CIVIL ENGINEERS
POCKET COMPUTER MONTHLY

SOFTWARE

In this month's issue we continue to illustrate the usefulness of the GCP approach by means of three programs. This month's software includes:

1. Walls Retaining Drained Sand
2. Chezy-Manning Formula for Flow in Channels
3. Wood Column Design

WALLS RETAINING DRAINED SAND

The design of a wall retaining drained non-cohesive soil requires a reasonably accurate approximation of:

A. The magnitude of the resultant of lateral pressure on the wall.

B. The location of that resultant.

C. The shape of the pressure diagram.

These three considerations are dependent on:

1. The strength property of the sand (angle of internal friction, $\emptyset$),
2. the height of the retained material,
3. the in-situ unit weight of the sand,
4. The manner in which the backfill was placed,
5. the angle of friction between the wall and the sand,
6. the angle of the retained surface with the horizontal,
7. The angle which the wall's surface of contact with the retained soil, makes with the vertical,
8. whether surface surcharge loads are anticipated during the life of the wall; if so, their location and magnitude,
9. the rigidity of the wall, and
10. whether the wall is a) built, then backfilled, or b) constructed as a braced wall as part of an excavation procedure.

It may not be well appreciated that the usual approach to the problem (the "active" case using theories of limit equilibrium) is not necessarily always correct — and may be unconservative!

For example, the computational procedures required to solve A, B, and C, are markedly different for a braced cut in sand, compared with a cantilever wall backfilled with sand. Indeed, consideration of any braced (rigid) wall, despite whether constructed in a cut, should include the possibility that the conditions required for the "active" case by Rankine/Coulomb procedure, may not be satisfied, particularly if the top of the wall is restrained against lateral movement. Where the retained height of a braced wall is relatively great, that is, more than about twenty or thirty feet, and where the backfill is well compacted during placement, assumptions of fully mobilized active earth pressure are probably invalid; other assumptions must be made. Indeed, if a high degree of compaction of backfill is carried out using heavy equipment, wedging of sand grains behind an unyielding wall may result in <u>higher</u> than at-rest lateral pressure, and may actually achieve partially-mobilized passive pressure.

A rule of thumb in determining whether the fully-mobilized active earth pressure condition may be assumed, is that the lateral strain in the wall due to the lateral pressure, is equal to 0.001H, min.

For example, if the basement wall of a building is 40 ft. deep and is laterally braced by the floor systems of the building at ten foot intervals, there is a strong likelihood that the amount of lateral movement in the wall would be less than .001 x 40 x 12=0.48 inch. If ½ inch of lateral displacement does not develop, it may be incorrect to assume the fully-mobilized active case. On the other hand, some lateral displacement may occur. The engineer must choose 1) the fully mobilized "active" condition, 2) the "neutral" or "at-rest" condition, 3) the "quasi-passive" condition, or somewhere in between.

If the at-rest case is to be assumed, the coefficient of lateral earth pressure on a vertical surface, for sand (level backfill), may be taken as:

$$K_o = 1 - \sin \phi$$

If one assumes a ϕ angle for sand equal to 30°, the resulting value of K_o is 0.5; this value contrasts with the K_a (active) value of 0.33 for the same condition, an increase of 50%, which could define the range within which the engineer might be working, in estimating the magnitude of lateral earth pressure. However, if the quasi-passive condition is applicable, the earth pressure coefficient must, of course, exceed the "at-rest" value; in such cases, K_o can be as large as 2.0.

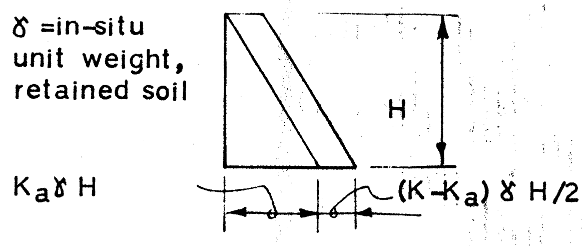
This discussion does not include solutions for lateral pressure on braced excavations. See standard works on the subject, such as "Foundation Engineering Handbook" by Winterkorn and Fang (1975), VanNostrand-Reinhold, pp. 466-469.

The design engineer is of course left to his own devices. It is our belief that, although most walls may be designed for the active case, many design situations including deep, braced rigid basement walls could be seriously underdesigned unless a more conservative earth pressure procedure is utilized.

If the active case is misapplied,

1. the magnitude of the lateral earth force would be underestimated, and
2. the assumption of triangular lateral earth pressure distribution may be incorrect, causing serious under-estimation of design pressure, particularly in the upper part of the wall.

We use the following procedure in order to obtain the lateral pressure diagram for "non-active" conditions: A trapezoidal earth pressure diagram is developed, comprised of the familiar active earth pressure triangle, plus a superimposed "layer" of uniform earth pressure. (This layer's "thickness" is determined by calculation of the associated lateral pressure at midheight of the wall.) The procedure is illustrated as follows:



GCP PROGRAM - WALLS RETAINING DRAINED SAND

I = retained height, ft.
J = in-situ unit weight of retained soil, pcf
K = Ø (angle of internal friction)
L = angle of retained surface with the horizontal, with appropriate sign
M = angle of the wall-soil surface of contact, with the vertical, with appropriate sign
2/3*Ø = Angle of friction, sand to wall

```
100  IF L> K LPRINT "ERROR:ANGLE
     OF SURFACE      EXCEEDS Ø ":END
110  N=2/3*K
120  A=(COS(K-M))^2
130  E=(1+(SIN(K+N)*SIN(K-L)/COS(N+M)/
     COS (L-M))^0.5)^2
140  A=A/(COS M)^2/COS(N+M)/E
150  B=A*J*I
160  C=B*I/2
170  D=N
```

For PC-1 revise Line 100 as follows:

```
100  IF L>K PRINT "ERROR:ANGLE OF
     SURFACE    EXCEEDS Ø ":END
```

See Page 10 for worked out examples.

CHEZY-MANNING FORMULA

For velocity of open channel flow of water, the Chezy-Manning Formula is often used by civil engineers for slope (actually energy gradient) values of up to 10% (0.1), as follows:

$$V = \frac{1.486}{n} r_h^{2/3} S^{1/2}$$

where

V = velocity (ft/sec)

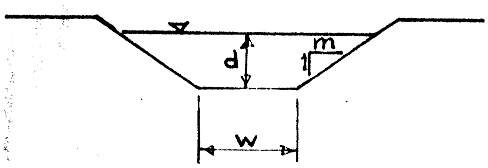
r_h = hydraulic radius, ft. $= \dfrac{\text{flow area, ft.}^2}{\text{wetted perimeter, ft.}}$

S = slope (ft/ft)

n = Manning Roughness Constant. Some examples are:
- Concrete 0.011 (smooth) to 0.017 (rough)
- Corr. Metal Pipe 0.022
- Brick 0.016
- Steel 0.013
- Natural 0.025 (good) to 0.06 (very poor)

TRAPEZOIDAL CHANNEL

Channels are often trapezoidal in shape and symmetrical.



We may write general expressions for area, A, and for wetted perimeter, W, in terms of three parameters: base width, w; side slope, m; and water depth, d. Dimensions should be in consistent units.

$$A = wd + md^2 = d(w+md)$$

$$W = 2(d^2 + m^2d^2)^{1/2} + w = 2d(1+m^2)^{1/2} + w$$

Therefore

$$r_h = \frac{d(w+d)}{(2d(1+m^2)^{1/2} + w)}$$

GCP PROGRAM-TRAPEZOIDAL CHANNEL

Input Parameters are:

I = d = water depth, ft.
J = w = width of base, ft.
K = n = Manning Coefficient
L = S = slope or energy gradient,ft/ft.
M = m = side slope (e.g., for a side slope of 3 horz. to 1 vert., m=3)

Output Parameters are:

Area, ft^2:

```
100 A=I*(J+M*I)
```

Hydraulic Radius, ft:

```
110 B=I*(J+I)/(2*I*(1 + M^2)^0.5+J)
```

Flow Velocity, fps:

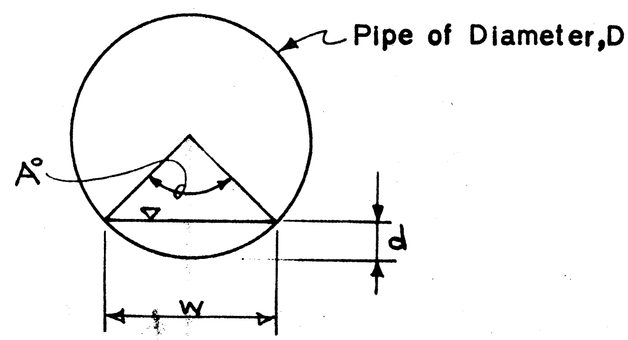
```
120 C=1.486/K * B^(2/3)*L^0.5
```

Discharge, cfs:

```
130 D=A*C
```

PIPE CHANNEL

Less-than-full flow through a circular conduit.



A° = 4(ASN√(d/D))

w = D SIN (A°/2)

$$\text{Area} = \frac{\pi D^2}{4} \frac{A°}{360} - \frac{w}{2}(D/2-d)$$

$$\text{Wetted Perimeter} = \pi D \frac{A°}{360}$$

$$r_h = (\text{Area}) \frac{360}{\pi D A°}$$

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GCP PROGRAM - PIPE CHANNEL

Input Parameters:

I = d = water depth, ft.
J = D = pipe diameter, ft.
K = n = Manning Coefficient
L = S = slope or energy gradient, ft./ft

Output Parameters are:

Angle, degrees:

```
100 E=4*ASN((I/J)∧.5)
```

Area, ft^2:

```
110 A= π*J ∧ 2/4*E/360-J*(SIN(E/2))/2*
    (J/2-I)
```

Hydraulic Radius, ft:

```
120 B=A*360/π/J/E
```

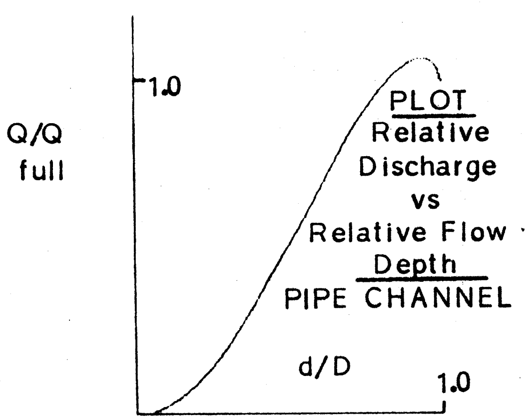
Flow Velocity, fps:

```
130 C=1.486/K*B∧(2/3)*L ∧0.5
```

Discharge, cfs:

```
140 D=A*C
```

As the flow depth, d, approaches the diameter, D, an interesting phenomenon occurs: the discharge quantity decreases; for this reason, pipes cannot be made to flow full unless surcharged. Flow discharge is optimum at about 0.95 ratio of depth to diameter. See plot below. However the least wetted perimeter occurs (most efficient) at d=D/2, a semicircle. Thus, the most efficient trapezoid is that which most closely resembles the semi-circle, as exemplified by a half-hexagon.

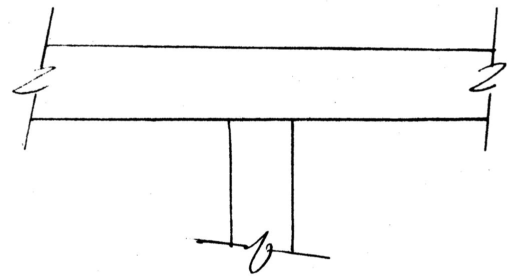


DESIGN OF SOLID WOOD COLUMNS

Ref: National Design Specification for Wood Construction, 1977 Ed., National Forest Products Association, Washington, D.C.

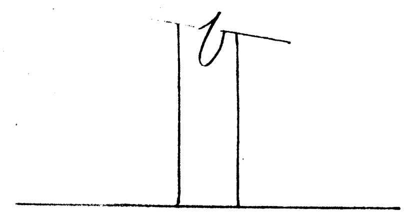
This analysis is for the design of a post, either isolated or built into a wall.

Where the top terminates at a beam, thus,



the post is considered pin-ended at the top.

Where the post terminates on a foundation, thus,



it is considered pin-ended at the base.

However, where the post is built in at base or top, such that it may be considered restrained against end rotation, at least partially, the provisions of 3.7.1.3 apply and the member may be regarded as having greater stability than the pin-end condition; the effective length of the column may thus be "reduced in accordance with good engineering practice."

The following table of reduction coefficients is used in our practice, and applies only to wood columns which are part of a structure ("braced structures") so that the ends of the column are held in alignment.

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	End Restraint Coefficient
Top and Bottom restrained against rotation (built-in)	0.7
One end restrained (built-in); other end pinned	0.85
Both ends pinned	1.0

Where the structure is not braced against relative lateral movement of column ends (for example, an open-sided one-story "shelter-type" structure with no braced bays or stiffening walls) the end restraint coefficient should be taken as 2.0. In addition, for such cases, columns would nearly always be designed to resist the moment due to lateral force associated with wind, and therefore must be fixed at the base.

The following procedures deal with wood columns resisting axial loading.

Wood columns are classified in three categories: 1) short, 2) intermediate, and 3) long or "Euler" columns. The parameter which governs this aspect is the L/D ratio, where $D = \sqrt{12} * r$, and r = radius of gyration.

1. If $L/D \leqslant 11$ the column is short; therefore

   $$F_c' = F_c$$

   where

   F_c = Design Tabulated Value for Axial Compression, psi, and

   F_c' = Max. Axial Comp. stress in the column.

2. If $11 < L/D \leqslant K$

   $$F_c' = F_c\left(1 - \frac{1}{3}\left(\frac{L/D}{K}\right)^4\right)$$

3. If $L/D \geqslant K$ the Euler case applies and

   $$F_c' = \frac{0.3E}{(L/D)^2}$$

   where

   $$K = 0.671\left(\frac{E}{F_c}\right)^{0.5}$$

   E = Modulus of Elasticity, psi

K is the minimum value of L/D at which the column may be expected to exhibit Euler-type buckling. For a circular section the "L/D ratio" becomes $\frac{4*L}{(I*\sqrt{12})}$, which is substituted in Line 125, for L/I.

GCP PROGRAM - AXIALLY LOADED COLUMN

Input Parameters:

- I = Greater Dimn, (or diam of circular section), in.
- J = Lesser Dimn, (or diam of circular section), in.
- K = F_c , Allowable axial stress, as tabulated, psi
- L = Unbraced Col. Length, strong way, ft.
- M = Unbraced Col. Length, weak way, ft.
- N = Elastic Modulus, psi
- O = Factor, Compression parallel to grain. See 2.2, 3.6.6 and Appendix B
- P = Axial Load, lb
- Q = End Restraint Coef, strong way
- R = End Restraint Coef, weak way

```
100 INPUT "(R)ECT, (S)QUARE,
    (C)IRC";U$:WAIT 400
105 IF Q=0 LET Q=1
110 IF R=0 LET R=1
120 A=12*Q*L/ I:B=12*R*M/J:IF O=0
    LET O=1
125 IF U$="C" LET A=12*Q*4*L/I/√12:
    B=12*R*4*M/J/√12
130 C=A:IF B>C LET C=B
150 IF C>50 PRINT "L/D>50; COLUMN
    INVALID":BEEP 4:END
160 D=.671*(N*O/K)∧.5*4/√12
170 IF C>=D LET B=.3*N*O/C/C:
    GOTO 200
180 IF C<=11 LET B=O*K:GOTO 200
190 B=K*(1-((C/D)∧4)/3)*O
200 F=I*J:IF U$ = "C" LET F=π*I∧2/4
210 A=P/F:IF A>B PRINT "COLUMN
    OVERSTRESSED"
```

Output parameters:

- A = Axial Stress in Column, modified by Load Factor, psi
- B = Allowable Axial Stress in Column,psi
- C = Critical L/D ratio

CIVIL ENGINEERS POCKET COMPUTER MONTHLY

PROGRAMMERS TIP

MASS STORAGE OF DATA/PC-2

Radio Shack's PC-2 "Owner's Manual" promises a "TRS-80 PC-2 Programming Guide" which "should be available in the summer of 1982". As of this week, no PC-2 Programming Guide is available from Radio Shack, to our knowledge.

However, we have three manuals for guidance, namely, the PC-2 Owner's Manuals for Computer and for Printer/ Plotter, and the Sharp PC-1500 "Instruction Manual." In addition, we have the "Quick Reference Card."

We have struggled with the problem of mass storage of data. Information regarding this problem is contained in the Radio Shack Printer/Plotter Manual, the Card, and the Sharp Manual. Of these, we have found the Sharp information to be reasonably reliable although incomplete; it is lacking in crucial areas. The Radio Shack information has been found to be incorrect in certain key aspects; in addition, it also is fatally incomplete.

The following is based on our study of the problem. It is correct as best we know it, as proven by working programs printed herein.

The PRINT# and INPUT# statements are intended to permit mass storage of data on tape, as string (characters) or numeric variables.

The following variable forms are used in the PC-2:

1) Fixed-memory variables, e.g., A, B, . . . ,Z or A$, B$, ..., Z$ which are also recognizable in the forms @(1), @(2), ...,@(26), and @$(1), @$(2), ... @$(26).

2) Dual or two-component alpha-numeric variables, e.g., AA, Z3, DY, or AA$, Z3$, DY$. (Illegal dual variables are IF, LF, LN, ON, OR, TO, PI. The alpha-numeric form, 3Z, is also illegal.)

3) Dimensional/subscripted variables, are also called arrays, e.g., A(1), AB(10), PQ(X), AX$(25). The maximum subscript is 255, minimum is zero; thus, 256 values are available in a one-dimensional array. A two-dimensional array is used to store data in rows and columns. The DIM statement is required for one and two-dimensional arrays. It is used to declare the number of storage registers which are to be assigned to each subscripted variable. Thus, DIM A(3,5) will reserve a 4 by 6 block of memory sites (storage registers), as follows:

	Ø	1	2	3	4	5
Ø						
1						
2						
3						

Note that four rows and six columns, thus 24 sites, are reserved.

The PRINT# statement allows mass storage of variables on tape, using cassette recorders #0 or #1 (which are also designated REM 0 and REM 1). As stated, this storage occurs either in the form of numbers or strings of characters. The INPUT# statement recovers these values from tape. The rules by which this is done are essentially rigid and inflexible.

Illustrations

After setting up the tape machine in the usual manner (the same procedure as is used for saving or loading programs), the following two programs may be run. We have set up these programs on tape machine #1 (REM 1) so as to illustrate all of the aspects of the procedure. The black plug must be inserted into the port marked "REM 1", which is toward the left.

Enter the following two programs in the PRO mode:

```
1Ø   "M" CLEAR
2Ø   A=1Ø:B=2Ø:AB=3Ø
3Ø   PRINT #-1, "TEST-RUN"; A,
     B, AB
4Ø   LPRINT A: LPRINT B: LPRINT
     AB
5Ø   END

1ØØ  "N" CLEAR
11Ø  AB=Ø: INPUT #-1, "TEST-RUN";
     A, B, AB
12Ø  LPRINT A: LPRINT B: LPRINT
     AB
13Ø  END
```

Before running the first program, note that it is necessary, prior to using REM 1, to type REM OFF, Enter. This will clear the remote control functions. Then type RMT ON, Enter. This procedure is required prior to executing the recording/loading function. The cassette interface will now be in a mode which is equivalent to having the REMOTE button in the ON position. (The REMOTE button affects only the REMØ control.)

The tape cassette machine should be set up correctly for recording, including correct volume and tone control settings. Then, the RECORD and PLAY buttons are depressed simultaneously.

Make a note of the odometer reading on the tape recorder.

Press DEF M.

The values assigned to A, B, and AB (10, 20, and 30, respectively) will be recorded on tape, and a prompt sign will appear in the display.

Release the RECORD/PLAY buttons. It is now necessary to deactivate the remote. This can be done by typing REM OFF, Enter. However, we prefer to simply unplug the black plug temporarily from the side of the tape machine.

Now rewind the tape to an odometer reading slightly lower than the reading which was recorded. See above. Reactivate the remote control. Type RMT ON, Enter. (Or replace the black plug.)

Press the PLAY button.

Press DEF N which will cause the three parameter values, 1Ø, 2Ø and 3Ø, to be re-entered and printed on tape. Since the computer was cleared before the re-entry, the success of this procedure is proved.

Note that in program "N", it is necessary to initialize the variable, AB, in line 11Ø, by assigning a value, zero. In general, all dual variables (e.g., AB, B2, XX, etc.) must be thus initialized prior to the INPUT # statement; otherwise an ERROR 43 occurs.

Programs "M" and "N" may be simplified in two ways:

Firstly, we believe that the use of a file name is not necessary for tape cassette storage, as contrasted with disk storage. In all cases, it is vital to rewind the tape correctly, and to properly "cue up" the data using the odometer reading. In the absence of a file name, the first data encountered will be entered. If you wish to eliminate the file name, delete "TEST-RUN"; from both programs "M" and "N" (including the semicolon).

To further simplify, use REM Ø. This requires that the black plug be inserted in the right-hand port marked REM Ø. Then delete -1, (including the comma) and the two lines become:

```
3Ø  PRINT# A, B, AB
11Ø AB=Ø:  INPUT# A, B, AB
```

When using REM Ø, use the REMOTE switch (rather than REM ON and REM OFF commands).

We always use REM Ø except for those cases when two cassette recorders are used simultaneously; for example, when Cassette Machine #Ø is used for program storage, and Cassette Machine #1 is used for data storage.

The following programs are illustrative of procedures for recording of character data (strings) on cassette tape:

```
10   "M" CLEAR
20   A$="THIS IS":B$="A TEST":
     AB$="RUN"
30   PRINT #-1, "TEST-RUN";A$,
     B$, AB$
40   LPRINT A$: LPRINT B$: LPRINT
     AB$
50   END

100  "N" CLEAR
110  AB$="":INPUT #-1, "TEST-RUN";
     A$, B$, AB$
120  LPRINT A$: LPRINT B$: LPRINT
     AB$
130  END
```

The above comments apply equally to this second program. Note, however, that the variable, AB$, is initialized by use of the double quotes, rather than by a zero.

The following programs are similar; they illustrate the use of subscripted variables, or arrays.

The use of the DIM statement eliminates the need for initialization of dual variables.

Note the efficiency of the array form. For example, A(*) records/recovers all values of the subscripted variable A(N). Therefore, for storage of data, the use of arrays is by far the preferred method.

```
10   "M" CLEAR: DIM A(1), AB(0)
20   A(0)=10:A(1)=20:AB (0)=30
30   PRINT #-1, "TEST-RUN":A(*),
     AB(*)
40   LPRINT A(0): LPRINT A(1):
     LPRINT AB(0)
50   END

100  "N" CLEAR: DIM A(1), AB(0)
110  INPUT #-1, "TEST-RUN";A(*),
     AB(*)
120  LPRINT A(0): LPRINT A(1):
     LPRINT AB(0)
130  END

10   "M" CLEAR: DIM A$(1), AB$(0)
20   A$(0)= "THIS IS":A$(1)="A TEST":
     AB$(0)="RUN"
30   PRINT #-1,"TEST-RUN";A$(*),
     AB$(*)
40   LPRINT A$(0): LPRINT A$(1):
     LPRINT AB$(0)
50   END

100  "N" CLEAR: DIM A$(1), AB$(0)
110  INPUT #-1, "TEST-RUN";A$(*),
     AB$(*)
120  LPRINT A$(0): LPRINT A$(1):
     LPRINT AB$(0)
130  END
```

Note that the DIM statements in each of the two programs "M" and "N", are identical. This is necessary, else an ERROR 43 may result. However, you may change the order, i.e., AB(0), A(1) instead of A(1), AB(0).

You may specify fewer variables in your INPUT# line than in your corresponding PRINT# line, but not more.

The PRINT# and INPUT# commands can be executed manually. Remember that RUN has the same effect as the CLEAR command; it clears the data! We do not typically use manual operation in storing our data; we prefer to write the statements in our programs. However, if you fear that data will not be properly recorded, you may prefer, until you develop confidence, to use the manual method.

Don't forget to provide DIM statements for arrays. Initialize non-subscripted dual variables before the corresponding INPUT# statement. Also be sure to cue up your tape properly before executing the INPUT# statement.

With patience and practice, you soon should be able to consistently store and recover data using cassettes for mass storage.

NEWS

NEW PORTABLE FROM RADIO SHACK

We believe in portability. Obviously, others do too.

Radio Shack will market their Model 100 Portable Computer in two versions, the 8K and 24K RAM, to sell for about $800 and $1000, respectively. RAM expansion modules (8K) will cost about $120. The machine is expandable to 32K. Built-in ROM (32K) includes Microsoft Extended BASIC, a text editor, communications software, an address-list manager, and an appointment-scheduling program. The unit will accomodate application modules, up to 32K of additional ROM.

Exciting aspects of this new unit include its 40 column by 8 line liquid crystal display. Plus a full typewriter keyboard, packaged in a 2-inch thick notebook sized unit, 4 pounds light! It's battery system includes 4 AA alkalines for operation, and a NiCad backup to preserve memory (data and programs) when powered down and while the AA batteries are being changed. Ports include modular phone jack for modem, RS-232 interface, a parallel interface, as well as ports for connection of an ordinary cassette recorder and a bar-code scanner. Other features include eight function keys, dot-addressible graphics characters, numeric keypad capability, sound generator, and built-in 300 baud, direct-connect modem.

A unit like the 100 is not a "pocket" computer, but it surely represents a new generation of portable power! The civil engineer who wants to take it with him/her to the job, home or branch office, can do so. Output will be copied from the screen unless a compact plug-in portable printer is to be offered. For now, we assume that hard output will require a standard printer.

What's next?

ERRATA

Our only ERRATA this month pertains to (of all places) our February ERRATA.

In February (pg. 8) we provided:

January Issue, Page 4, Line 3ØØ should read:

```
3ØØ IF U$ "P" THEN 38Ø
```

What we meant was:

```
3ØØ IF U$<>"P" THEN 38Ø
```

CASSETTES

We offer Cassette Tapes with documentation at $20 each for:

1) Statistics-Confidence Program, PC-1 or PC-2
2) GCP with or without Printer, PC-1 or PC-2
3) Wood Column and Wood Foundation Wall, PC-1 or PC-2
4) Steel Column, PC-1 or PC-2, and Steel Beam-Column, PC-2
5) Hazen-Williams and Chezy Manning Flow Formulas, PC-1 or PC-2
6) Walls Retaining Drained Sand, PC-1 or PC-2
7) Accounts Receivable, PC-2-This program prints detailed invoices, including aging. Prepares summary of business during the time period. Suitable for up to five hourly categories of charge rates. Requires 8K module.

Note: Civil Engineers Pocket Computer Monthly supports Radio Shack's PC-1 and PC-2 (Sharp PC-1211 and PC-1500) We believe our software will be helpful to civil engineers who have other equipment.

WORKED-OUT EXAMPLES

WALLS RETAINING DRAINED SAND

This analysis requires input of wall height, insitu unit weight of retained soil, angle of internal friction Ø of retained material, slope angle ω of retained surface, angle β of back of wall.

The usual range of Ø is 20° to 40°. If the angle of the retained slope, ω, exceeds Ø, the system is unstable; the program will provide an error message.

The angle ω is measured from the horizontal: upslope is positive; downslope is negative.

The angle β is measured from the vertical; counterclockwise is positive; clockwise is negative. See example.

The angle of friction between the soil and the back of the wall is taken at 2/3 Ø; if you wish to use another value, change Line 11Ø accordingly.

The output is A, B, and C.

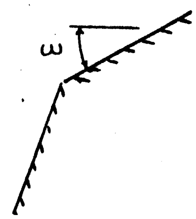
- A = Coefficient of lateral earth pressure
- B = Lateral earth pressure on a vertical surface, at elevation of base of wall, psf.
- C = Total horizontal force on wall, lb.

Run #1 A ten foot vertical wall retains sand at 100 pcf with a Ø angle of 30°, level backfill. The coefficient of lateral earth pressure is 0.3, the lateral pressure at the base is 297 psf, and the force on the wall is 1487 lb/ft of wall.

```
LAT SOIL PR, WALL
**   **   **   **

RET.HT.,FT. =
            10
UNIT WT, RET.MAT =     COMP. RESULTS:
           100
PHI =                  LAT.PRESS.COEF. =
            30            2.973138572E-01
RET.ANGLE =            LAT.PR, BASE, PSF =
             0                297.3138572
WALL ANGLE =           FORCE, WALL, LB. =
             0                1486.569286
```

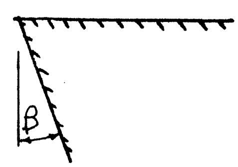
Run #2 A ten foot inclined wall retains sand at 120 pcf with a Ø angle of 30°. The angle of the retained surface is 30°. The incline of the wall's back face is -20° with the vertical.




```
LAT SOIL PR, WALL
**   **   **   **

RET.HT.,FT. =
            10
UNIT WT, RET.MAT =     COMP. RESULTS:
           120
PHI =                  LAT.PRESS.COEF. =
            30            4.679111138E-01
RET.ANGLE =            LAT.PR, BASE, PSF =
            30                561.4933366
WALL ANGLE =           FORCE, WALL, LB. =
           -20                2807.466683
```

Run #3 A 12 foot inclined wall retains sand at 125 pcf with a Ø angle of 35°. The retained surface is level. The incline of the wall's back face is +20° with the vertical.




```
LAT SOIL PR, WALL
**   **   **   **

RET.HT.,FT. =
            12
UNIT WT, RET.MAT =
           125
PHI =
            35
RET.ANGLE =
             0         COMP. RESULTS:
WALL ANGLE =
            20         LAT.PRESS.COEF. =
                          4.266866059E-01
                       LAT.PR, BASE, PSF =
                              640.0299089
                       FORCE, WALL, LB. =
                              3840.179453
```

AXIALLY LOADED WOOD COLUMNS, SQUARE, RECTANGULAR OR ROUND

This analysis requires input of the two dimensions of the column (or the diameter of a round column), allowable compressive stress perpendicular to the grain, unbraced length in strong and weak directions, modulus of elasticity, load factor, axial load, and finally the bending coefficients at the ends, strong and weak directions.

If the L/D ratio is excessively great (over 50) an error message appears and the program stops.

The output is axial stress, allowable axial stress, and the critical L/D ratio. If the column is overstressed, an appropriate message appears in the display while the output is being printed.

Run #1 — A 4 x 6 column (3½ x 5½ actual dimensions) of #2KD Southern Pine, 15 ft. long, is intended to carry 6 tons (12,000 lb) in axial compression. It is plumb and is part of a braced structure, that is, the ends are held in alignment (no sidesway). The column is braced at midheight in the weak direction. It is to carry snow loading; therefore, the load factor is 1.15. It is "built-in" at the upper end in the strong direction; therefore the column end condition coefficient is taken as 0.85.

The output reveals a successful column; the allowable stress, 713 psi exceeds the axial stress, 623 psi.

It may be of interest to compare the L/D ratio with the K value. In order to obtain the K value you may output the value, D, which is the K value. Simply press D, Enter, in the RUN Mode. In this case K=26.3 which is less than the critical L/D, 27.8; the column therefore is a "long" or "Euler" column.

It should be noted that, if the midheight bracing is removed, L/D exceeds 50 and the column is invalid.

```
**WOOD  COLUMN**
**   **   **   **

GREATER DIMN, IN =
                 5.5
LESSER DIMN, IN =
                 3.5
COMP.STR, PSI =
                1200
UNB.L, STRONG, FT =
                  15
UNB.L, WEAK, FT =
                 7.5
E, PSI =
             1600000
FACTOR =
                1.15  COMP. RESULTS:
AXIAL LOAD, LB =
               12000  AXIAL STR, PSI =
END COEF, STRONG =         623.3766234
                0.85  ALL.AX.STR., PSI =
END COEF, WEAK =           713.3153914
                   1  L/D RATIO, CRIT. =
                           27.81818182
```

Run #2 — Run #2 resembles Run #1. The column is unbraced full height. Its height however is ten feet. Other parameter values remain the same. The message "Column Overstressed" appears in the display. The allowable axial stress, 470 psi, is exceeded by the actual axial stress 623 psi. The column is "long"; the L/D ratio of 34.2 exceeds K (27.8) considerably. The column's capacity is 3.5 * 5.5 * 469.6 = 9040 lb.

```
**WOOD  COLUMN**
**   **   **   **

GREATER DIMN, IN =
                 5.5
LESSER DIMN, IN =
                 3.5
COMP.STR, PSI =
                1200
UNB.L, STRONG, FT =
                  10
UNB.L, WEAK, FT =
                  10
E, PSI =
             1600000
FACTOR =              COMP. RESULTS:
                1.15
AXIAL LOAD, LB =      AXIAL STR, PSI =
               12000       623.3766234
END COEF, STRONG =    ALL.AX.STR., PSI =
                0.85       469.5833332
END COEF, WEAK =      L/D RATIO, CRIT. =
                   1       34.28571429
```

CHEZY-MANNING FORMULA

TRAPEZOIDAL CHANNEL

Two runs are presented which illustrate the influence, in terms of discharge, of the surface conditions on the bottom and sides of the channel. A trapezoidal natural drainage ditch is designed to flow at 4 ft. maximum depth on a gradient of 0.2%. It incorporates a base width of 8 ft. and 3 to 1 side slopes. If the bottom is maintained in very good condition, the flow velocity is 3.39 ft/sec and the discharge is 271 cfs. However, if the bottom condition deteriorates such that the Manning Roughness Coefficient is 0.04, the velocity reduces to 2.12 ft/sec and the discharge to 170 cfs.

```
C-M FORMULA/TRAP
**    **   **    **

WATER DEPTH,FT =
                 4
BASE WIDTH,FT =
                 8  COMP. RESULTS:
MANNING COEF =
             0.025  FLOW AREA,FT2 =
GRADIENT =                        80
             0.002  HYD.RADIUS,FT =
SIDE SLOPE =                1.44151844
                 3  AV.VELOCITY,FPS =
                           3.392182642
                    DISCHARGE,FPS =
                           271.3746114
```

```
C-M FORMULA/TRAP
**    **   **    **

WATER DEPTH,FT =
                 4
BASE WIDTH,FT =
                 8  COMP. RESULTS:
MANNING COEF =
              0.04  FLOW AREA,FT2 =
GRADIENT =                        80
             0.002  HYD.RADIUS,FT =
SIDE SLOPE =                1.44151844
                 3  AV.VELOCITY,FPS =
                           2.120114151
                    DISCHARGE,FPS =
                           169.6091321
```

PIPE CHANNEL

These two runs illustrate the influence of water depth for gravity flow in a pipe. This illustration is based on a concrete pipe in good condition (smooth) of 42 inch diameter, laid on a gradient of 1%. At full depth, the velocity is 12.4 fps. At 95% depth, the velocity increases to 14.6 fps. See the curve on page 4.

```
C-M FORMULA/PIPE
**    **   **    **

WATER DEPTH,FT =
               3.5
PIPE DIAM,FT =
               3.5
MANNING COEF =
             0.011
GRADIENT =
              0.01  COMP. RESULTS:

                    AREA,FT2 =
                         9.621127501
                    HYD.RADIUS,FT =
                       8.749999999E-01
                    AV.VELOCITY,FPS =
                         12.3584733
                    DISCHARGE,CFS =
                         118.902448
```

```
C-M FORMULA/PIPE
**    **   **    **

WATER DEPTH,FT =
              3.33
PIPE DIAM,FT =
               3.5
MANNING COEF =
             0.011
GRADIENT =
              0.01  COMP. RESULTS:

                    AREA,FT2 =
                         10.63764153
                    HYD.RADIUS,FT =
                         1.126859308
                    AV.VELOCITY,FPS =
                         14.62870634
                    DISCHARGE,CFS =
                         155.6149341
```