KUBRICKY CONSTRUCTION CORP.
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WILTON, NY 12831
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KUBRICKY CONSTRUCTION CORP.
A PROUD MEMBER OF THE D.A. COLLINS™ COMPANIES

Rutland City BRF 3000 (2014036)
SUBMITTAL 24

Issued **12/19/14**
Respond by 01/02/15

To

Timothy Pockette, PE

Topic	Wave Equation Analysis - Ripley Rd for ICE 60S (HP14x102 & HP14x117)
Status	For Approval
Spec section	505.04
Subsection	(d)(2)
Received from submitter	12/18/14
Sent to approver	12/19/14
Required from approver	1/2/15

From

Volker H.D. Burkowski

Signed by [signature] Date 12/19/14

Proceed as Indicated ______________________ Date ______________
Owner Authorized Representative

GEOSCIENCES TESTING AND RESEARCH, INC.

55 Middlesex Street, Suite 225, N. Chelmsford, MA 01863
Ph: (978)251-9395, Fx: (978)251-9396

December 17, 2014 GTR Project # - 14.227

Mr. Volker Burkowski
Project Manager
Kubricky Construction Corp.
269 Ballard Road
Wilton, NY 12831

Re: Wave Equation Analysis Report
Bridge Replacement Rutland City BRF 3000 (19)
Rutland, Vermont

Dear Volker:

At your request, we have performed Wave Equation Analyses (WEAPs) using the program GRLWEAP™ for the ICE I-60S diesel hammer at the above-referenced project. Steel HP14x102 and HP14x117 sections are proposed for the bridge abutments and piers, respectively. The WEAP input and assumptions, including the soil, pile, and hammer details are summarized in the following letter. Appendix A contains literature on the wave equation analysis and the GRLWEAP program. A copy of the Pile and Driving Equipment Data Form is provided in Appendix B.

Soil

The generalized subsurface conditions at the abutments and pier consist of granular soil varying from silty sand to sandy gravel overlying bedrock. The soil is primarily medium dense and becomes very dense over the lower depths. Boulders and cobbles were frequently encountered within the granular soil. Bedrock was encountered at elevations ranging from +453 feet to +459 feet. For a more detailed description of the subsurface conditions, refer to the Geotechnical Report and/or the boring logs.

Pile

Steel H piles (HP14x102) are proposed for the support of the abutments. A minimum pile penetration of 40 feet below the bottom of the abutment is required. The factored axial load was reported to be 174 kips. Based on AASHTO LRFD Bridge Design Specifications, the resistance factor is 0.65 (dynamic load testing) and the required nominal resistance is 268 kips. The cross-sectional area is 30 square inches. Some of the abutment piles will be driven on a 1H:12V batter.

Steel H piles (HP14x117) are proposed for the support of the piers. A minimum pile penetration of 50 feet below the bottom of the pier is required. The factored axial load was reported to be 255 kips. Based on AASHTO LRFD Bridge Design Specifications, the resistance factor is 0.65 (dynamic load testing) and the required nominal resistance is 392 kips. The cross-sectional area is 34.4 square inches. All of the pier piles will be driven on a 1H:12V batter.

A reinforced shoe will be attached to the tips of the piles. The maximum allowable compressive and tensile driving stresses are 45 ksi, based on AASHTO guidelines of 90% of the yield strength (Grade 50). Refer to Appendix B for further details on the piles.

Driving System

An ICE 60S single acting diesel hammer is proposed to drive the piles. The maximum continuous rated energy for the hammer is 60 kip-ft (based on a ram weight of 7 kips and a stroke 8.6 feet). The over-stroke and maximum rated energy is 10.2 feet and 71.4 kip-ft, respectively. The cushion material, as reported by the manufacturer, is a Nylon and Aluminum, with an elastic modulus of 175 ksi, thickness of 2 inches, and coefficient of restitution of 0.92. The hammer cushion area is 491 square inches. The helmet weight (including anvil and insert) is 2.44 kips. Refer to Appendix B for further details on the hammer.

Analysis

Seven cases were analyzed based on variations in pile type, verticality, penetration, tip conditions, and resistance distribution. An HP14x102 abutment pile with a penetration of 40 feet (minimum tip elevation), toe quake of 0.12 inches, and 75% end bearing was modeled in Case 1. Case 2 is similar to Case 1, except a pile penetration of 55 feet and 50% end bearing was used. Case 3 represents a 55 feet penetration with a high resistance of 750 kips, toe quake of 0.04 inches and end bearing of 90% (rock conditions). Case 4 was modeled on a 1H:12V batter with reduce hammer efficiency.

Cases 5 through 7 were based on the 1H:12V batter HP14x117 pier piles (with a reduced hammer efficiency). Case 5 represents a penetration length of 50 feet (minimum tip), toe quake of 0.12 inches and a percent end bearing of 75%. Case 6 is similar to Case 5, except a pile penetration of 60 feet and lower end bearing of 50% was modeled. Case 7 represents the batter piles driven to rock (toe quake of 0.04 inches with 90% end bearing).

Typical GRL recommended quake and damping parameters for granular soils were used. The vertical piles were performed using the typical GRLWEAP recommended internal hammer efficiency of 80% for piles driven with an open-ended diesel hammer. The batter piles were performed with an internal hammer efficiency of 75% (5% reduction) to account for the batter angle of 1H:12V. This is lower than the efficiency reduction of 1% recommended in the VAOT Standard Specifications. We have found that reductions generally less than 5% are not significant enough and that a 5% reduction for minor batter angles is more appropriate (based on PDA measurement experience). Each wave equation analysis was performed for a resistance ranging from 100 to 950 kips. This range of capacity brackets the driving resistance that may develop during the pile installation.

Results

Table 1 summarizes the results of the analyses. The maximum compressive and tensile driving stresses, blow count, stroke, and transferred energy at the ultimate capacity are presented in Table 1. Appendix C contains the output summaries and bearing graphs for each analysis.

Conclusions

The wave equation analyses indicate the following:

1. The abutment and pier piles are specified to be driven to the required minimum tip elevations/pile penetrations stated in the plans.

2. For the abutment piles (nominal resistance of 268 kips), we recommend a preliminary driving criterion of 3 blows per inch for 6 consecutive inches with the hammer operating at an output setting resulting in a stroke of 7.5 feet (corresponding to a transferred energy of around 23 to 24 kip-ft). This includes the abutment batter piles. The PDA can be used to determine the setting used for the required stroke.

3. For the pier piles (nominal resistance of 392 kips), we recommend a preliminary driving criterion of 4 blows per inch for 6 consecutive inches with the hammer operating at an output setting resulting in a stroke of 8 feet (corresponding to a transferred energy of around 21 to 22 kip-ft). The PDA can be used to determine the setting used for the required stroke.

4. We also recommend a refusal criterion of 15 blows for one inch or 10 blows per half inch for cases where the piles ‘take up” abruptly.

5. The WEAP analyses indicate that the compressive and tensile driving stresses were below the allowable limit for the cases analyzed.

6. The abutment and pier piles may need to be driven to higher resistance than required to achieve the minimum tip elevation/pile penetration. Since the resistance may increase, the stroke and energy will also increase. The hammer is capable of installing the piles using a 10 foot over-stroke to around 750 to 950 kips at 8 to 14 bpi within the allowable pile stresses (see cases 3 and 7).

7. The above recommendations are preliminary and highly sensitive to actual hammer performance. Dynamic testing will be performed to assess driving stresses, evaluate transferred energies delivered to the pile, and estimate pile capacity during driving. The preliminary driving criteria, hammer setting and recommendations above may be modified pending the results of the dynamic testing program.

This analysis does not account for variations in the soil profile significantly different from those encountered in the borings. Other factors not considered in this analysis are scour requirements, bending (due to misaligned hammer impacts), soil setup and relaxation effects, lateral and uplift requirements, cyclic loading, effective stress changes (due to changes in the water table, excavations, and/or fills), settlement, and pile group effects. The owner's geotechnical professional should evaluate if any of these issues are applicable to the foundation design.

The results of the wave equation analysis depend on a variety of hammer, pile, and soil input conditions. Attempts have been made to base the analysis on the best available information; however, the predicted stresses and blow counts may vary from those encountered in the field, due to the factors outline above. Further refinements may be made using the PDA™ to provide a better assessment of the pile capacity and the driving criteria at the time of driving.

This report has been prepared in accordance with generally accepted geotechnical engineering principles with specific application to this project. Our conclusions are based on applicable standards of practice, including any information reported to and/or prepared for us. No other warranty, expressed or implied, is made.

We appreciate this opportunity to work with you on this project. If you have any questions regarding this analysis, please contact us at (978) 251-9395.

Sincerely,
Geosciences Testing and Research, Inc.

Curtis A. George. P.E.
Project Manager

Les R. Chernauskas, P.E.
Principal

Attachments: Table 1, Appendices A through C

14.227 Rutland City BRF 3000 (19) WEAP Letter

TABLE

TABLE 1
SUMMARY OF WAVE EQUATION RESULTS
PROPOSED BRIDGE REPLACEMENT RUTLAND CITY BRF 3000 (19)
RUTLAND, VT
ICE-60S OPEN-ENDED DIESEL HAMMER

Case	Pile Type	Pile Alignment	Pile [1] Embedment (feet)	Percent End Bearing (%)	Tip Quake (in)	Nominal Resistance (kips)	Compressive[2] Driving Stress (ksi)	Max Tens[2] Driving Stress (ksi)	Blow[3] Count (blows/ft)	Stroke (feet)	Transferred Energy (kip-ft)
1	HP14x102	Vertical	40	75	0.12	268	24.3	0.3	22	7.6	24.0
2		Vertical	55	50	0.12	268	22.8	0.1	20	7.5	23.7
3		Vertical	55	90	0.04	750	44.5	4.9	95	10.1	33.9
4		1H:12V Batter	55	90	0.04	268	24.9	0.2	25	7.7	21.4
5	HP14x117	1H:12V Batter	50	75	0.12	392	24.5	0.6	40	8.2	22.4
6		1H:12V Batter	60	50	0.12	392	22.9	0.2	39	8.1	21.3
7		1H:12V Batter	60	90	0.04	950	43.2	3.9	166	10.2	30.8

Notes:
1. The pile embedments are referenced from grade.
2. Maximum compressive and tensile driving stresses in the pile recommended to be less than or equal to 45 ksi (Fa=0.9*Fy, where Fy=50 ksi).
3. The blow count represents the average over the final foot of penetration.

APPENDIX A
WAVE EQUATION LITERATURE

GRLWEAP Version 2010

Accurately Simulates Pile Driving

GRLWEAP 2010 is the software of choice for industry-leading piling professionals all around the world.

1. Calculates driving resistance, dynamic pile stresses, and estimated capacities based on field observed blow count, for a given hammer and pile system.
2. Helps select an appropriate hammer and driving system for a job with known piling, soil and capacity requirements.
3. Determines whether a pile will be overstressed at a certain penetration or if refusal will likely occur before a desired pile penetration is reached (driveability analysis).
4. Estimates the total driving time.

GRLWEAP 2010: Available in Standard and Offshore Wave versions

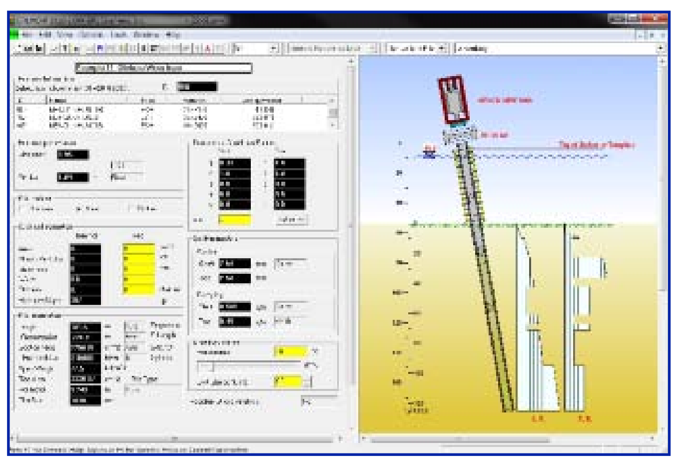
The most widely used pile driving simulation software is now more powerful and user friendly. New features improve the accuracy of predicted stresses, bearing capacities, blow counts and installation time:

- Four static geotechnical analysis options: **ST** method, **SA** method with an updated input method, **CPT** method and a method based on American Petroleum Institute **(API)** requirements.
- Variable toe area input for consideration of plugging in selected soil layers.
- Simplified input for analysis of battered piles.
- More flexible Driveability Analyasis input.
- Friendlier interface with spreadsheet programs.

Exclusive Features of Offshore Wave Version:

GRLWEAP Offshore Wave Version is particularly well suited to analyze free riding hammers on non-uniform and/or inclined piles.

- Pipe Pile Builder simplifies input of complex pipe pile sections and add-ons.
- Alternate hammer location may be modeled (pile top, bottom or in-between).
- Static bending analysis for inclined pile driving.
- Fatigue Analysis output tables show stress ranges and extrema with number of occurrences for fatigue damage studies.
- Option to consider Soil Plug Weight.



Offshore Wave Input Screen.

Pile Dynamics, Inc.

Quality Assurance for Deep Foundations

30725 Aurora Road Cleveland Ohio 44139 USA
tel: +1-216-831-6131 fax: +1-216-831-0916
Email: info@pile.com www.pile.com

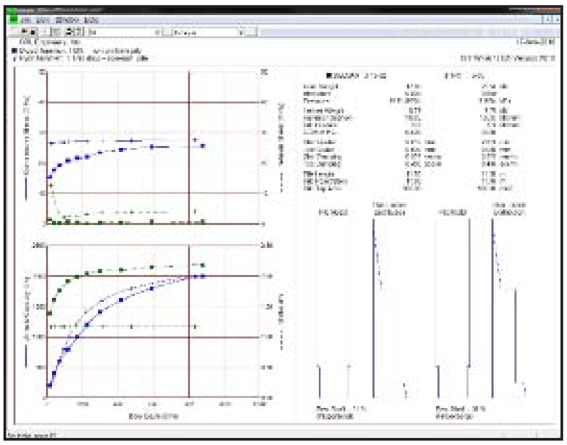
GRLWEAP Version 2010

Accurately Simulates Pile Driving

Background:

GRLWEAP - GRL Wave Equation Analysis of Pile Driving - simulates motions and forces in a foundation pile when driven by either an impact or vibratory hammer. (Replaces blow count with speed of penetration for vibratory hammers.) Its continuously updated, internet accessible hammer database featuers over 800 hammer models and extensive driving system data.

During the early development of the GRLWEAP program in the 1970s and continuously since that time, the program authors have improved program performance by matching GRLWEAP results with measurements by the Pile Driving Analyzer®.



Superimposed bearing graphs compare two hammers.

GRLWEAP Output Graphics

The **Bearing Graph** depicts the relationship of capacities, pile driving stresses and stroke versus blow count. It can be used to estimate the pile bearing capacity given an observed blow count; the required blow count for a specified capacity; or the maximum capacity that a hammer-pile-soil system can achieve.

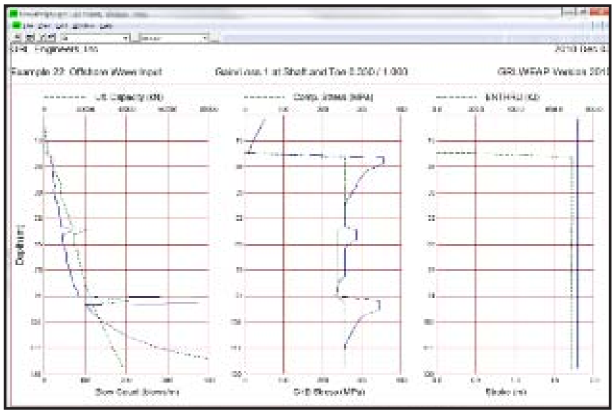
The **Driveability Graph** is a plot of capacity, blow count and dynamic stress extrema versus depth. It allows for consideration of pile add-ons, hammer energy and efficiency changes, cushion deterioration, soil resistance degradation and soil setup during driving interruptions. The numerical summary also includes an estimate of driving time based on the calculated number of blows and on the hammer blows per minute rate.

The **Inspector's Chart** compares stroke (or hammer energy) versus blow count for a single capacity value. Inspector's Charts are used for diesel hammers and external combustion hydraulic (ECH) hammers to determine, for a given bearing capacity, the required blow count versus variable hammer energy.

The **Variables vs. Time** graph shows any calculated quantity as a function of time for comparison with measurements or illustration of stress wave propagation.

Computational process features:

- Smith-type lumped mass hammer and pile model with Newmark predictor-corrector type analysis.
- Realistic non-linear stress-strain analysis of pile with splices, slacks, cushions, and other material interfaces.
- Basic Smith-type soil model with several research extensions.
- Bearing graph analysis with proportional, constant shaft or constant toe resistance.
- Thermodynamic analysis for diesel hammers.
- Iterative diesel hammer analysis for stroke calculation.
- Residual stress (multiple blow) analysis.
- Multi-material analysis for composite piles.
- Two-pile analysis for mandrel driven piles.
- Static soil analysis based on soil type, SPT N value, CPT data files or API method.



Driveability Graph

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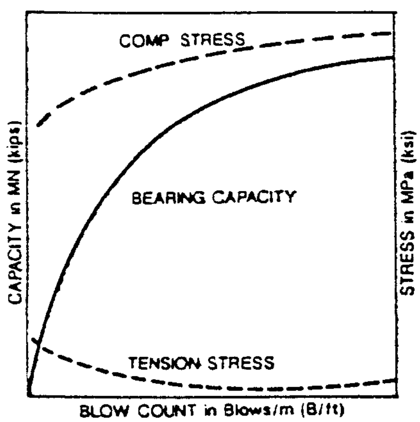
GRL Software: Wave Equation Analysis of Piles

GRLWEAP™, GRLINP, GRLGRF Programs

PROGRAM HISTORY AND BACKGROUND

In 1955 E.A.L. Smith of the Raymond Pile Driving Company presented a concept of pile driving analysis by the wave equation. Smith had developed a rational and complete analysis method for the design and construction control of impact driven piles was the development of a rational and complete approach which included:

- A pile model based on the one-dimensional wave equation.
- A soil model including a static elasto-plastic and a dynamic viscous component.
- A model for relatively simple hammers.
- A computational procedure which yielded a bearing graph, *i.e.*, a relationship between both ultimate capacity and pile stresses and pile set per blow.
- Recommendations for all model parameters.



The Bearing Graph

The first calculations were performed by Smith manually[1]. However, not long after his first paper was published, he developed a computer program which was the first non-military application of electronic computation in engineering. Thus, while "Wave Equation" really means a differential equation, this term has become synonymous with a numerical analysis procedure.

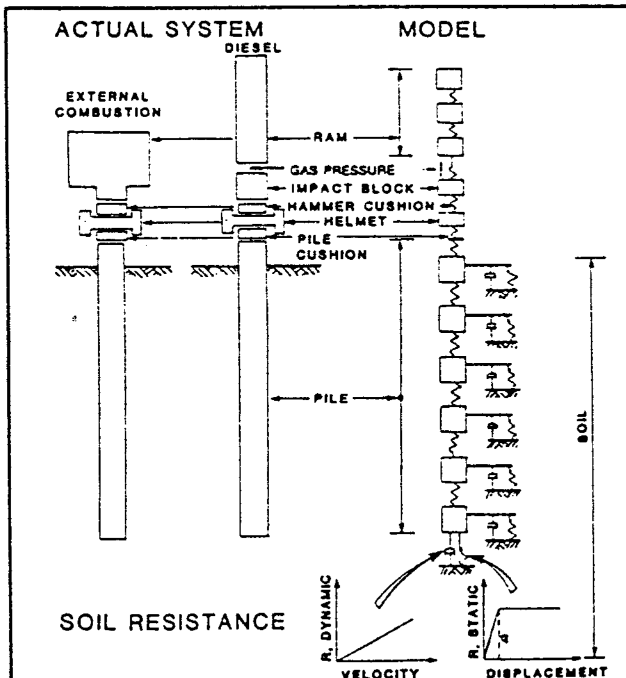
After Smith several researchers investigated the correlation of predictions of bearing capacity with static load test results[2]. These efforts confirmed the soundness of the basic approach. Thus, starting in 1974, the Federal Highway Administration sponsored further work. One of the objectives of these efforts was the realistic modeling of diesel hammers. With a large amount of data available from earlier research, the research team at *Case Institute of Technology*, now working at GRL, developed the WEAP program[3].

In 1986 the program was further improved for the FHwA by the incorporation of a residual stress analysis based on the work of Hery[4] and Holloway[5].

WEAP was also adapted to personal computers and new findings about hammer performance were incorporated in the program and its hammer data file. This work plus additional correlations lead to the WEAP87 package which included both a mainframe and a PC computer program, an expanded hammer data file and extensive documentation[6].

The GRLWEAP program package includes the basic WEAP87 code plus several additional powerful options. The preprocessor GRLINP and the postprocessor GRLGRF make this software particularly user friendly.

1. Smith, E.A.L., "Impact and Longitudinal Wave Transmission," *Transactions ASME*, August, pp. 963-973, 1955
2. Forehand, P.W., and Reese, J.L., "Prediction of Pile Capacity by the Wave Equation, "*Journal of te SM and F Division, ASCE*, Vol. 90, 1964
3. Goble, G.G., and Rausche, F., WEAP Program Documentation, National Information Service, Washington, D.C., 1976
4. Hery, P., "Residual Stress Analysis in WEAP," *MSCE Thesis*, University of Colorado, Boulder, 1983
5. Holloway, D.M., Clough, G.W., and Vesic, A.S., "The Effects of Residual Stresses on Pile Performance Under Axial Loads," *Proceedings*, 10th Annual Offshore Technology Conference, Houston, TX, 1978
6. Goble Rausche Likins and Associates, Inc., GRLWEAP Documentation, Cleveland, 1988

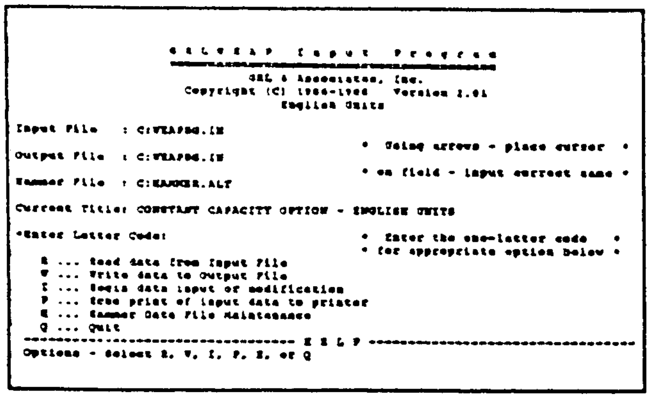


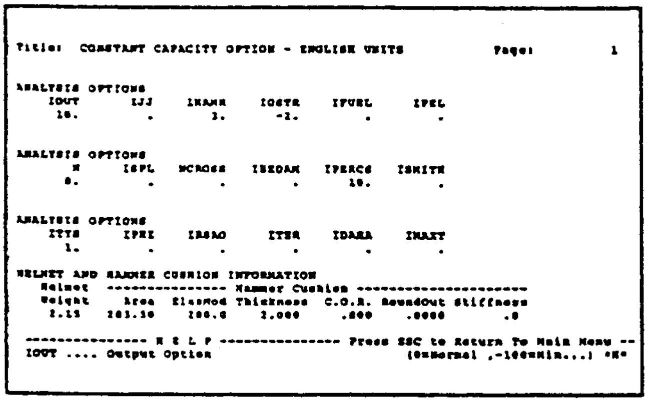
The Analysis Model

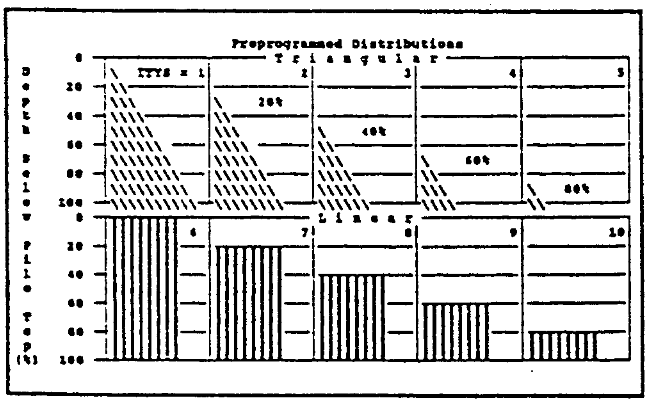
Goble Rausche Likins and Associates, Inc.

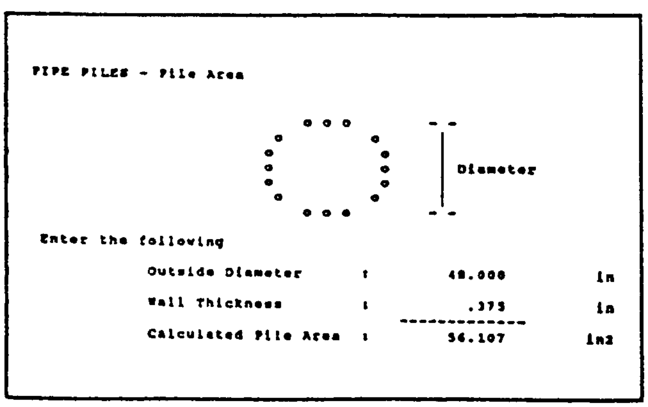
4535 Emery Industrial Parkway
Cleveland, Ohio 44128

phone: (216) 831-6131 fax: (216) 831-0916 telex: 985-662









The GRLINP program offers a maximum of conveniently available help and a simple input preparation. Basically, GRLINP offers on the main screen the following functions:

- Read and modify an existing GRLWEAP input data file.
- Accept keyboard input and write a new GRLWEAP input data file.
- Search for and display data contained on the hammer data file.
- Accept keyboard input and modify or create hammer data files.
- Provide the user help in the form of short variable descriptions and complete data tables (including hammer listings, helmet weights, cushion sizes and properties, pile types and cross section calculator and soil dynamic parameters).
- Check all input data and request extended input depending on user selected options.

The four screens shown on this page give examples of the method of input preparation, help and options. The first screen contains the main menu, file names and title entry. Menu options include file reading, writing, hammer maintenance and normal data entry.

The second screen shows the first page of data requests. Simple cursor movement control allows the user to choose any of the displayed quantities for which a short help message is displayed at the bottom of the screen. Additional help becomes available by striking the "H" key. Examples of such help screens are shown, first the "canned" shaft resistance distributions and second a pipe pile area calculator (calculators for other pile cross sections are also available).

GRLWEAP Hardware Requirements

GRLWEAP is a batch mode type program adapted to IBM-PC computers or compatible machines. The PC must be equipped with at least 528 kb of memory and two disk drives. Math coprocessor, hard drive and screen graphics adaptor are highly recommended accessories. GRLGRF is only helpful if either a graphics adaptor and printer or an HP 7400 series plotter is available. PC analyses by GRLWEAP are convenient and quick with an AT or 386 type machine, however, for those wishing to use a main frame, the WEAP87 source code is also available.

IBM and HP are trademarks of International Business Machines Corporation and Hewlett Packard, respectively.

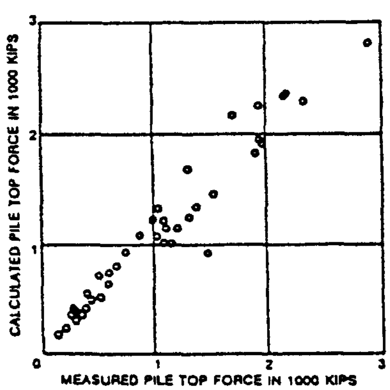
PROGRAM CAPABILITIES

GRLWEAP is a batch mode program, *i.e.*, the user writes a data file containing **all input data** and then runs the program. The batch mode operation has the advantage of allowing an engineer to prepare up to 10 data sets which then can be analyzed in a single run without further user involvement. Also the user may prepare input with a variety of programs such as simple line editor or the more sophisticated **GRLINP** program.

The program **documentation** contains *Background Report, Users Manual, Installation Manual, Microcomputer Input/Output Information* and examples in both English (ft, kips) and SI (m, kN) units. The Users Manual contains a wealth of data which greatly reduces the effort in the preparation of the analysis. This data is also summarized in the GRLINP help files.

GRLWEAP **output** is written to the screen, printer and/or disk file. Screen output includes all numerical results, *e.g.*, the bearing graph data, graphics of various pile variables as they are calculated, and the bearing graph. Of course, the graphics output may also be sent to a graphics printer. The written disk file can be read by the **GRLGRF** program for additional output to screen, graphics printer or plotter. Of particular value is the **Hammer Data File** which contains more than 240 entries and the related collection of driving system parameters (helmet weights, cushion materials) which have been compiled and preprogrammed for user convenience.

WEAP already contained a number of special features which were retained in GRLWEAP. For example, the numerical integrations are performed according to a predictor-corrector algorithm. Hammer components, cushions, and splices are modeled with a partially non-linear force-deformation relationship. In this way very satisfactory correlations of predicted and measured maximum pile top forces were achieved as shown in the figure on the left.

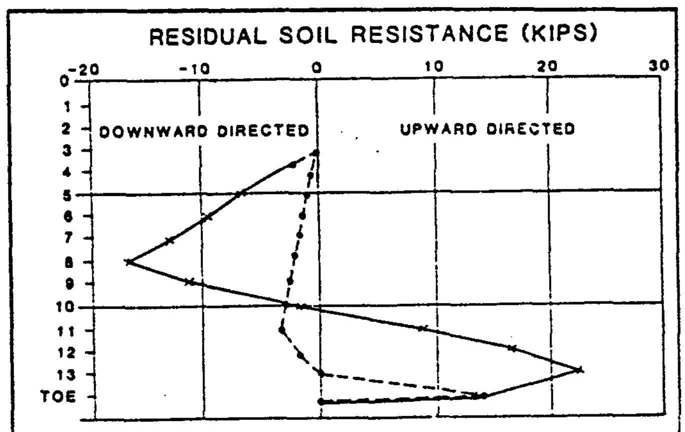


Pile Top Force Correlation

GRLWEAP also offers a variety of important analysis options. The user may choose a **Standard Analysis**, *i.e.*, an analysis at a given depth. The standard analysis can be done with either **fixed toe resistance**, or with **fixed skin resistance**, or with both **variable skin and toe resistance**. Alternatively, the pile is analyzed as it penetrates into the ground by the so-called **Capacity *vs* Depth Analysis.** This analysis requires input of friction, end bearing, quake, and damping values. The program calculates at each required depth the total shaft resistance subject to a reduction factor to model dynamic effects. From shaft and toe resistance it subtracts the dead weight components (hammer assembly, impact block, helmet, pile above grade). The resulting blow count, stresses and other results can be plotted by GRLGRF (see last page).

There are **three diesel hammer options.** The first calculates **stroke for fixed Maximum Combustion Pressure** (MCP). The second gives **MCP for a fixed stroke.** For the third option a **variable MCP yields a variable stroke given a single capacity,** *e.g.*, the required design load times the safety factor. The last option is for construction control and leads to a required blow count for an observed stroke and blow count. The corresponding modified bearing graph can be plotted by GRLGRF.

Another important option produces a **Residual Stress Analysis** (RSA). For RSA several blows are consecutively analyzed.



Residual Forces for Flexible (x) and Stiff (•) Pipe Pile

After each analysis the final pile and soil deformations are saved and used as initial values for the next blow. Thus, the RSA includes the energy remaining in pile and soil between blows which leads to lower blow counts (higher predicted capacities) and higher calculated stresses than the traditional WEAP approach. RSA is recommended for very flexible piles.

SOFTWARE SUPPORT

GRL's engineers pride themselves with providing the best possible service to GRLWEAP users. Updates are provided and questions are answered regarding program installation, program performance and applications, for one year after program purchase. Important findings about GRLWEAP are regularly published in the **GRL NEWSLETTER.** Support is extended beyond the initial one year period if the user opts to receive continued support. User recommendations for program enhancements or improvements of general interest are included in program updates.

APPENDIX B
PILE AND DRIVING EQUIPMENT DATA FORM

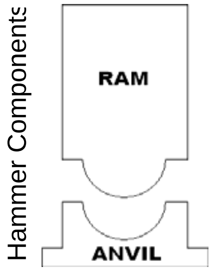
Contract #: ##

Project: Bridge Replacement Rutland City

County: Rutland VT

Structure Name and/or No.: BRF 3000 (19)

Pile Driving Contractor or Subcontractor: Kubricky (piles driven by)



Hammer

Manufacturer: ICE

Type: OED

Rated Energy: 60 kip-ft

Model: 60S

Serial No.:

at 8.57 ft Length of stroke

Modifications:

Capblock (Hammer Cushion)

Material: Nylon/Aluminum

Thickness: 2 in Area: $491 in^2$

Modulus of Elasticity (E): 175 ksi

Coefficient of Restitution (e): 0.92

Pile Cap

Helment
Bonnet
Anvil Block
Drivehead

Weight: 2.44 kips

Pile Cusion

Material: NA

Thickness:

Area:

Modulus of Elasticity (E):

Coefficient of Restitution (e):

Pile

Pile Type: HP14x117 or HP14x102

Length (in leads): 40 to 60 ft

Weight/ft.: 117 or 102 lb/ft

Wall Thickness:

Taper: na

Cross Sectional Area: $34.4 in^2$ or 30.0 in2

Nominal Resistance: 392 kips or 268 kips

Description of Splice: n/a

Tip Treatment Description: Reinforced Steel Point

Submitted by: CAG

Date: 12/12/2014

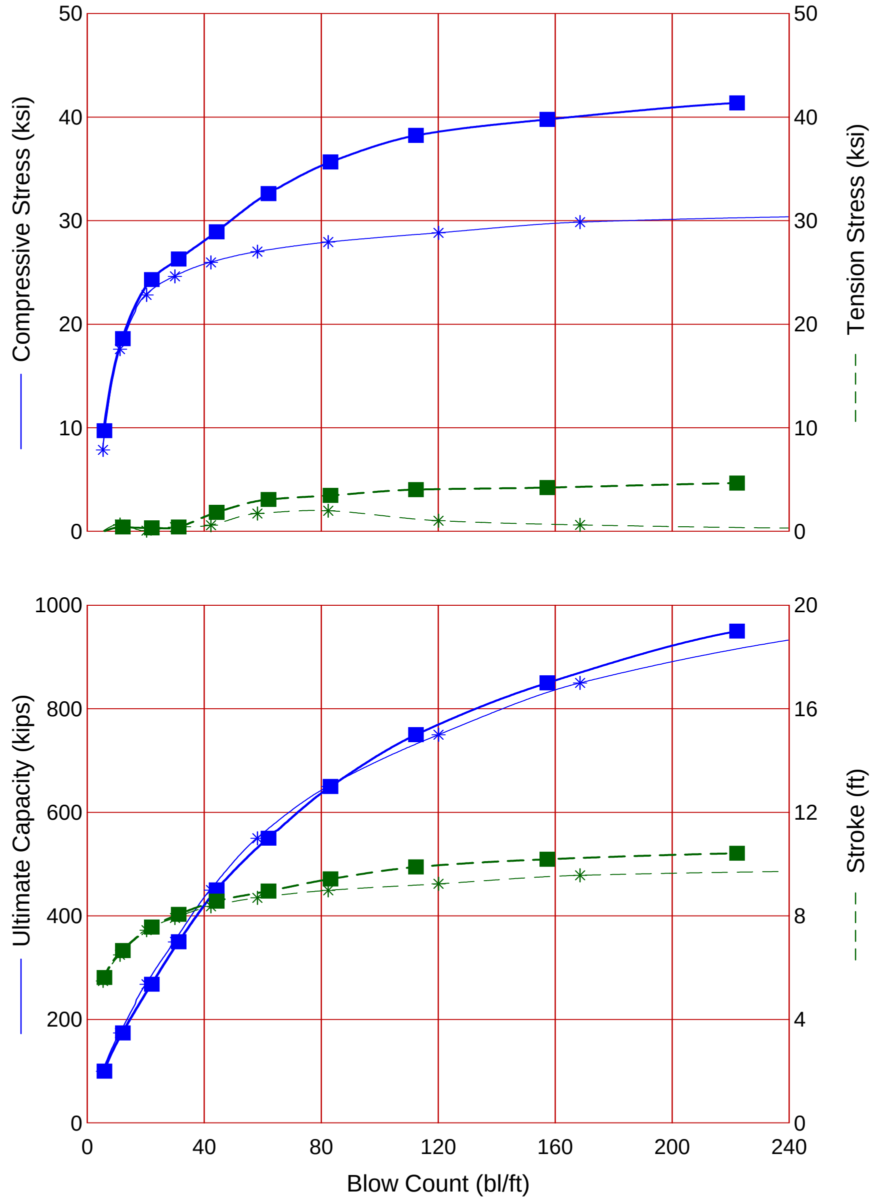
PILE AND DRIVING EQUIPMENT DATA FORM

APPENDIX C
GRLWEAP OUTPUT SUMMARY
AND BEARING GRAPHS

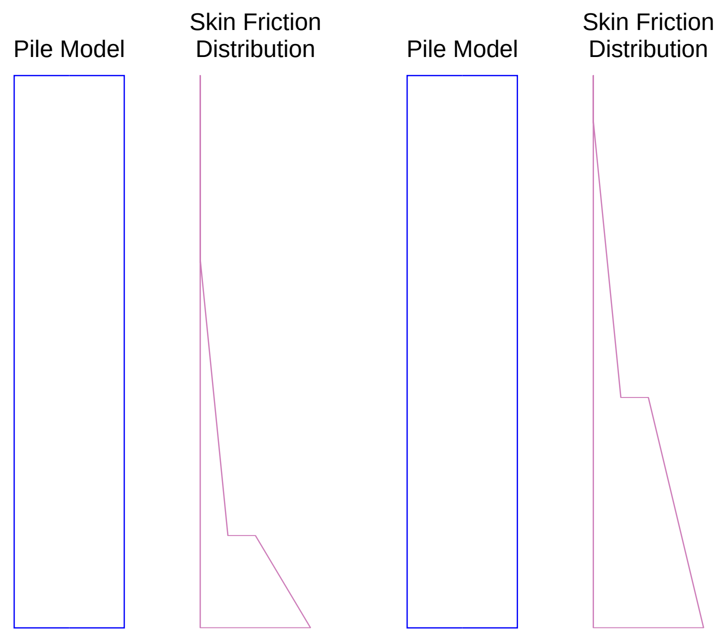
Geosciences Testing & Research Inc — 17-Dec-2014

■ Rutland BRF3000 (19) Case 1

✳ Rutland BRF3000 (19) Case 2 — GRLWEAP Version 2010



	■ ICE 60-S		✳ ICE 60-S	
Ram Weight	7.00		7.00	kips
Efficiency	0.800		0.800	
Pressure	1150 (100%)		1150 (100%)	psi
Helmet Weight	2.44		2.44	kips
Hammer Cushion	42963		42963	kips/in
COR of H.C.	0.920		0.920	
Skin Quake	0.100	in	0.100	in
Toe Quake	0.120	in	0.120	in
Skin Damping	0.050	sec/ft	0.050	sec/ft
Toe Damping	0.150	sec/ft	0.150	sec/ft
Pile Length	60.00		60.00	ft
Pile Penetration	40.00		55.00	ft
Pile Top Area	30.00		30.00	in2



Res. Shaft = 25 %
(Proportional)

Res. Shaft = 50 %
(Proportional)

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Rutland BRF3000 (19) Case 1 — GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
100.0	9.72	0.00	5.9	5.62	23.71
174.0	18.60	0.42	12.2	6.66	23.37
268.0	24.31	0.34	22.1	7.57	23.98
350.0	26.29	0.42	31.3	8.06	24.50
450.0	28.92	1.84	44.3	8.57	26.48
550.0	32.61	3.08	62.0	8.96	28.45
650.0	35.67	3.47	83.2	9.43	30.60
750.0	38.22	4.03	112.4	9.89	32.84
850.0	39.77	4.23	157.3	10.19	34.29
950.0	41.37	4.66	222.2	10.42	35.28

Rutland BRF3000 (19) Case 2

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/ft	Stroke ft	Energy kips-ft
100.0	7.87	0.00	5.4	5.49	23.59
174.0	17.59	0.65	11.2	6.50	23.26
268.0	22.83	0.08	20.3	7.45	23.69
350.0	24.63	0.41	30.0	7.92	23.50
450.0	25.98	0.60	42.3	8.37	24.90
550.0	27.01	1.73	58.2	8.70	26.17
650.0	27.93	2.00	82.4	8.99	27.22
750.0	28.83	1.03	120.1	9.24	28.35
850.0	29.86	0.63	168.5	9.57	29.95
950.0	30.47	0.28	261.2	9.75	30.81

Geosciences Testing & Research Inc
■ Rutland BRF3000 (19) Case 3
✳ Rutland BRF3000 (19) Case 4

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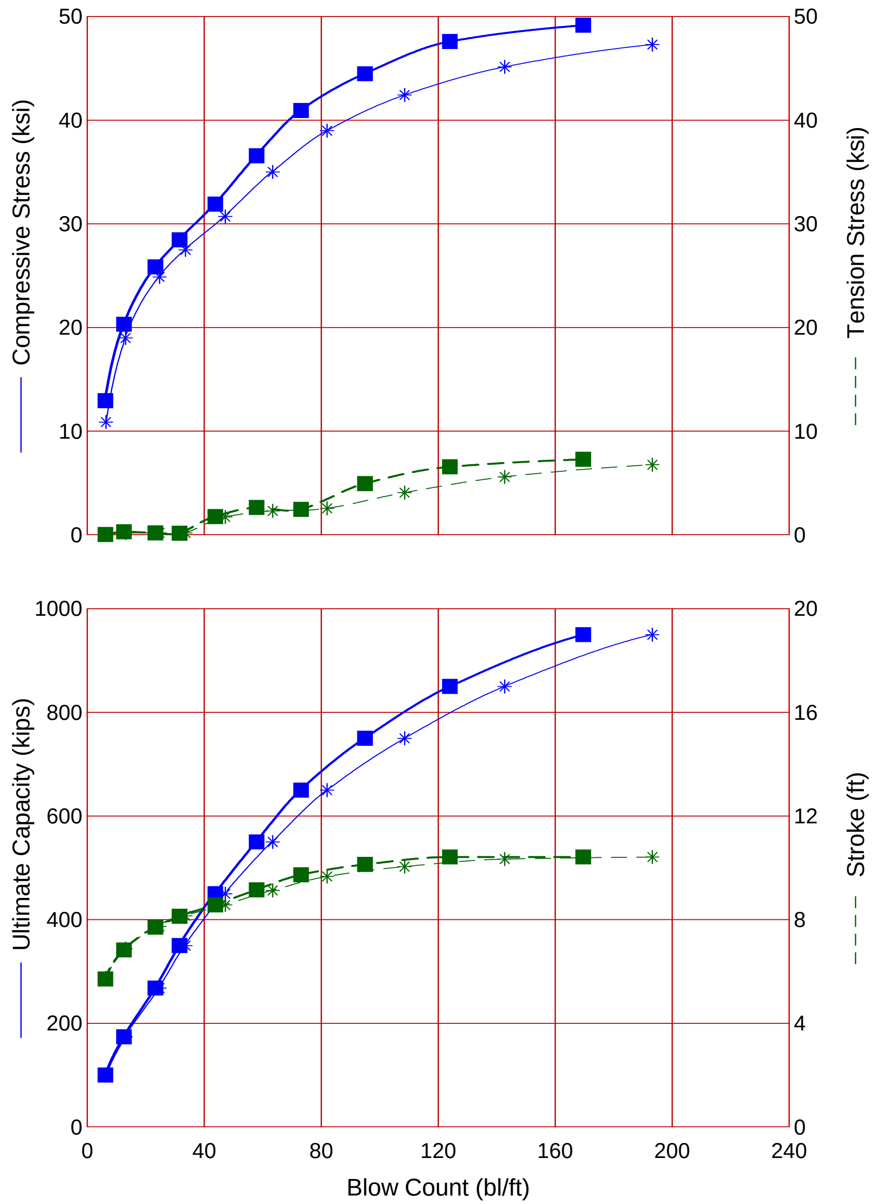
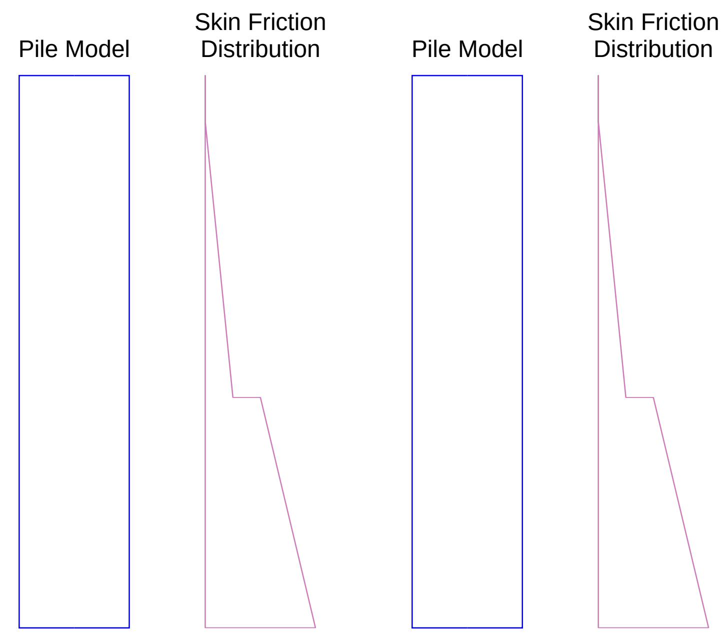
GRLWEAP Version 2010



	■ ICE 60-S		✳ ICE 60-S	
Ram Weight	7.00		7.00	kips
Efficiency	0.800		0.750	
Pressure	1150 (100%)		1150 (100%)	psi
Helmet Weight	2.44		2.44	kips
Hammer Cushion	42963		42963	kips/in
COR of H.C.	0.920		0.920	
Skin Quake	0.100	in	0.100	in
Toe Quake	0.040	in	0.040	in
Skin Damping	0.050	sec/ft	0.050	sec/ft
Toe Damping	0.150	sec/ft	0.150	sec/ft
Pile Length	60.00		60.00	ft
Pile Penetration	55.00		55.00	ft
Pile Top Area	30.00		30.00	in2



Res. Shaft = 10 %
(Proportional)

Res. Shaft = 10 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
100.0	12.94	0.02	6.2	5.71	24.07
174.0	20.30	0.29	12.6	6.83	23.84
268.0	25.85	0.19	23.3	7.71	23.26
350.0	28.45	0.15	31.6	8.13	23.90
450.0	31.90	1.76	43.8	8.57	25.88
550.0	36.56	2.63	57.9	9.15	28.88
650.0	40.94	2.44	73.1	9.73	31.82
750.0	44.48	4.94	95.0	10.13	33.86
850.0	47.59	6.56	124.0	10.42	35.21
950.0	49.16	7.29	169.6	10.42	35.29

Rutland BRF3000 (19) Case 4

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/ft	Stroke ft	Energy kips-ft
100.0	10.88	0.00	6.4	5.76	22.41
174.0	18.99	0.19	13.1	6.88	21.91
268.0	24.88	0.20	24.7	7.74	21.38
350.0	27.49	0.18	33.6	8.15	21.96
450.0	30.71	1.72	47.2	8.57	23.95
550.0	35.00	2.31	63.4	9.13	26.57
650.0	38.99	2.56	82.0	9.67	29.07
750.0	42.43	4.08	108.5	10.05	30.99
850.0	45.14	5.59	142.7	10.34	32.35
950.0	47.29	6.76	193.2	10.42	32.80

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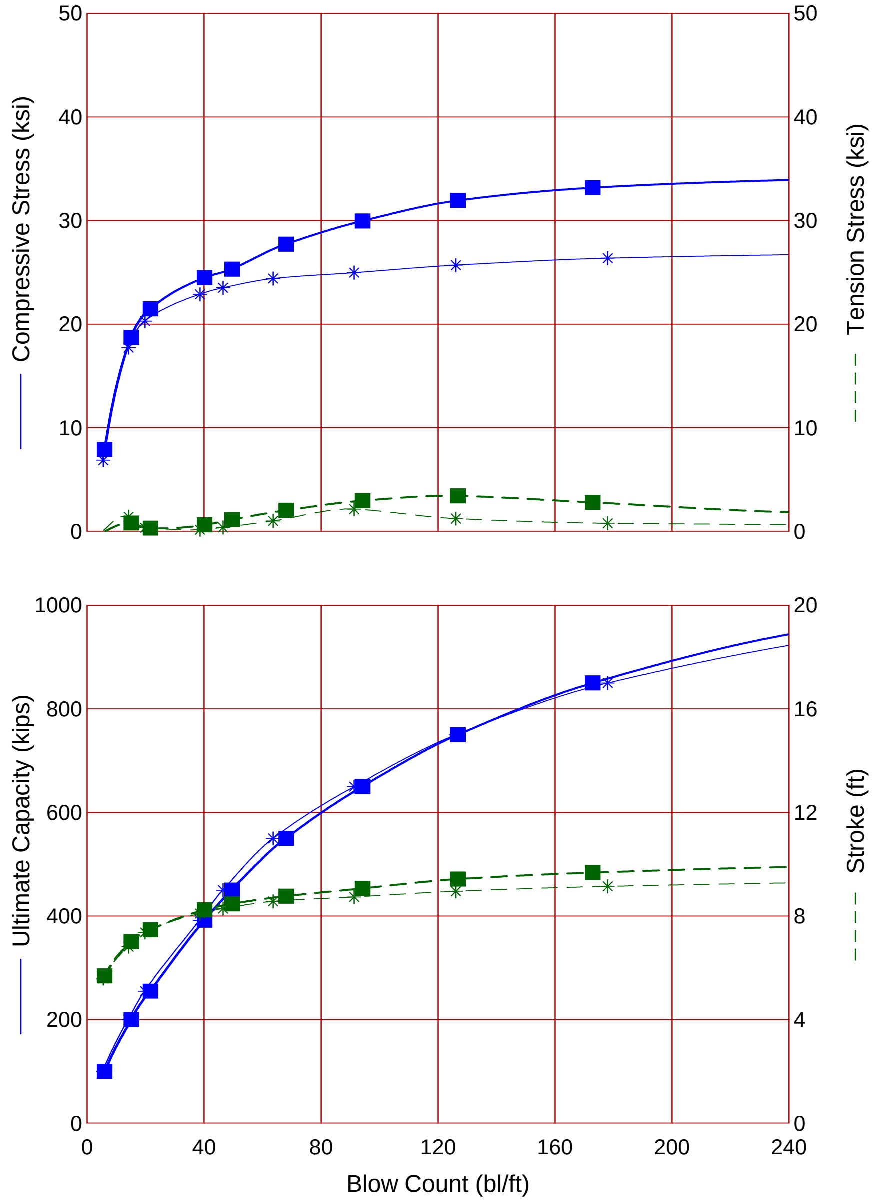
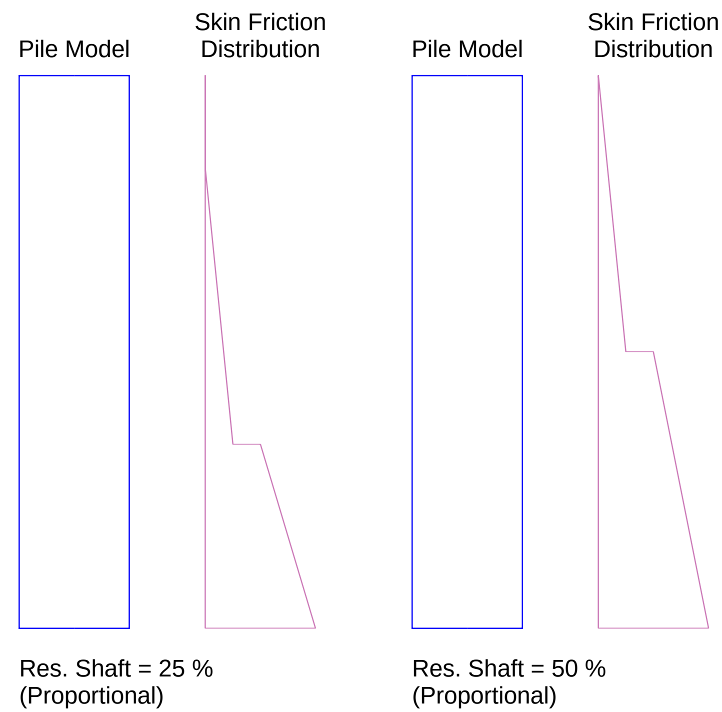
■ Rutland BRF3000 (19) Pier Case 5

✳ Rutland BRF3000 (19) Pier Case 6 — GRLWEAP Version 2010



	■ ICE 60-S		✳ ICE 60-S	
Ram Weight	7.00		7.00	kips
Efficiency	0.750		0.750	
Pressure	1150 (100%)		1150 (100%)	psi
Helmet Weight	2.44		2.44	kips
Hammer Cushion	42963		42963	kips/in
COR of H.C.	0.920		0.920	
Skin Quake	0.100	in	0.100	in
Toe Quake	0.120	in	0.120	in
Skin Damping	0.050	sec/ft	0.050	sec/ft
Toe Damping	0.150	sec/ft	0.150	sec/ft
Pile Length	60.00	ft	60.00	ft
Pile Penetration	50.00	ft	60.00	ft
Pile Top Area	34.40	in2	34.40	in2



Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
100.0	7.90	0.00	6.0	5.69	22.23
200.0	18.71	0.80	15.2	7.01	21.59
255.0	21.47	0.31	21.7	7.47	21.75
392.0	24.49	0.62	40.2	8.24	22.37
450.0	25.30	1.13	49.6	8.47	23.20
550.0	27.71	2.03	68.1	8.77	24.42
650.0	29.96	2.96	94.2	9.07	25.71
750.0	31.93	3.43	126.8	9.43	27.26
850.0	33.17	2.80	172.9	9.68	28.40
950.0	33.96	1.82	246.3	9.91	29.31

Rutland BRF3000 (19) Pier Case 6

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
100.0	6.87	0.00	5.5	5.59	22.57
200.0	17.73	1.42	14.2	6.82	21.38
255.0	20.30	0.36	19.8	7.37	21.65
392.0	22.88	0.17	38.6	8.10	21.32
450.0	23.51	0.38	46.5	8.29	21.77
550.0	24.40	1.01	63.6	8.57	22.57
650.0	24.97	2.15	91.3	8.74	23.22
750.0	25.70	1.24	126.1	8.96	24.21
850.0	26.37	0.79	178.0	9.15	25.14
950.0	26.82	0.62	272.3	9.33	25.70

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Rutland BRF3000 (19) Pier Case 7

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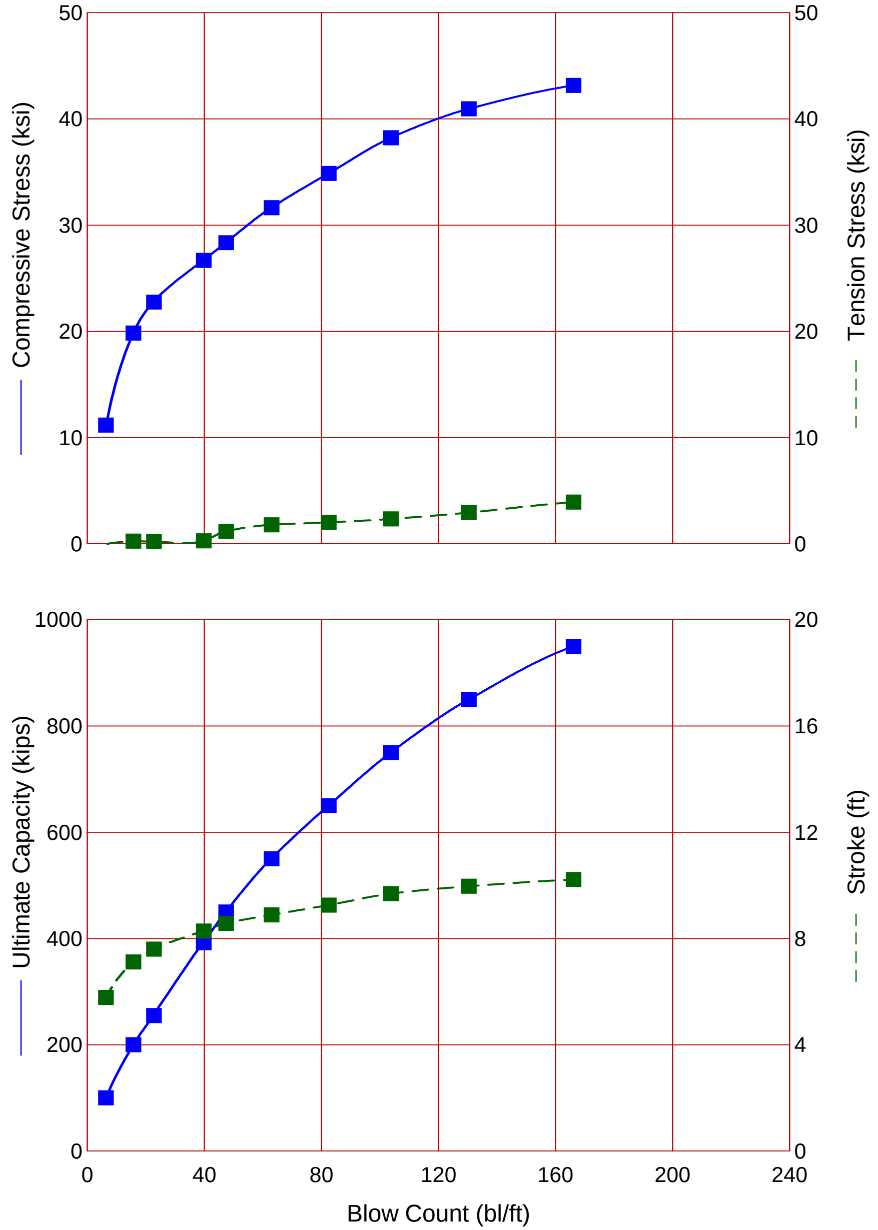
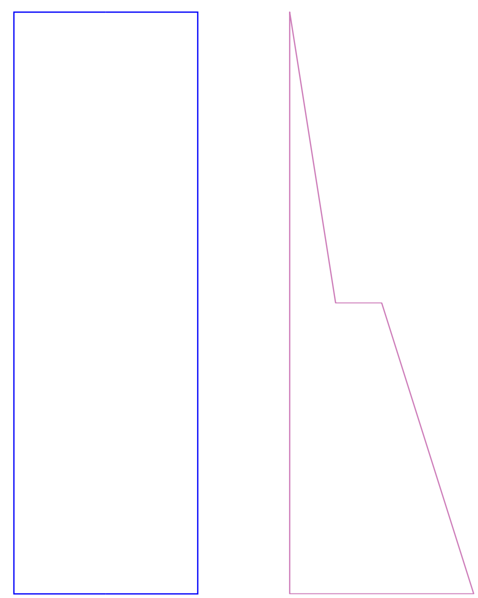


ICE 60-S

Ram Weight	7.00	kips
Efficiency	0.750	
Pressure	1150 (100%)	psi
Helmet Weight	2.44	kips
Hammer Cushion	42963	kips/in
COR of H.C.	0.920	
Skin Quake	0.100	in
Toe Quake	0.040	in
Skin Damping	0.050	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	60.00	ft
Pile Penetration	60.00	ft
Pile Top Area	34.40	in2

Pile Model

Skin Friction Distribution



Res. Shaft = 10 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
100.0	11.17	0.00	6.4	5.78	22.47
200.0	19.84	0.26	15.8	7.12	21.54
255.0	22.75	0.23	22.8	7.60	21.09
392.0	26.68	0.28	39.8	8.28	21.79
450.0	28.34	1.19	47.5	8.57	23.05
550.0	31.62	1.80	63.0	8.89	24.76
650.0	34.85	2.03	82.5	9.26	26.31
750.0	38.21	2.35	103.8	9.69	28.26
850.0	40.94	2.95	130.4	9.97	29.67
950.0	43.15	3.93	166.2	10.22	30.75