About Lloyds

• Established in Belfast 1991
• Company now has offices Ireland, UK and Poland.
• Companies employ 40 people in these regions
• Since 1991 we have completed approximately 200k pile integrity tests. 100K dynamic tests 8K static pile load tests.
• Company has accreditation Quality Management Status ISO 9001
• Associate company of Datum Monitoring
Presentation Agenda

• Background to Dynamic Pile Testing and Capwap Analysis
• Static Load Testing
• Changes to Piling Practice
• Lessons Learned (or were they ?)
Why test at all?

- Professional Duty of Care
- Control Measure Insure
- Risk Management
- Quality & Confidence
Why should we use Dynamic Pile Testing

- The Irish construction industry spends a lot on deep foundations (in Ireland estimated at 40-50 million euro/year)
- We want low risk of failure - remediation is expensive
- We want safe infrastructure and buildings
- Testing and analysis allows for optimizing a foundation, consideration of greater use of Preliminary Pile Testing in advance of contract works.
Evolution of PDA

1958
1965
1973
1982
1992
1997
2007
Types of Piles Tested Using Dynamic Testing Process

**Displacement Piles**
- Precast concrete
- Prestressed Concrete
- Steel H-section
- Timber
- Driven cast-in-situ
- Sheet piles
- Minipiles

**Replacement Piles**
- Bored:
- CFA
- Rotary
- Minipiles
PDA Testing (terminology)

Hammer System

Hammer

Falling Hammer Ram

Drive System Assembly

Pile Top, Head, Butt

Pile Shaft, Skin

Pile Bottom, Toe, Base
Dynamic Pile Testing (P.D.A.)

- Remote Pile Driving Analyser
- Strain Gauge
- Accelerometer Gauge

TYPICAL USE ON PILES

Engineers Ireland Seminar 4th November 2015
Typical Dynamic Test Trace

Lloyd Acoustics Ltd.
N8 Cashel-Mitchellstown Road Improvement Scheme
PDA OP: Gareth Stevenson

PILE DRIVING ANALYZER ®
Version 2004.096
East Abutment SAP7
STEEL H PILE
02/10/2006 11:23:25
CSB 129.9 MPa
CSX 154.5 MPa
TSX 39.1 MPa
EMX 27.8 kN-m
RMX 2348 kN
LTD 0.0 m
BTA 100.0 (%)
RXS 2730 kN
DMX 16 mm
LE 19.8 m
AR 161.30 cm^2
EM 206943 MPa
SP 77.3 kN/m3
WS 5123.0 m/s
EA/C 651 kN-s/m
LP 18.8 m
F12 A12
F1: [5929] 97.5 (0.75)
F2: [6058] 97.4 (0.8)
A1: [70751] 1070 g's/v (0.8)
A2: [42720] 1070 g's/v (0.8)

Lloyd Acoustics Ltd.
DUNGARVEN RETAIL
PDA OP: Sean Hagan

PILE DRIVING ANALYZER ®
Version 2004.096
BLKAP115
Precast
30/08/2006 19:47:52
CSB 16.4 MPa
CSX 18.8 MPa
TSX 0.8 MPa
EMX 20.3 kN-m
RMX 1185 kN
LTD 0.0 m
BTA 100.0 (%)
RXS 1349 kN
DMX 21 mm
LE 13.4 m
AR 756.25 cm^2
EM 39647 MPa
SP 24.3 kN/m3
WS 4000.0 m/s
EA/C 750 kN-s/m
LP 12.5 mm
F12 A12
F1: [5926] 92.4 (0.8)
F2: [85492] 96.1 (0.8)
A1: [77688] 1050 g's/v (1)
A2: [42720] 1070 g's/v (1)
Damage Detection: Spliced pile Example

**Good Pile**

**Bad Pile: Early reflection**

Engineers Ireland Seminar 4th November 2015
‘CAPWAP’ - Analysis

Engineers Ireland Seminar 4th November 2015
Likins, Rausche, 2004. “Correlation of CAPWAP with Static Load Tests”. Proc. 7th Int’l Conf. on Application of Stresswave Theory to Piles: Malaysia
Dynamic Testing of Bored Cast InSitu Piles and Reaction Beam setup
Kentledge Testing

PAST

PRESENT or should it be?

Engineers Ireland Seminar 4th November 2015
Reaction Beam
Static Load Test Systems

600T compression test

1200T Compression test Mallow
Pile Shaft Instrumentation
Test Beam Strain Logger Setup
Pile Head Displacement Data Outputs

![Graph showing Pile Head Displacement Data Outputs](image-url)
Strain Data Outputs
Pile Integrity Testing (P.I.T)
Piling & Testing has evolved

• Engineers have greater knowledge of our soils with improved site investigation
• Piling contractors can offer broader range of piling alternatives
• Pile design is asking for greater SWL & DVL pile load capacity
• Engineers have adopted quality control using pile foundation testing
Piling through the years
Driven Piling Techniques

Pile driving
Bored Piling Drilling Techniques

Rotary
Bored
CFA
Lessons Learned
What can go wrong?

- Inadequate Site Investigation
- Platform Design Failures
- Wrong Pile Type
- Unsupervised Pile Installation
- Wrong Hammer Selection
- Pile Relaxation
- Poor Pile Preparation
Rossary Quay Enniskillen

- Site passed for development of luxury apartments and town houses alongside River Erne, Enniskillen
- Decision by developer was to design a Load Transfer Platform (LTP)
- Residents reported “cracking in walls” in early 2002
- Reports of roads and gardens becoming very uneven
Rossary Quay

- Borehole logs for the early discussions were used from a “site close by”!
- Site was liable to flooding, with poorly draining soils
- Risks of the limestone undergoing carcification
• Borehole undertaken in 1997 recommended that in order to avoid differential settlements it would be necessary to pile 100% of the development.

• The site investigation exposed presence of bedrock overlain by thin deposits of boulder clay, followed by very soft lacustrine deposits.

• Predictions of placing 1 metre of stone in-fill would lead to settlement equalling 800mm.

• The risks of excessive sinking comes directly as a result of the low shear strength of the lower bound sub soils incapable of withstanding any substantial loads.
• Design decision opted for the road and gardens to be constructed on LTP using “triangular arrangement of piles”. The main structures would be constructed on the traditional piles driven to rock.

• Remarkably, a late decision was made to construct roads and houses on the LTP and only four storey buildings were piled to rock.
• Engineers must ensure they choose contractors with the correct level of knowledge and experience

• All Decisions should be made within the compliance of engineering ethics

• Lack of communication between consultant>Engineer>Contractor can have catastrophic consequences
N7 Nenagh to Limerick High Quality Dual Carriageway 2008
Challenges encountered from pile testing at Nenagh Bypass

- Peat bog overlying dense / coarse gravels overlying rock
- Two Sections of this carriageway traversed existing peat bogs, Anaholty Bog and Drominboy Bog
- Slenderness ratio of piles versus driven depths
- Temporary piling platform very unstable
- Pile depths predicted between 18-21m along the length of the bog
- Static Compression Load tests “but how?”
• FK Lowry were nominated as piling contractor
• Contract estimated at 200,000 linear metres of precast concrete piling
• Piling rigs weighed in excess of 60 T each and working within close proximity of each other was prohibited
• Concrete casting for the piles was setup at site compound with concrete quality control plan
• **Selection of pile type**
  discounted displacement piles leaving only driven concrete or steel as feasible choices

• **Dynamic pile testing**
  demonstrated pile capacity was achievable but at a greater depth than predicted

• **Transfer of load axially**
  into the pile despite over lengths

• **Greater pile depths**
  brought greater challenges to
  
  - Pile Quake
  - Pile Bending
  - Pile stress on joints
• Lloyd Acoustics asked to provide alternative method for static load tests (SLT)

• Stability of the bog proved very difficult for piling rigs but impossible for scheduled “Kentledge type tests”

• Risk of Platform failure under footprint of “Kentledge tests” was high

• Sacrificial drill anchors were chosen - at each SLT location sized dependant on maximum load capacity
Piled carriageway through an existing peat bog

• Advantages of the sacrificial anchors: They had to be drilled minimum 4 metres into a competent rock, thereby confirming the pile depth at each of these locations
• Small light-weight “cradle beams” were selected with test capacities of <3000kN
• Testing commenced in April 2009
• 10% of the 8000 piles driven were dynamically tested, 185 No. were static load tested (28 of these were preliminary type)