CAPWAPC FEATURES 1990

by

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CAPWAPC FEATURES 1990

Version 1.990-1

From the outside, CAPWAPC has not undergone many changes, however, several features have been added which may not be readily apparent to the user who doesn't read manuals. The following is a list of major changes.

Residual Stress Analysis

Setting REss in CV to a value greater than 0 invokes the residual stress analysis option. This means that after each dynamic analysis a static analysis will be automatically carried out. Then at least one additional dynamic analysis is performed which uses the final pile displacement and soil resistance values of the previous analysis as starting values. The number of additional analyses is either the value of REss (if it has been set just before a series of analyses) or it is 1 (normal) or 2 (after a change of the resistance distribution in RI).

Notes:

If UNld is set to 0 then the results will be identical for RSA and Non-RSA (this is obvious to the experienced pile dynamicist).

The initial conditions calculated from the final stress state of the previous analysis include non-zero pile displacements, zero pile velocities, non-zero pile forces, non-zero soil resistance forces. Quiz question: what are the initial upwards and downwards traveling waves.

Prior to a residual dynamic analysis, the "residual" pile top displacement is subtracted from all pile displacements. The blow count (BlctFin) is then easily calculated as the inverse of the residual top displacement. Convergence of the residual stress analysis is simply judged by comparing the previous and current total residual pile compression. The user is responsible for conducting sufficiently many analyses. (The match quality number may also be used as a convergence criterion).

First experiences with this new feature have indicated a change in resistance distribution, reduction in the predicted total capacity, and increase (yes, unfortunately) in the match quality number.

A More Forgiving Slack Model

Slacks modeled by the previous CAPWAPC were either open or closed. Waves were then either completely reflected or completely transmitted. This made for either a short pile or a long pile, respectively and matching of real data was nearly impossible. The reason is that in reality nothing is either yes or no, it is always more or less.

The 1990 slack model has been devised similar to GRLWEAP which represents a spring with slack with a linearly increasing stiffness starting at zero in compressive direction and after overcoming the tension slack in tensile direction. Since the continuous model of CAPWAPC is much less forgiving than Smith's lumped mass approach, a modification was necessary. The algorithm is now basically as follows:

If the either tension or compressive slack were entered greater than 10, then the splice is considered open and subject to the appropriate limiting slack force.

If the segment deformation is within either the compressive or the tensile slack distance then the pile force for no slack is calculated and multiplied with the square of the ratio of deformation divided by slack distance. The resulting force (less than or equal to the no-slack-force) is applied to the two sides of the slack. Obviously, as the deformation nears the end of the slack, the transmitted force very quickly approaches the normally transmitted force. Near zero deformation, practically no force is transmitted (Figure 1).

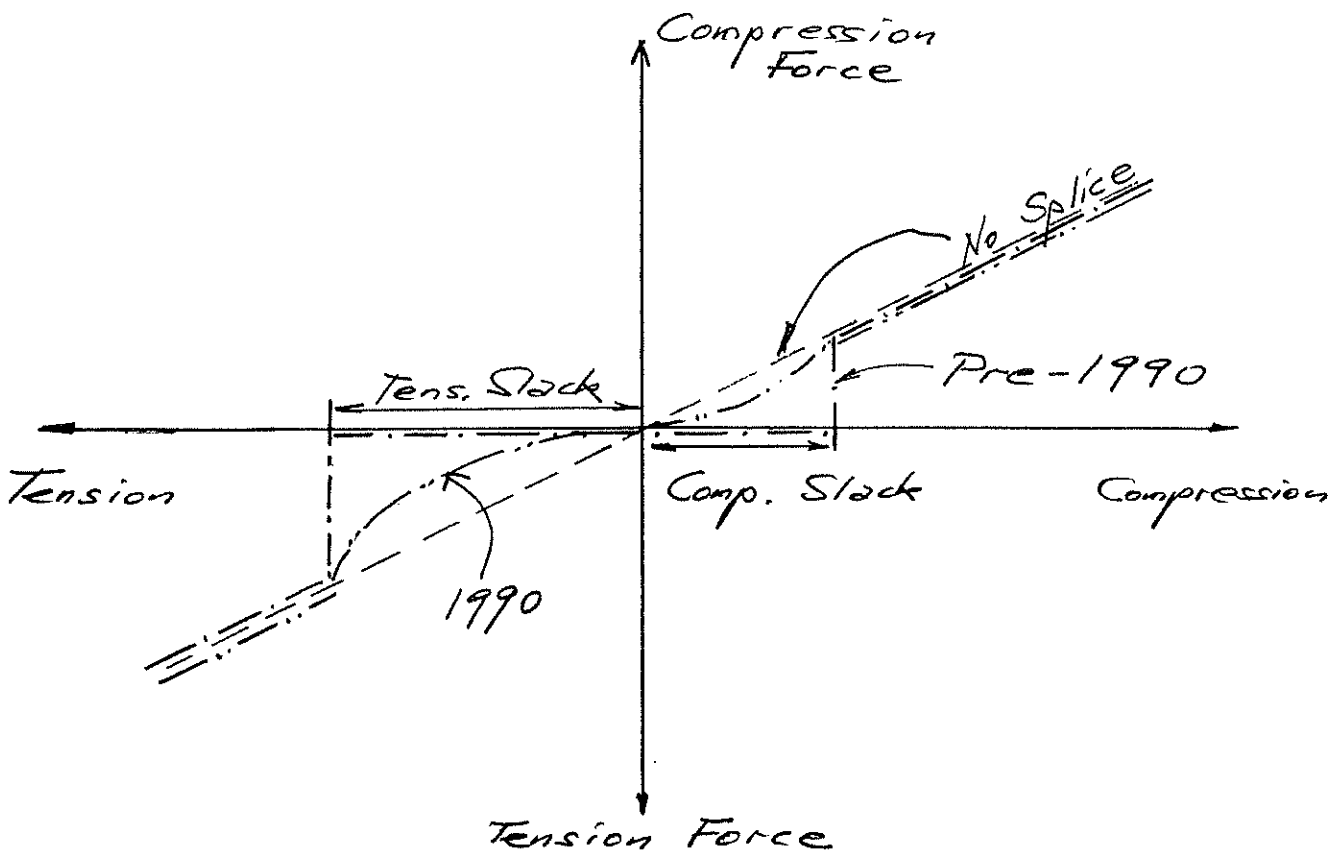


Figure 1: Previous and 1990 Slack Model in CAPWAPC

Correct Unit Skin Friction for all Piles

The final CAPWAPC result table includes a column entitled unit skin friction. This value is calculated from the individual Ru forces and a circumference value. The 1990 CAPWAPC allows the user to enter variable circumference values as a function of pile length. The final unit skin friction values printed in the final table are then based on a circumference which is an average for each segment. The input data review displayed prior to analysis also contains the unit skin friction as a guide to the user.

Note:

The fact that CAPWAPC now calculates more accurately the unit skin friction values does not necessarily increase the accuracy of your CAPWAP analysis.

Graphical Display of Tension and Compression Maxima
Graphical Display of Quakes and Damping Factors
Graphical Display of Residual/Ultimate Resistance Forces

The tension and compression maxima provide for a visualization of potentially damaging forces. Only the 10 values contained in the extrema table can be accessed. Quakes and damping factors and residual and ultimate resistance forces are displayed for all $N_{soil}+1$ soil segments. Residual resistance forces are only correct if residual stress analysis is performed. Under normal circumstances, the so-called residual resistance forces are the resistance forces active at the end of the dynamic analysis (Figure 2).

Note:

These Bar Charts can only be displayed on the screen or dumped to graphics printer using "Print Screen"; they cannot be plotted on a pen plotter.

Plot of Resistance - Time Curves

This was the only PDA-type set of curves missing in CAPWAPC. The J-value of the R_s curve is the one that (to the nearest 1/10th) produces an R_{max} equal to the current CAPWAP capacity.

Damping Factors for Non-Proportional Damping

CAPWAP usually apportions a total skin damping factor to the skin soil segments in

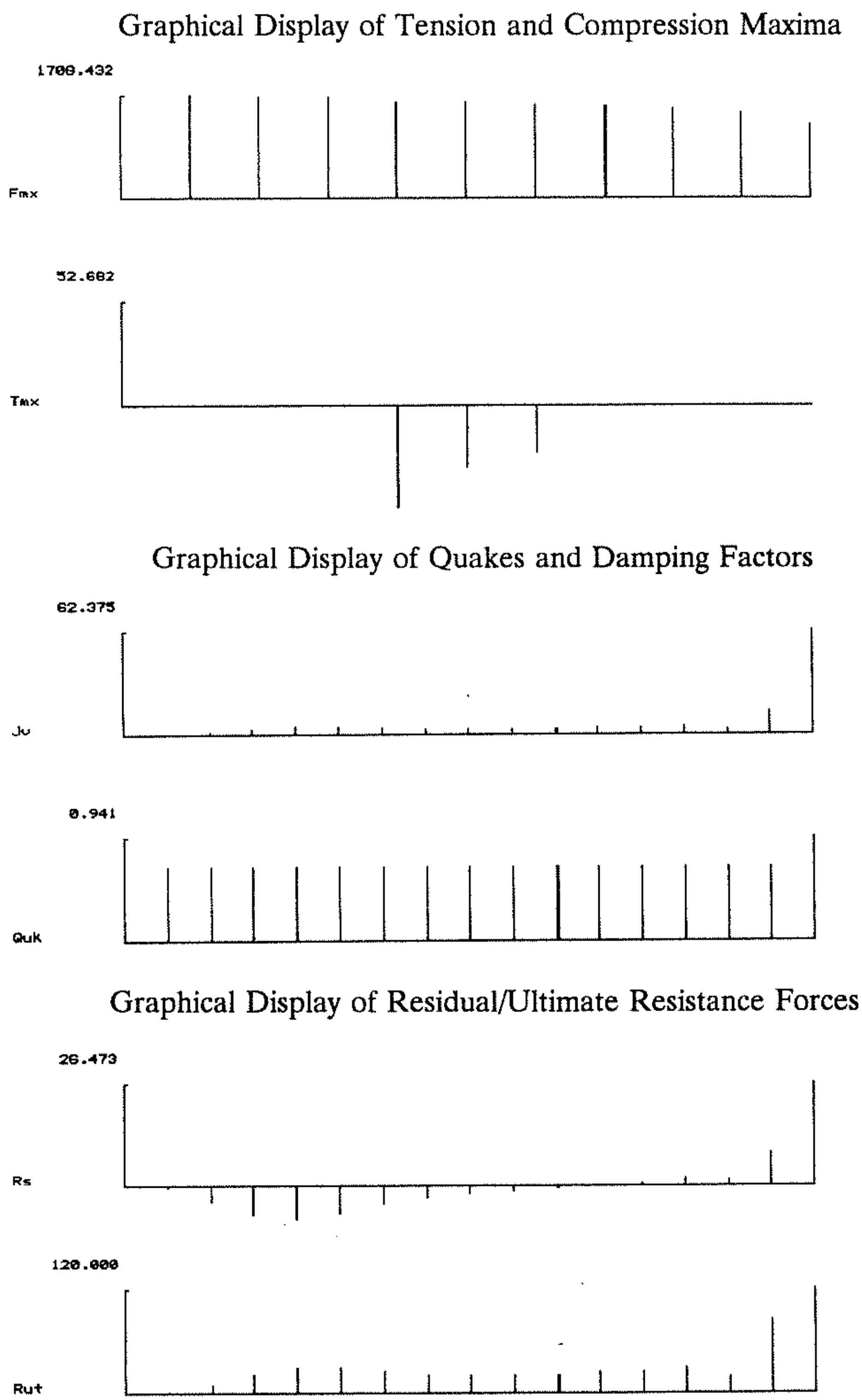


Figure 2: 1990 Bar Chart Displays

Table 1: Damping Multiplier Input

```
Damping Factors, Added Damping, Multipliers, Approx. Damping Forces
               1       2       3       4       5       6       7       8       9      10
DFac   1      .5     4.1     9.3    12.5    12.6    10.5     8.7     8.3     8.4     8.9
DAdd   1      .0      .0      .0      .0      .0      .0      .0      .0      .0      .0
DMul   1     1.0     1.0     1.0     1.0     1.0     1.0     1.0     1.0     1.0     1.0
DFor   1     2.7    20.8    47.1    60.7    60.9    47.3    37.5    36.0    35.4    35.9

DFac  11    10.8    10.2    12.8     8.0    36.5   153.5
DAdd  11      .0      .0      .0      .0      .0      .0
DMul  11     1.0     1.0     1.0     1.0     1.0      .0
DFor  11    43.8    40.1    49.9    29.6   141.5   595.7

 0 ... Exit
 1 ... Enter Added Damping
 2 ... Enter Damping Multiplier
 3 ... Display Damping Values
2
Enter Damping Multiplier
I1, D1, I2, D2
```

proportion to the static skin resistance forces. Until now added damping had to be used to produce a non-proportional damping distribution. Thus, distinguishing the damping intensity of soil layers known to be of different grain size was not a simple task. Now a relative intensity factor may be assigned to each segment.for example, if the lower half of the pile bears in clay and the upper half in sand then the upper damping multipliers may be 1 and the lower ones 4. The resulting difference in damping factors would correspond to Smith's recommendation (Table 1).

Note:

Automated friction distribution may not be successful if the damping factors are not constant.

Limit Display for CAPWAPC Variables

CAPWAP apprentices will appreciate that assignment of unusual CAPWAPC variables will now cause the display of recommended ranges. The user may also ask for these ranges (LI in CV). A few of the recommendations are actually based on current dynamic quantities,

Table 2: The New CAPWAPC Variable Menu

```
CAPWAPC Variables:
QSkn      .675  QToe      .941  CSkn     1.700  CToe     1.400  AUto          1.
RSkn      .000  RToe      .000  UNld      .000

JSkn      .200  JToe      .200  SSkn      .164  SToe      .520  OPtd          0.
PIld      .030  SKdp      .000  BTdp      .000  MSkn      .00   MToe        .00

PLug      .300  TGap      .000                  RDsw      500.  ANat          3.
T.wt      .612  DMxt     3.591  IMpd    311.87                  REss          1.

NAxxxx to change NAme to xxxx, - "H" for Help
LIi for Recommended Limit of i-th Quantity

li20
Recommended Range:     .000<= TGap <=   2.650
```

e.g., the maximum recommended toe quake is the difference between maximum toe displacement and toe gap. Their ranges may therefore change during the analysis (Table 2).

Note:

The recommendations contained in the software are based on experience and represent average situations. Your site conditions may occasionally require parameters outside the recommended ranges.

Extension of Smith Toe Damping Option

The toe damping force often should be low at the time of maximum toe displacement when the toe quake is low or where a gap exists. The Smith damping model reduces the viscous damping by the ratio of actual to ultimate resistance. The Smith model is therefore convenient for the reduction of damping in the gap or large quake situations.

It was found, however, that the viscous model is superior in the late record portions where static resistance has decreased to very small magnitudes. The new Smith toe damping option (OPtd = 2 in CV) will mix the two models: until the static resistance at the toe is fully activated, damping is multiplied by R_s/R_u. After activation has been accomplished the usual viscous approach is applied.

Change of Limit of Segment Numbers

GRL had to perform analyses on very long piles (1500 ft or 450 m). It was therefore necessary to increase the number of pile segments to 320. This was accomplished by simultaneously limiting the number of soil segments to 160.

Data Bank Generation

You may be interested in summarizing important data in a data bank. For example, pile type, capacity, soil type, correlation data and other quantities may be of interest. CAPWAPC contains many interesting parameters, the program now writes a data file. At the end of the CAPWAPC session the data file may then be augmented by missing information such as soil type or static load test results. The combined information is then written to a new file.

GRL uses the Paradox program to summarize and organize large volumes of data. For this reason a little program was written that interrogates the user for further information. The little program then writes the data in Paradox format to a file named with a specific user chosen name. A printout of the data contained in the data file is shown in Table 3.

Notes:

The CAPWAPC written file will be lost after the next program termination.

Table 3: Summary Data File

Unit System	9ChMETRIC
Job No./File Name (e.g.891122.1X)	9Ch901000-0
Pile ID and BoR or EoR	12ChBOR 130
Soil Type at Skin like Sa/Si	10ChSA/SI
Soil Type at Toe like Sa/Si	10ChSA TILL
Pile Type like PPC or HP14x79	10ChCEP 10"
Length Below Gages	32.7700
X-Sectional Area at Top	21000.0000
Elastic Modulus at Top	78.5000
Hammer	8ChB400
Blow Count	680.0000
Force Unit	4Ch kN
Match Quality Number	2.5657
Case Skin Damping	.5200
Case Toe Damping	.4923
Average Skin Quake	.6754
Quake of First Toe Soil Segment (Toe Q)	.9408
Toe Resistance Gap	.0000
Total CAPWAPC Predicted Capacity	1279.8840
Predicted Toe Resistance	838.8866
Friction at Segment Above Toe Segment	21.4718
Friction at Toe Segment	97.5016
Top Maximum Force	1633.6130
Top ENTHRU	26.7431
Top Maximum Velocity	5.5654
Top Maximum Displacement	2.6890
Toe Maximum Force	1167.8440
Toe Transferred Energy	8.0023
Toe Maximum Displacement	.9994
Maximum Compressive Stress	22.7130
Maximum Tensile Stress	.2550
RA2	1320.2680
Rsp(0.0)	1537.6510
Rsp(0.1)	1392.4600
J	.2000
Rmx(0.0)	2000.3590
Rmx(0.3)	1589.6740
Rmx(0.5)	1315.8840
Rmx(0.7)	1201.3800
Rmx(0.9)	1197.6700
Rsu(0.0)	.0000
Maximum Load in Load Test	.0000
Davisson Load Test Capacity	.0000
Maximum Top Displacement in Load Test	

Uplift Test

One of our users wanted to subject the static CAPWAP results to a simulated uplift test. An option was therefore built into the program which would make a static analysis with (a) no end bearing and (b) only (80%) friction (this is the default value).

Notes:

There may be great differences between static uplift tests and uplift capacity predicted from compressive impact testing.

The plot made by CAPWAPC will not indicate that whether or not the load set curve was calculated for an uplift condition.

Static Analysis Changes (TGap, CSkn, CToe)

A resistance gap may be a dynamic condition. It is usually not observed in static test results. For this reason, the simulated static test is now calculated with a toe quake that is the sum of the dynamic toe quake and the resistance gap.

Similarly, the static analysis will ignore a soil coefficient of restitution greater than 1. (The user may have chosen such an unusual factor in his dynamic analysis, if he had a small quake and a large gap. The effective quake was then really greater than the toe quake dynamically analyzed and a larger unloading quake would also be expected).

Directory Assistance

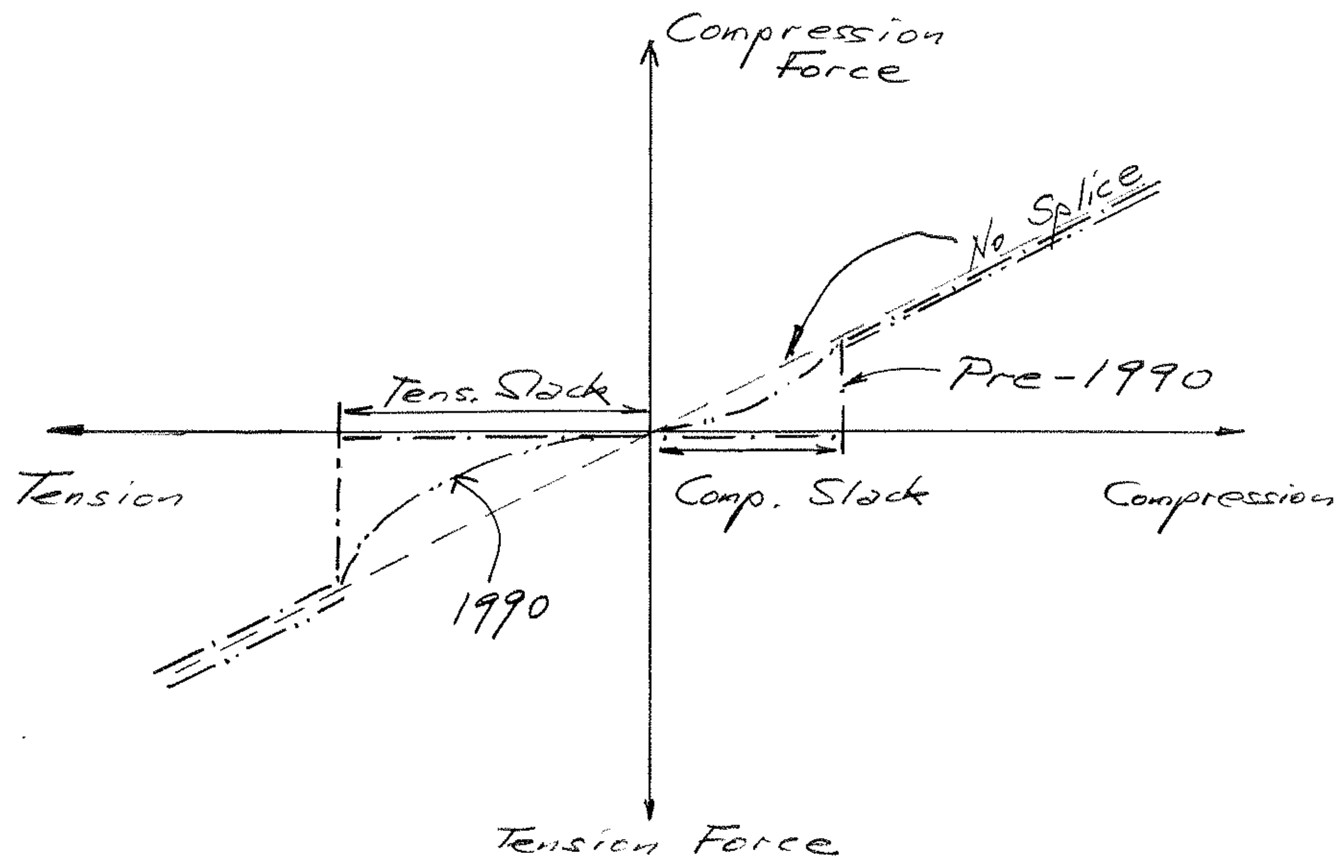
The user now can request a directory display in CAPWAPC at the time when a file name input is requested. The occurrence of a ? or * in the file name specification will prompt the search of the drive specified in the user response.

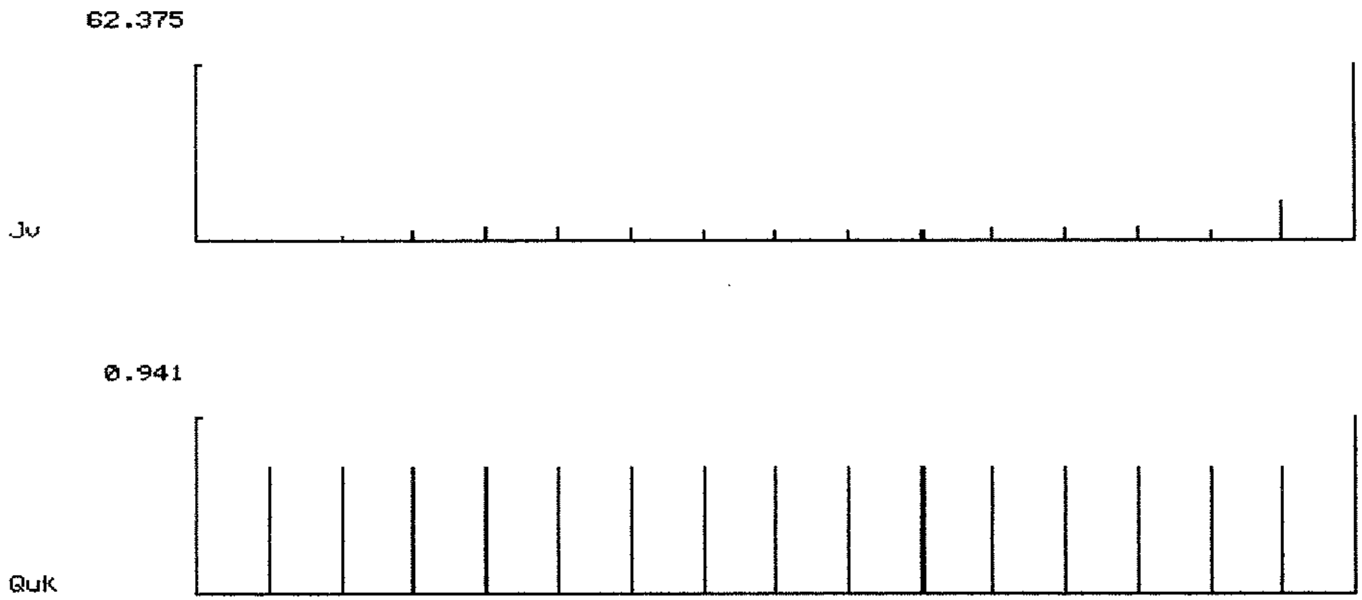
Title and File name Editing

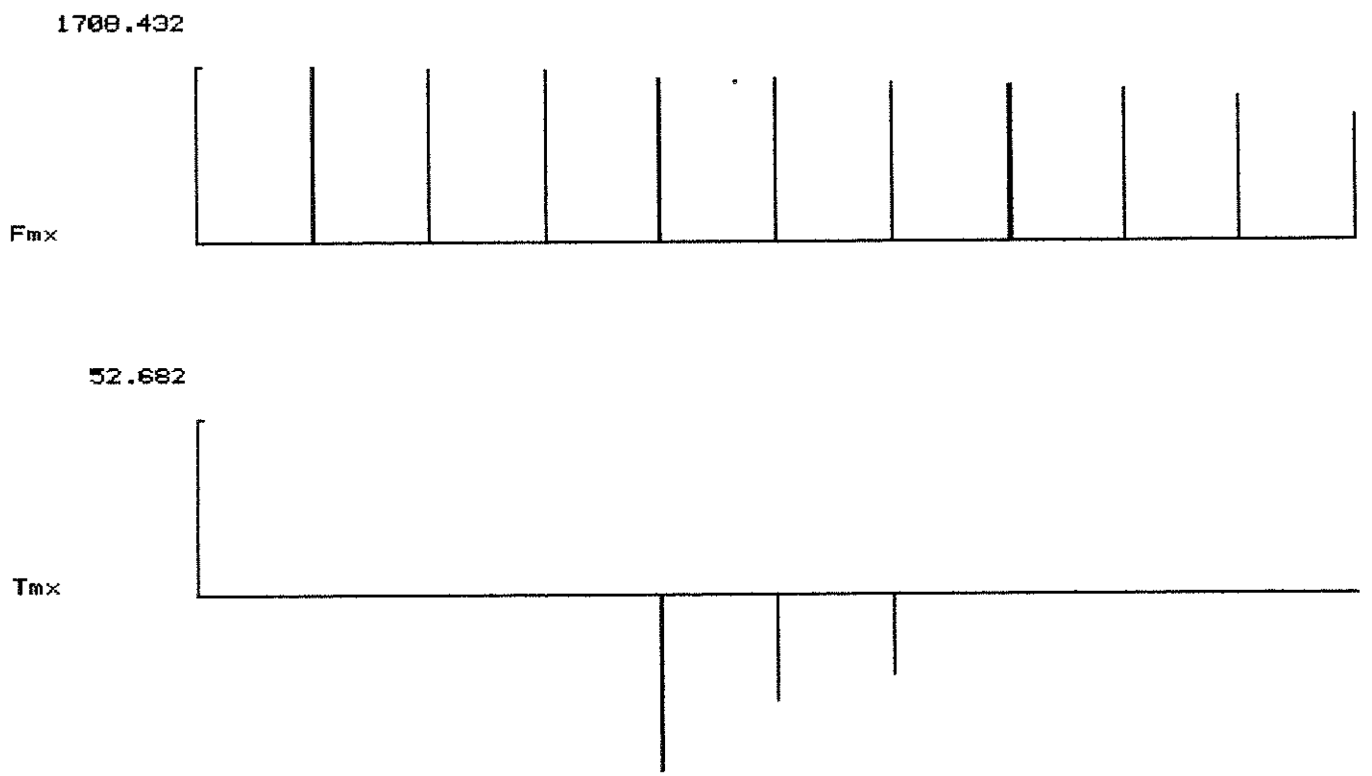
An editing feature has been built into code. You may use the Insert, Delete keys for lengthening and shortening any name or title. Any character keys would overtype existing text and arrows or back space move the cursor.

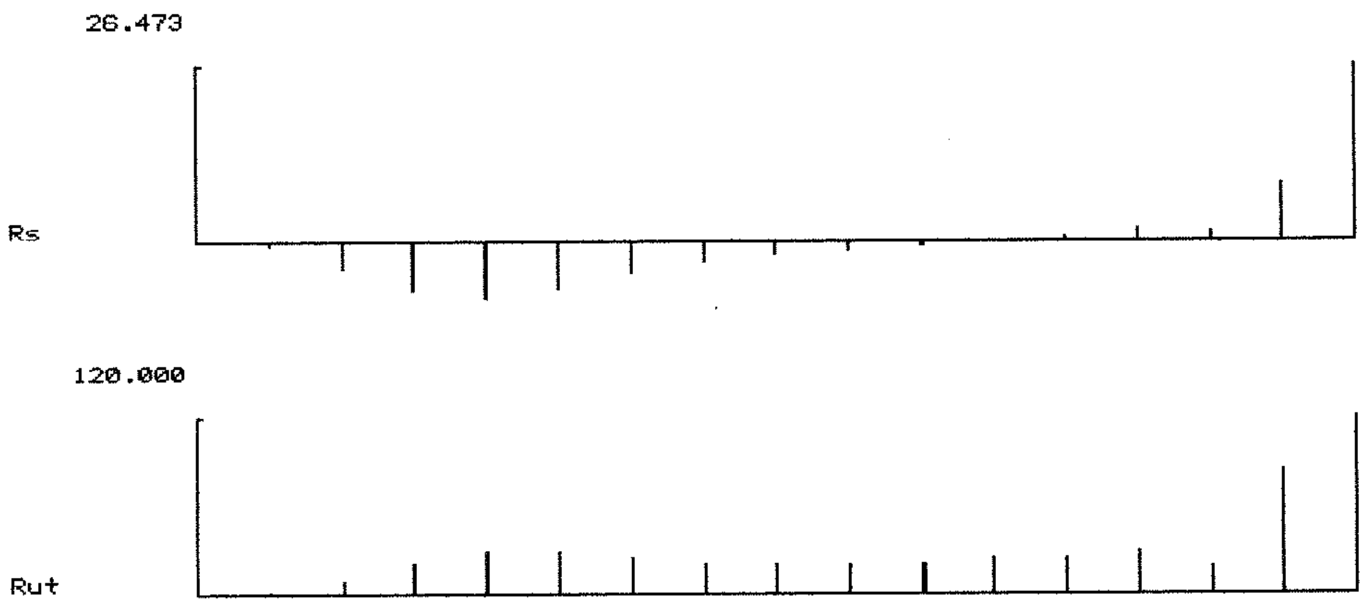
Fast Menu Display

Increased speed of program performance has been achieved with a faster menu display and a reduced number of required "Returns". In order to help your memory, the previous entry and the associated replaced value is also indicated at the top of the display.


Compression Force
No Splice
Pre-1990
Tens. Slack
Tension
Comp. Slack
Compression
1990
Tension Force


62.375
Jv
0.941
QuK


1700.432
Fmx
52.682
Tmx


26.473
Rs
120.000
Rut

```
CAPWAPC Variables:
 [illegible]kn      .675  QToe        .941  CSkn       1.700  CToe       1.400  AUto          1.
 [illegible]kn      .000  RToe        .000  UNld        .000

JSkn      .200  JToe        .200  SSkn        .164  SToe        .520  OPtd          0.
PIld      .030  SKdp        .000  BTdp        .000  MSkn         .00  MToe         .00

PLug      .300  TGap        .000                    RDsw        500.  ANat          3.
T.wt      .612  DMxt       3.591  IMpd      311.87                    REss          1.

NAxxxx to change NAme to xxxx, - "H" for Help
LIi for Recommended Limit of i-th Quantity

li20
Recommended Range:    .000<= TGap <=   2.650
```

```
QI Quake Input              OU Output           CM Graph Current Mtch
PM Pile Model Input         NI New Input        BM Graph Best Match
```

Damping Factors, Added Damping, Multipliers, Approx. Damping Forces

		1	2	3	4	5	6	7	8	9	10
DFac	1	.5	4.1	9.3	12.5	12.6	10.5	8.7	8.3	8.4	8.9
DAdd	1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
DMul	1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
DFor	1	2.7	20.8	47.1	60.7	60.9	47.3	37.5	36.0	35.4	35.9
DFac	11	10.8	10.2	12.8	8.0	36.5	153.5				
DAdd	11	.0	.0	.0	.0	.0	.0				
DMul	11	1.0	1.0	1.0	1.0	1.0	.0				
DFor	11	43.8	40.1	49.9	29.6	141.5	595.7				

```
 0 ... Exit
 1 ... Enter Added Damping
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2
Enter Damping Multiplier
I1, D1, I2, D2
```
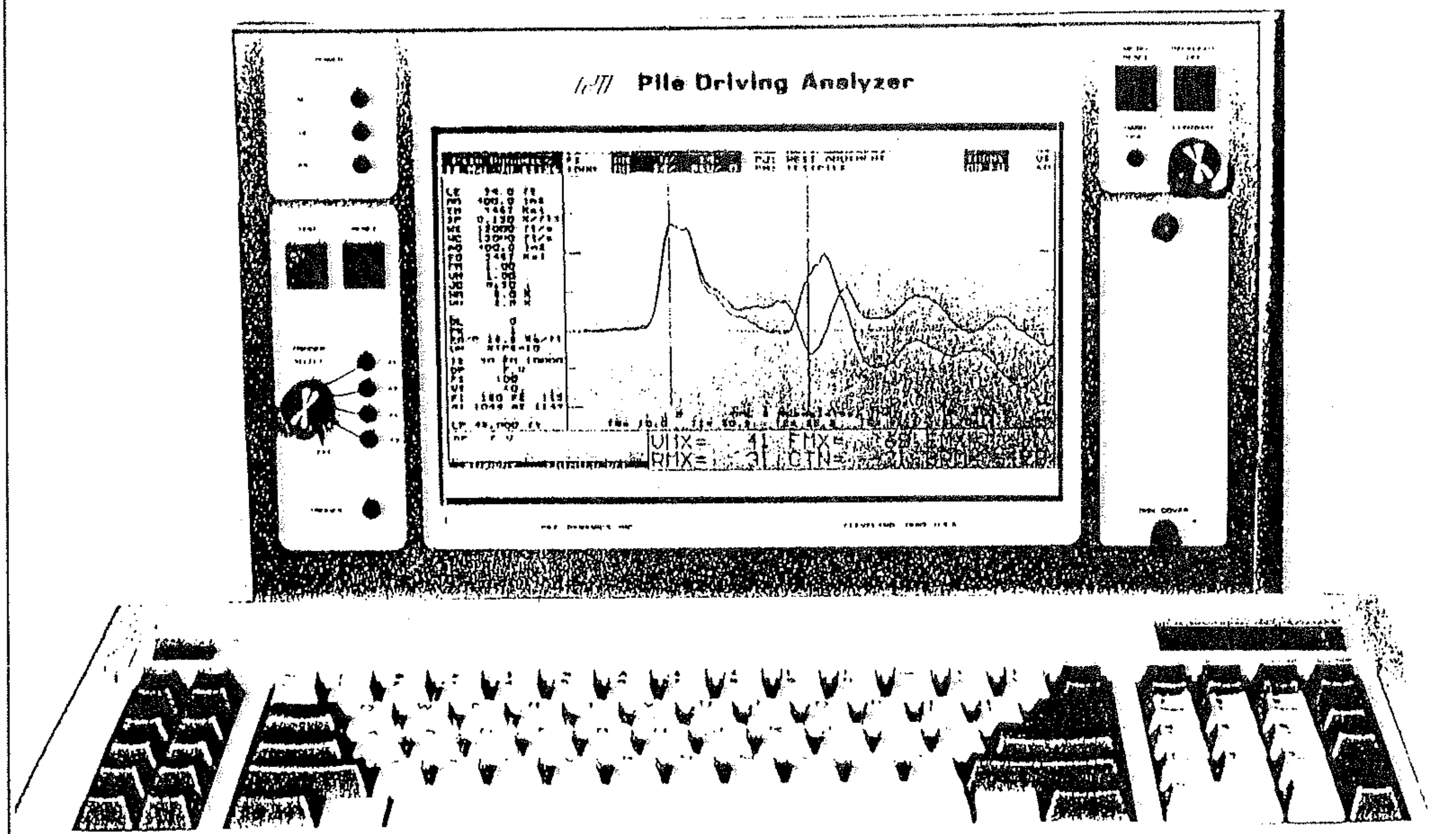

Cleveland 1990



PDA USERS DAY • CLEVELAN

June 28 and 29, 1990

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