Electrical Density Gauge

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Transportation Research Board
Meeting January 2009
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Electrical Density Gauge™
Construction Aid Monitors Compaction

The Electrical Density Gauge (EDG) is a non-nuclear alternative for nuclear gauges in determining the physical properties of compacted soils used in road beds and foundations. The EDG is a portable, battery-powered instrument capable of being used anywhere in the world without the problems associated with nuclear safety.

The EDG measures and displays the wet and dry density, gravimetric moisture content and percent compaction. Easy-to-use, the EDG can be used as a construction aid to monitor day-to-day compaction operations by providing performance and measurement results highly comparable to those achieved with traditional methods, including nuclear gauge, sand-cone and oven drying methods.

The EDG's accuracy is achieved using point-to-point radio frequency, measuring directly between electrodes driven into the soil, ensuring positive measurements through the soil at full depth of electrodes. No need to make sure the soil is homogeneous or to rely on radio frequency "waves" to penetrate soil materials from the surface. For the contractor the advantages of using the EDG is that it does not require a highly trained or licensed technician, is easy to learn which enables anyone to be trained and is simple to use that measurements are fast and can be done at greater intervals for a more thorough evaluation.

HUMBOLDT

1.800.544.7220 • 1.708.456.6300 • fax: 1.708.456.0137 www.humboldtmfg.com • email: info@humboldtmfg.com
7300 West Agatite Avenue, Norridge, Illinois 60706-4704 USA

Technology Methods

- Radio Frequency Measurements
  - 3 Mega-hertz (100 meter wave length)
- Dart Length and Spacing controls sample size
  - Easy to control and very definitive
  - e.g.: 6” dart at 14” spacing = 0.5 cu ft
- Onboard geo-electrical algorithms for moisture,
- Onboard geo-electrical algorithms for moisture, density & compaction

The Electrical Density Gauge Technology For Soil Material Compaction And Soil Moisture Testing In Geotechnical Engineering

Measurements of the soil electrical parameters current (Is), voltage (Vs), and phase (Ps) are made with circuitry that is well known in the field of electronic engineering, and implementation of these measurement means can take a variety of forms. The frequency source used in the EDG operates at 3.0 mHz.

From the electrical soil measurements, the software then calculates resistance (Rs) and capacitance (Cs), the quotient Cs/Rs, and real impedance (Zs).

Cs/Rs $\rightarrow$ weight of water by a linear equation

And:

And;

Z $\rightarrow$ wet density of the soil material by a second linear equation.

EDG Series C Instrument

Soil Model Upload And Download Capabilities

GPS Feature and GPS Mapping Program

Windows Excel Easy Interface

Enhanced Data Entry And Data Management Features

Data Graphing Features and Soil Model Field Editing

Model Sharing – Clearing House Program

Electrical Density Gauge,
Model – C Technical Specifications

EDG is packaged in a water-resistant enclosure and employs water resistant connectors.
EDG will operate correctly to an altitude of 10,000 ft.
Wet Density Range: As found in typical compacted earth sites
Dry Density Accuracy: Typically within 3% of standard physical tests
Moisture Content Range: As found in typical compacted earth sites
Moisture Content Accuracy: Typically within 2% of standard test
Maximum RS-232 Cable Length: 50 ft.
Internal Power: 12V lead acid gel cell, 4.0 AH capacity
Operating Time Before Recharge: Approx. 8 hr.
Ambient Temperature Range: 0 deg. C to 50 deg. C
Ambient Humidity Range: 5% to 90% non-condensing
EDG Console Weight: 11 lb.
EDG Console Dimensions: 13.5 in. x 12 in. x 6 in.
Weight of EDG Accessories: Approx. 4 lb.

Memory Capacity:

- •Job Sites: 30

Memory Capacity:

- •Job Sites: 30
- •Field Tests per Job Site: 30
- •Soil Models: 30
- •Soil Tests per Soil Model: 3 to 16

Intelligent Compaction

(Delaware Case Study)

Christopher L. Meehan, PhD

Faraz S. Tehrani

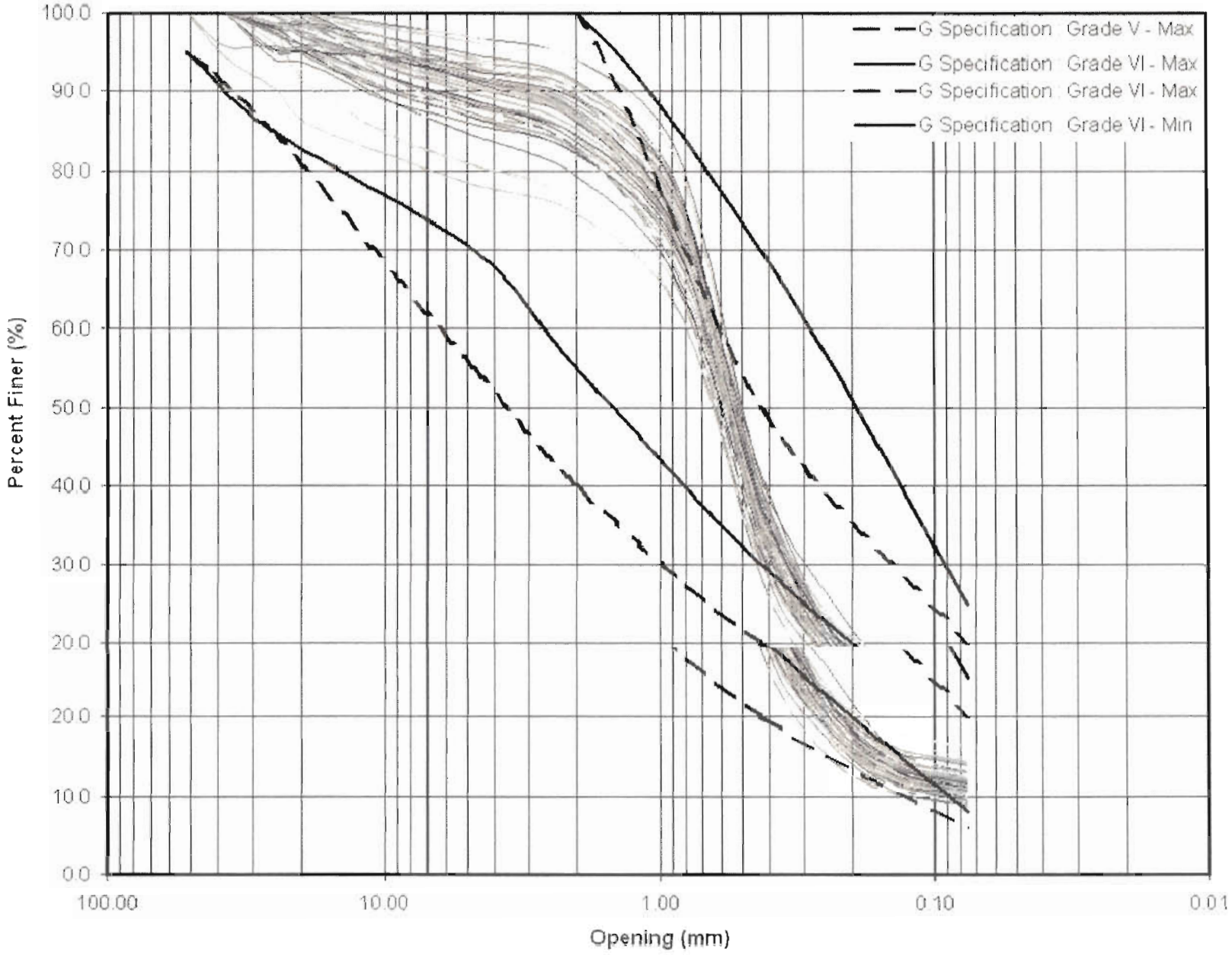
Department of Civil & Environmental Engineering

General Descriptions

- Embankment:
  - 200 ft by 20 ft embankment
  - Five 8 in. loose lift layers
  - Final height after compaction: 3.0 ft
- Material:
  - Well-graded sand with silt (SW-SM) which conforms to DelDOT "Select Fill" borrow

conforms to DelDOT "Select Fill" borrow
specifications (Class G, Grades 5 & 6) .

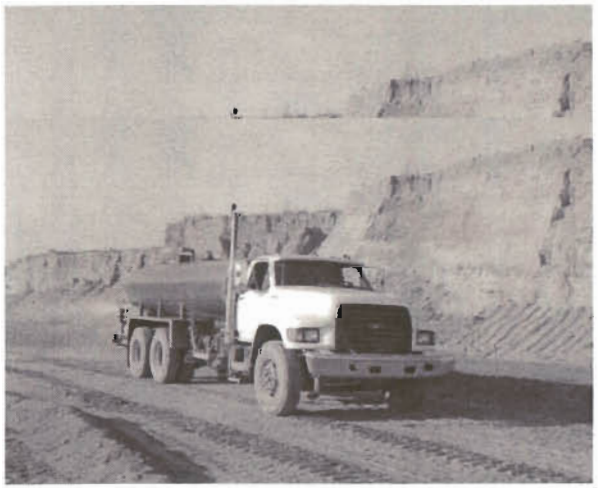
Sieve Analysis Results



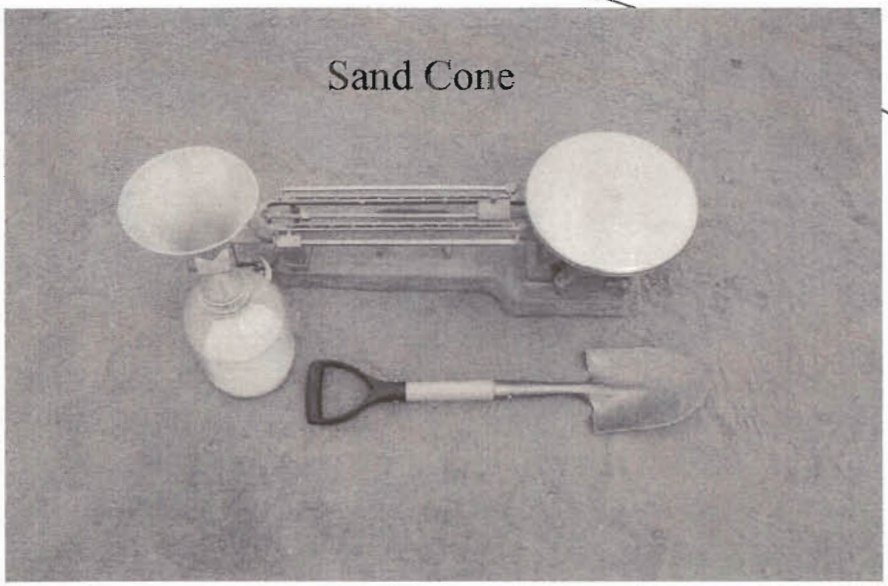
Equipment Utilized

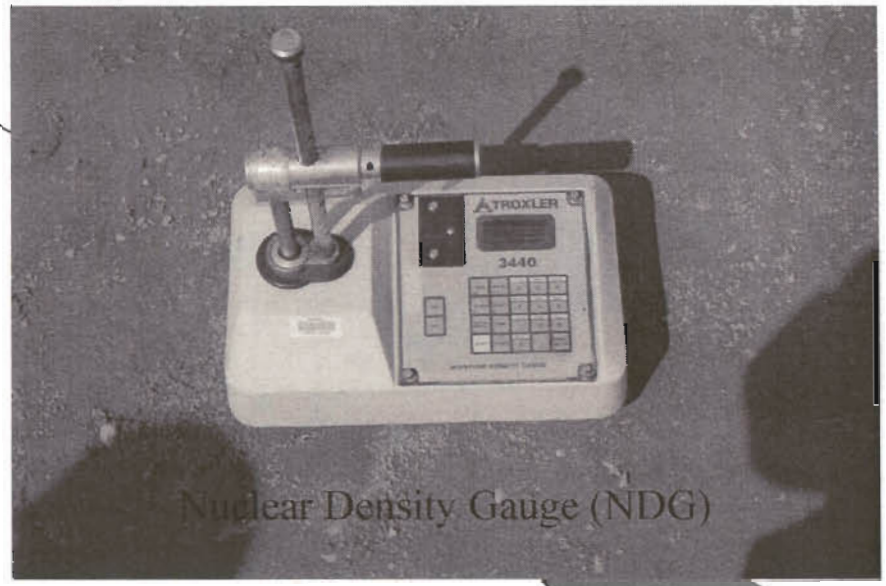
Construction Equipment:

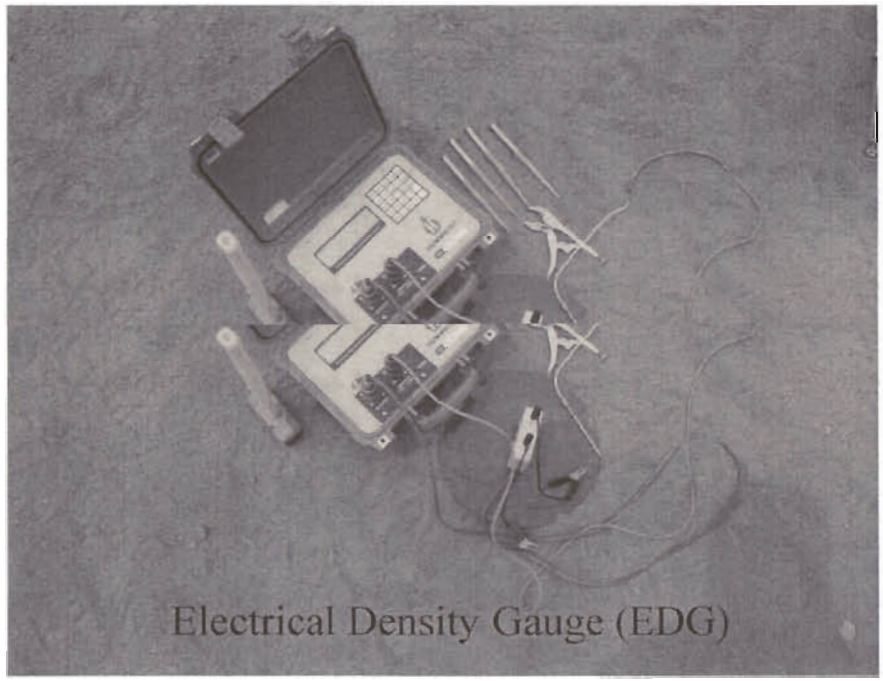
- Caterpillar 980H bucket loader
- Caterpillar D6K dozer
- Water Truck
- Caterpillar CS56 compactor



Univ. of Delaware Project 2008

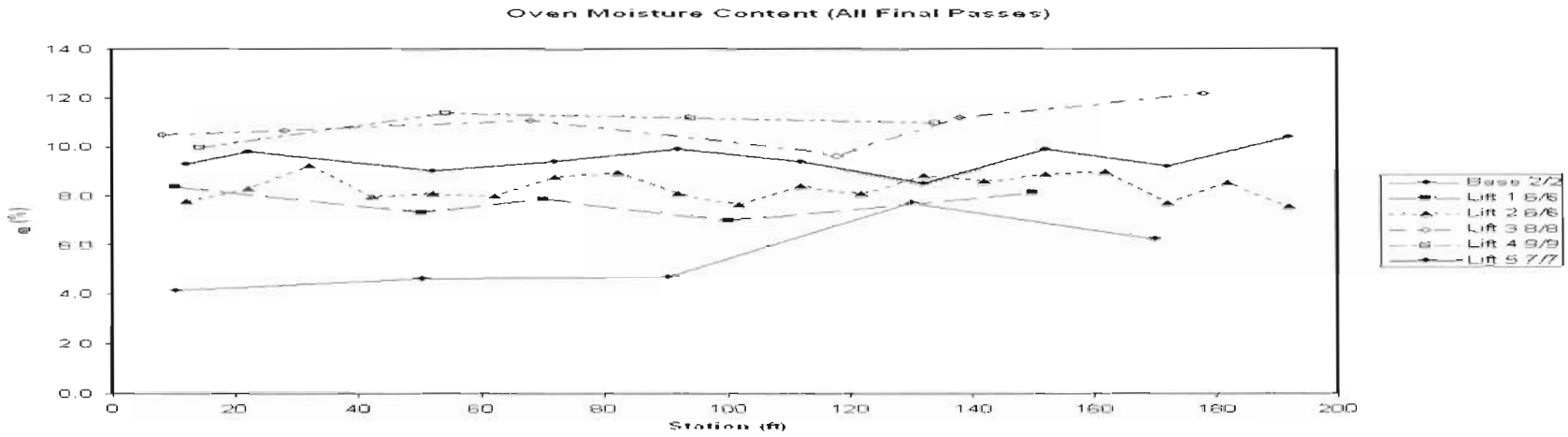

Sand Cone

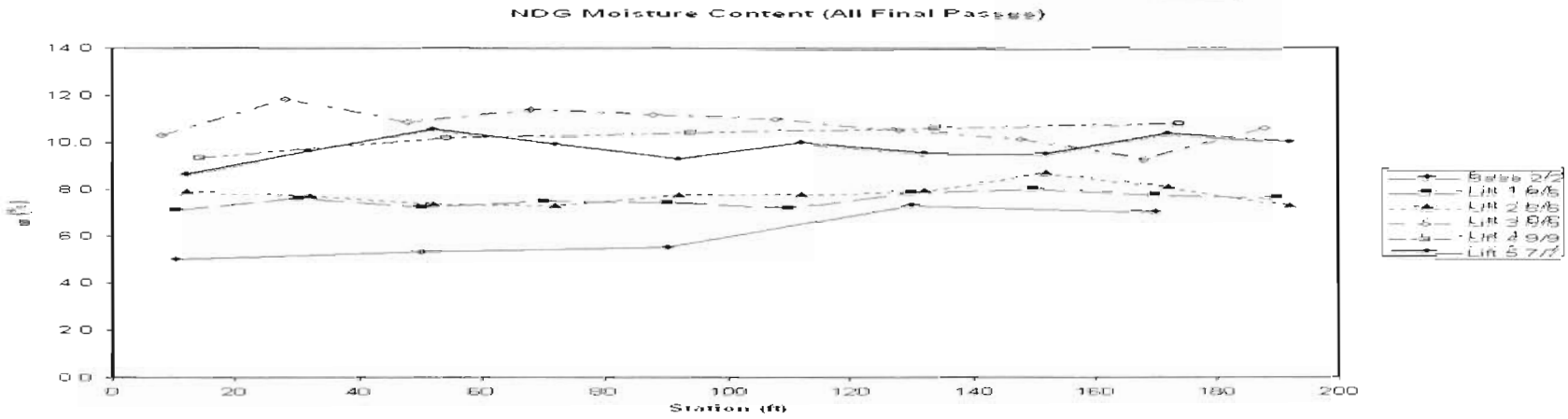

TROXLER
3440
Nuclear Density Gauge (NDG)


Electrical Density Gauge (EDG)

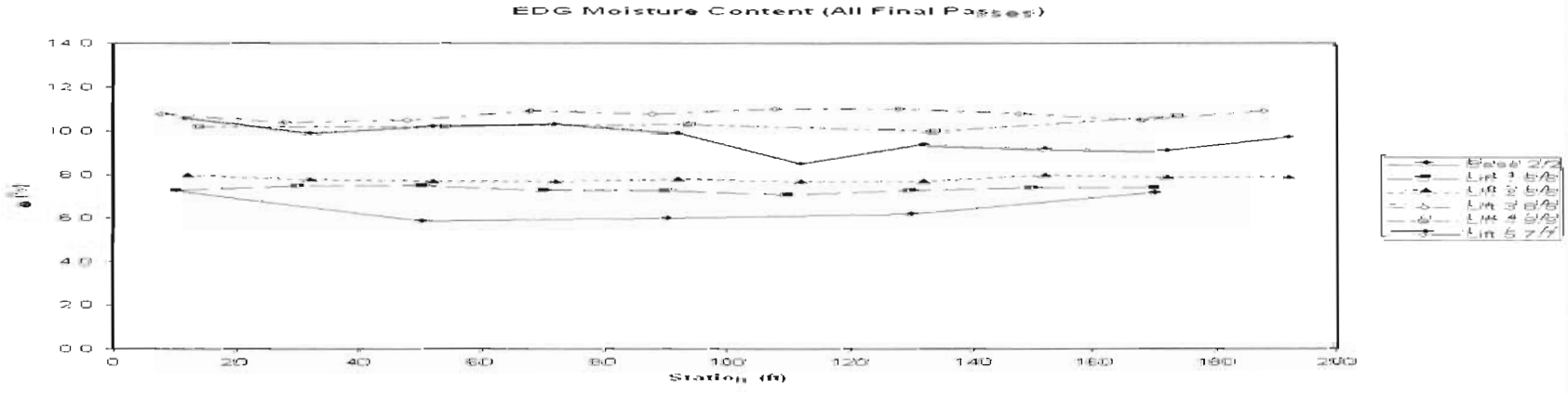
University of Delaware Project 2009
The Results of Density-Based Tests

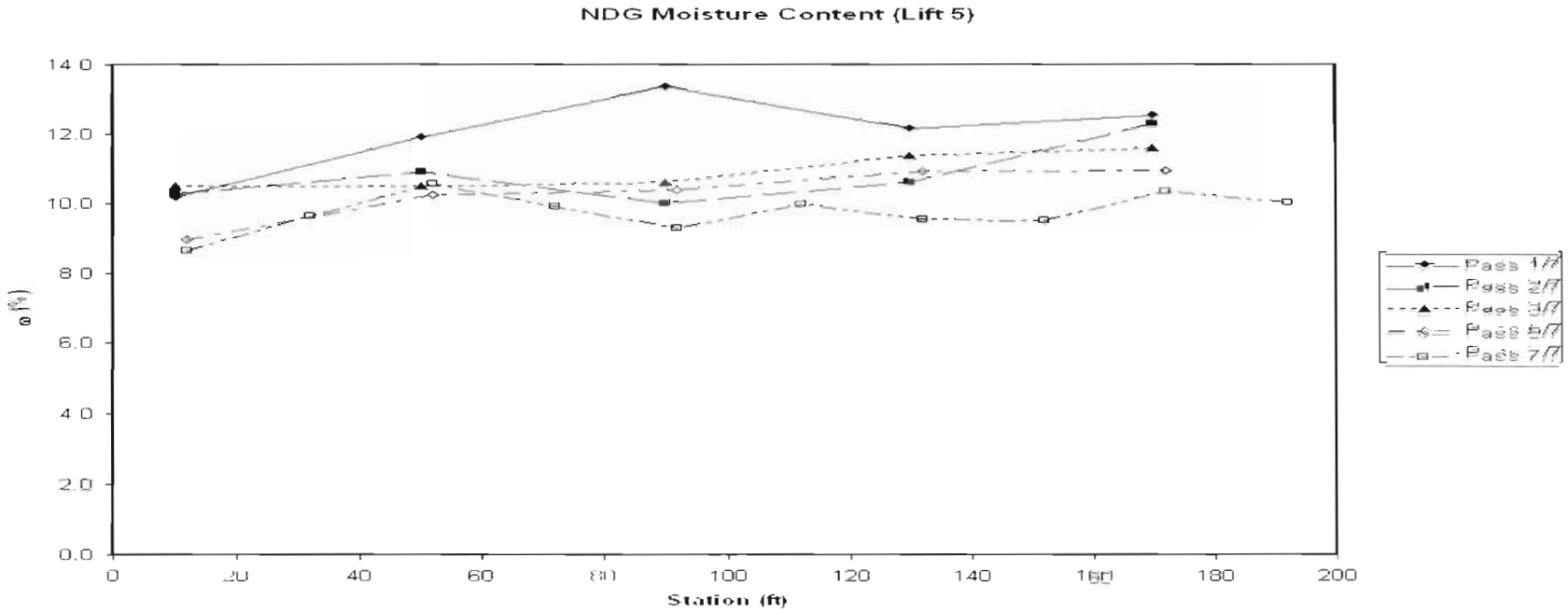
Measuring:
Moisture Content
Dry Unit Weight

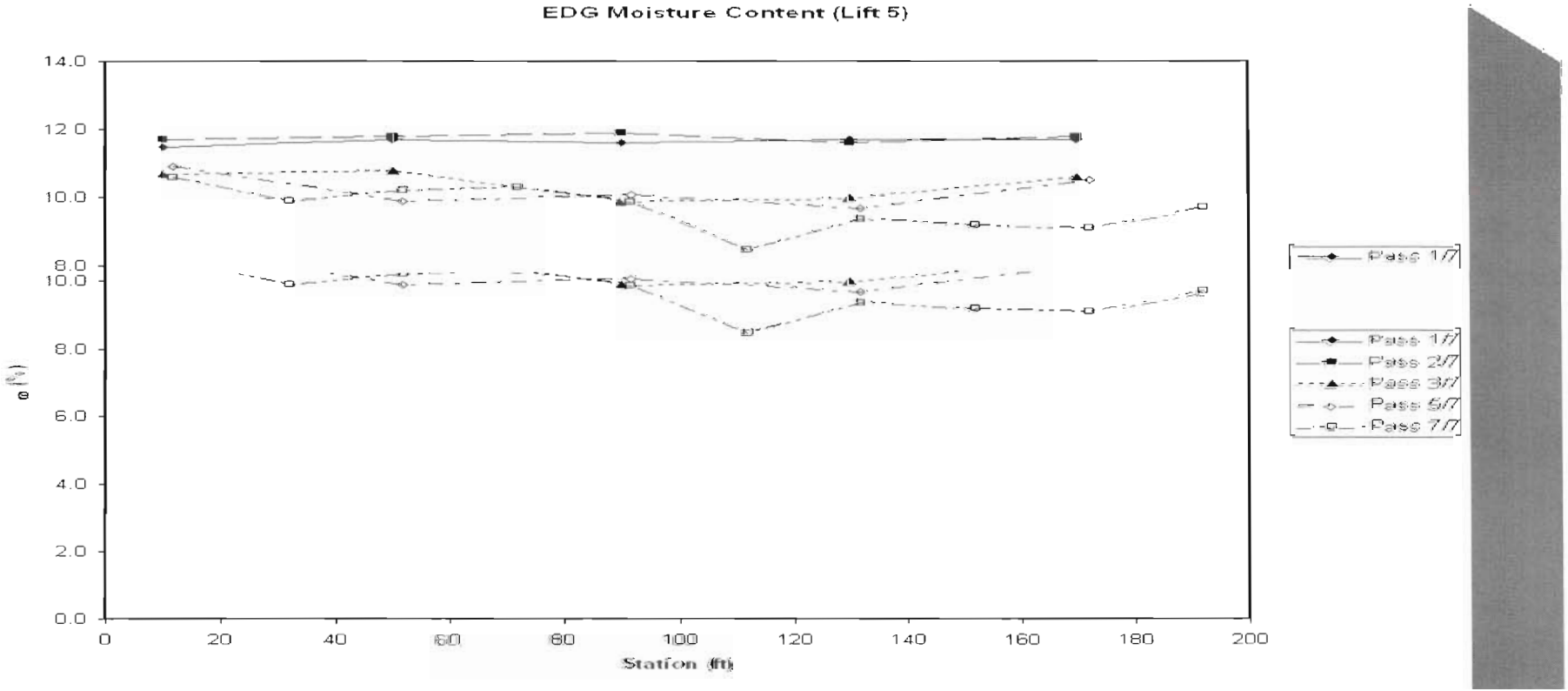

Oven Moisture Content (All Final Passes)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Station (ft)
Base 2/2
Lift 1 5/5
Lift 2 6/6
Lift 3 8/8
Lift 4 9/9
Lift 5 7/7

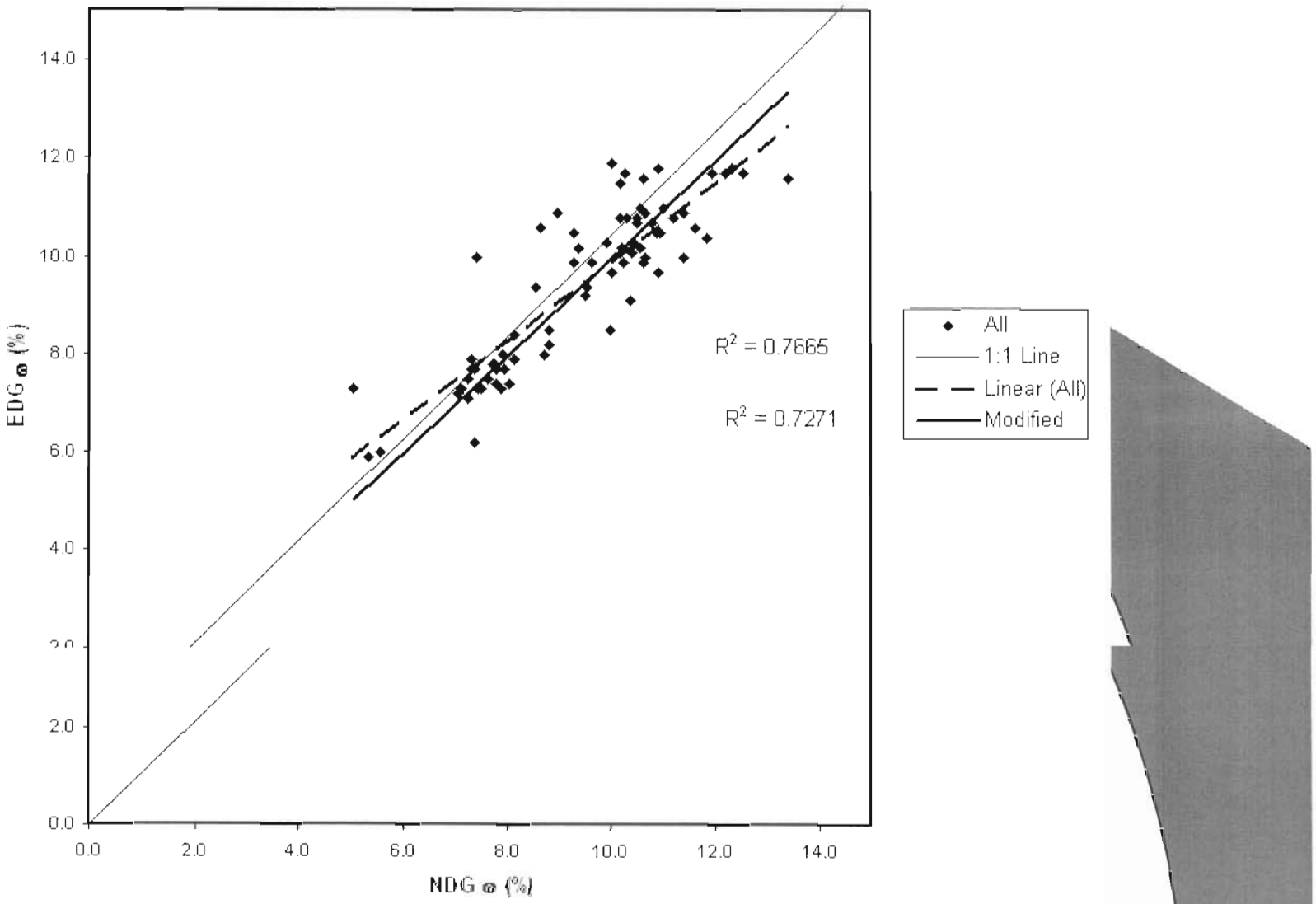

NDG Moisture Content (All Final Passes)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Station (ft)
Base 2/2
Lift 1 5/5
Lift 2 6/6
Lift 3 8/8
Lift 4 9/9
Lift 5 7/7

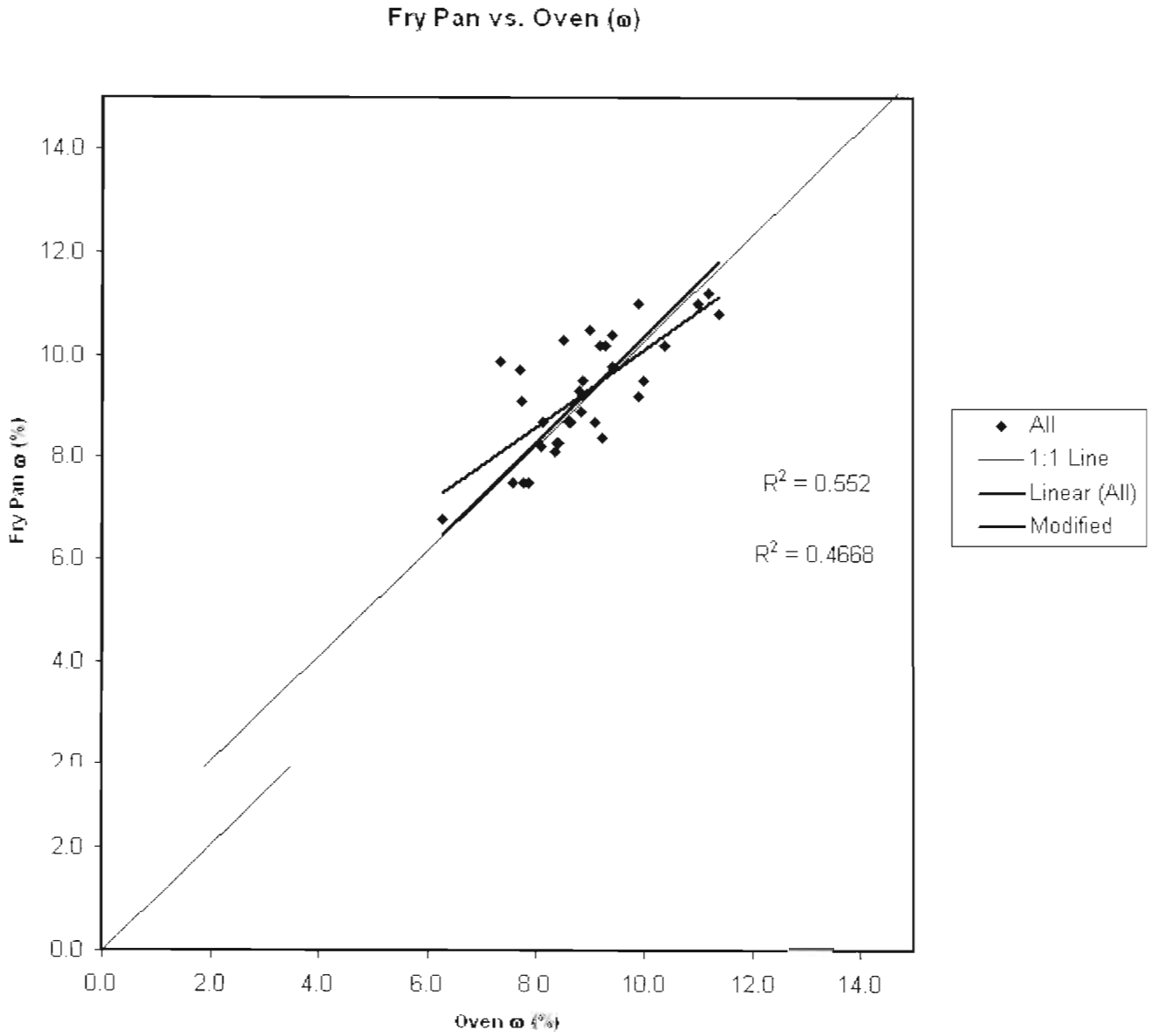

EDG Moisture Content (All Final Passes)
Station (ft)


EDG Moisture Content (All Final Passes)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Station (ft)
Base 2/2
Lift 1 5/5
Lift 2 6/6
Lift 3 8/8
Lift 4 9/9
Lift 5 7/7

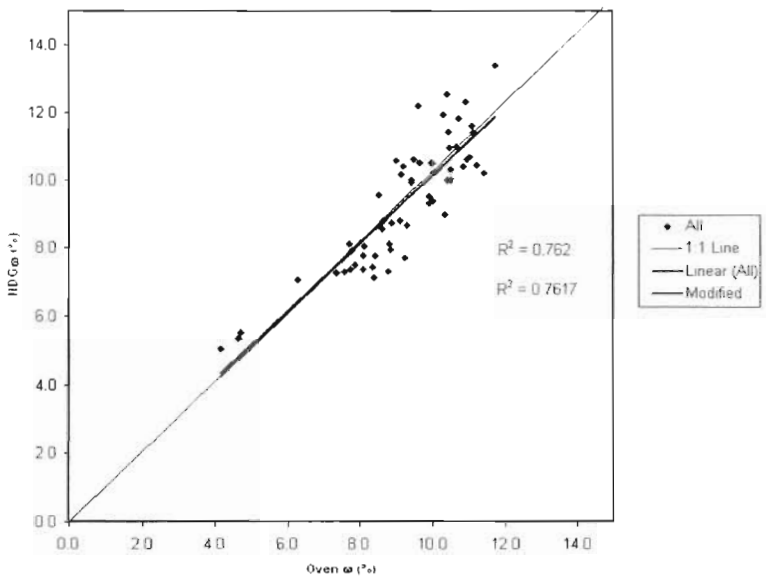

NDG Moisture Content (Lift 5)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Station (ft)
Pass 1/7
Pass 2/7
Pass 3/7
Pass 5/7
Pass 7/7


EDG Moisture Content (Lift 5)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Station (ft)
Pass 1/7
Pass 1/7
Pass 2/7
Pass 3/7
Pass 5/7
Pass 7/7

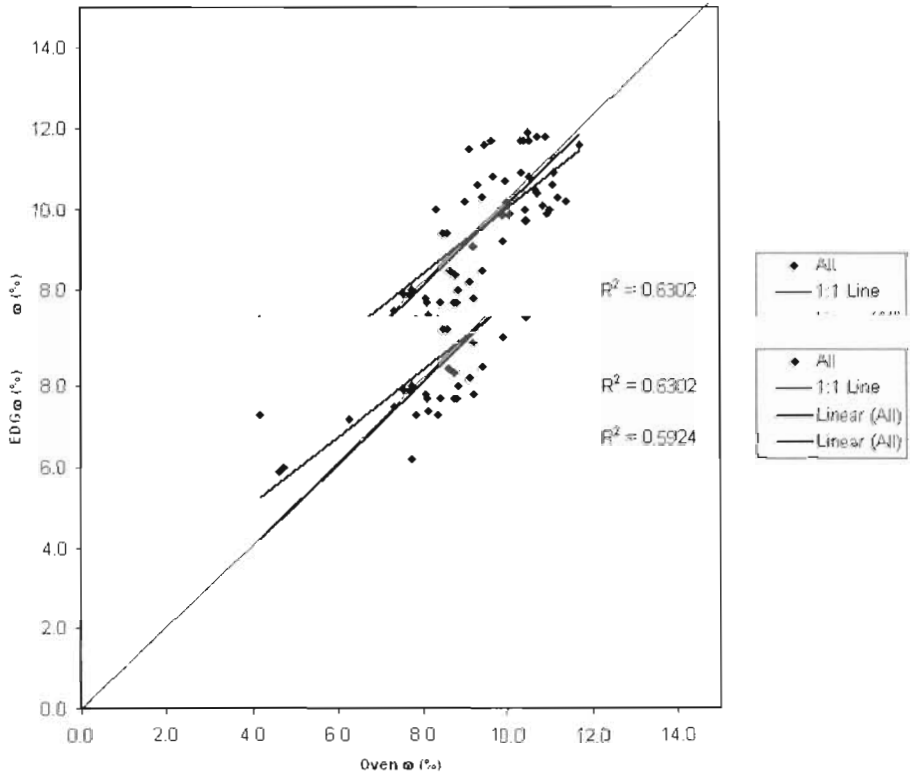

EDG vs. NDG (ω)
EDG ω (%)
NDG ω (%)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
R2 = 0.7665
R2 = 0.7271
All
1:1 Line
Linear (All)
Modified


Fry Pan vs. Oven (ω)
Fry Pan ω (%)
Oven ω (%)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
R2 = 0.552
R2 = 0.4668
All
1:1 Line
Linear (All)
Modified

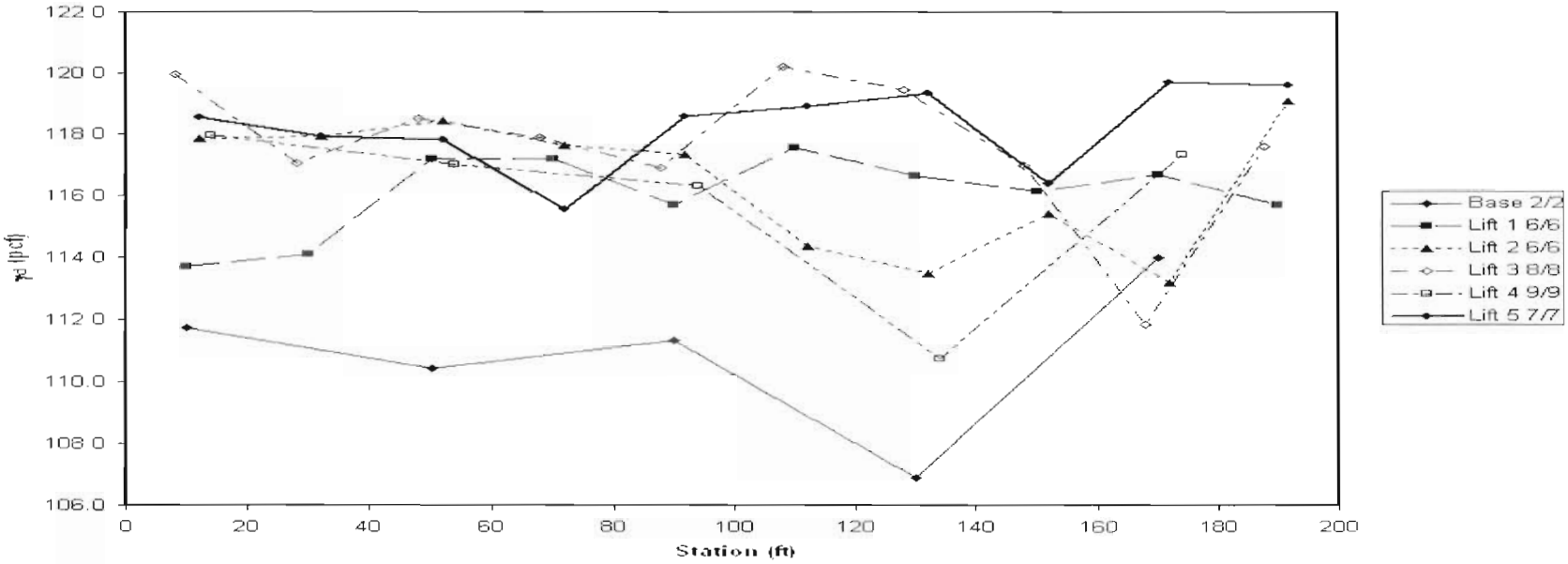
NDG vs. Oven (ϖ)



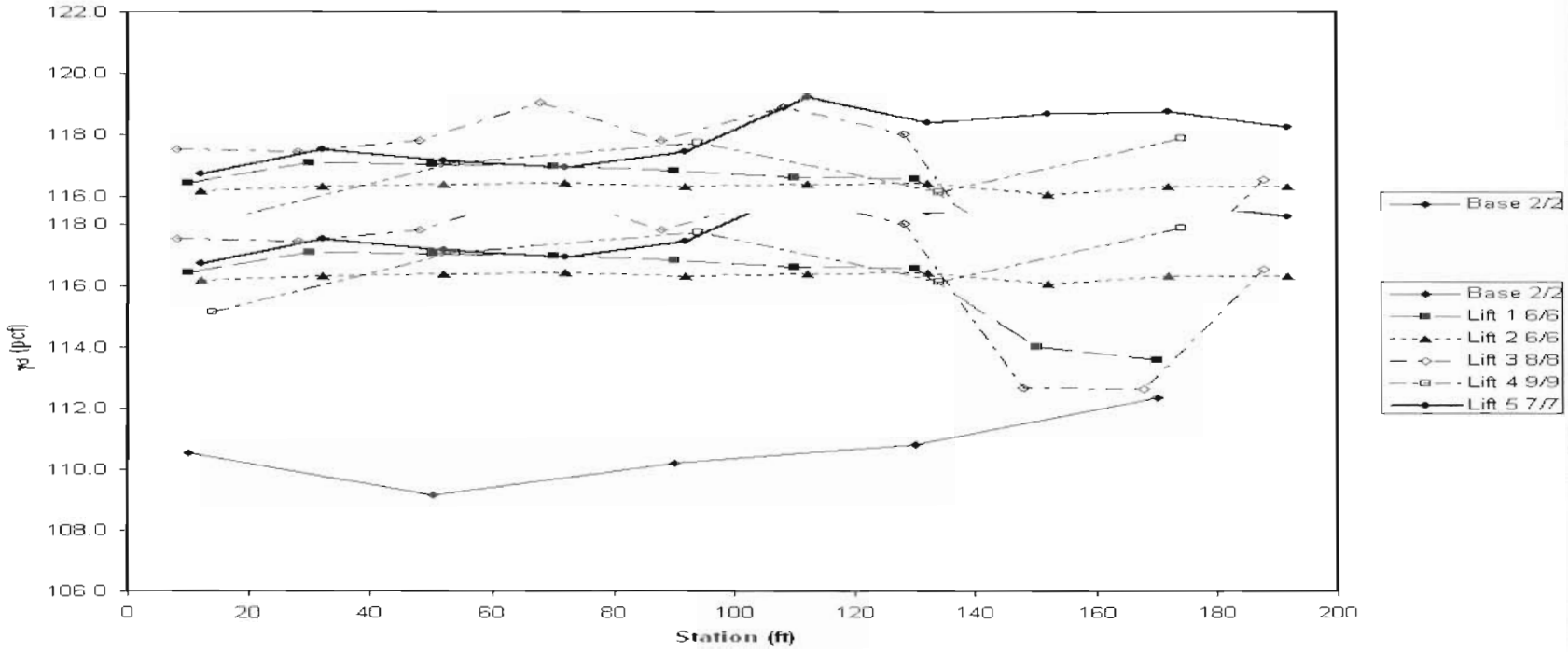
EDG vs. Oven (ϖ)

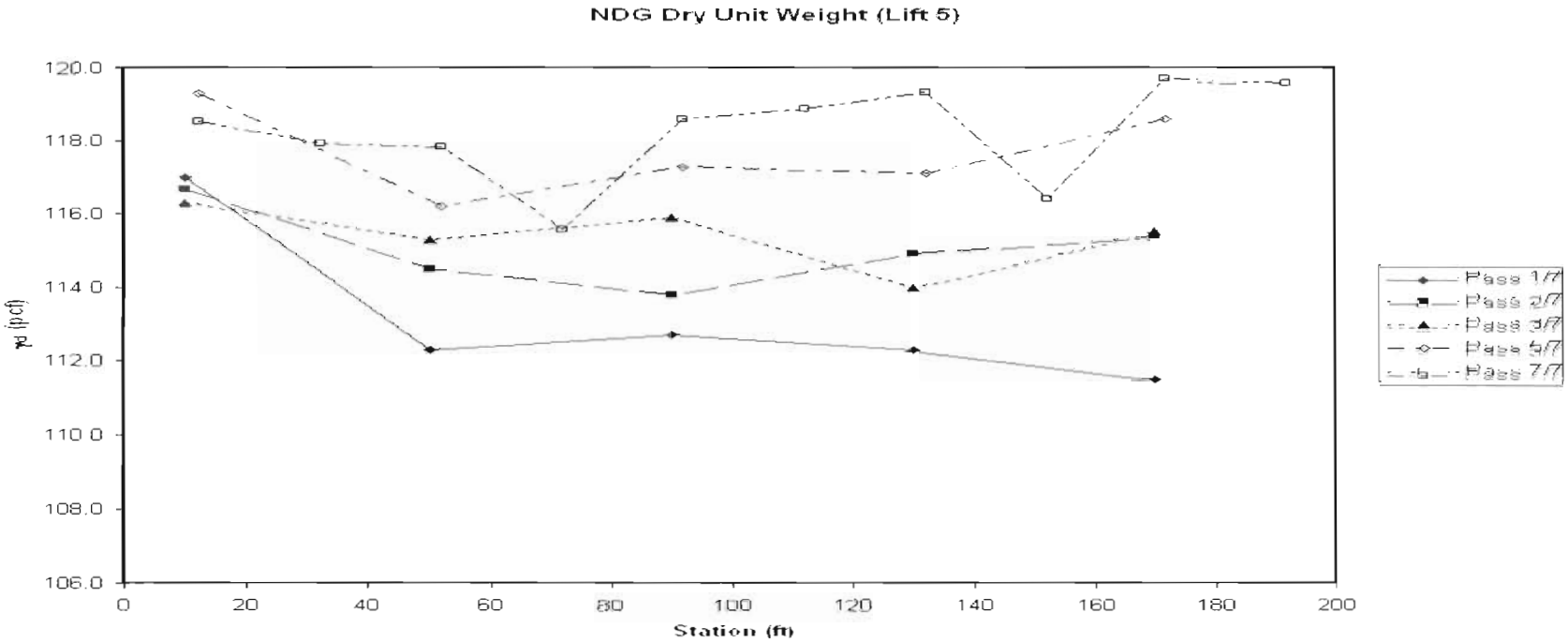


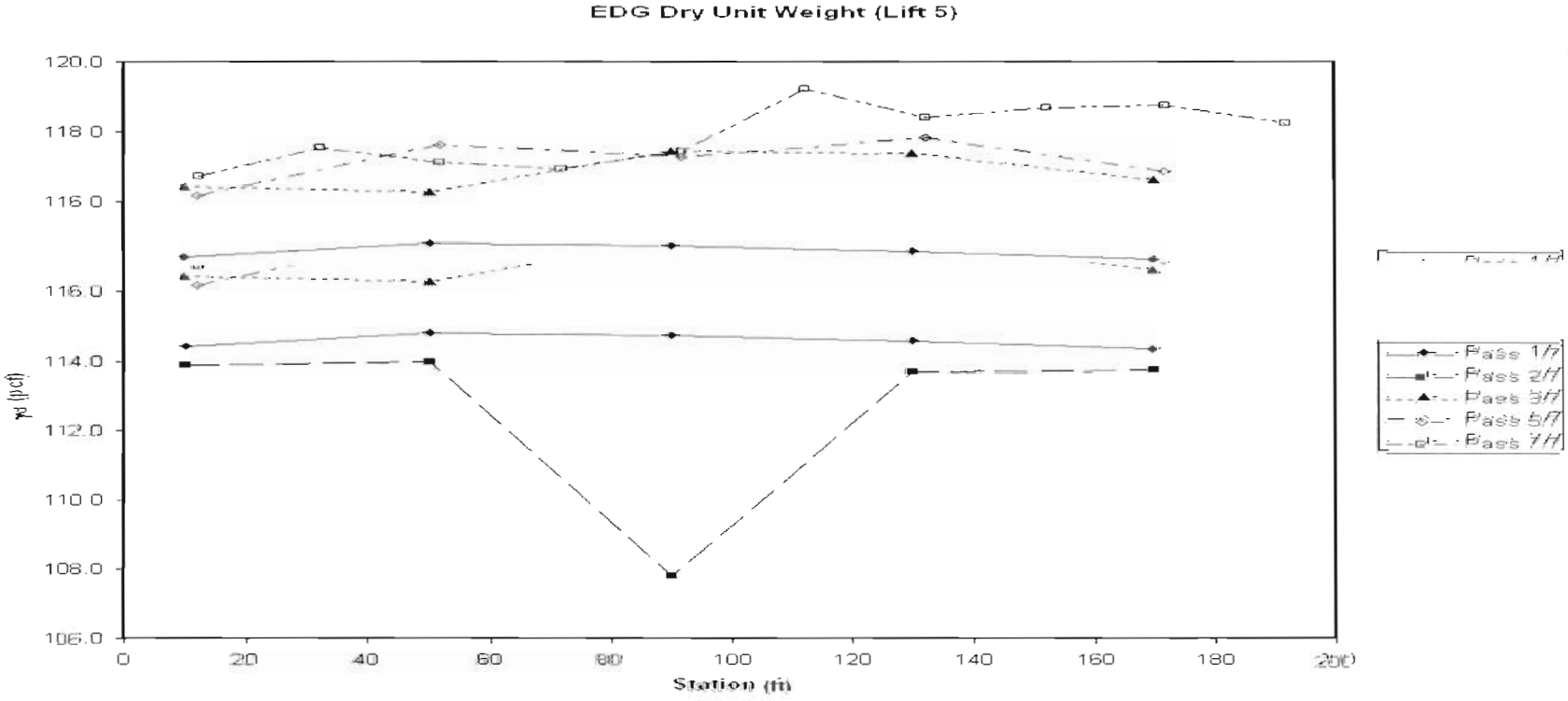
NDG Dry Unit Weight (All Final Passes)



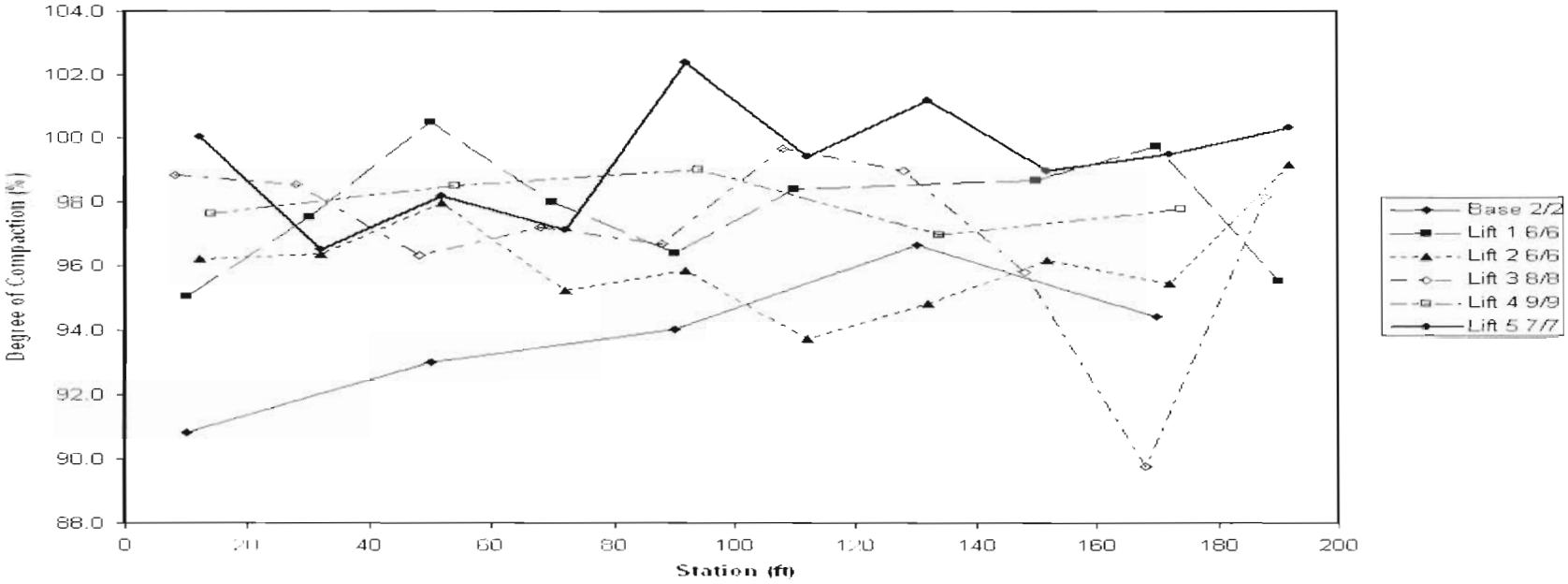
EDG Dry Unit Weight (All Final Passes)



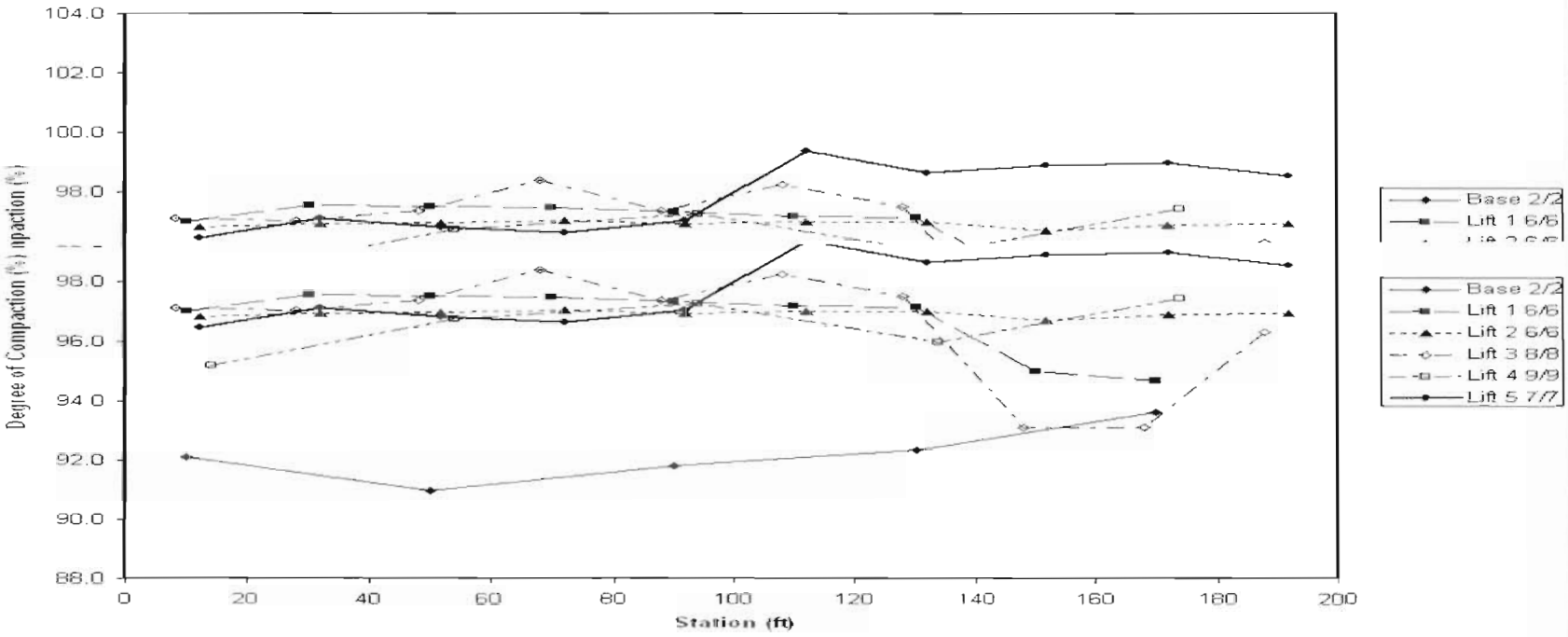

NDG Dry Unit Weight (Lift 5)
120.0
118.0
116.0
114.0
112.0
110.0
108.0
106.0
γd (pcf)
0
20
40
60
80
100
120
140
160
180
200
Station (ft)
Pass 1/f
Pass 2/f
Pass 3/f
Pass 5/f
Pass 7/f


EDG Dry Unit Weight (Lift 5)
120.0
118.0
116.0
114.0
112.0
110.0
108.0
106.0
γd (pcf)
0
20
40
60
80
100
120
140
160
180
200
Station (ft)
Pass 1/f
Pass 2/f
Pass 3/f
Pass 5/f
Pass 7/f

NDG Compaction Degree (All Final Passes)



EDG Compaction Degree (All Final Passes)



EDG 2009 Possible Research Projects

Louisiana State University & LDOT

Kentucky Cabinet of Transportation

University of Delaware – DelDOT

Vermont Agency of Transportation

Nevada Department of Transportation Site Access

Nevada Department of Transportation Site Access

EDG Internal R & D Program

ASTM & AASHTO Standards Development

Dennis Anderson, P.E.
Electrical Density Gauge, LLC
Carson City, Nevada

Electricaldensitygauge.com

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Faraz S. Tehrani, MS Candidate UD

University of Delaware
Department of Civil & Environmental
University of Delaware
Department of Civil & Environmental
Engineering

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