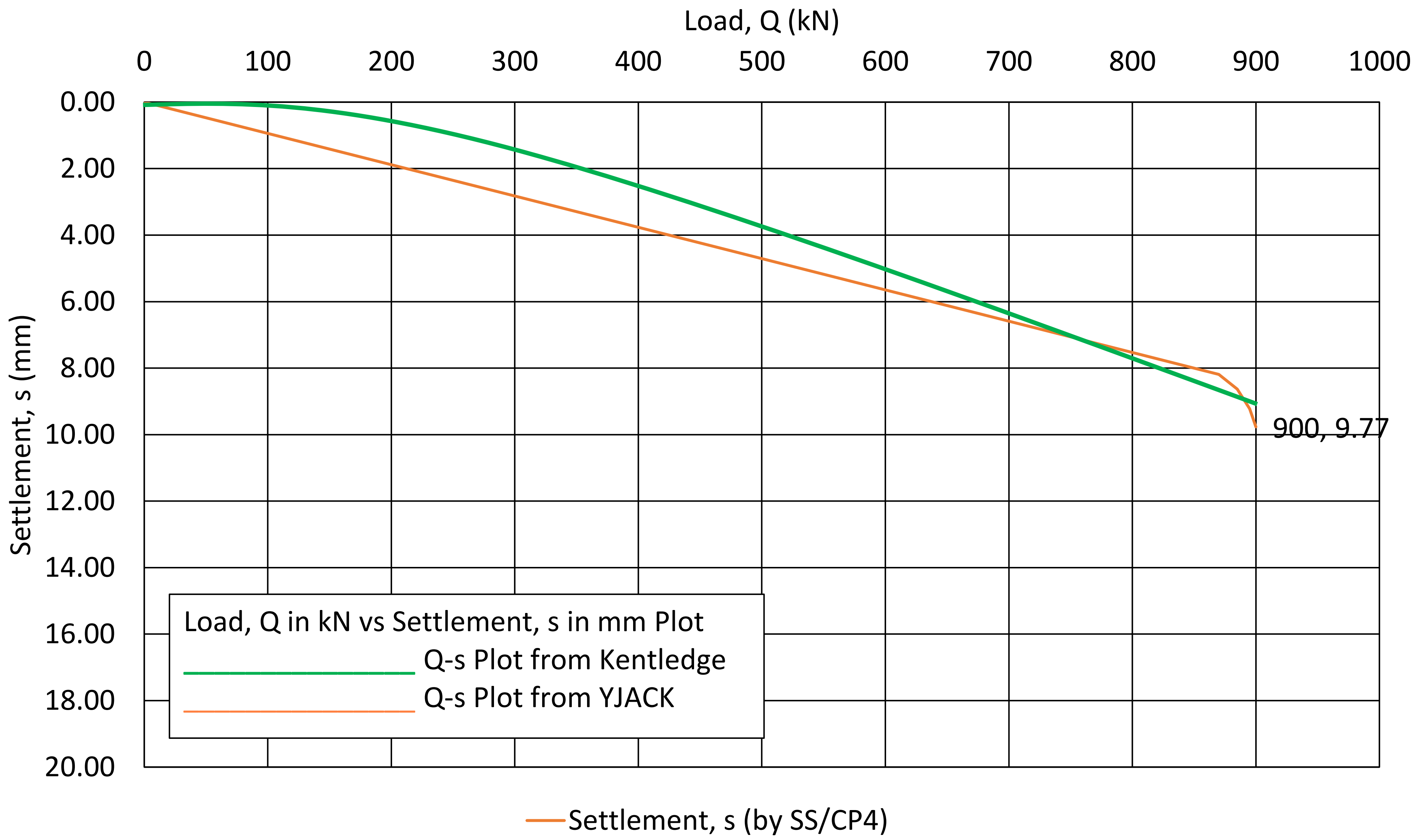

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1A; Test Date: 2015.12.31)
Load, Q (kN)
450
400
350
300
250
200
150
100
50
0
02:24
02:52
03:21
03:50
04:19
04:48
05:16
05:45
Time, t (hh:mm)
Load kN

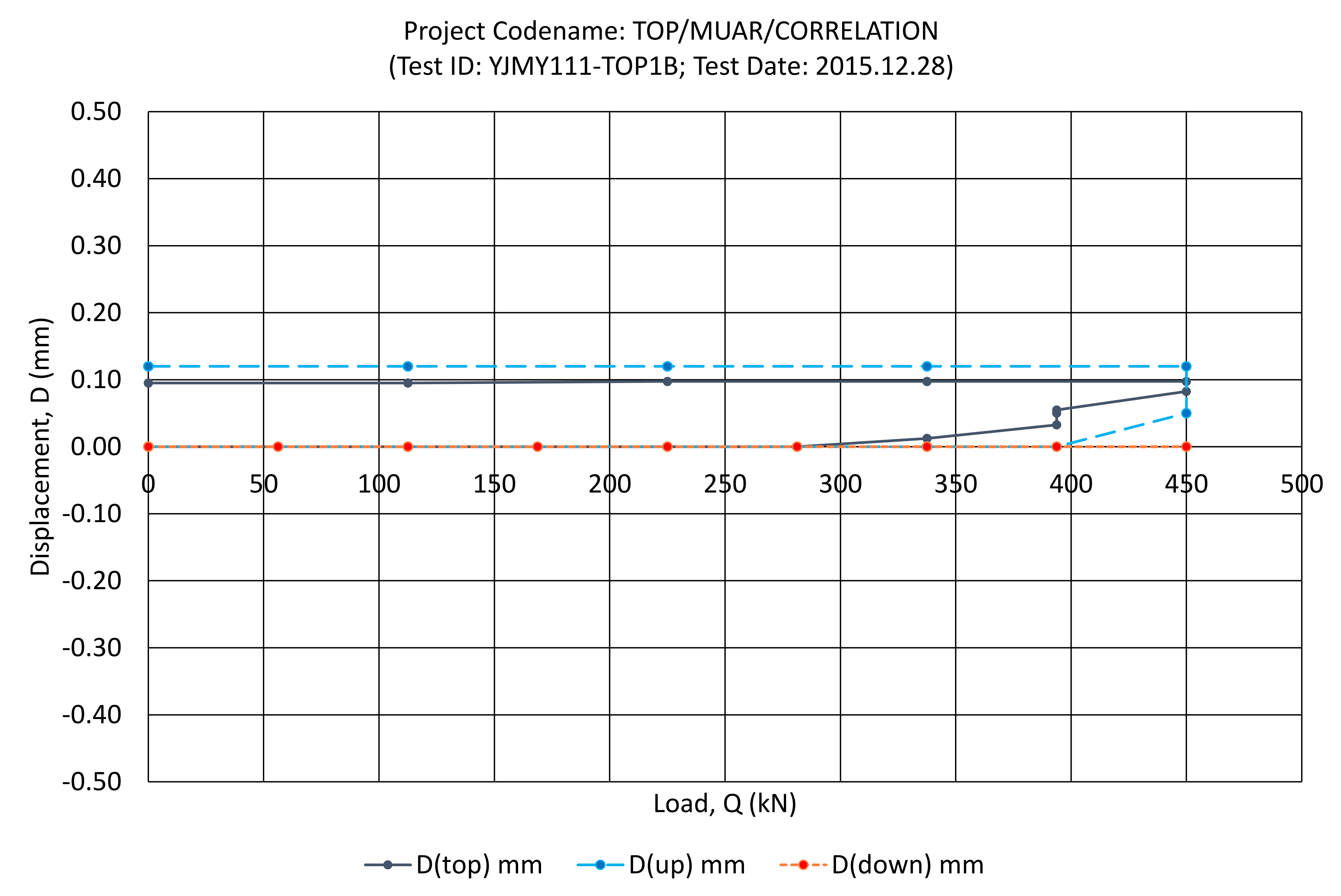

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1A; Test Date: 2015.12.31)
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
Displacement, D (mm)
02:24
02:52
03:21
03:50
04:19
04:48
05:16
05:45
Time, t (hh:mm)
D(top) mm
D(up) mm
D(down) mm


Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1A; Test Date: 2015.12.31)
Displacement, D (mm) with 0-offset
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
0
50
100
150
200
250
300
350
400
450
500
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm

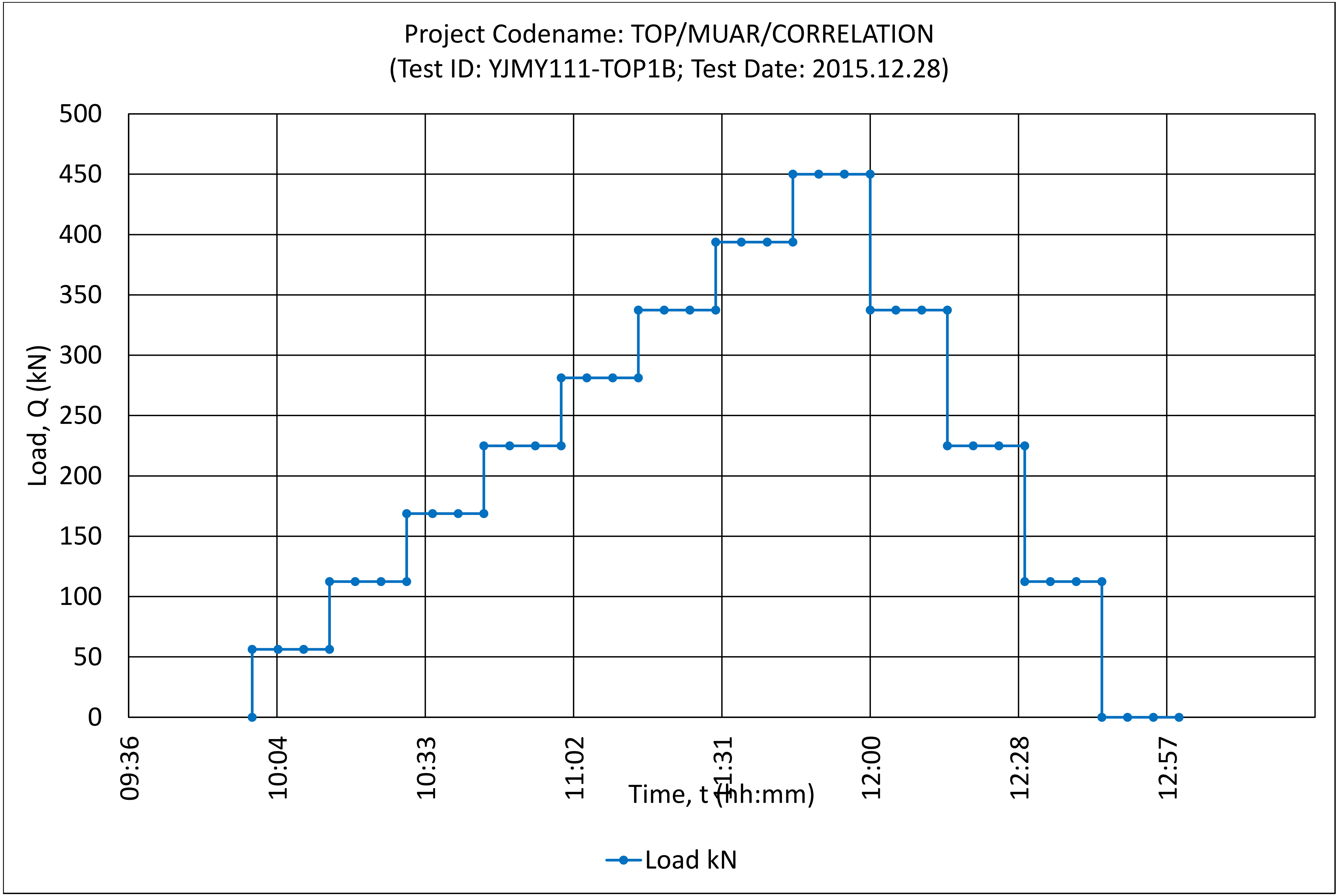

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1A; Test Date: 2015.12.31)
Displacement, D (mm) with 0-offset
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
-4.00
-4.50
-5.00
0
50
100
150
200
250
300
350
400
450
500
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm

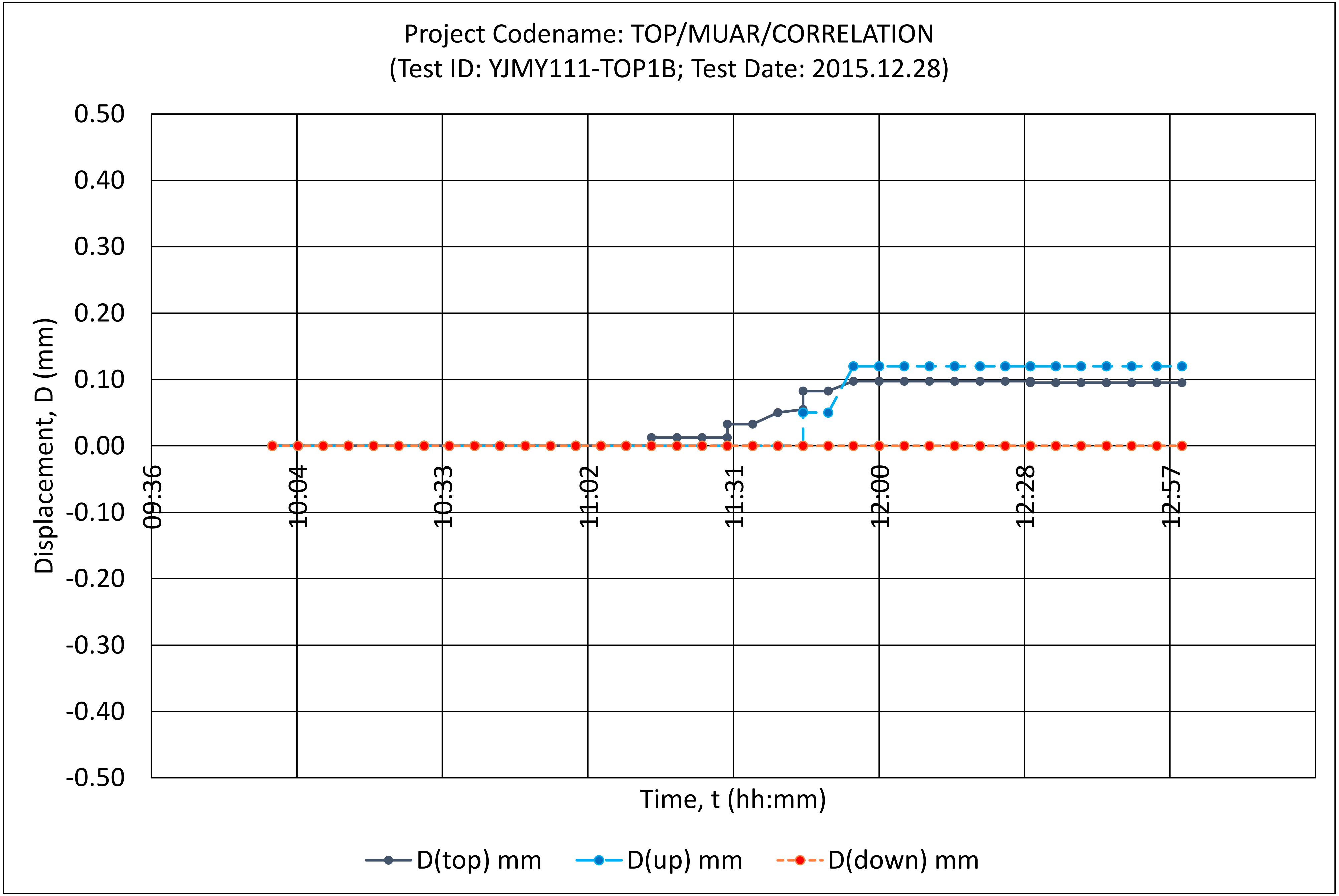
Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1A; Test Date: 2015.12.31)

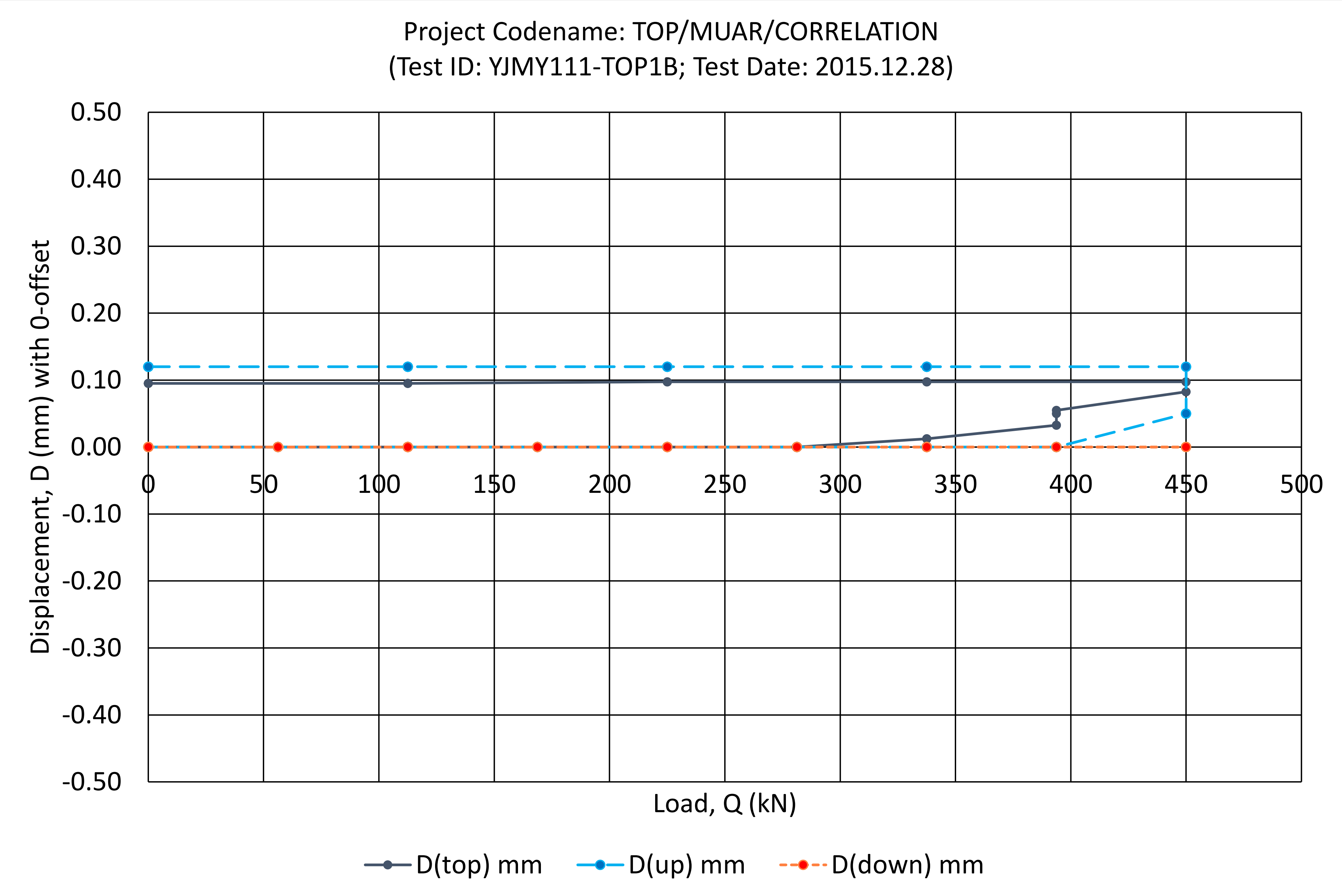


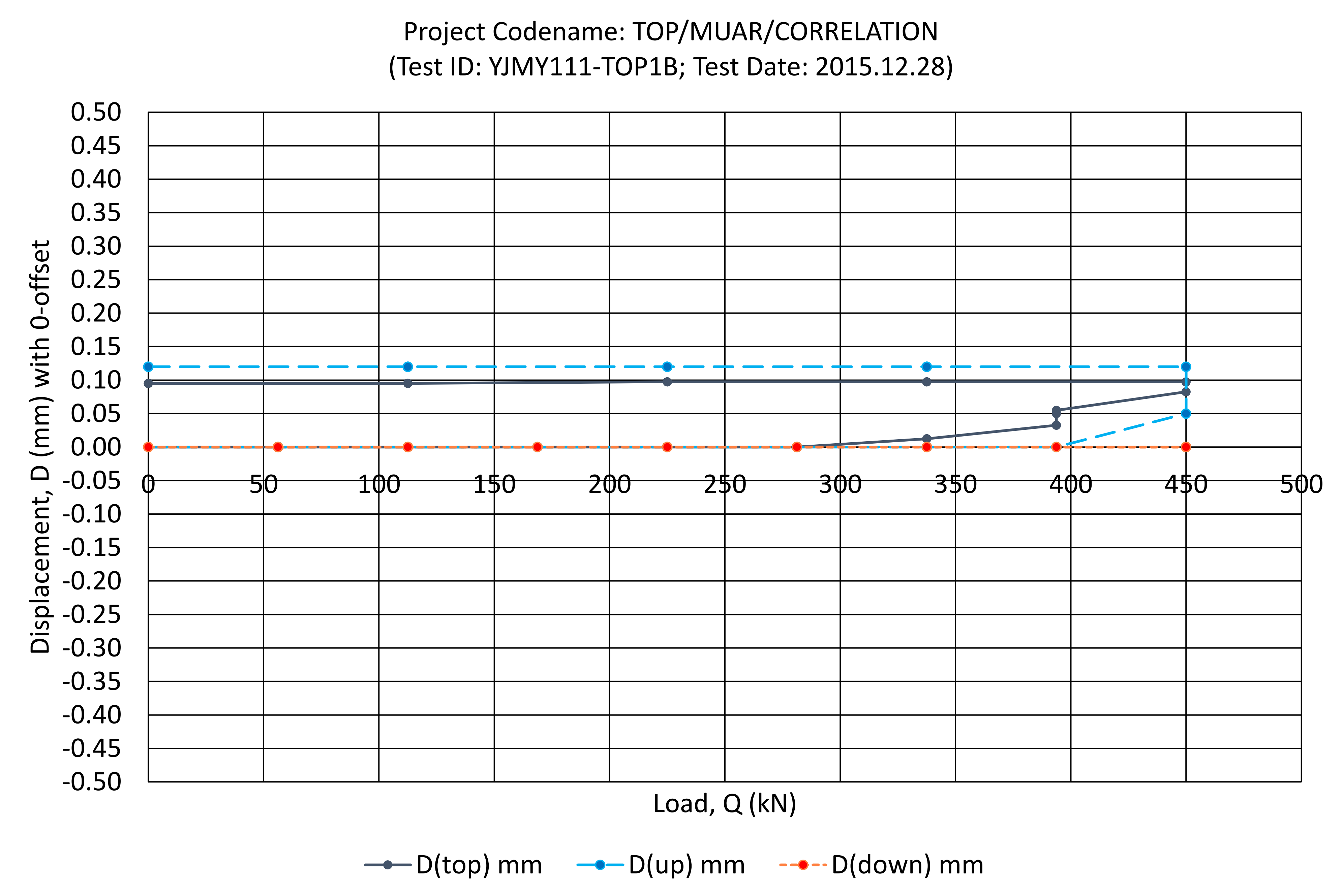


Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1B; Test Date: 2015.12.28)
Displacement, D (mm)
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
0
50
100
150
200
250
300
350
400
450
500
Load, Q (kN)
D(top) mm
D(up) mm
D(down) mm

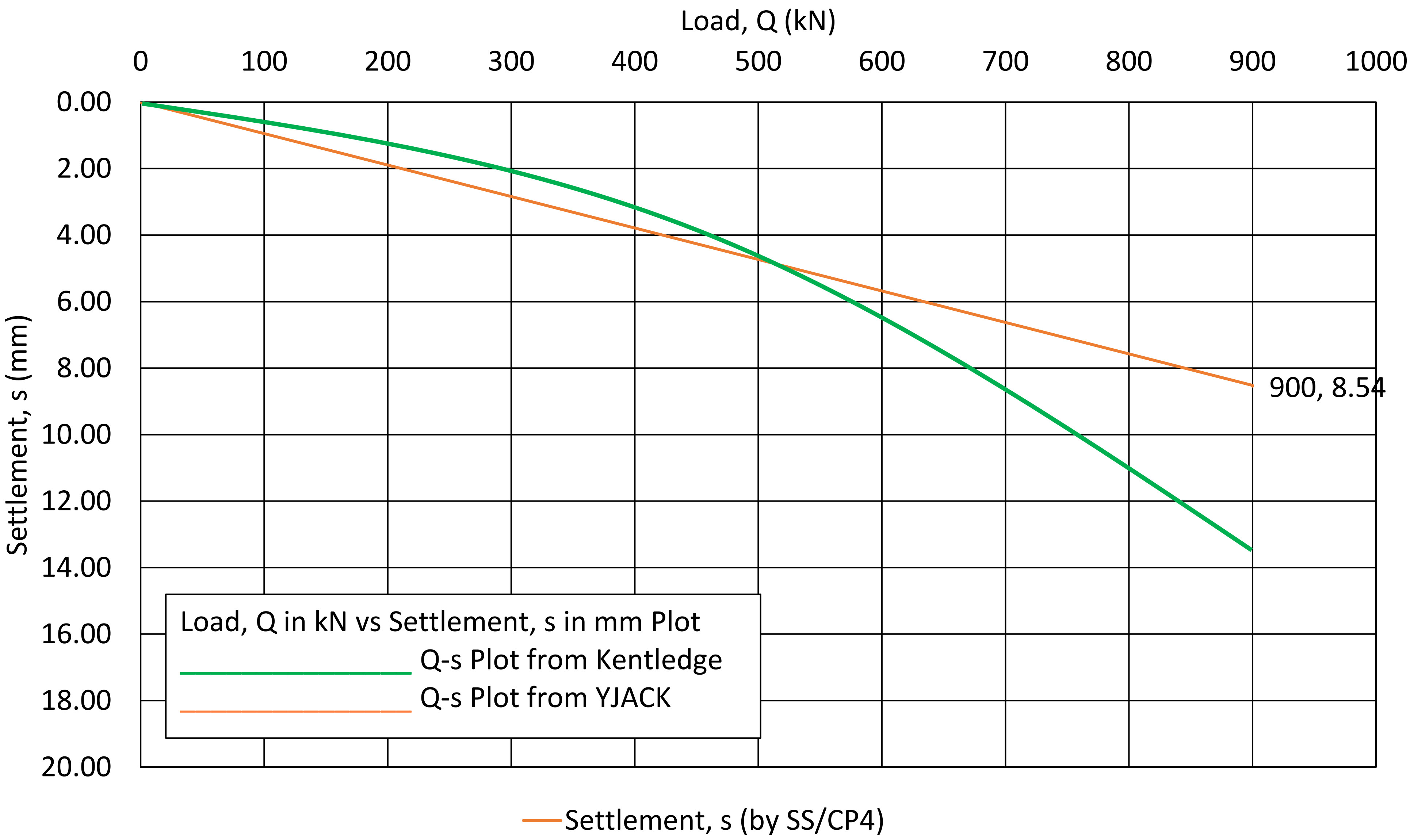

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1B; Test Date: 2015.12.28)
Load, Q (kN)
0
50
100
150
200
250
300
350
400
450
500
09:36
10:04
10:33
11:02
11:31
12:00
12:28
12:57
Time, t (hh:mm)
Load kN


Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1B; Test Date: 2015.12.28)
Displacement, D (mm)
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
09:36
10:04
10:33
11:02
11:31
12:00
12:28
12:57
Time, t (hh:mm)
D(top) mm
D(up) mm
D(down) mm


Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1B; Test Date: 2015.12.28)
Displacement, D (mm) with 0-offset
Load, Q (kN)
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
0
50
100
150
200
250
300
350
400
450
500
D(top) mm
D(up) mm
D(down) mm


Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1B; Test Date: 2015.12.28)
Displacement, D (mm) with 0-offset
Load, Q (kN)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
-0.30
-0.35
-0.40
-0.45
-0.50
0
50
100
150
200
250
300
350
400
450
500
D(top) mm
D(up) mm
D(down) mm

Project Codename: TOP/MUAR/CORRELATION
(Test ID: YJMY111-TOP1B; Test Date: 2015.12.28)



APPENDIX D

Field Sheets

Thick documents. Will be furnished upon request.

APPENDIX E

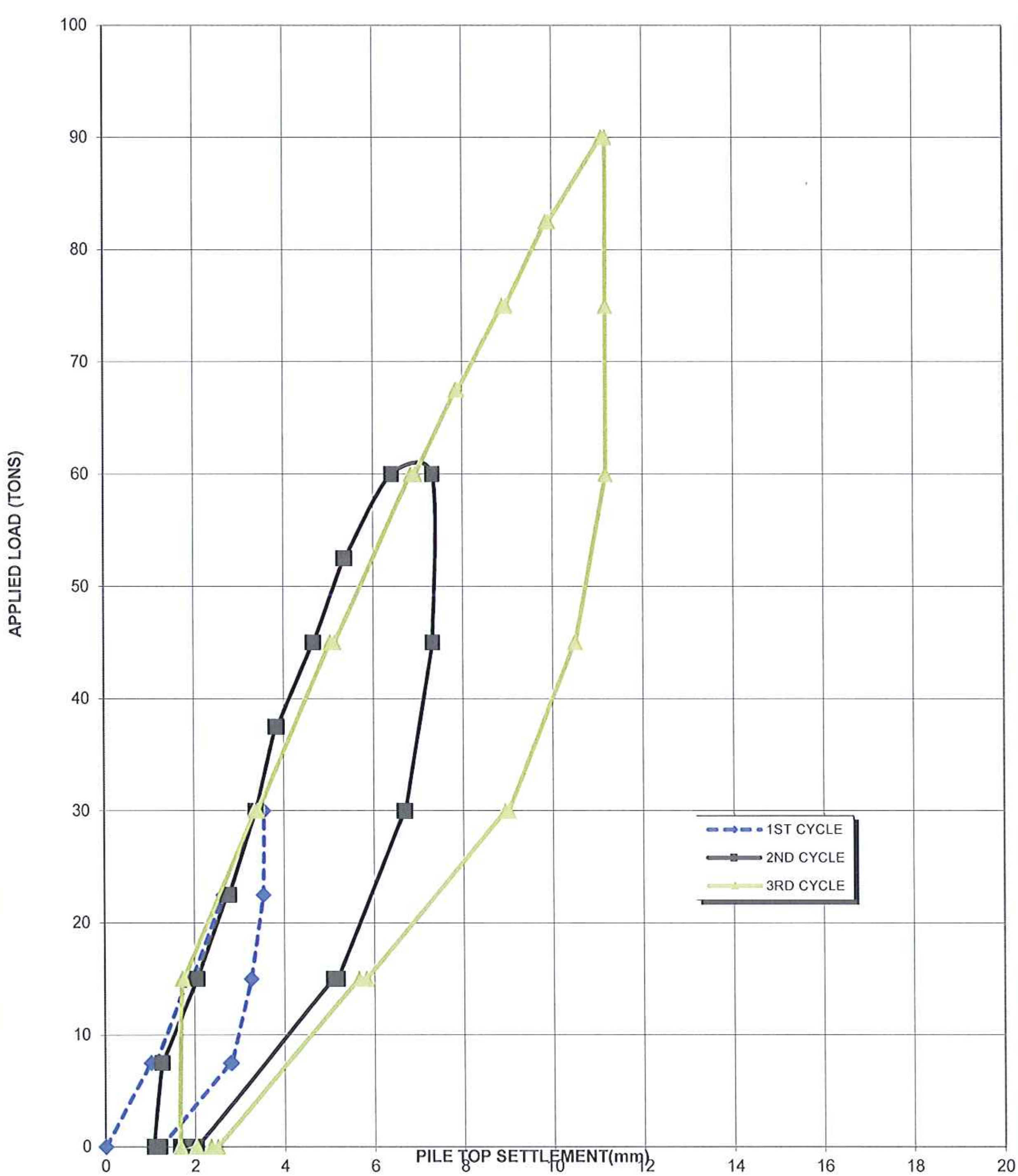
Project: Maintain Load test at Muar

Summary of Test Pile Record

Pile No.	Pile Top Settlement (mm)					
	1st Cycle		2nd Cycle		3rd Cycle	
	100%	0%	200%	0%	300%	0%
1A	3.53	1.09	7.33	1.59	11.17	2.34
1B	3.32	0.50	6.64	0.51	14.94	3.03
2A	4.00	0.53	7.93	1.15		
2B	3.43	0.09	7.63	0.98		

In Correlation Study, shall take the Q-s Plot with 0-offset in settlement.

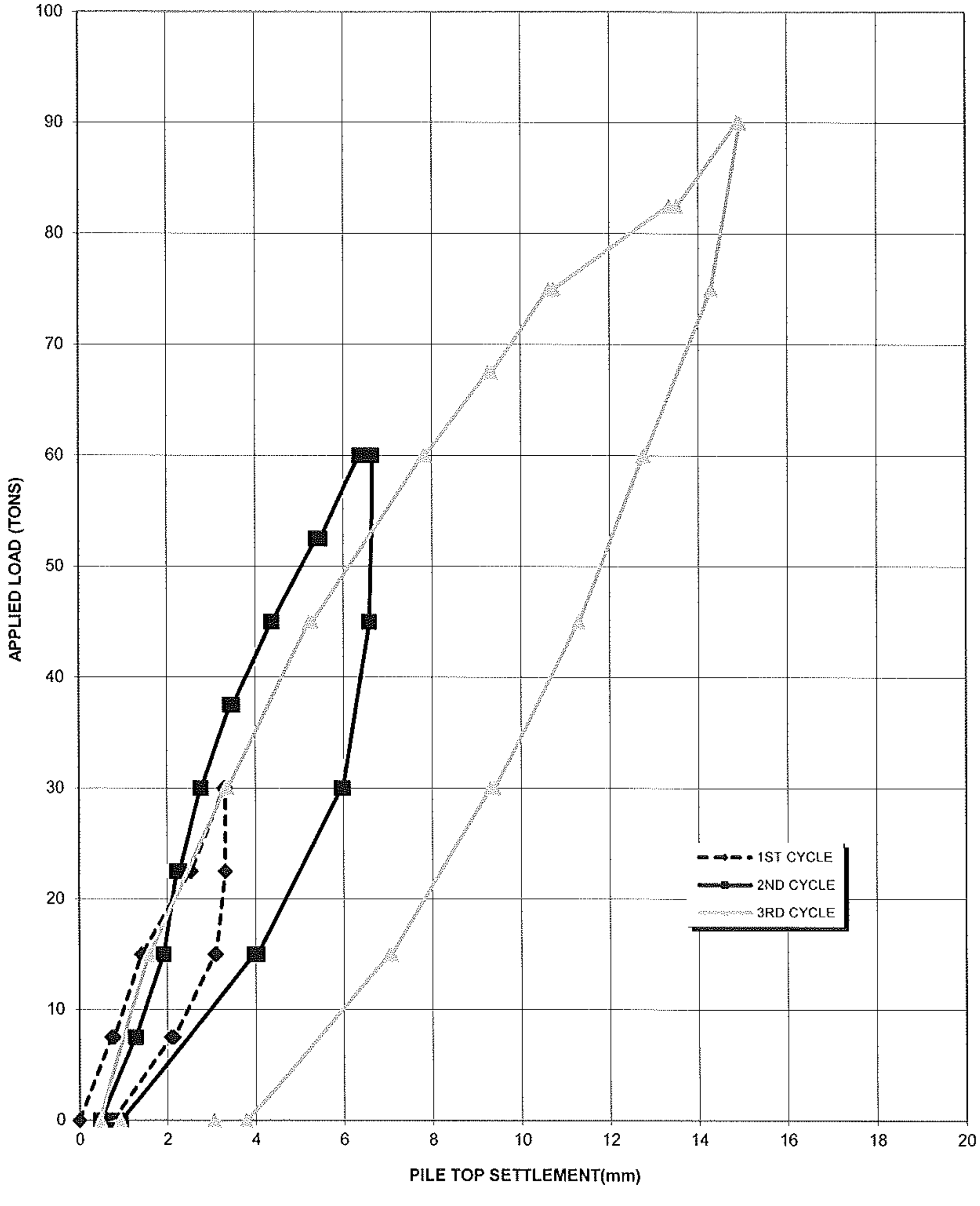
Muar
FIGURE 2 : LOAD VS SETTLEMENT CURVE
Test Pile Top 1A, 300mm dia Spun Pile



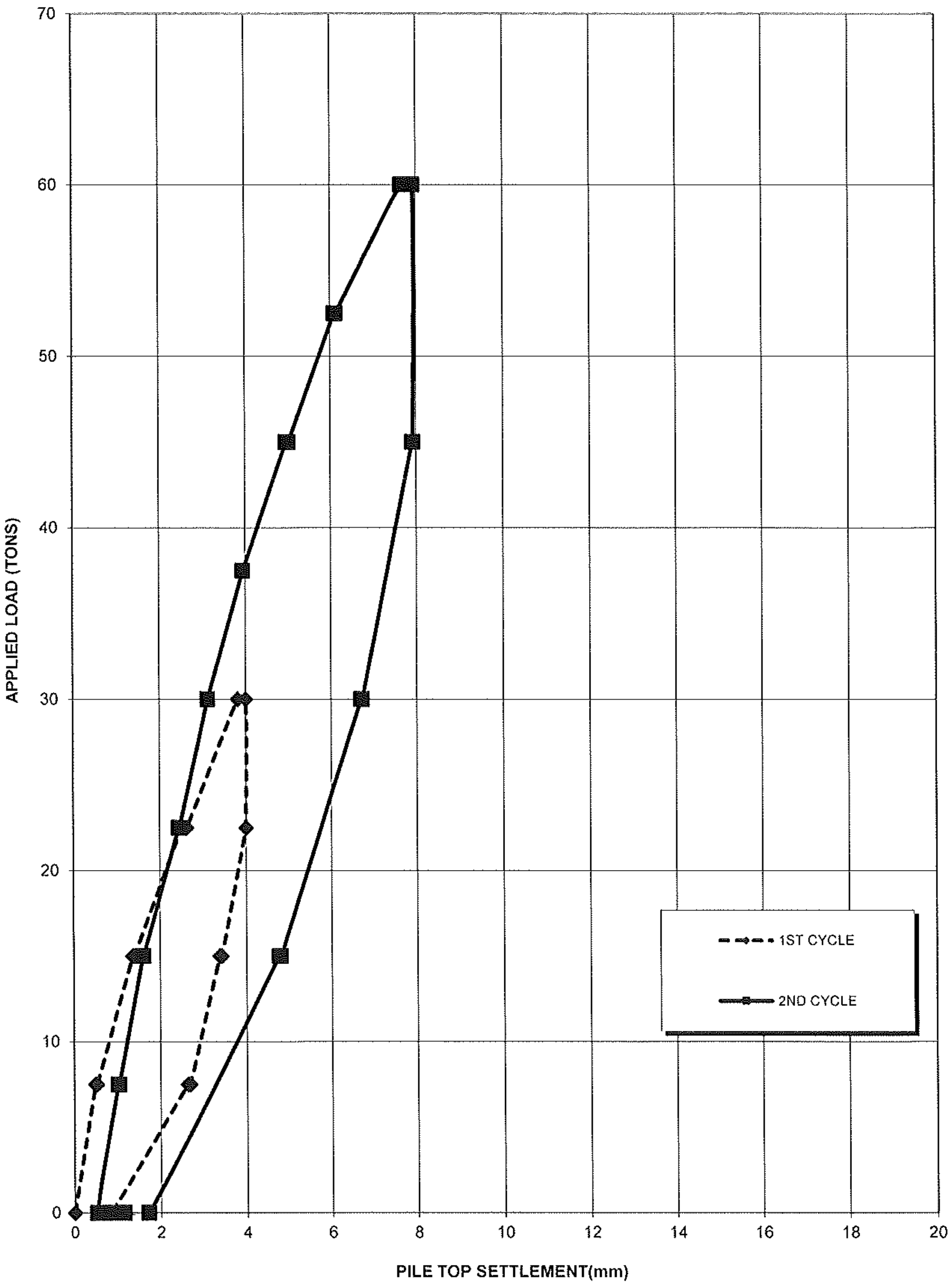
MUAR

FIGURE 2 : LOAD VS SETTLEMENT CURVE

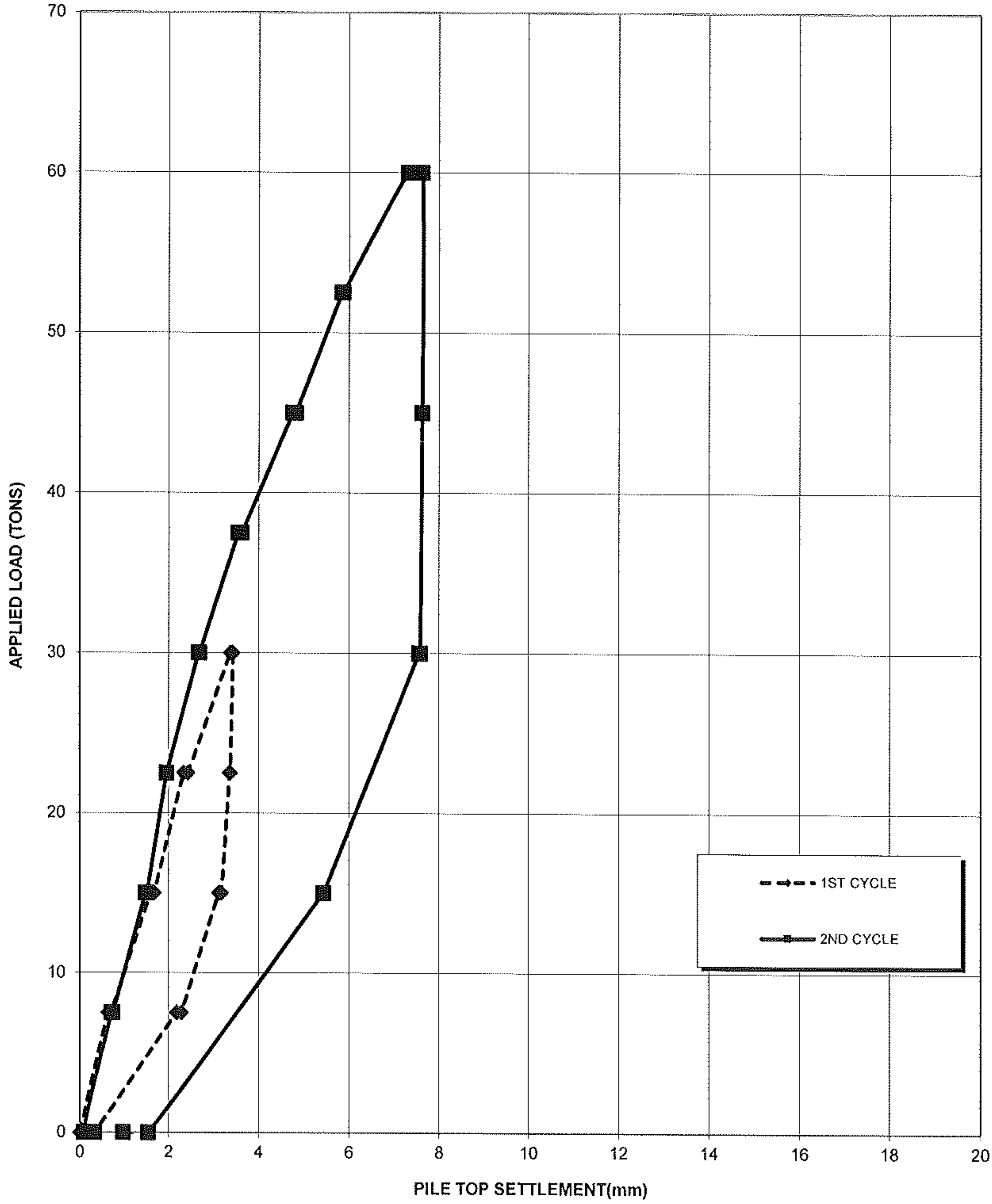
Test Pile Top 1B, 300mm dia Spun Pile



Muar
FIGURE 2 : LOAD VS SETTLEMENT CURVE
Test Pile Top 2A, 300mm Spun Pile



Muar
FIGURE 2 : LOAD VS SETTLEMENT CURVE
Test Pile Top 2B, 300mm Spun Pile



ATTACHMENT A

YJACK Technology Sdn Bhd (1086910-H)
25-2, Jalan Pandan Prima 1, Dataran Pandan Prima, 55100 Kuala Lumpur, Malaysia.
(T)+6016-2168129/2158129 (F)+603-92026811 (W)www.YJACKpiletest.com

Standard Operating Procedure (SOP) for Technical and Project Department
Constructing YJACK Q-s Plot from BD Pile Testing

Q-D Plot
(JKR Specifications)
Q-D: Load-Displacement

Q-D Plot
(not consider W(up))
Note/01
W(up): bouyant weight, or upper section weight

Determine Qu Value
(consider W(up) and γ)
γ: tension over compression factor
Chinese Standard DB45/T564 (2009)

Qu = Q(up)/γ + Q(dn) - W(up)
(data based on max test load)

Check Qu Value
(shall Qu ≥ test load)
no → Tes Pile Concluded Failed
(Qu not achieve test load)
yes, pass

Q-D Plot
(test load plot with 0-offset)

Q-s Table (Rigid)
(construct Q-s rigid plot)
Singapore Standard SS/CP4 (2003), Clause 7.6.7
Q-s: Load-Settlement

Note/02
Q-s Table (Elastic)
(construct Q-s elastic plot)

Q-s Plot (Rigid)
(construct Q-s rigid plot)

Q-s Plot (Elastic)
(construct Q-s elastic plot)

Q-s Plot (YJACK)
(equivalent Q-s plot)

Q-s Plot (conventional)
(test load plot with 0-offset)
add-in
2 Q-s Plots in 1 Chart
(YJACK and conventional)
Correlation Study
(YJACK vs conventional)

Acceptance Criteria
(JKR Specifications)

Within Acceptance Limit
(ultimate & serviceability)
no → Tes Pile Concluded Failed
(failed or partially failed)
yes, pass

Tes Pile Concluded Pass
(pass all acceptance limit)

Note/01
The W(up) is a constant value. In relatively small working load and long pile condition, the early few loading steps may has low loading, but after considerations to substract the measured Q value with W(up), the Q-D data points may have negative values to indicate "negative friction", in which this does not make sense. Hence in YJACK Plot Method, ignored W(up) in ploting the Q-D Plot and considered this W(up) in-conjunction with tension-compression factor to evaluate Qu value.

Note/02
Follow Malaysian Local Practise. Refer to OCELL Test Report appendix.

This SOP shall be deemd as YJACK Plot Method in constructing Q-s Plot from BD Testing (i.e. YPLOT Method).

Authorized By: Chief Executive Officer	Managed By: Chief Technical Officer	Effective Date: 2017/03/08

CONSTRUCTION OF THE EQUIVALENT TOP-LOADED LOAD-SETTLEMENT CURVE FROM THE RESULTS OF BI-DIRECTIONAL LOAD TEST (BDLT)

Introduction:
BDLT can provide a good estimate of a curve showing the load versus settlement of a top-loaded driven or bored pile (drilled shaft) with the following assumptions, which is consider good sense and usually conservative:

1. The end bearing load-movement curve in a top-loaded shaft has the same loads for a given movement as the net (subtract buoyant weight of pile above hydraulic jack) end bearing load-movement curve developed by the bottom of the hydraulic jack when placed at or near the bottom of the shaft.

2. The side shear load-movement curve in a top-loaded shaft has the same net shear, multiplied by an adjustment factor 'F' for a given downward movement as occurred in the BDLT for that same movement at the top of the jack in the upward direction. The same applies to the upward movement in a top-loaded tension test. Unless noted otherwise, a factor F=0.95 for compression in cohesionless soils and F=0.80 for tension tests in all soils is used.

3. The pile behaves as a rigid body, but includes the elastic compressions that are part of the movement data obtained from a bidirectional load test (BDLT). Procedure 1 interprets an equivalent top-load test (TLT) movement curve and procedure 2 corrects the effects of the additional elastic compressions in a TLT.

4. The part of the shaft below the hydraulic jack (one or multi level) has the same load-movement behavior as when top-loading the entire shaft. The subsequent 'end bearing movement curve' refers to the movement of the entire length of shaft below the jack.

Procedure 1:
Figure A shows BDLT results and Figure B shows the construction of equivalent top loaded settlement curve. Each of the curves shown has points numbered from 1 to 12 such that the same point number on each curve has the same movement magnitude.

With the above assumptions, the equivalent curve can be constructed as follows:
Select an arbitrary movement such as the 0.40 inches to give point 4 on the shaft side shear load movement curve in Figure A and record the load of 2,090 tons in shear at that movement. With the initial assumption of a rigid pile, the top of pile moves downward the same as the bottom. Therefore, find point 4 with 0.40 inches of upward movement on the end bearing load movement curve and record the corresponding load of 1,060 tons.

Adding these two loads will give the total load of 3,150 tons due to side shear plus end bearing at the same movement and thus gives point 4 on the Figure B load settlement curve for an equivalent top-loaded test. Procedure 1 can be used to obtain all the points in Figure B up to the component that moved the least at the end of the test, in this case point 5 in side shear.

Suitable hyperbolic curve fitting technique can be used for extrapolation of the side shear curve to produce end bearing movement data up to 12. Some judgment is required for deciding on the maximum number of data points to provide good fit with high correlation coefficient, r^2. Using the same movement matching procedure described earlier, the equivalent curve to points 6 to 12 can be extended. The dashed line shown in Figure B, signify that this part of the equivalent curve depends partly on extrapolated data.

If the data warrants, the extrapolations of both side shear and end bearing to extend the equivalent curve to a greater movement than the maximum measured (point 12) will be used. An appendix in this report gives the details of the extrapolation(s) used with the present BDLT and shows the fit with the actual data.

Procedure 2:
The elastic compression in the equivalent top load test always exceeds that in the BDLT. It produces more top movement and also additional side shear movement, which then generate more side shear, more compression, etc. An exact solution of this load transfer problem requires knowing the side shear vs. vertical movement (t-y) curves for a large number of pile length increments and solving the resulting set of simultaneous equations or using finite element or finite difference simulations to obtain an approximate solution for these equations.

The attached analysis P.6 gives the equations for the elastic compressions that occur in the BDLT with one or two levels of hydraulic jacks. Analysis P.7 gives the equations for the elastic compressions that occur in the equivalent TLT. Both sets of equations do not include the elastic compression below the hydraulic jack because the same compression takes place in both the BDLT and the TLT. This is equivalent to taking $I_3 = 0$. Subtracting the BDLT from the TLT compression gives the desired additional elastic compression at the top of the TLT. The additional elastic compression is then added to the 'rigid' equivalent curve obtained from Part 1 to obtain the final, corrected equivalent load-settlement curve for the TLT on the same pile as the actual BDLT.

Note that the above p.6 and p.7 give equations for each of three assumed patterns of developed side shear stress along the pile. The pattern shown in the center of the three is applicable to any approximate determined side shear distribution. Experience has shown the initial solution for the additional elastic compression, as described above, gives an adequate and slightly conservative (high) estimate of the additional compression versus more sophisticated load-transfer analyses as described in the first paragraph of this Part II.

The analysis p.8 provides an example of calculated results in English units on a hypothetical 1-stage, single level BDLT using the simplified method in Part II with the centroid of the side shear distribution 44.1% above the base of the hydraulic jack. Figure C compares the corrected with the rigid curve of Figure B. Page 9 contains an example equivalent to that above in SI units.

The final analysis p.10 provides an example of calculated results in English units on a hypothetical 3-stage, multi level BDSLT using the simplified method in Part II with the centroid of the combined upper and middle side shear distribution 44.1% above the base of the bottom hydraulic jack. The individual centroids of the upper and middle side shear distribution lie 39.6% and 57.9% above and below the middle hydraulic jack, respectively. Figure E compares the corrected with the rigid curve. Page II contains an example equivalent to that above in SI units.

Other Tests: The example illustrated in Figure A has the maximum component movement in end bearing. The procedures remain the same if the maximum test movement occurred in side shear. Then we would have extrapolated end bearing to produce the dashed-line part of the reconstructed top-load settlement curve.

The example illustrated also assumes a pile top-loaded in compression. For a pile top-loaded in tension we would, based on Assumptions 2 and 3, use the upward side shear load curve in Figure A, multiplied by the F = 0.80 noted in Assumption 2, for the equivalent top-loaded displacement curve.

Expected Accuracy: There are only five series of tests that provide the data needed to make a direct comparison between actual, full scale, top-loaded pile movement behaviour and the equivalent behaviour obtained from a BDLT by the method described herein. These involved three sites in Japan and one in Singapore, in a variety of soils, with three compression tests on bored piles (drilled shafts), one compression test on a driven pile and one tension test on a bored pile. The largest bored pile had a 1.2 m diameter and a 37 m length. The driven pile had a 1-m increment modular construction and a 9 m length. The largest top loading = 28 MN (3,150 tons).

The following references detail the aforementioned Japanese tests and the results therefore:

> Kishida H. et al., 1992, "Pile Loading Tests at Osaka Amenity Park Project", Paper by Mitsubishi Co., also briefly described in Schmertmann (1993, see bibliography). Compares one drilled shaft in tension and another in compression.
>
> Ogura, H. et al., 1995, "Application of Pile Toe Load Test to Cast-in-place Concrete Pile and Precast Pile", special volume 'Tsuchi-to-Kiso' on Pile Loading Test, Japanese Geotechnical Society, Vol. 3, No. 5, Ser. No. 448. Original in Japanese. Translated by M.B. Karkee, GEOTOP Corporation. Compares one drilled shaft and one driven pile, both in compression.

We compared the predicted equivalent and measured top load at three top movements in each of the above four Japanese comparisons. The top movements ranged from ¼ inch (6 mm) to 40 mm, depending on the data available.

The (equiv./meas.) ratios of the top load averaged 1.03 in the 15 comparisons with a coefficient of variation of less than 10%. These available comparisons help support the practical validity of the equivalent top load method described herein.

L.S. Peng, A.M. Koon, R. Page and C. W. Lee report the results of a class-A prediction by others of the TLT curve from a BDLT on a 1.2 m diameter, 37.2 m long bored pile in Singapore, compared to an adjacent pile with the same dimensions actually top-loaded by kentledge. They report about a 4% difference in ultimate capacity and less than 8% difference in settlements over the 1.0 to 1.5 times working load range – comparable to the accuracy noted above. Their paper was published in March 1999 in the Proceedings of the International Conference on Rail Transit, held in Singapore and published by the Association of Consulting Engineers Singapore.

B.H. Fellenius has made several finite element method (FEM) studies of a BDLT in which he adjusted the parameters to produce good load-deflection matches with the BDLT up and down load-deflection curve. He then used the same parameters to predict the TLT deflection curve. We compared the FEM-predicted curve with the equivalent load-deflection predicted by the previously described Part I and II procedures, with the results again comparable to the accuracy noted above. A paper by Fellenius et. al. titled "BDLT and FE Analysis of a 28 m Deep Barrette in Manila, Philippines", awaiting publication in the ASCE Journal of Geotechnical and Environmental Engineering, details one of the comparisons.

Limitations: The engineer using these results should judge the conservatism of the aforementioned assumptions and extrapolation(s) before utilizing the results for design purposes. For example, brittle failure behaviour may produce movement curves with abrupt changes in curvature (not hyperbolic). However, the hyperbolic fit method and the assumptions used usually produce reasonable equivalent top load settlement curves.

Example of the Construction of an Equivalent Top-Loaded Settlement Curve (Figure B)
From BDLT Results (Figure A)

Figure A

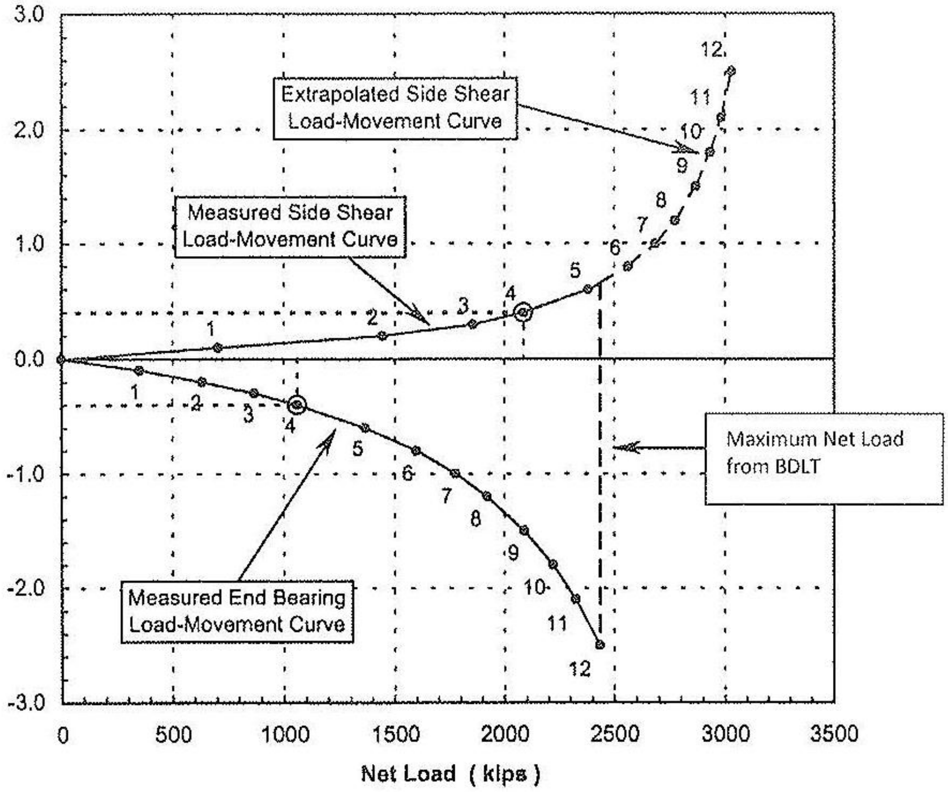
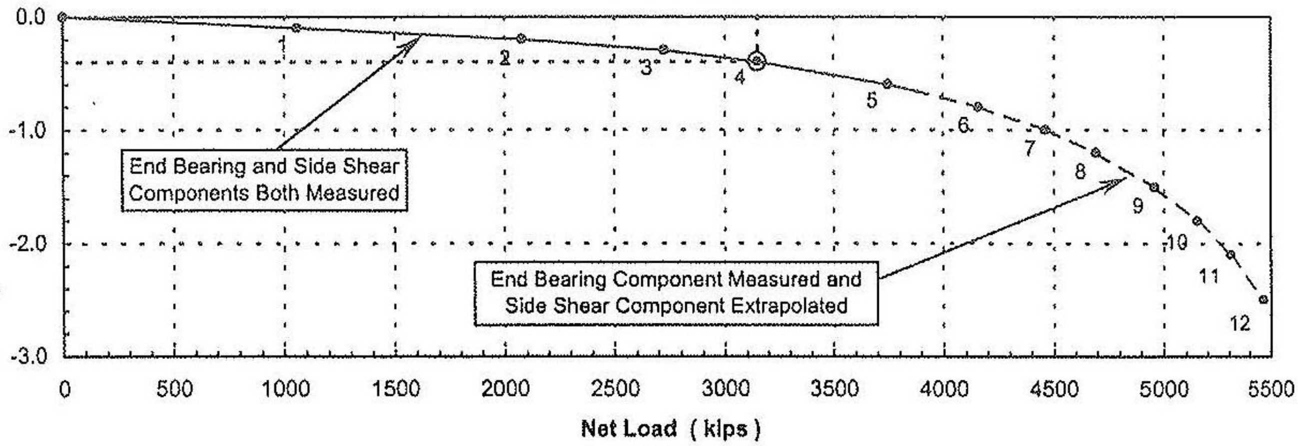
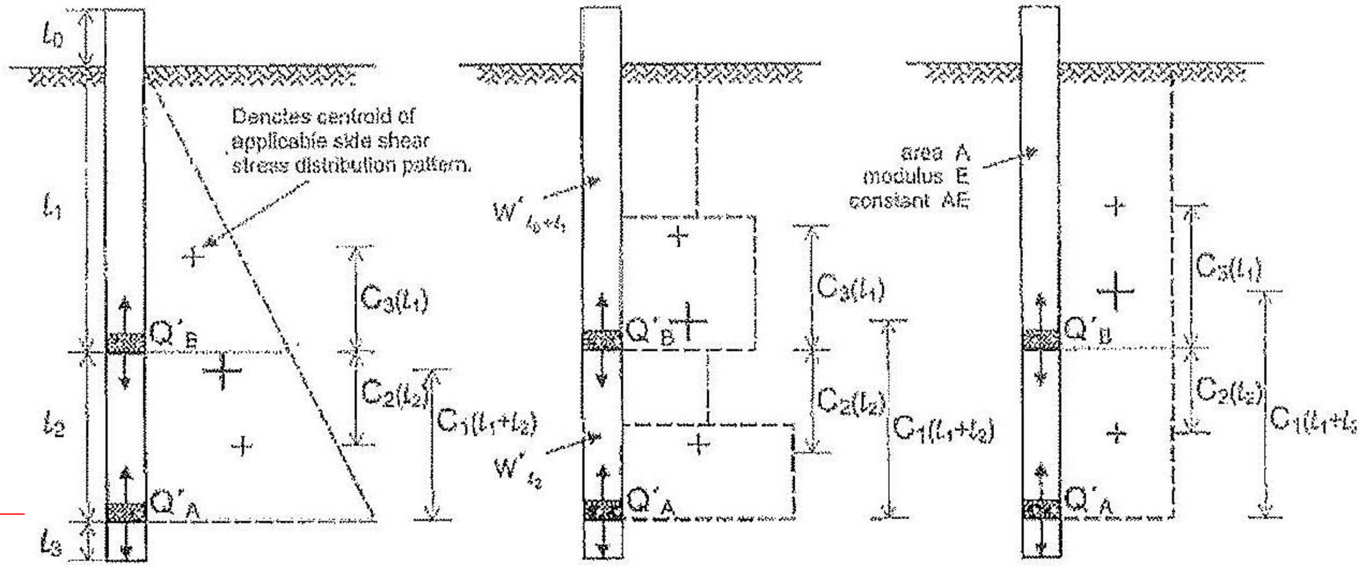


Figure B



Theoretical Elastic Compression in BDLT
Based on Pattern of Development Side Shear Stress



1-Stage Single Level Test (Q'A only): $\delta_{BDLT} = \delta_{\uparrow e1} + \delta_{\downarrow e2}$

$C_1 = \frac{1}{3}$	Centroid Factor $= C_1$	$C_1 = \frac{1}{2}$
$\delta_{\uparrow(\ell_1+\ell_2)} = \frac{1}{3}\frac{Q'_{\uparrow A}(\ell_1+\ell_2)}{AE}$	$\delta_{\uparrow(\ell_1+\ell_2)} = C_1\frac{Q'_{\uparrow A}(\ell_1+\ell_2)}{AE}$	$\delta_{\uparrow(\ell_1+\ell_2)} = \frac{1}{2}\frac{Q'_{\uparrow A}(\ell_1+\ell_2)}{AE}$

3-Stage Multi Level Test (Q'A and Q'B): $\delta_{BDLT} = \delta_{\uparrow e1} + \delta_{\downarrow e2}$

$C_3 = \frac{1}{3}$	Centroid Factor $= C_3$	$C_3 = \frac{1}{2}$
$\delta_{\uparrow\ell_1} = \frac{1}{3}\frac{Q'_{\uparrow B}\ell_1}{AE}$	$\delta_{\uparrow\ell_1} = C_3\frac{Q'_{\uparrow B}\ell_1}{AE}$	$\delta_{\uparrow\ell_1} = \frac{1}{3}\frac{Q'_{\uparrow B}\ell_1}{AE}$
$C_2 = \frac{1}{3}\left(\frac{3\ell_1+2\ell_2}{2\ell_1+\ell_2}\right)$	Centroid Factor $= C_2$	$C_2 = \frac{1}{2}$
$\delta_{\downarrow\ell_2} = \frac{1}{3}\left(\frac{3\ell_1+2\ell_2}{2\ell_1+\ell_2}\right)\frac{Q'_{\downarrow B}\ell_2}{AE}$	$\delta_{\downarrow\ell_2} = C_2\frac{Q'_{\downarrow B}\ell_2}{AE}$	$\delta_{\downarrow\ell_2} = \frac{1}{2}\frac{Q'_{\downarrow B}\ell_2}{AE}$

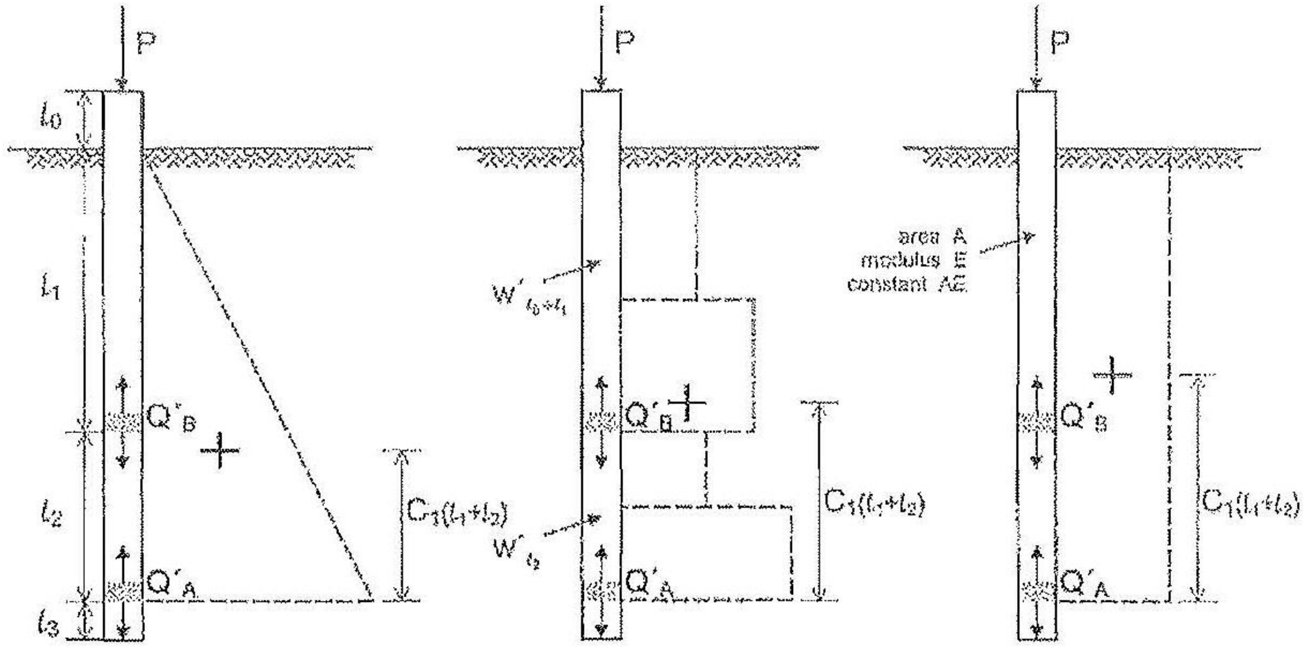
Net Loads:

$Q'_{\uparrow A} = Q_{\uparrow A} - W'_{\ell_0+\ell_1+\ell_2}$ $\quad Q'_{\uparrow B} = Q_{\uparrow B} - W'_{\ell_0+\ell_1}$ $\quad Q'_{\downarrow B} = Q_{\downarrow B} + W'_{\ell_2}$

W' = pile weight, bouyant where below water table

Q'B is the 2nd level BD-JACK.
In YJACK Validation Program, only single level (1) YJACK installed, hence ignored Q'B level.
Only consider Q'A level.

Theoretical Elastic Compression in Top Loaded Test
Based on Pattern of Development Side Shear Stress



Top Loaded Test: $\delta_{TLT} = \delta_{\downarrow l_0} + \delta_{\downarrow l_1+l_2}$

$\delta_{\downarrow l_0} = \dfrac{Pl_0}{AE}$	$\delta_{\downarrow l_0} = \dfrac{Pl_0}{AE}$	$\delta_{\downarrow l_0} = \dfrac{Pl_0}{AE}$
$C_1 = \dfrac{1}{3}$	Centroid Factor $= C_1$	$C_1 = \dfrac{1}{2}$
$\delta_{\downarrow l_1+l_2} = \dfrac{(Q'_{\downarrow A}+2P)}{3}\dfrac{(l_2+l_2)}{AE}$	$\delta_{\downarrow l_1+l_2} = \left[(C_1)Q'_{\downarrow A}+(1-C_1)P\right]\dfrac{(l_1+l_2)}{AE}$	$\delta_{\downarrow l_1+l_2} = \dfrac{(Q'_{\downarrow A}+P)}{2}\dfrac{(l_1+l_2)}{AE}$

Net and Equivalent Loads:

$Q'_{\downarrow A} = Q_{\downarrow A} - W'_{l_0+l_1+l_2}$ $\qquad P_{single} = Q'_{\downarrow A} + Q'_{\uparrow A}$ $\qquad P_{multi} = Q'_{\downarrow A} + Q'_{\uparrow B} + Q'_{\downarrow B}$

Component loads Q selected at the same (±) Δ_{BDSLT}.

ATTACHMENT B

CONTROLLED COPY

Please refer to separate document.

ATTACHMENT C

NORTHLAB SEAMS (M) SDN BHD (284237-U)
No.47-G & 47-1, Jalan PJU 1A/41B, Pusat Dagangan NZX, Ara Jaya,
47301 Petaling Jaya, Selangor Darul Ehsan, Malaysia.
Tel: 603-78858211 Fax: 603-78858511
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MS ISO/IEC 17025 CALIBRATION SAMM NO 049

CALIBRATION CERTIFICATE

Cert. No.	**: KP/15/0153-1**	**Job No.**	**: KCW099115**
Date of Issue	**: 25-Apr-15**	**Page**	**: 1 of 1**

Customer	: **YJACK TECHNOLOGY SDN BHD** LEVEL 16, 1 SENTRAL, KL SENTRAL, 50470 KUALA LUMPUR,MALAYSIA	*Date Received*	: 24-Apr-15
		Date Calibrated	: 25-Apr-15
		*Calibration Due Date**	: 25-Apr-16
		Ambient Temperature	: 20°C ± 2°C
		Relative Humidity	: 55% r.h. ± 10% r.h.
Instrument	: **PRESSURE GAUGE**	*Serial No.*	: ---
		Tag / ID No.	: 908
Manufacturer	: ENERPAC	*Range*	: (0 to 10000 psi gauge)
Model No.	: G4039L	*Resolution*	: 100 psi/div.

"This laboratory is accredited in accordance with recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF Communique dated 18 June 2005)."

The described instrument has been checked and calibrated at **NORTHLAB SEAMS (M) SDN BHD** under the ambient conditions stated above.

METHOD OF CALIBRATION

1. The method of calibration is as per method no. P08 in NLLQM/001/12 of the Quality Manual.

	Standard instrument used	Serial No.	Traceability	Via Cert No.	Due Date
1	Hydraulic Dead Weight Tester	23703/480	NML(M'SIA)	NML/1728/M/14	07-Jul-17

RESULTS OF CALIBRATION

APPLIED EQUIVALENT VALUE	*INSTRUMENT READING (psi)*							
	INCREASING				*DECREASING*			
	Before Adj.		*After Adj.*		*Before Adj.*		*After Adj.*	
(psi)	*Rdg*	*Error*	*Rdg*	*Error*	*Rdg*	*Error*	*Rdg*	*Error*
0.0	0	0.0	---	---	0	0.0	---	---
1,994.6	2,000	5.4	---	---	2,000	5.4	---	---
3,989.3	4,000	10.7	---	---	4,000	10.7	---	---
5,983.9	6,000	16.1	---	---	6,000	16.1	---	---
7,978.6	8,000	21.4	---	---	8,000	21.4	---	---
9,973.2	10,000	26.8	---	---	---	---	---	---

1. The estimated uncertainty of measurement to be associated with the results is ± 13 psi , calculated at a level of confidence of approximately 95% with a coverage factor of k=2.

REMARKS

1. The user should decide on the usability of this instrument.
2. *Recalibration date specified by customer.
3. The user should be aware that any number of factors may cause this instrument to drift out of calibration before the specified calibration interval has expired.

Calibrated by	**Approved Signatory**
A.GANDHY	BIJI.N

NORTHLAB SEAMS

NORTHLAB SEAMS (M) SDN BHD (284237-U)
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47301 Petaling Jaya, Selangor Darul Ehsan, Malaysia.
Tel: 603-78858211 Fax: 603-78858511
Email : northlabseams.my@northlab.biz Website : www.northlab.biz

CALIBRATION CERTIFICATE

Cert. No.	: **KD/15/0427-6**	***Job No.***	: **KCW099115**
Date of Issue	: **28-Apr-15**	***Page***	: **1 of 2**

Customer	: **YJACK TECHNOLOGY SDN BHD** LEVEL 16, 1 SENTRAL, KL SENTRAL, 50470 KUALA LUMPUR,MALAYSIA	*Date Received* *Date Calibrated* *Calibration Due Date** *Ambient Temperature* *Relative Humidity*	: 24-Apr-15 : 28-Apr-15 : 28-Apr-16 : 20 ± 1°C : 55 ± 5% r.h.
Instrument	: **DIAL GAUGE**	*Serial No.* *Tag No.*	: SXD 860 : ---
Manufacturer	: MITUTOYO	*Cal Range*	: 0 ~ 50 mm
Model No.	: 3058S-19	*Resolution*	: 0.01 mm

This laboratory is accredited in accordance with recognized international standard ISO/IEC 17025:2005.This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF communique dated 18 june 2005).
The described instrument has been checked and calibrated at **NORTHLAB SEAMS (M) SDN BHD** under the ambient conditions stated above.

METHOD OF CALIBRATION

1. The instrument was calibrated as per method no. Procedure-017 in NLQM/001/10 of the Quality Manual and with reference to Digimatic Indicators and Linear Gauges as a guide.

	Standard instrument used	Serial No.	Traceability	Via Cal.Cert.No	Due date
1.	Gauge Block Set	0800165	NPL(UK)	ML/2013/0408	11-Jun-15

RESULTS OF CALIBRATION

1. The results of calibration are given on the attached calibration data sheet(s).

REMARKS

1. The user should decide on the usability of this instrument.
2. *Recalibration date specified by client.
3. The user should be aware that any number of factors may cause this instrument to drift out of calibration before the specified calibration interval has expired.

Calibrated by

HAYATI BT SEMAN

Approved Signatory

AZHAR BIN SALMAN

NORTHLAB SEAMS
NORTHLAB SEAMS (M) SDN BHD (284237-U)
No.47-G & 47-1, Jalan PJU 1A/41B, Pusat Dagangan NZX, Ara Jaya,
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Email : northlabseams.my@northlab.biz Website : www.northlab.biz

CALIBRATION CERTIFICATE

Cert No.	:	KD/15/0427-6	*Job No.*	:	KCW099115
Date of Issue	:	28-Apr-15	*Page*	:	2 of 2

RESULTS OF CALIBRATION

FEATURE INSPECTED : ACCURACY	
NOMINAL VALUE (mm)	*MEASURED VALUE (mm)*
0	0.000
5	5.000
10	10.000
15	15.000
20	20.000
25	25.000
30	30.000
35	35.000
40	40.000
45	44.998
50	49.998
REPEATABILITY	*0.002 mm*

1. The expanded measurement uncertainty associated with the results is ± 0.001mm estimated at a level of confidence of approximately 95% with a coverage factor of k = 2.

Calibrated by

HAYATI BT SEMAN

Approved Signatory

AZHAR BIN SALMAN

NORTHLAB SEAMS (M) SDN BHD (284237-U)
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CALIBRATION CERTIFICATE

Cert. No.	**: KD/15/0427-2**	***Job No.***	**: KCW099115**
Date of Issue	**: 28-Apr-15**	***Page***	**: 1 of 2**

Customer	: **YJACK TECHNOLOGY SDN BHD** LEVEL 16, 1 SENTRAL, KL SENTRAL, 50470 KUALA LUMPUR,MALAYSIA	*Date Received*	: 24-Apr-15
		Date Calibrated	: 28-Apr-15
		*Calibration Due Date**	: 28-Apr-16
		Ambient Temperature	: 20 ± 1°C
		Relative Humidity	: 55 ± 5% r.h.
Instrument	: **DIAL GAUGE**	*Serial No.*	: SXD 865
		Tag No.	: ---
Manufacturer	: MITUTOYO	*Cal Range*	: 0 ~ 50 mm
Model No.	: 3058S-19	*Resolution*	: 0.01 mm

This laboratory is accredited in accordance with recognized international standard ISO/IEC 17025:2005.This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF communique dated 18 june 2005).
The described instrument has been checked and calibrated at **NORTHLAB SEAMS (M) SDN BHD** under the ambient conditions stated above.

METHOD OF CALIBRATION

1. The instrument was calibrated as per method no. Procedure-017 in NLQM/001/10 of the Quality Manual and with reference to Digimatic Indicators and Linear Gauges as a guide.

	Standard instrument used	Serial No.	Traceability	Via Cal.Cert.No	Due date
1.	Gauge Block Set	0800165	NPL(UK)	ML/2013/0408	11-Jun-15

RESULTS OF CALIBRATION

1. The results of calibration are given on the attached calibration data sheet(s).

REMARKS

1. The user should decide on the usability of this instrument.
2. *Recalibration date specified by client.
3. The user should be aware that any number of factors may cause this instrument to drift out of calibration before the specified calibration interval has expired.

Calibrated by	Approved Signatory
HAYATI BT SEMAN	AZHAR BIN SALMAN

NORTHLAB SEAMS (M) SDN BHD (284237-U)
No.47-G & 47-1, Jalan PJU 1A/41B, Pusat Dagangan NZX, Ara Jaya,
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CALIBRATION CERTIFICATE

Cert No.	:	KD/15/0427-2	*Job No.*	:	KCW099115
Date of Issue	:	28-Apr-15	*Page*	:	2 of 2

RESULTS OF CALIBRATION

FEATURE INSPECTED : ACCURACY	
NOMINAL VALUE (mm)	*MEASURED VALUE (mm)*
0	0.000
5	5.000
10	10.000
15	15.002
20	20.000
25	25.000
30	30.000
35	35.000
40	40.000
45	45.000
50	50.000
REPEATABILITY	*0.002 mm*

1. The expanded measurement uncertainty associated with the results is ± 0.001mm estimated at a level of confidence of approximately 95% with a coverage factor of k = 2.

Calibrated by

HAYATI BT SEMAN

Approved Signatory

AZHAR BIN SALMAN

NORTHLAB SEAMS (M) SDN BHD (284237-U)
No.47-G & 47-1, Jalan PJU 1A/41B, Pusat Dagangan NZX, Ara Jaya,
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CALIBRATION CERTIFICATE

Cert. No.	: **KD/15/0427-5**	***Job No.***	: **KCW099115**
Date of Issue	: **28-Apr-15**	***Page***	: **1 of 2**

Customer	: **YJACK TECHNOLOGY SDN BHD** LEVEL 16, 1 SENTRAL, KL SENTRAL, 50470 KUALA LUMPUR,MALAYSIA	*Date Received* *Date Calibrated* *Calibration Due Date** *Ambient Temperature* *Relative Humidity*	: 24-Apr-15 : 28-Apr-15 : 28-Apr-16 : 20 ± 1°C : 55 ± 5% r.h.
Instrument	: **DIAL GAUGE**	*Serial No.* *Tag No.*	: SXD 868 : ---
Manufacturer	: MITUTOYO	*Cal Range*	: 0 ~ 50 mm
Model No.	: 3058-19	*Resolution*	: 0.01 mm

This laboratory is accredited in accordance with recognized international standard ISO/IEC 17025:2005.This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF communique dated 18 june 2005).
The described instrument has been checked and calibrated at **NORTHLAB SEAMS (M) SDN BHD** under the ambient conditions stated above.

METHOD OF CALIBRATION

1. The instrument was calibrated as per method no. Procedure-017 in NLQM/001/10 of the Quality Manual and with reference to Digimatic Indicators and Linear Gauges as a guide.

	Standard instrument used	Serial No.	Traceability	Via Cal.Cert.No	Due date
1.	Gauge Block Set	0800165	NPL(UK)	ML/2013/0408	11-Jun-15

RESULTS OF CALIBRATION

1. The results of calibration are given on the attached calibration data sheet(s).

REMARKS

1. The user should decide on the usability of this instrument.
2. *Recalibration date specified by client.
3. The user should be aware that any number of factors may cause this instrument to drift out of calibration before the specified calibration interval has expired.

Calibrated by	Approved Signatory
HAYATI BT SEMAN	AZHAR BIN SALMAN

NORTHLAB SEAMS

NORTHLAB SEAMS (M) SDN BHD (284237-U)
No.47-G & 47-1, Jalan PJU 1A/41B, Pusat Dagangan NZX, Ara Jaya,
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CALIBRATION CERTIFICATE

Cert No.	:	KD/15/0427-5	*Job No.*	:	KCW099115
Date of Issue	:	28-Apr-15	*Page*	:	2 of 2

RESULTS OF CALIBRATION

FEATURE INSPECTED : ACCURACY	
NOMINAL VALUE (mm)	*MEASURED VALUE (mm)*
0	0.000
5	5.002
10	10.000
15	15.002
20	20.000
25	25.000
30	30.000
35	35.000
40	40.000
45	45.002
50	50.000
REPEATABILITY	*0.002 mm*

1. The expanded measurement uncertainty associated with the results is ± 0.001mm estimated at a level of confidence of approximately 95% with a coverage factor of k = 2.

Calibrated by

HAYATI BT SEMAN

Approved Signatory

AZHAR BIN SALMAN

NORTHLAB SEAMS (M) SDN BHD (284237-U)

No.47-G & 47-1, Jalan PJU 1A/41B, Pusat Dagangan NZX, Ara Jaya,
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CALIBRATION CERTIFICATE

Cert. No.	: **KD/15/0427-4**	***Job No.***	: **KCW099115**
Date of Issue	: **28-Apr-15**	***Page***	: **1 of 2**

Customer	: **YJACK TECHNOLOGY SDN BHD** LEVEL 16, 1 SENTRAL, KL SENTRAL, 50470 KUALA LUMPUR,MALAYSIA	*Date Received*	: 24-Apr-15
		Date Calibrated	: 28-Apr-15
		*Calibration Due Date**	: 28-Apr-16
		Ambient Temperature	: 20 ± 1°C
		Relative Humidity	: 55 ± 5% r.h.
Instrument	: **DIAL GAUGE**	*Serial No.*	: SXD 869
		Tag No.	: ---
Manufacturer	: MITUTOYO	*Cal Range*	: 0 ~ 50 mm
Model No.	: 3058S-19	*Resolution*	: 0.01 mm

This laboratory is accredited in accordance with recognized international standard ISO/IEC 17025:2005.This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF communique dated 18 june 2005).
The described instrument has been checked and calibrated at **NORTHLAB SEAMS (M) SDN BHD** under the ambient conditions stated above.

METHOD OF CALIBRATION

1. The instrument was calibrated as per method no. Procedure-017 in NLQM/001/10 of the Quality Manual and with reference to Digimatic Indicators and Linear Gauges as a guide.

	Standard instrument used	Serial No.	Traceability	Via Cal.Cert.No	Due date
1.	Gauge Block Set	0800165	NPL(UK)	ML/2013/0408	11-Jun-15

RESULTS OF CALIBRATION

1. The results of calibration are given on the attached calibration data sheet(s).

REMARKS

1. The user should decide on the usability of this instrument.
2. *Recalibration date specified by client.
3. The user should be aware that any number of factors may cause this instrument to drift out of calibration before the specified calibration interval has expired.

Calibrated by	Approved Signatory
HAYATI BT SEMAN	AZHAR BIN SALMAN

NORTHLAB SEAMS (M) SDN BHD (284237-U)
No.47-G & 47-1, Jalan PJU 1A/41B, Pusat Dagangan NZX, Ara Jaya,
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CALIBRATION CERTIFICATE

Cert No.	:	KD/15/0427-4	*Job No.*	:	KCW099115
Date of Issue	:	28-Apr-15	*Page*	:	2 of 2

RESULTS OF CALIBRATION

FEATURE INSPECTED : ACCURACY	
NOMINAL VALUE (mm)	*MEASURED VALUE (mm)*
0	0.000
5	4.998
10	10.000
15	14.998
20	20.000
25	25.000
30	30.000
35	35.000
40	40.000
45	44.998
50	49.998
REPEATABILITY	*0.002 mm*

1. The expanded measurement uncertainty associated with the results is ± 0.001mm estimated at a level of confidence of approximately 95% with a coverage factor of k = 2.

Calibrated by

HAYATI BT SEMAN

Approved Signatory

AZHAR BIN SALMAN

NORTHLAB SEAMS (M) SDN BHD (284237-U)

No.47-G & 47-1, Jalan PJU 1A/41B, Pusat Dagangan NZX, Ara Jaya,
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CALIBRATION CERTIFICATE

Cert. No.	: **KD/15/0427-3**	***Job No.***	: **KCW099115**
Date of Issue	: **28-Apr-15**	***Page***	: **1 of 2**

Customer	: **YJACK TECHNOLOGY SDN BHD** LEVEL 16, 1 SENTRAL, KL SENTRAL, 50470 KUALA LUMPUR,MALAYSIA	*Date Received*	: 24-Apr-15
		Date Calibrated	: 28-Apr-15
		*Calibration Due Date**	: 28-Apr-16
		Ambient Temperature	: 20 ± 1°C
		Relative Humidity	: 55 ± 5% r.h.
Instrument	: **DIAL GAUGE**	*Serial No.*	: SXD 881
		Tag No.	: ---
Manufacturer	: MITUTOYO	*Cal Range*	: 0 ~ 50 mm
Model No.	: 3058S-19	*Resolution*	: 0.01 mm

This laboratory is accredited in accordance with recognized international standard ISO/IEC 17025:2005.This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF communique dated 18 june 2005).
The described instrument has been checked and calibrated at **NORTHLAB SEAMS (M) SDN BHD** under the ambient conditions stated above.

METHOD OF CALIBRATION

1. The instrument was calibrated as per method no. Procedure-017 in NLQM/001/10 of the Quality Manual and with reference to Digimatic Indicators and Linear Gauges as a guide.

	Standard instrument used	Serial No.	Traceability	Via Cal.Cert.No	Due date
1.	Gauge Block Set	0800165	NPL(UK)	ML/2013/0408	11-Jun-15

RESULTS OF CALIBRATION

1. The results of calibration are given on the attached calibration data sheet(s).

REMARKS

1. The user should decide on the usability of this instrument.
2. *Recalibration date specified by client.
3. The user should be aware that any number of factors may cause this instrument to drift out of calibration before the specified calibration interval has expired.

Calibrated by	Approved Signatory
HAYATI BT SEMAN	AZHAR BIN SALMAN

NORTHLAB SEAMS
NORTHLAB SEAMS (M) SDN BHD (284237-U)
No.47-G & 47-1, Jalan PJU 1A/41B, Pusat Dagangan NZX, Ara Jaya,
47301 Petaling Jaya, Selangor Darul Ehsan, Malaysia.
Tel: 603-78858211 Fax: 603-78858511
Email : northlabseams.my@northlab.biz Website : www.northlab.biz

CALIBRATION CERTIFICATE

Cert No.	:	KD/15/0427-3	*Job No.*	:	KCW099115
Date of Issue	:	28-Apr-15	*Page*	:	2 of 2

RESULTS OF CALIBRATION

FEATURE INSPECTED : ACCURACY	
NOMINAL VALUE (mm)	*MEASURED VALUE (mm)*
0	0.000
5	5.002
10	10.000
15	15.000
20	20.000
25	25.002
30	30.000
35	35.000
40	40.000
45	45.000
50	50.000
REPEATABILITY	*0.002 mm*

1. The expanded measurement uncertainty associated with the results is ± 0.001mm estimated at a level of confidence of approximately 95% with a coverage factor of k = 2.

Calibrated by

HAYATI BT SEMAN

Approved Signatory

AZHAR BIN SALMAN

NORTHLAB SEAMS

NORTHLAB SEAMS (M) SDN BHD (284237-U)
No.47-G & 47-1, Jalan PJU 1A/41B, Pusat Dagangan NZX, Ara Jaya,
47301 Petaling Jaya, Selangor Darul Ehsan, Malaysia.
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CALIBRATION CERTIFICATE

Cert. No.	: KD/15/0427-7	*Job No.*	: KCW099115
Date of Issue	: 28-Apr-15	*Page*	: 1 of 2

Customer	: **YJACK TECHNOLOGY SDN BHD** LEVEL 16, 1 SENTRAL, KL SENTRAL, 50470 KUALA LUMPUR,MALAYSIA	*Date Received*	: 24-Apr-15
		Date Calibrated	: 28-Apr-15
		*Calibration Due Date**	: 28-Apr-16
		Ambient Temperature	: 20 ± 1°C
		Relative Humidity	: 55 ± 5% r.h.
Instrument	: **DIAL GAUGE**	*Serial No.*	: TGG 778
		Tag No.	: ---
Manufacturer	: MITUTOYO	*Cal Range*	: 0 ~ 50 mm
Model No.	: 3058S-19	*Resolution*	: 0.01 mm

This laboratory is accredited in accordance with recognized international standard ISO/IEC 17025:2005.This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer joint ISO-ILAC-IAF communique dated 18 june 2005).
The described instrument has been checked and calibrated at **NORTHLAB SEAMS (M) SDN BHD** under the ambient conditions stated above.

METHOD OF CALIBRATION

1. The instrument was calibrated as per method no. Procedure-017 in NLQM/001/10 of the Quality Manual and with reference to Digimatic Indicators and Linear Gauges as a guide.

	Standard instrument used	Serial No.	Traceability	Via Cal.Cert.No	Due date
1.	Gauge Block Set	0800165	NPL(UK)	ML/2013/0408	11-Jun-15

RESULTS OF CALIBRATION

1. The results of calibration are given on the attached calibration data sheet(s).

REMARKS

1. The user should decide on the usability of this instrument.
2. *Recalibration date specified by client.
3. The user should be aware that any number of factors may cause this instrument to drift out of calibration before the specified calibration interval has expired.

Calibrated by — HAYATI BT SEMAN

Approved Signatory — AZHAR BIN SALMAN

NORTHLAB SEAMS (M) SDN BHD (284237-U)
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CALIBRATION CERTIFICATE

Cert No.	:	KD/15/0427-7	*Job No.*	:	KCW099115
Date of Issue	:	28-Apr-15	*Page*	:	2 of 2

RESULTS OF CALIBRATION

FEATURE INSPECTED : ACCURACY	
NOMINAL VALUE (mm)	*MEASURED VALUE (mm)*
0	0.000
5	4.998
10	10.000
15	15.000
20	20.000
25	25.000
30	30.000
35	35.000
40	40.000
45	44.998
50	49.998
REPEATABILITY	*0.002 mm*

1. The expanded measurement uncertainty associated with the results is ± 0.001mm estimated at a level of confidence of approximately 95% with a coverage factor of k = 2.

Calibrated by

HAYATI BT SEMAN

Approved Signatory

AZHAR BIN SALMAN

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