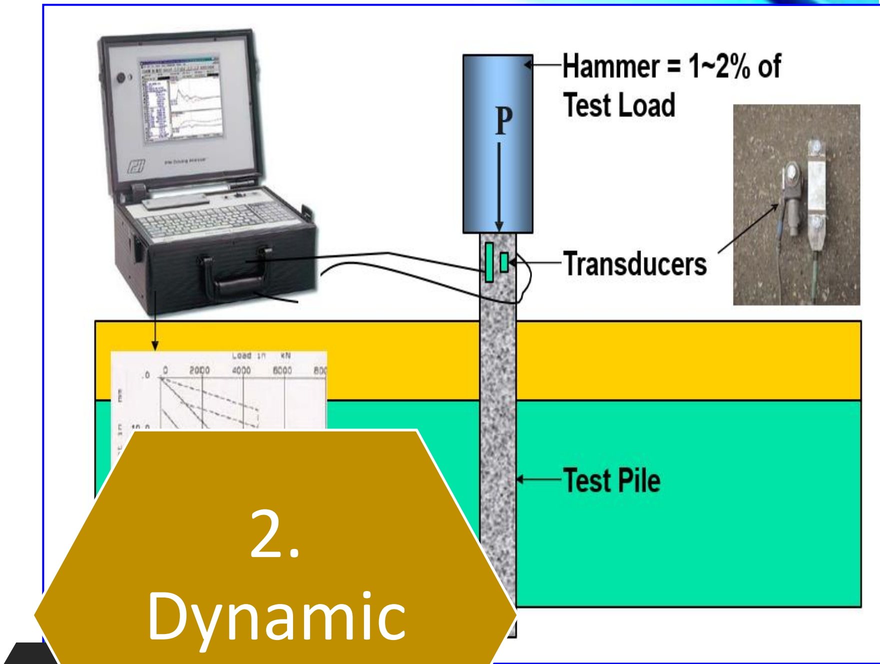
PILE LOAD TEST

Prior to the construction, an in situ type of load testing are carried out in order to determine information as follows:

- The ultimate strength of each pile must fulfill the structural and geotechnical limits for a safe foundation to perform as required
- The bearing capacity of deep foundations
- To study the behavior of pile settlement under the applied loads



CATEGORY OF LOAD TEST

1. Statnamic Load Test
2. Dynamic Load Test
3. Static Load Test

Pile Driving Analyser (PDA)

Kentledge Load Test

Pile Jack-in Load Test

Bi-Directional Load Test

Static Load Test

a) The general testing method is to impose a static vertical load on a test pile for certain duration and with increment on loads intervals and required cycles.
b) Static load test differs from the statnamic load test and dynamic load testing in that the pressure applied to the pile is slower.
c) Static load test can be executed by Kentledge or Pile Jack-in Machine.

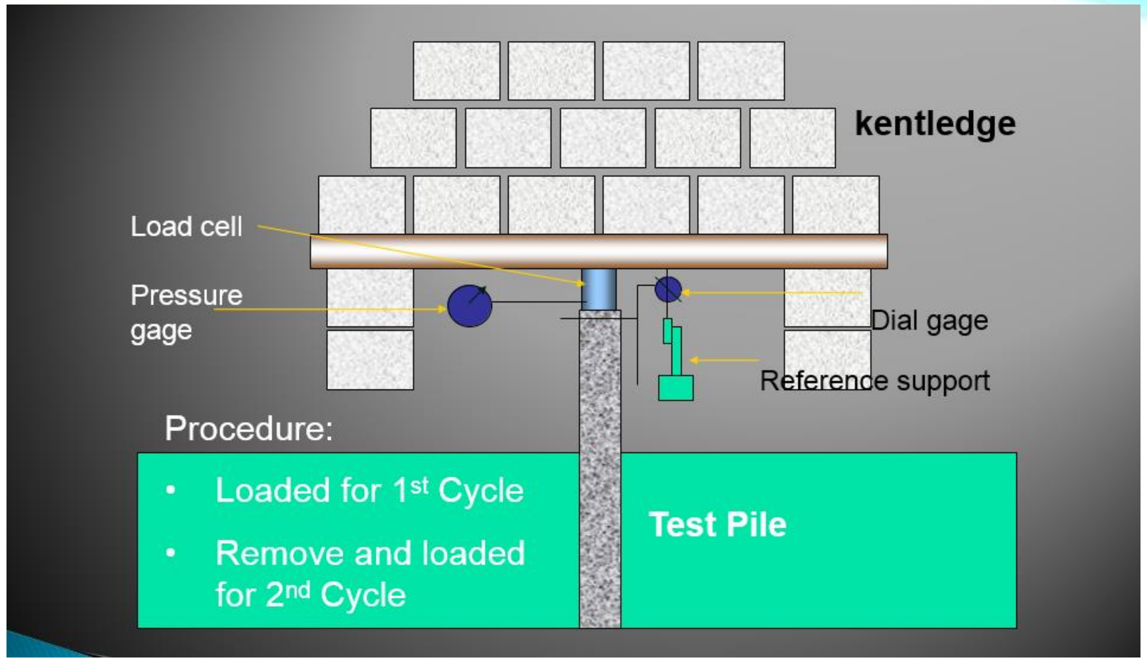
Kentledge Load Test

a) Kentledge refers concrete weights used in load testing. This method involves the construction of a platform upon which massive weights are placed.
b) These weights bear down on the pile putting it under load.
c) Gauges measure resistance, movement of the pile, and other readings to determine the properties of the ground

Jack-in Machine Load Test

Jack-in machine and steel beam sections makes up the whole static load test systems in which the hydraulic jack impose vertical force on the test pile.

Method of Testing for Static Load Test



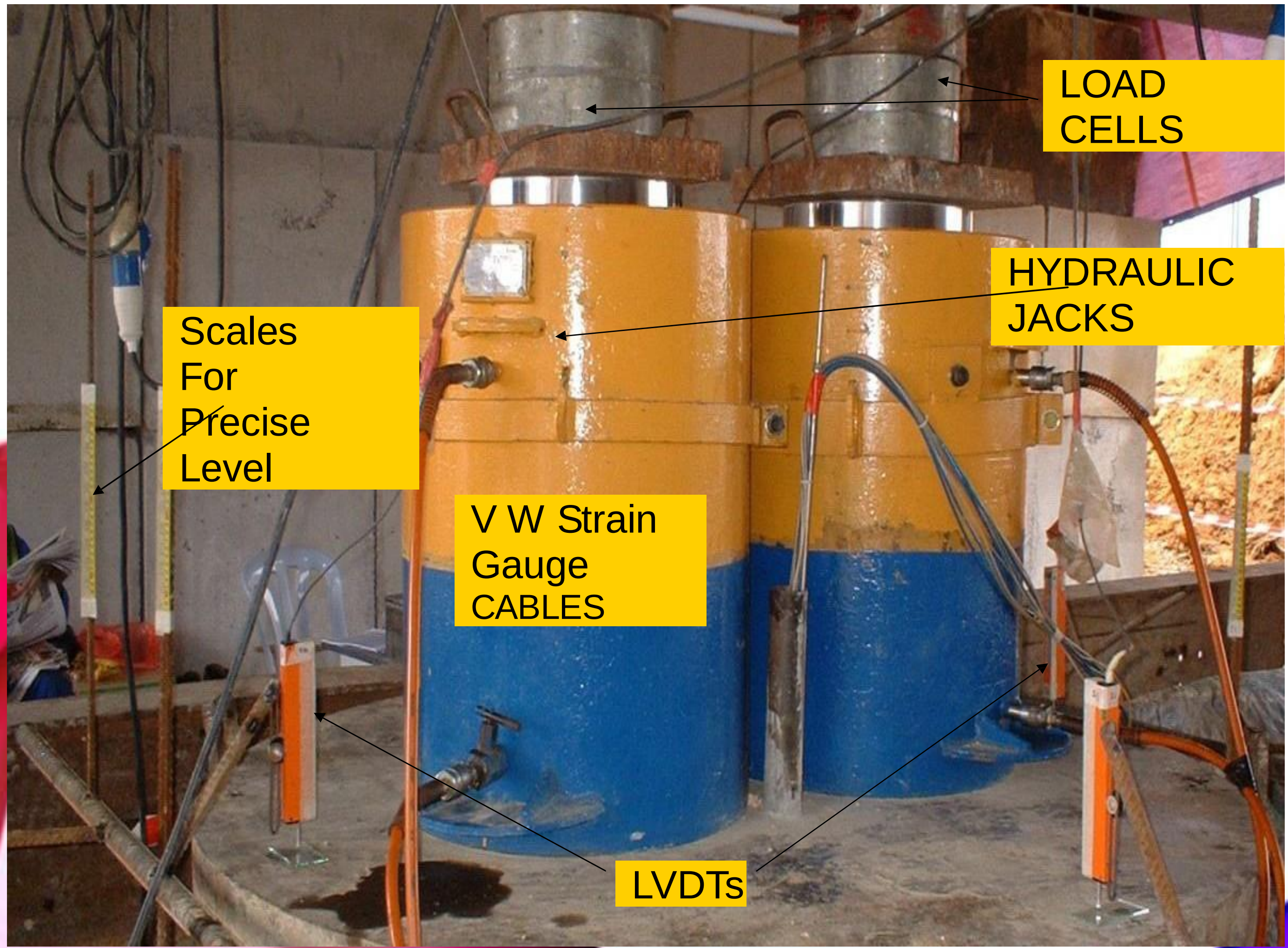
- Prior to testing, load test equipment should be completely set out on firm ground.
- The kentledge / pile jack-in machine shall be placed directly on top of the centroid of a mild steel plate which rest directly on top of the pile.

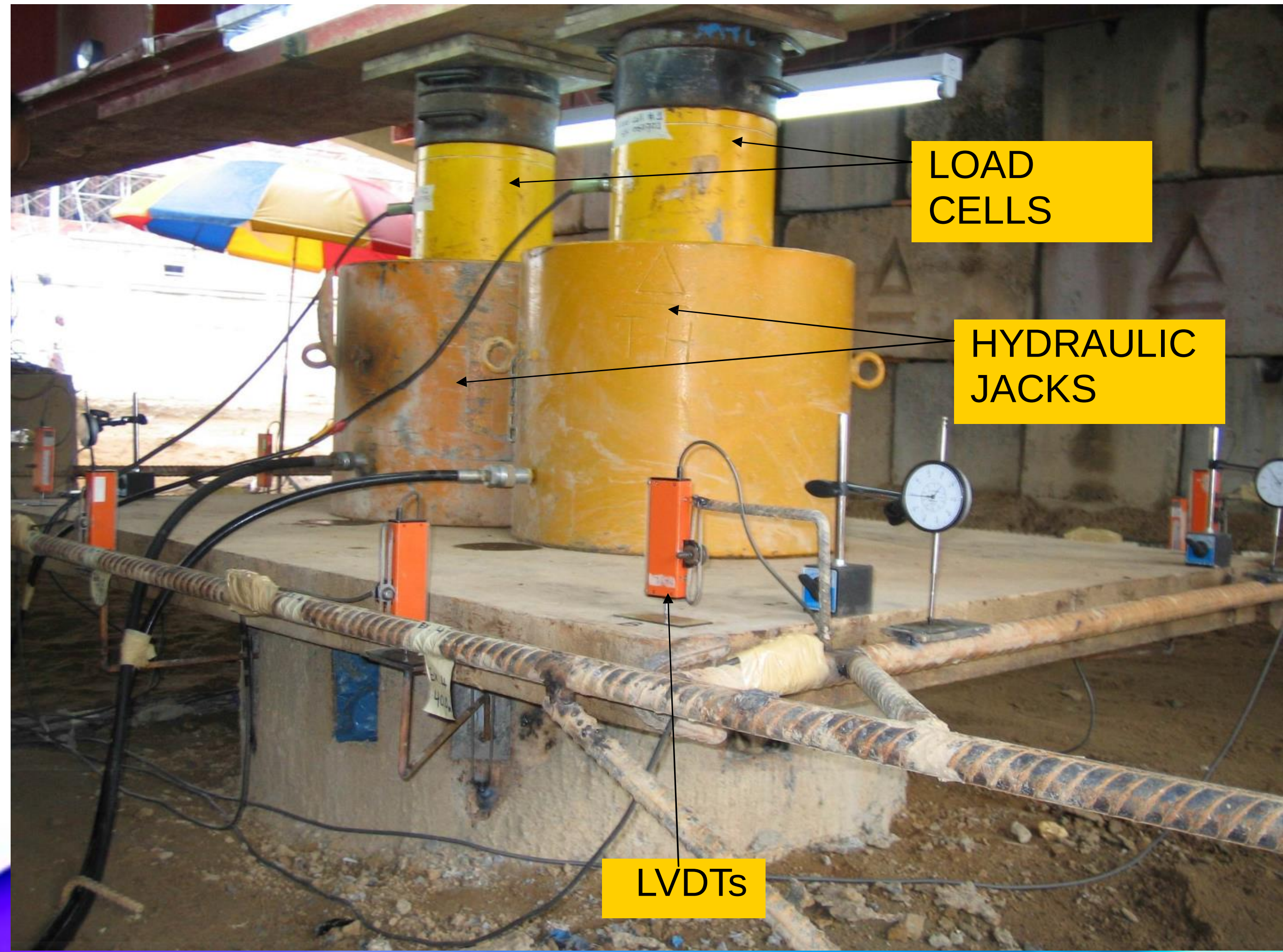
Kentledge Load Test

Jack-in Machine Load Test

Method of Testing for Static Load Test

When vertical load is imposed, the pressure applied to the jack shall be measured by calibrated pressure gauge.





Method of Testing for Static Load Test

- The pile is tested from zero landing to 2 times of the working load design for the pile. Testing will be done in 2 cycles, 1st cycles for 100% of working load, 2nd cycle for 200% of working load.
- The load increments shall be 25% of working load with minimum holding time of 2 hours. For load decrement, the test load shall be decreased in 4 equal stages with 60 minutes interval.

Cycles	Working load (%)	Min holding time (hour)
1st Cycles	25	2
	50	2
	75	2
	100	12
	75	1
	50	1
	25	1
	0	1

Cycles	Working load (%)	Min holding time (hour)
2nd Cycles	25	2
	50	2
	75	2
	100	2
	125	2
	150	2
	175	2
	200	24
	150	1
	100	1
	50	1
	0	1

Method of Testing for Static Load Test

Monitoring of test pile settlement can be done by as follows :

i. Measured by 4 LVDT connected to data logger (As per JKR Spec).
ii. Four numbers of dial gauge which is equally spaced out around the pile head and connected to the independent reference frame.

Any monitoring system shall be supported by an auxillary system such as an optical levelling method by reference to a remote datum.

Static Load Test Results

The pile tested shall be deemed to have failed if:

- The total settlement under the Working Load exceeds 12.5 mm; or
- The residual settlement after removal of the test load at working load exceeds [(diameter of pile or diagonal width for non-circular pile / 120) + 4] mm or 12.5 mm whichever is the lower value; or
- The total settlement under twice the Working Load exceeds 38 mm, or 10% of pile diameter / width whichever is the lower value.

Summary Of Average Pile Top Settlement From Corrected LVDTs And Scale Readings

Time (hr)	Total Load (kN)	Total Pile Top Settlement (mm) (Fr LVDTs Average)	Pile Top LVDT S1 (mm)	Pile Top LVDT S2 (mm)	Pile Top LVDT S3 (mm)	Pile Top LVDT S4 (mm)	Scale Reading R1 (mm)	Scale Reading R2 (mm)	Reference Beam Movement (mm)	Scale Reading TBM 1 (mm)	Level Station Movement (mm)	Corrected Total Pile Top Settlement (mm) (Fr LVDTs)	Scale Reading T1 (mm)	Scale Reading T2 (mm)	Corrected Total Pile Top Settlement (mm) (Fr Precise Level)	Average Corrected Total Pile Top Settlement (mm)
(1st Cycle)																
24/09/2017 11:27	0	0.00	0.00	0.00	0.00	0.00	40.20	40.00	0.00	60.00	0.00	0.00	10.10	10.50	0.00	0.00
24/09/2017 13:33	610	1.56	1.11	0.99	2.13	2.01	40.10	40.10	0.00	59.85	0.15	1.71	11.70	11.85	1.63	1.67
24/09/2017 15:30	1245	3.01	2.55	2.39	3.64	3.47	40.25	40.30	0.17	59.90	0.10	3.29	13.05	13.40	3.03	3.16
24/09/2017 17:31	1897	4.52	4.06	3.91	5.18	4.92	40.50	40.70	0.50	59.80	0.20	5.22	14.80	15.20	4.90	5.06
25/09/2017 5:30	2574	5.71	5.34	5.08	6.21	6.21	40.50	40.90	0.60	59.10	0.90	7.21	16.10	16.50	6.90	7.05
25/09/2017 6:33	1678	3.95	3.65	3.41	4.39	4.34	40.00	40.65	0.23	58.15	1.85	6.02	13.90	14.20	5.60	5.81
25/09/2017 7:42	1024	2.18	1.91	1.69	2.59	2.52	40.00	40.55	0.17	58.05	1.95	4.30	12.15	12.55	4.00	4.15
25/09/2017 8:43	627	1.11	0.82	0.62	1.53	1.48	40.00	40.50	0.15	57.80	2.20	3.46	11.20	11.50	3.25	3.36
25/09/2017 9:45	0	-0.96	-1.49	-1.65	-0.33	-0.37	40.00	40.55	0.17	57.80	2.20	1.42	9.25	9.80	1.43	1.42
(2nd Cycle)																
25/09/2017 9:45	0	-0.96	-1.49	-1.65	-0.33	-0.37	40.00	40.55	0.17	57.80	2.20	1.42	9.25	9.80	1.43	1.42
25/09/2017 11:40	637	0.36	-0.17	-0.23	0.99	0.85	40.00	40.80	0.30	57.50	2.50	3.16	10.30	11.05	2.88	3.02
25/09/2017 14:11	1385	1.94	1.47	1.40	2.52	2.38	40.05	41.05	0.45	57.75	2.25	4.64	11.85	12.55	4.15	4.40
25/09/2017 18:26	1932	4.59	4.15	4.06	5.21	4.95	40.30	41.30	0.70	58.80	1.20	6.49	14.75	15.80	6.18	6.33
25/09/2017 20:27	2543	5.69	5.23	5.07	6.34	6.11	40.60	41.40	0.90	58.55	1.45	8.04	15.95	17.05	7.65	7.84
25/09/2017 22:28	2973	6.44	6.02	5.83	7.08	6.85	40.50	41.70	1.00	58.55	1.45	8.89	16.95	17.80	8.53	8.71
26/09/2017 0:30	3647	8.09	7.71	7.55	8.66	8.43	40.60	41.80	1.10	58.10	1.90	11.09	18.40	19.40	10.50	10.79
26/09/2017 2:28	4161	9.54	9.25	9.12	10.00	9.79	40.30	41.65	0.87	57.80	2.20	12.62	19.65	20.40	11.93	12.27
27/09/2017 2:28	4613	12.10	12.11	11.90	12.28	12.08	40.25	41.90	0.98	57.10	2.90	15.97	22.15	23.05	15.20	15.59
27/09/2017 3:29	3471	10.14	10.12	9.98	10.34	10.13	40.00	41.40	0.60	56.70	3.30	14.04	20.00	20.95	13.48	13.76
27/09/2017 4:52	2415	7.51	7.47	7.35	7.72	7.49	40.00	41.40	0.60	56.60	3.40	11.51	17.45	18.55	11.10	11.30
27/09/2017 5:48	1207	4.14	4.11	4.06	4.31	4.08	40.00	41.15	0.48	56.40	3.60	8.21	14.15	15.10	7.93	8.07
27/09/2017 6:50	0	0.12	-0.16	-0.41	0.55	0.52	39.85	41.10	0.38	56.15	3.85	4.35	10.50	11.35	4.48	4.41

Bi-Directional Load Test (Osterberg Cell)

Introduction

- The Osterberg Cell® (O-Cell®) is one of alternative method of static load testing for drilled shafts and piles.
- The O-Cell is a hydraulically driven, individually calibrated, sacrificial loading device installed within the foundation unit.
- Working in two directions, upward against side-shear resistance and downward against end-bearing resistance, the O-Cell automatically separates the resistance and displacement data for each component of the pile. The jack provides the static loading which required no external loading / reaction system.
- Testing is performed until either ultimate upward or downward capacity is reached or the maximum O-Cell stroke or load capacity is reached. Use of strain gages within the foundation can help to determine the distribution of load throughout the foundation length.

Principle of Testing

Bi-Directional Load Test (Osterberg Cell)

a) The test analyses and determine shear resistance and end bearing capacity of piles under test especially is restricted site access. The cells assembly location will ideally be located at the middle of total pile capacity (= skin friction + end bearing).

b) The main aim of positioning the assembly will be to "balance" the bi -directional forces in the pile so that failure in one direction does not occur prematurely.

c) Two main features of bi-directional testing, which can make it preferable over top down static load testing, are:

   i. Saving in terms of cost, transport, installation and erection of kentledge, anchors or anchor piles as well as the associated reaction system required above ground level.

   ii. Significant improvement in terms of safety; assembly of a loading system at the head of the pile is not required and the loads applied are buried.

Bi-Directional Load Test (Osterberg Cell)

The testing pile is loaded by the embedded load cell in upward and downward directions

When the load is applied through the load cell, it works in two directions.

The lower segment of the pile balances the applied load through end bearing load and side friction, while the upper segment through side friction.

A calibrated electronic pressure gauge will be used to monitor the hydraulic jack pressure

For measurement of the displacement of the cell (top and bottom parts), telltales will be used. The end of telltales will be connected to LVDTs (linear vertical displacement transducer) to measure displacements

Bi-Directional Load Test (Osterberg Cell)

Test Results

- The total settlement under the Working Load exceeds 12.5 mm; or
- The total settlement under twice the Working Load exceeds 38 mm, or 10% of pile diameter / width whichever is the lower value.

YJACK

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

Loading Schedule Table Sheet for Pile Size BP1050; Working Load 8,600kN, Test Load 17,200kN

Project Name: Hospital Tawau, Sabah

Test Pile Data		YJACK Data	
Pile Type:	Bored Pile	YCELL Model:	4GYJDN800
Pile Size:	1,050 mm	YCELL Stroke:	80 mm
Work Load in F(BD):	8,600 kN	YCELL Capacity in F(BD):	2,100 kN
Test Load in F(BD):	17,200 kN	YCELL Effective Area:	233,500 mm2
Safety Factor:	2.0	YCELL Quantity:	1 NOS
Applied Working Load in F(1D):	4,300 kN	YJACK Capacity in F(BD):	2,100 kN
Applied Test Load in F(1D):	8,600 kN	YJACK Effective Area:	233,500 mm2

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

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

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	1,075.0	4.6	46.0	20	0,20	2,150	2,419
50	2,150.0	9.2	92.1	20	0,20	4,300	4,838
75	3,225.0	13.8	138.1	20	0,20	6,450	7,256
100	4,300.0	18.4	184.2	360	20,40,60	8,600	9,675
75	3,225.0	13.8	138.1	20	0,20	6,450	7,256
50	2,150.0	9.2	92.1	20	0,20	4,300	4,838
25	1,075.0	4.6	46.0	20	0,20	2,150	2,419
0	0.0	0.0	0.0	60	20,40,60	0	0
25	1,075.0	4.6	46.0	20	0,20	2,150	2,419
50	2,150.0	9.2	92.1	20	0,20	4,300	4,838
75	3,225.0	13.8	138.1	20	0,20	6,450	7,256
100	4,300.0	18.4	184.2	20	0,20	8,600	9,675
125	5,375.0	23.0	230.2	20	0,20	10,750	12,094
150	6,450.0	27.6	276.2	20	0,20	12,900	14,513
175	7,525.0	32.2	322.3	20	0,20	15,050	16,931
200	8,600.0	36.8	368.3	720	20,40,60	17,200	19,350
150	6,450.0	27.6	276.2	20	0,20	12,900	14,513
100	4,300.0	18.4	184.2	20	0,20	8,600	9,675
50	2,150.0	9.2	92.1	20	0,20	4,300	4,838
0	0.0	0.0	0.0	60	20,40,60	0	0
* 60 min or settlement rate less than 0.25mm/hr (whichever longer)				1520	test duration in minutes		

Bi-Directional Installation

Bi-Directional Load Test (Osterberg Cell)

1. Preparation of bi-directional cell

2. Rebar cage installation

3. Rebar cage will put to the cell (perpendicular) and weld together to fabricate as a single piece with the rebar cage

4. During execution, the rebar cage will be spliced together over the bored hole.

Bi-Directional Installation

Bi-Directional Load Test (Osterberg Cell)

5. Attachment of the sensors and measuring apparatus.

6. Lifting of rebar cages into bored hole.

7. Rebar cages lower down to bored hole.

Bi-Directional Installation

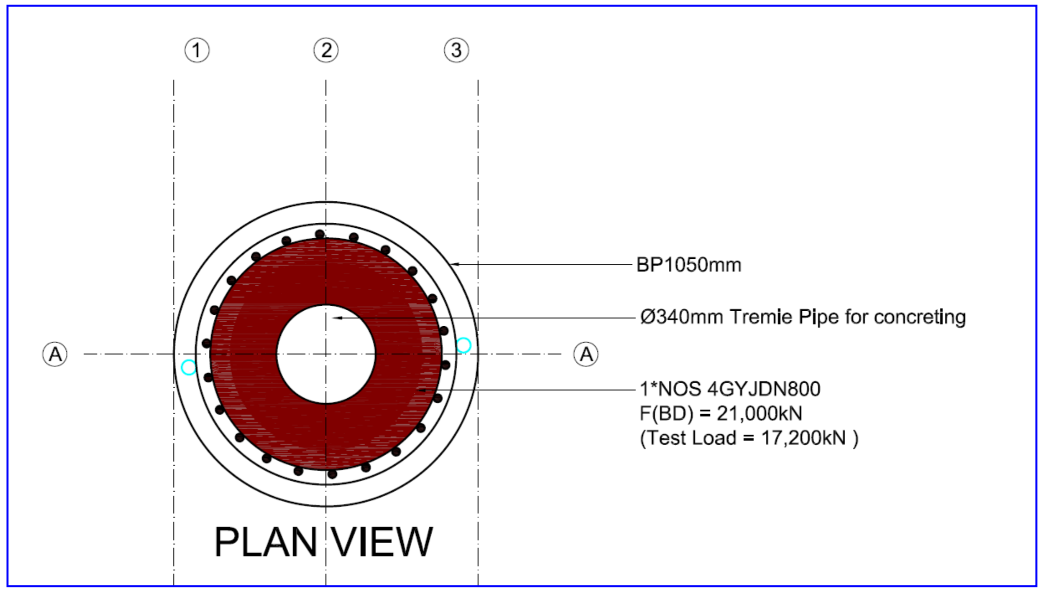
Bi-Directional Load Test (Osterberg Cell)

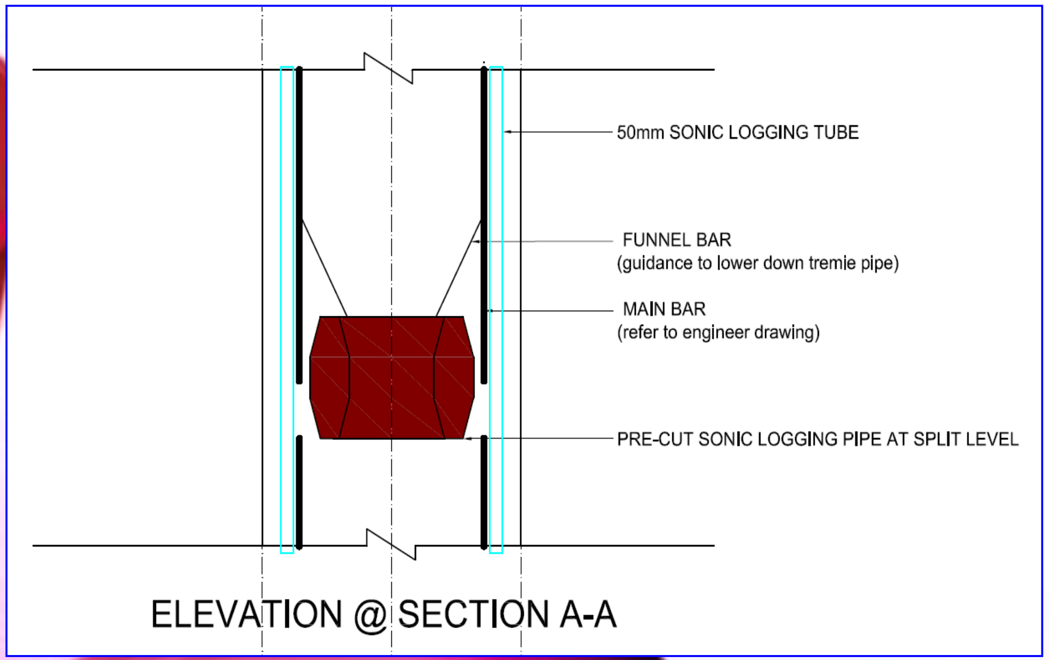
8. Rebar cages lower down to bored hole.

9. Bi-directional instrumentation.

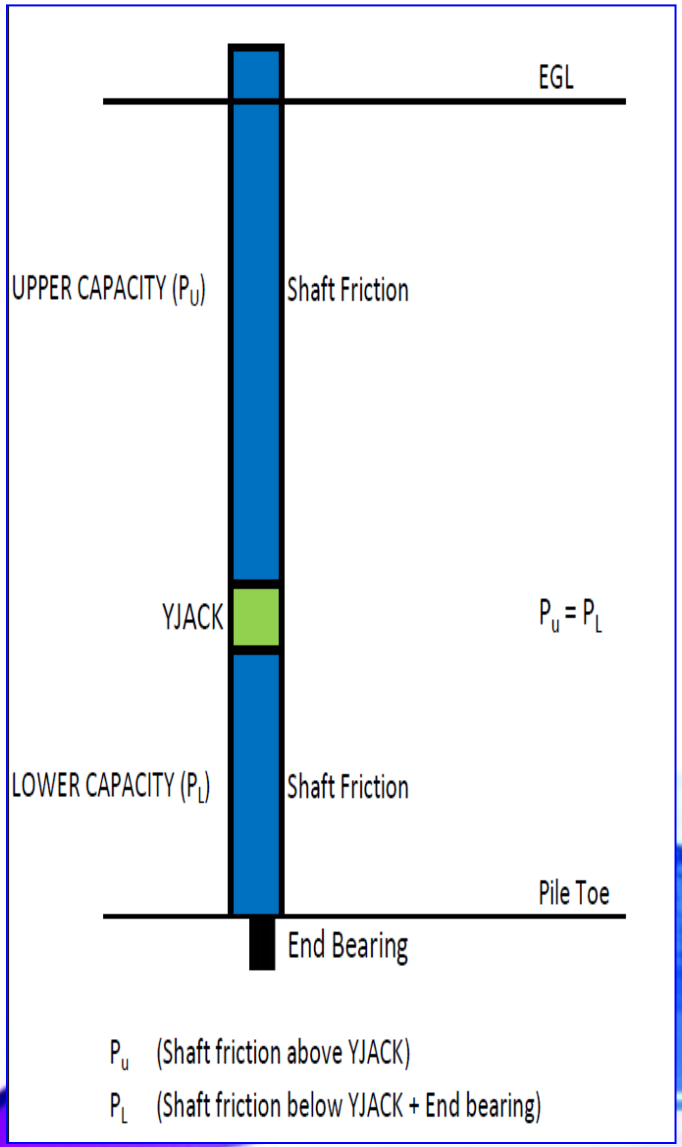
Bi-Directional Load Test (Osterberg Cell)

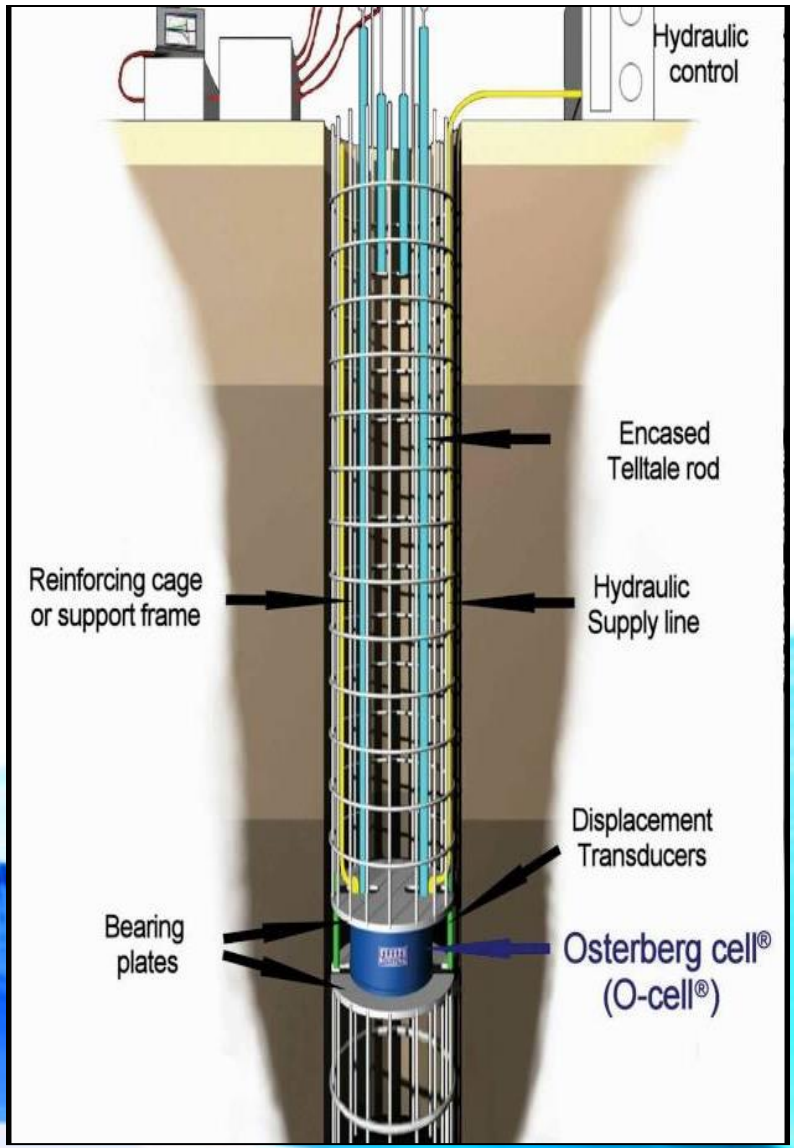
Bi-directional Cell's Cross Section





Bi-directional Cell's Arrangement



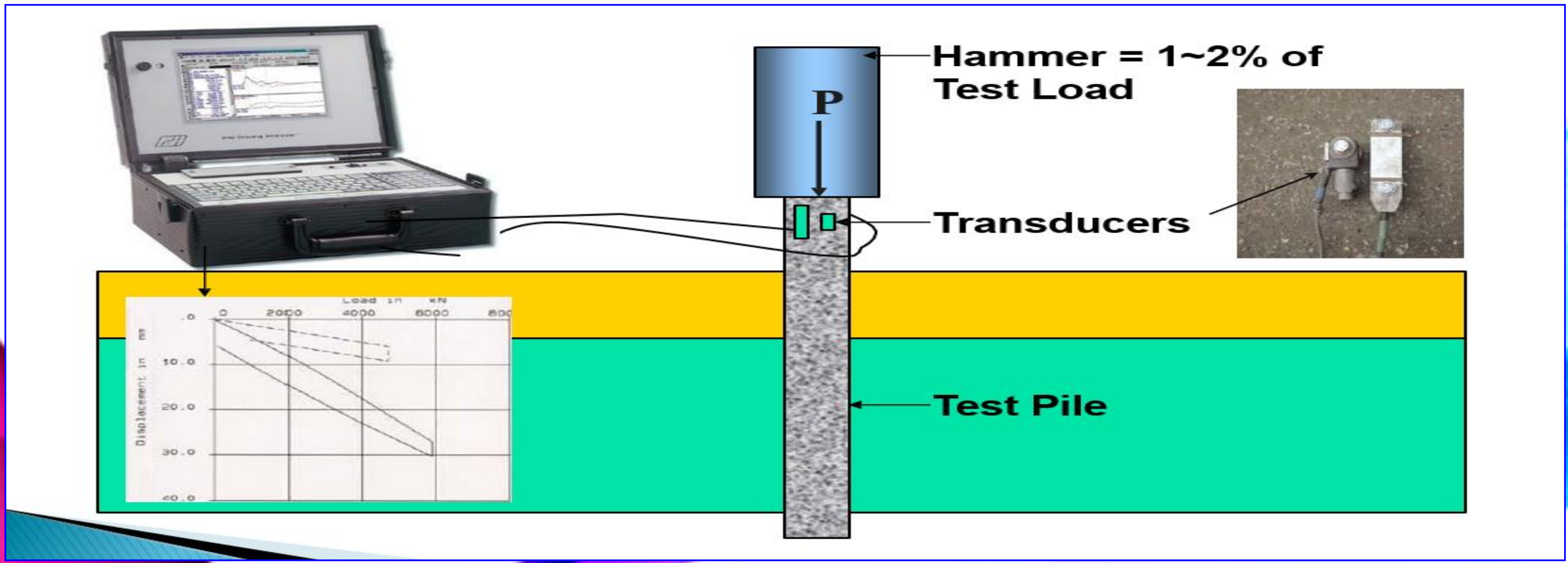


Dynamic Load Test

Introduction

Dynamic Load Testing is performed using the Pile Driving Analyser (PDA). The CAPWAP computer software is develop for PDA test data acquisition which allow full and accurate analysis of the PDA filed data.

PDA tests is a High Strain Dynamic Load Tests which can be applied after pile installation for concrete piles. The test consists of estimating soil resistance and its distribution from force and velocity measurements obtained near the top of a foundation impacted by a hammer or drop weight. The impact produces a compressive wave that travels down the shaft of the foundation.



Dynamic Load Test

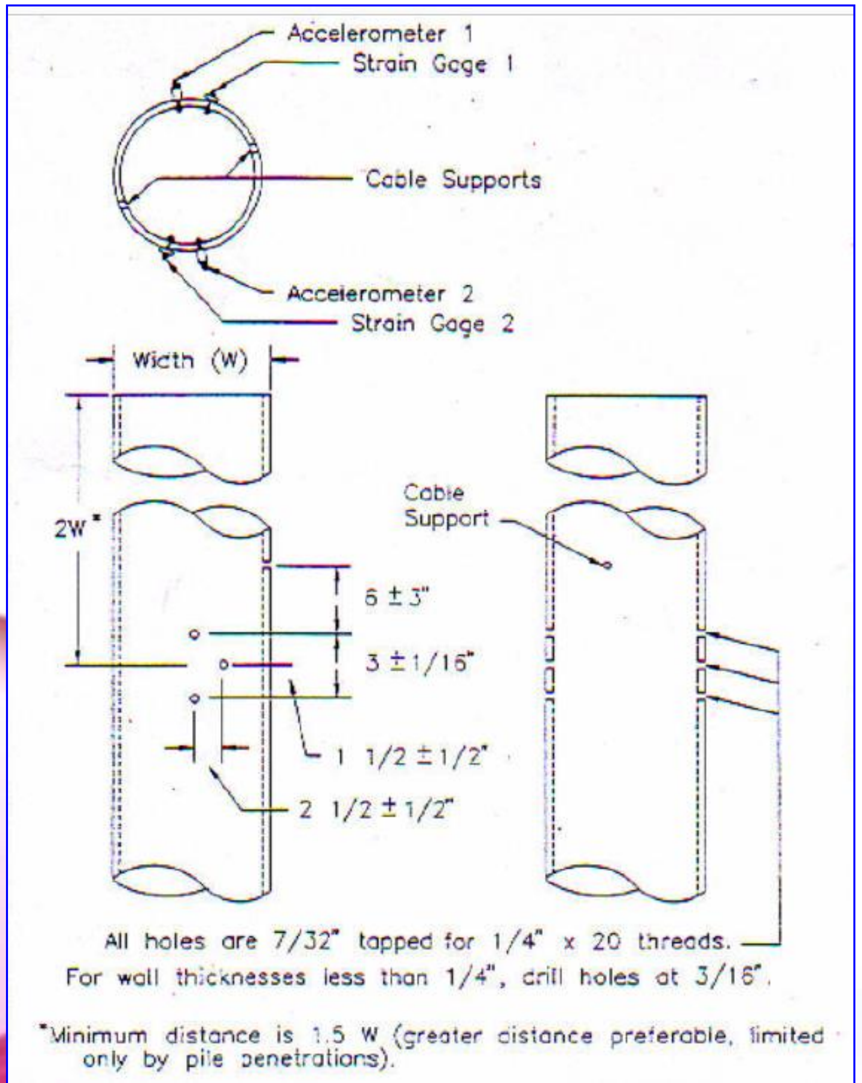
Test Operation

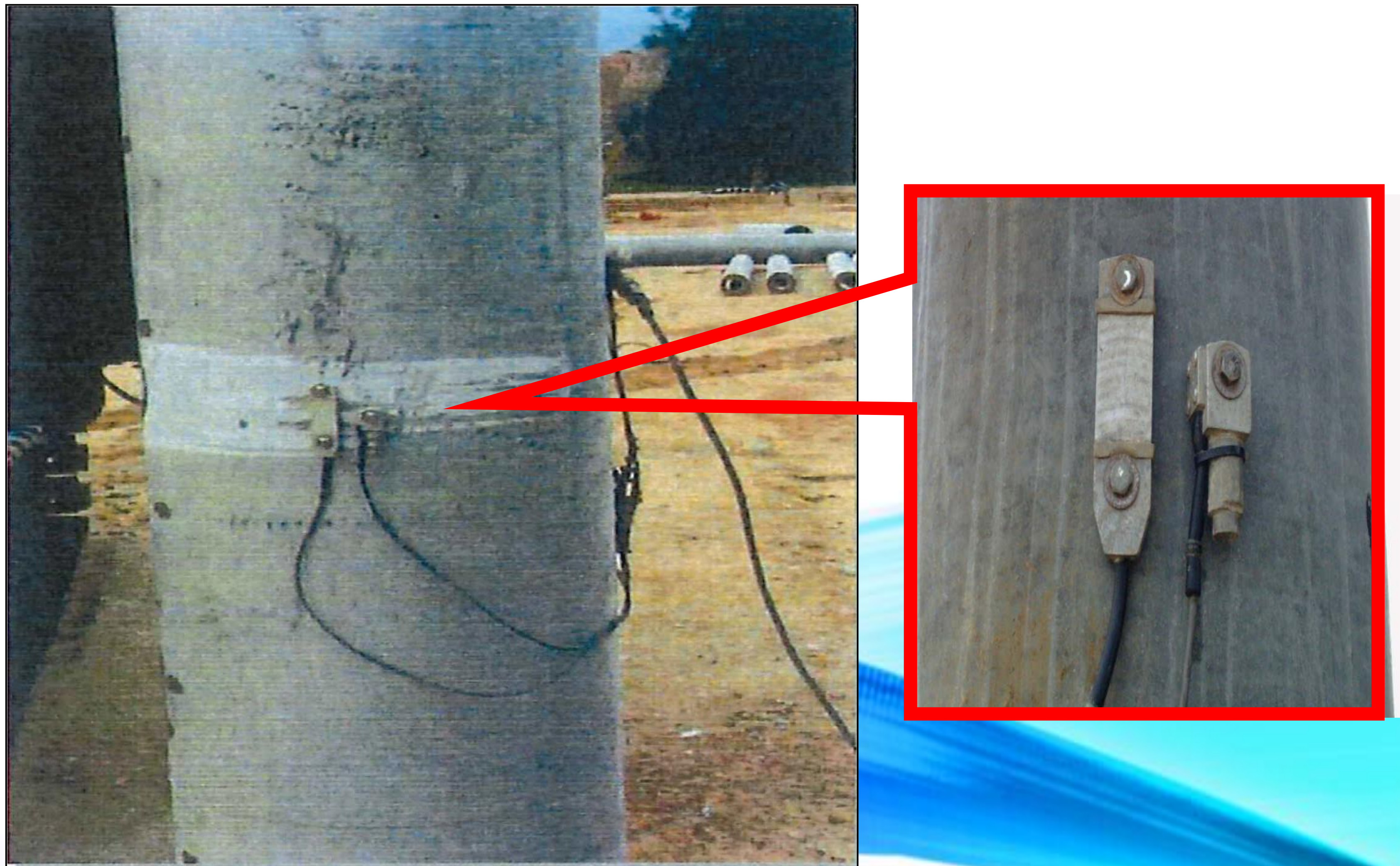
When vertical load is imposed, the pressure applied to the jack shall be measured by calibrated pressure gauge.

Dynamic Load Test

Test Operation

A pair of strain transducers obtains the signals necessary to compute force, while measurements from a pair of accelerometers are integrated to yield velocity. These sensors are connected to an instrument, that records, processes and displays data and results.





Dynamic Load Test

Test Operation

- The wave assumes an opposite direction (a reflection) when it encounters soil resistance forces along the shaft or at the toe.
- These reflections travel upward along the shaft and arrive at the pile top at times that are related to their location along the shaft.
- The sensors near the pile top take measurements that translate what is happening to the traveling waves and make it possible to estimate soil resistance and its distribution.

Dynamic Load Test

Termination of Test

The PDA test shall be terminated based on the following conditions:

a. The mobilized capacity achieve the specified load test
b. The induced driving stress achieves the specified limits
c. The integrity of the pile starts to deteriorate and unsatisfactory
d. The ultimate pile capacity is achieved to the specified criteria.

Dynamic Load Test

Test Results

The pile tested shall be deemed failed if:

a. The total settlement under the Working Load exceeds 12.5 mm; or
b. The total settlement under twice the Working Load exceeds 38 mm
c. Pile BTA < 80%
d. Pile integrity : Damaged / Broken
e. DFN > 25mm

Pile Identification	G 2-2
Location	-
Type of Testing	Restrike
Date of Driven/Casted	17-05-17
Date of testing	22-05-17
Pile Type & Size (mm)	350mmØ spun pile
Grade (Mpa)	80
Working Load (tons)	65
Test Load (tons)	130
Total Length (m)	33
Pile Combination (m): Top –Bottom	9 + 12 + 12
Length Below Gauges (m)	31.4
Penetration (m)	30.9
Area (cm^2)	615.75
Density (T/m^3)	2.6
Wave Speed (m/s)	4400
Hammer Name	7.0 Tons Jttn
Ram Weight (tons)	7.0 Tons

SUMMARY OF PDA FIELD RESULTS

LP (m)	RMX (tons)	FMX (tons)	CSX (Mpa)	EMX (tonne-m)	Hram (m)	Eram (T-m)	Eff (%)	Set/ 10 blows (mm)	BTA (%)	Pile Integrity
31.2	164	158	26	1.6	0.35	2.45	52	2	83	Intact

SUMMARY OF CAPWAP ANALYSIS RESULTS

Skin Friction (tons)	End Bearing (tons)	Pile Capacity (tons)	Settlement 1 (mm)	Settlement 2 (mm)
131	31	162	4	9

This pile was structurally intact at the time of testing. It had achieved activated static capacity of 162 tons at the time of testing.

Pile head settlement for this pile at the test load of 130 tons was computed to be 9mm at the time of testing.

Statnamic Load Test

Introductions

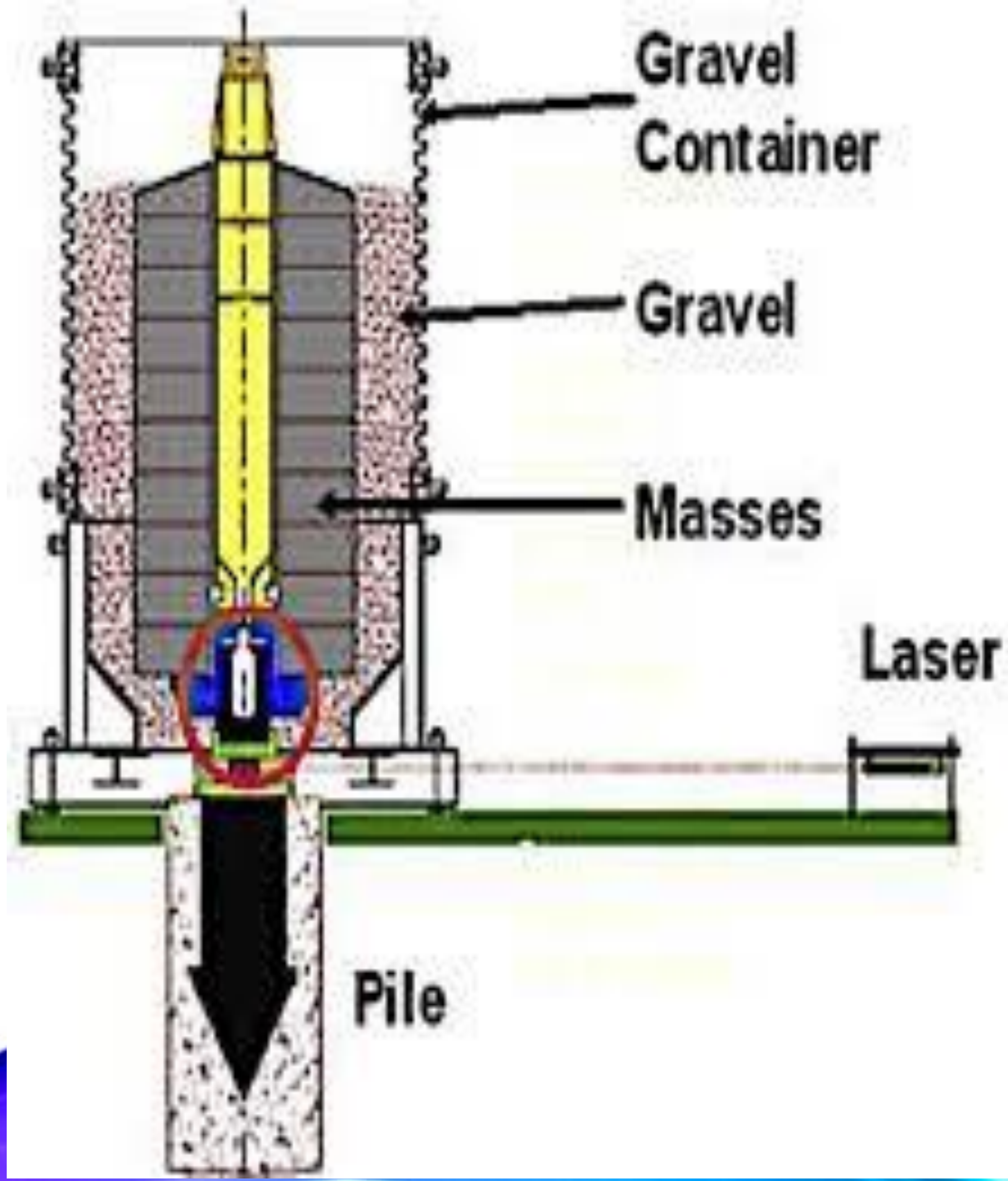
1. Statnamic pile testing is based upon launching a reaction mass. It works by accelerating a mass upward that in turn imparts a load onto the foundation pile below the Statnamic device.
2. For catching the fall back of this reaction mass, Statnamic uses unique techniques based upon gravel and hydraulic systems.
3. As the device does not rely on gravity to apply loads as in static or drop weight testing it can be used vertically, horizontally and inclined to test raked piles. The ability to test horizontally has led to the method being used for lateral load testing of piles and simulation of ship impacts on mooring bodies.
4. Test device are capable of assessing the high load carrying capacity of deep foundations up to 30MN

Statnamic Load Test

Test Operation

1. To prepare the test, the cylinder with pressure chamber is connected to the pile head and the reaction mass (only 5-10% of the load tested) is placed over the piston.

2. Statnamic loading is applied in a gradually increasing manner and unloading is achieve by a controlled venting of the pressure.



Statnamic Load Test

Test Operation

3. The test starts with igniting the solid fuel propellant inside the pressure chamber, generating high-pressure gases and accelerating the reaction mass.

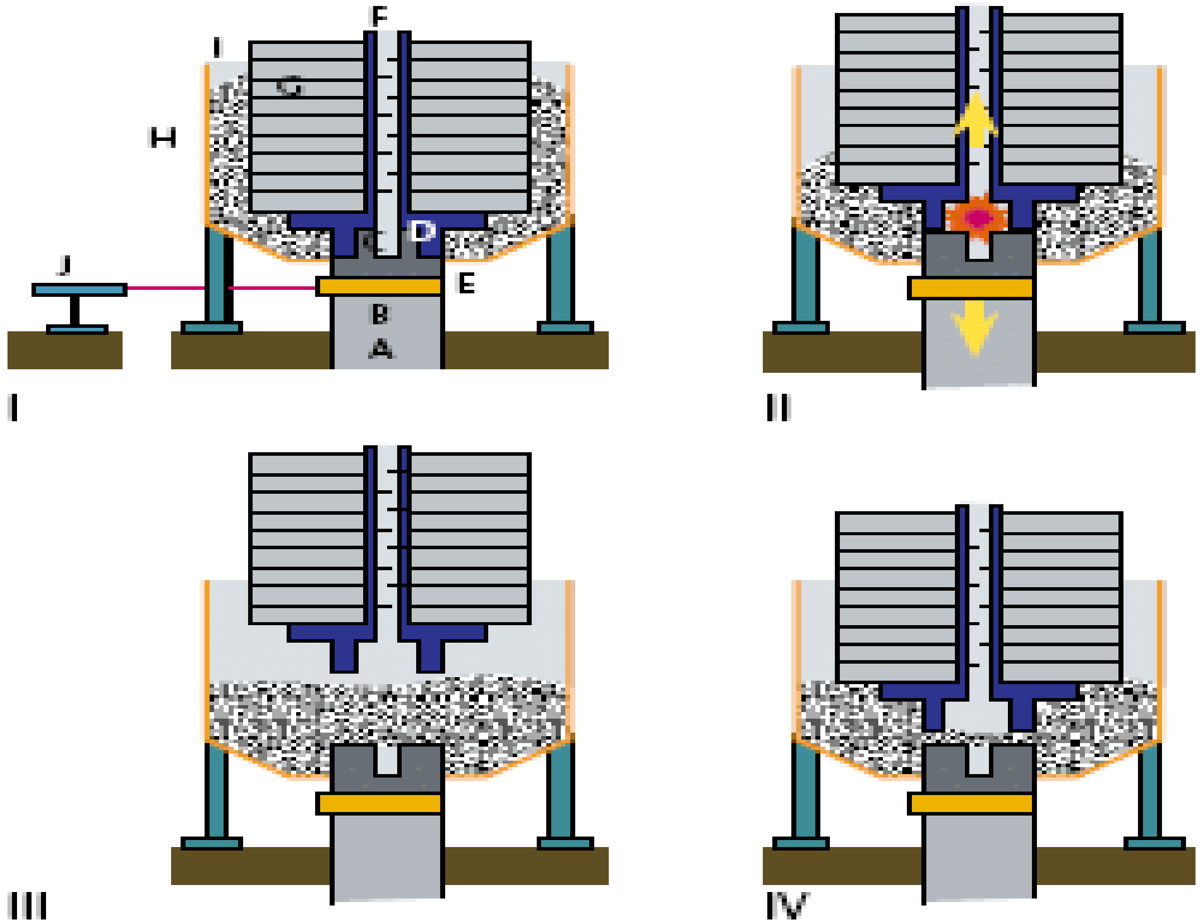
   It creates a large pressure which drives the reaction mass upward.

   An equal and opposite force pushes downward on the pile. At this moment, the actual loading of the pile takes place.

Statnamic Load Test

Test Operation

4. The space caused by the upward movement of the reaction mass will be filled by gravel.
5. The gravel catches the reaction mass and transfers the impact forces to the subsoil.
6. The applied force, displacement and acceleration are directly monitored. All signals are measured by the data acquisition system whereby the mobilized capacity and static load displacement behavior can immediately be presented in a load-displacement diagram.



Four stages of a Statnamic test with gravel catch system.

A = pile to be tested	F = silencer
B = load cell	G = reaction mass
C = cylinder & pressure chamber	H = gravel container
D = piston	I = gravel chamber
E = platform	J = optical measuring system

General Comparison of Piling Testing Methodologies

	Program	Set Up Time	Availability	Logistics	Safety	Cost
Statnamic	7 to 10 days (plus availability)	◔	◔	◑	◕	●
MLT with Kentledge Blocks	4 to 7 weeks	●	●	◔	◔	◔
MLT with Reaction Piles	2 to 3 months	●	●	◕	◑	◑
O-Cell	2 to 3 months	◑	◔	●	●	◕
PDA	2 to 3 weeks (plus availability)	◔	◔	◑	◕	◕

Most ● ◕ ◑ ◔ Least