Open-File Report

RELA: REgional Liquefaction Assessment, An Interactive Computer Program

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Open-File Report 85-468

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May, 1985
INTRODUCTION

Seed and others (1982, 1983) have developed a simple yet effective procedure through which liquefaction potential of sand deposits can be determined on the basis of field testing and small amount of laboratory testing. The approach, known as the simplified procedure, uses standard penetration test (SPT) or cone penetration test (CPT) data as input and is applicable to sand and silty sand deposits.

An earlier report described the computer program PETAL which performs various steps of computations specified in the simplified procedure and assesses the liquefaction potential in terms of cyclic stress ratio, $\tau_{av}/\sigma'_v$, and modified penetration resistance, $N_1$ (Chen, 1984). For certain types of investigation, it may be more effective to evaluate the liquefaction potential in terms of depth and uncorrected penetration resistance, especially if the investigation is concerned with similar deposits in a given region or with changes in groundwater conditions.

The report describes the computer program RELA (for REgional Liquefaction Assessment) which generates liquefaction potential boundary curves in terms of depth and uncorrected penetration resistance for specified groundwater conditions. RELA is coded in FORTRAN and programmed to run in an interactive mode with a VAX 11/780 computer. The storage requirement to execute RELA is less than 15-K bytes and thus the program can be easily modified to run on many personal computers.
GENERAL DESCRIPTION

Typical results from the simplified procedure or PETAL are shown in Fig. 1. The curve is the boundary between conditions of liquefaction and no liquefaction. If a point (A in Fig. 1, for example) is to the left of the boundary curve, the deposit whose estimated values of $t_{av}/\sigma_v$ and $N_1$ correspond to those of that point is considered prone to liquefy. If a point (B for example) lies to the right of the boundary curve, the corresponding deposit is considered safe from liquefaction. The task that RELA performs is to generate the boundary curve in terms of depth and penetration resistance for different groundwater conditions such as those shown in Fig. 2, and therefore is essentially an inverse operation of PETAL. The criteria on which RELA is based are the same as those specified by the simplified procedure and used in PETAL. Specifics not included in this presentation are referred to the earlier reports.

For each depth, $z$, considered in RELA, subroutine STRESS first computes the overburden effective stress, $\sigma_v^\prime$, and the total stress, $\sigma_v$, for the design groundwater condition and $\sigma_v^\prime$ for the test groundwater condition. The design groundwater condition specifies the depth to groundwater table expected during the design earthquake and the test groundwater condition is referred to as the actual depth to groundwater table when penetration resistance was measured. RELA, however, does not consider the existence of capillary zones and, therefore, is not suitable for application to soil deposits in which the capillary zone causes significant changes in the effective stress. The stress quantities at both groundwater conditions are needed in converting the modified penetration resistance, $N_1$, to uncorrected penetration resistance as measured. From the $\sigma_v^\prime$ and $\sigma_v$ for the design groundwater condition, the
Figure 1.— Typical result from program PETAL
Figure 2.-- Typical result from program RELA
depth, and the peak acceleration specified for the design earthquake, the cyclic stress ratio, \( \frac{\tau_{av}}{\sigma'_{v}} \) is estimated in the same manner as prescribed in the simplified procedure. If \( \sigma'_{v} \) exceeds 1.5 ton/ft\(^2\), \( \frac{\tau_{av}}{\sigma'_{v}} \) is corrected to allow for the stress ratio reduction due to increasing confining pressure (Seed, 1983). A revised \( N' \) corresponding to the reduced stress ratio is then used for the conversion.

If the deposit in question qualifies as a silty sand, \( N' \) is first compensated for the correction made for grain size effects. A correction factor, \( C_n \), is then determined according to the relative density of the deposit and the \( \sigma'_{v} \) for the test groundwater condition. Dividing \( N' \) by \( C_n \) results in the uncorrected penetration resistance. If applicable, this uncorrected penetration resistance is further compensated for the effect of shallow depth (less than 10 ft). In RELA, the uncorrected penetration resistance is expressed in terms of both the standard penetration test (SPT) in blow count/ft and the cone penetration test (CPT) tip resistance in Kg/cm\(^2\).

A new feature in RELA is the consideration of the liquefaction potential of gravelly soils. This consideration is based on the fact that during cyclic shear, it takes more number of cycles for gravelly soils to reach peak pore pressure than for sands. If the ratio of time to reach peak pore pressure for a gravelly deposit to that for sands is known or can be assumed, a separate relationship between normalized shear stress and number of cycles to cause liquefaction can be established. As illustrated in Fig. 3, the dotted curve for a gravelly sand is based on the results by Liu and others (1979) who found that for that particular gravelly sand of 45% gravel content, the number of cycles to reach peak pore pressure is 4 times of that for sands with zero
Figure 3.-- Relations of shear stress versus number of cycles to liquefy for different soils
($\tau_s$ is the shear stress to cause sand to liquefy in one cycle)
gravel content. RELA is capable of taking this type of relationships into account and generates the corresponding boundary curves accordingly.

As the program is coded in an interactive mode, all input to RELA are prompted and entered from the keyboard of remote computer terminals. The input required to execute RELA are self-explanatory as will be demonstrated later in the sample run. After the input are entered, RELA proceeds to perform computation for each depth considered and stores the results in a data file attached to I/O UNIT 16. The depths considered are generated internally from the depth to the design groundwater table downward to the cutoff depth according to the input depth increment, dz. The cutoff depth is set to be the least of (1) the total depth of the deposit, (2) 80 ft, or (3) the depth at which the uncorrected penetration blow-count for the boundary curve exceeds 80 blow counts/ft. The latter two criteria are used because, as depth increases, estimated of $\tau_{av}/'v$ based on the simplified procedure becomes less reliable and because correlation between high SPT blow-counts and soil behavior is not as well-established.
For a demonstration run, consider a site consisting of two layers with their depths and densities listed below:

<table>
<thead>
<tr>
<th>Layer</th>
<th>Depth</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 1</td>
<td>30 ft</td>
<td>110 pcf</td>
</tr>
<tr>
<td>Layer 2</td>
<td>85 ft</td>
<td>125 pcf</td>
</tr>
</tbody>
</table>

The design groundwater condition is 15 ft below the surface, and the test groundwater condition is 50 ft. The design earthquake is assumed to have a 6.5 magnitude and a peak acceleration of 0.3 g. The depth increment, dz, is 3 ft.

Two sets of computations are to be performed. The first set considers the deposits as sands with a relative density of 55%. The second set treats the deposits as gravelly sands of the same density. The time to reach peak pore pressure for these gravelly sands is 3.5 times of that for sands.

The entire interactive session is reproduced and shown next. For distinction, input from the keyboard are printed in light italic. The output file from I/O UNIT 16 resulted from this sample run is also included. Data in columns 2, 9, and 10 are used for constructing the boundary curves.
(REPRODUCTION OF THE INTERACTIVE SESSION FOR THE SAMPLE RUN)

RELA: basic units are in LBS and FT

enter title of this run in 72 characters or less
demo run, set 1

site description: enter no. of layers (<10)
2
enter depth(ft) and density(pcf) with decimals of layer 1
30.0, 110.0
enter depth(ft) and density(pcf) with decimals of layer 2
85.0, 125.0

enter expected depth of ground water during the design earthquake, and ground water depth when penetration test was performed -- 7.0, 20.0
15.0, 50.0

enter quake mag. and max acc (g) -- 7.5, 0.25
6.5, 0.3

enter depth increment, dz (1.0 to 5. ft) and relative density (0.4 for 40%), with a MINUS sign if sand is silty
3.0, 0.55

enter 0 if deposit is not gravelly
0

enter integer>0 for a new set of computation
9

RELA: basic units are in LBS or FT

enter title of this run in 72 characters or less
demo run, set 2

site description: enter no. of layers (<10)
2
enter depth(ft) and density(pcf) with decimals of layer 1
30.0, 110.0
enter depth(ft) and density(pcf) with decimals of layer 2
85.0, 125.0

enter expected depth of ground water during the design earthquake, and ground water depth when penetration test was performed -- 7.0, 20.0
15.0, 50.0

enter quake mag. and max acc (g) -- 7.5, 0.25
6.5, 0.3

enter depth increment, dz (1.0 to 5. ft) and relative density (0.4 for 40%), with a MINUS sign if sand is silty
3.0, 0.55

enter 0 if deposit is not gravelly
0

enter integer>0 for a new set of computation
9
enter equake mag. and max acc (g) -- 7.5, 0.25
6.5, 0.3

enter depth increment, dz (1.0 to 5. ft)
and relative density (0.4 for 40%), with a MINUS
sign if sand is silty
3.0, 0.55

enter 0 if deposit is not gravelly
9

enter multiple of time required for gravelly soil
to reach peak pore pressure when compared to
that for sand -- 4.1
3.5

enter integer>0 for a new set of computation
0
the site consists of 2 layers w/ depths & dens:

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</tr>
<tr>
<td></td>
<td>110.0 (pcf)</td>
<td>125.0 (pcf)</td>
</tr>
</tbody>
</table>

input relative density = 0.55

input eq. mag.= 6.50  max. acc. = 0.30 g
design ground water table depth = 15.0 ft.
testing ground water table depth = 50.0 ft.

count | depth | effective stress | total stress | effective stress | total stress | stress ratio | modified | uncorrected | spt-bc,N | cpt-Qc | kg/cm² | remarks
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<td>37.1</td>
<td>167.2</td>
<td>**Kd</td>
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</tbody>
</table>

* NOTE: remark Cn implies effective overburden pressure out of range, Cn=1.8 is assumed

Kd implies that correction for eff. overburden pressure > 1.5 tons/sq.ft was applied.
** correction for gravelly sands included **

demo run, set 2

the site consists of 2 layers w/ depths & dens:
1  30.0 (ft)  110.0 (pcf)
2  85.0 (ft)  125.0 (pcf)

input relative density = 0.55

input eq. mag. = 6.50  max. acc. = 0.30 g

design ground water table depth = 15.0 ft.
testing ground water table depth = 50.0 ft.

count  depth  design stress (psf)  testing stress (psf)  stress  modified  uncorrected  opt-Qc  remarks
      effective  total    effective  total    ratio  N1  spt-bc,N  kg/cm2
  (1)  (2)    (3)     (4)     (5)     (6)   (7)    (8)    (9)     (10)    (11)
  1  15.0  1650.0   1650.0  1650.0   1650.0  0.19   10.9    9.9     44.6
  2  18.0  1792.8   1980.0   1980.0  1980.0  0.21   11.9   11.8     53.1
  3  21.0  1935.6   2310.0   2310.0  2310.0  0.22   12.8   13.6     61.1
  4  24.0  2078.4   2640.0   2640.0  2640.0  0.23   13.5   15.3     68.8
  5  27.0  2221.2   2970.0   2970.0  2970.0  0.24   14.0   16.9     76.1
  6  30.0  2364.0   3300.0   3300.0  3300.0  0.25   14.5   18.5     83.0
  7  33.0  2551.8   3675.0   3675.0  3675.0  0.26   14.7   20.0     90.0
  8  36.0  2739.6   4050.0   4050.0  4050.0  0.26   14.8   21.5     96.7
  9  39.0  2927.4   4425.0   4425.0  4425.0  0.26   14.8   22.7    102.0
 10 42.0  3115.2   4800.0   4800.0  4800.0  0.26   15.2   24.4    109.0 **Kd
 11 45.0  3303.0   5175.0   5175.0  5175.0  0.25   15.2   25.4    114.4 **Kd
 12 48.0  3490.8   5550.0   5550.0  5550.0  0.25   15.1   26.3    118.4 **Kd
 13 51.0  3678.6   5925.0   5925.0  5925.0  0.25   14.9   27.0    121.4 **Kd
 14 54.0  3866.4   6300.0   6300.0  6300.0  0.24   14.7   27.2    122.4 **Kd
 15 57.0  4054.2   6675.0   6675.0  6675.0  0.24   14.5   27.4    123.1 **Kd
 16 60.0  4242.0   7050.0   7050.0  7050.0  0.23   14.3   27.5    123.6 **Kd
 17 63.0  4429.8   7425.0   7425.0  7425.0  0.22   14.1   27.6    124.0 **Kd
 18 66.0  4617.6   7800.0   7800.0  7800.0  0.22   13.8   27.6    124.0 **Kd
 19 69.0  4805.4   8175.0   8175.0  8175.0  0.21   13.5   27.3    123.0 **Kd
 20 72.0  4993.2   8550.0   8550.0  8550.0  0.21   13.2   27.1    121.9 **Kd
 21 75.0  5181.0   8925.0   8925.0  8925.0  0.20   12.9   26.8    120.5 **Kd
 22 78.0  5368.8   9300.0   9300.0  9300.0  0.19   12.5   26.4    119.0 **Kd

* NOTE: remark Cn implies effective overburden pressure out of range, Cn=1.8 is assumed
Kd implies that correction for eff. overburden pressure > 1.5 tons/sq.ft was applied.
REFERENCES CITED


Liu, L., Li, K., and Bing, D., 1979, Earthquake damage of Baihe Dam and liquefaction characteristics of sand and gravel materials: Research Institute of Water Conservancy and Hydroelectric Power, Beijing, China.


Program Listing

If the user has access to the VAX 11/780 computer of the Office of Earthquakes, Volcanoes and Engineering, U.S. Geological Survey in Menlo Park, California, he can simply execute RELA by entering the command:

```
run pub1:chen.liq)rela
```

and the output file for016.dat will be in the user's working directory.

Listing of RELA and its subroutines are reproduced in the following pages.
RELA: REgional Liquefaction Assessment

This program generates liquefaction potential curves postulated in the simplified procedure in terms of depth and uncorrected penetration resistance. The program is intended for the assessment of liquefaction potential of similar deposits in a given region where considerations of depth and ground water condition are important.


dimension dref(9), rd(9), sv8(16), cn8(16), sv4(16), cn4(16),
& xf(20), yf(20), rmk(5), xn(9), yt(9), ut(9), title(18), resu(11,51)
common /blka/den(9), th(9), depth(9), nlayer, zgw, zgwt
data rmk/"'cpt','silt','*Cn','**Kd'/
digitized values of curve in fig. 40, ref. 1
data rd/1.0,0.9794,0.9668,0.9478,0.9346,0.9189,0.9009,
& 0.8709,0.40/
data dref/0.0,11.825,15.469,21.643,27.268,31.752,34.813,
& 39.535,100.0/
digitized values of the M=7.5 curve in fig. 57, ref. 1
data xn/5.288,11.014,15.308,20.702,26.094,29.823,31.468,33.426,
& 34.714/
data ut/0.05333,0.1133,0.1588,0.2166,0.2765,0.3297,0.3529,0.3949,
& 0.4379/
digitized values of curves in fig 47, ref. 1
data sv8/0.7732,0.9447,1.2934,1.7221,1.9845,2.2949,2.6744,3.1689,
& 3.5984,4.1400,4.7297,5.3664,6.1172,7.2153,8.1312,9.0241/
data cn8/1.5965,1.4295,1.2288,1.0780,1.0114,0.9536,0.8951,0.8357,
& 0.7952,0.7400,0.6936,0.6513,0.6035,0.5619,0.5310,0.5003/
data sv4/0.7732,0.9447,1.2934,1.7221,1.9845,2.1597,2.5362,2.9828,
& 3.4533,4.0370,4.5796,5.1473,5.8070,6.7640,7.7940,8.7560/
data cn4/1.5965,1.4295,1.2288,1.0780,1.0114,0.9685,0.8963,0.8281,
& 0.7643,0.6903,0.6397,0.5980,0.5556,0.5014,0.4649,0.4337/

format statements
2 format(18a4)
4 format(')
6 format(' enter depth(ft) and density(pcf) with decimals of layer' & i3)
8 format('1')
16 format(' the site consists of',i3 ' layers w/ depths & dens:')
18 format(20x,i4,f10.1,' (ft)',f15.1,' (pcf)')
20 format(' input eq. mag.=',f5.2,' max. acc. =',f5.2,' g'& & design ground water table depth =',f6.1,' ft.'& & testing ground water table depth =',f6.1,' ft.')
22 format(' count depth design stress (psf) testing stress ',& '(psf) stress modified uncorrected cpt-Qc remarks'/ & 15x,'effective total effective total ratio',& & N1 spt-bc,N kg/cm2'/)
23 format(3x,3h(1),4x,3h(2),6x,3h(3),8x 3h(4),7x,3h(5),8x,3h(6),& 7x,3h(7),8x,3h(8),8x,3h(9),8x,4h(10),5x,4h(11)/)
24 format(i5,f7.1,2f10.1,2x2f10.1 f10.2,f10.1 ,f11.1 ,f12.1,& & 3x,a1,x,aiO)
26 format('/ input relative density =',f6.2)
28 format('// * NOTE: remark Cn implies effective overburden',& ' pressure out of range, Cn=1.8 is assumed')
30 format('/ Kd implies that correction for eff. overburden',& ' pressure > 1.5 tons/sq.ft was applied. )

1000 write(16,8)

c
write(6,4)
write(6,4)
write(6,4)
write(6,*) 'RELA: basic units are in LBS and FT'
write(6,4)
write(6,*) ' enter title of this run in 72 characters or less'
write(6,4)
read(5,2) title
write(6,4)
write(6,4)
write(6,*) ' site description: enter no. of layers (<10)' write(6,4)
read*, nlayer
do 40 i=1,nlayer
write(6,6) i
write(6,4)
read*, depth(i), den(i)
40 continue
  th(1) = depth(1)
do 60 i=2,nlayer
  th(i) = depth(i) - depth(i-1)
60 continue
write(6,4)
write(6,*) ' enter expected depth of ground water during'
write(6,*) ' the design earthquake, and ground water depth'
write(6,*) ' when penetration test was performed - 7.0, 20.0'
write(6,4)
read*, zgw, zgwt

15
write(6,4)
write(6,*), ' enter earthquake mag. and max acc (g) -- 7.5, 0.25'
write(6,4)
read*, eqm, amax
write(6,4)
write(6,*) ' enter depth increment, dz (1.0 to 5. ft)'
write(6,*) ' and relative density (0.4 for 40%), with a MINUS'
write(6,*) ' sign if sand is silty'
write(6,4)
read*, dz, rden
write(6,4)
isilt = 0
zlimit = 80.0
if(depth(nlayer) .lt. 80.0) zlimit=depth(nlayer)
if(rden .lt. 0.) isilt=1
rden = abs(rden)
c
to check if gravelly deposit is being considered
c
write(6,*), ' enter 0 if deposit is not gravelly'
write(6,4)
read*, igrav
if(igrav .eq. 0) go to 70
write(16,66)
66 format(' * * * correction for gravelly sands included * * *\)'
write(6,*) ' enter multiple of time required for gravelly soil'
write(6,*) ' to reach peak pore pressure when compared to'
write(6,*) ' that for sand -- 4.1'
write(6,4)
read*, gfac
70 continue
c
call getfac(eqm,fac,igrav,gfac)
c
to establish reference stress-ratio vs n1 curve
c
do 80 i=1,9
   yt(i) = ut(i)*fac
80 continue
c
z = zgw
if(z .le. 0.) z=1.0
dbc = 0.0
if(isilt .eq. 1) dbc=7.5
ic = 0
c
100 ic = ic+1
c
xshw = 1.0
if(z .lt. 10.0) xshw=0.75
xcpt = 4.5/xshw
if(isilt .eq. 1) xcpt=4.0/xshw
icn = 0
call stress(z,sum1,sum2,s3,s4)

to determine stress reduction factor rd & ave stress-ratio

j = 1
do 220 loop=1,8
  j = j+1
  if(dref(j) .gt. z) go to 240
220 continue
240 fact = rd(j-1) + (z-dref(j-1))*(rd(j)-rd(j-1))/(dref(j)-dref(j-1))
atau = 0.65*fac1*amax*sum2
  taur = atau/sum1

to determine modified penetration resistance, N1

kdpt = 0
facdpt = 1.0
if(sum1 .gt. 3000.) kdpt=1

correction for overburden pressure .gt. 1.5 tf according
to Seed, 1983, as listed in the documentation of RELA

if(kdpt .ne. 0) facdpt=1.07-3.348*0.01*0.001*sum1
  taud = taur/facdpt

if(taud .le. yt(9)) go to 320
  i=8
  go to 380
320 if(taud .ge. yt(1)) go to 340
    i=1
    go to 380
340 do 360 i=1,8
    if(taud .le. yt(i+1)) go to 380
360 continue
380 bcmod = xn(i)+(taud-yt(i))*(xn(i+1)-xn(i))/(yt(i+1)-yt(i))

to determine Cn from S3, effective stress during testing

ysig = s3/1000.0
if(rden .ge. 0.60) go to 480
  do 460 i=1,16
    xf(i) = cn4(i)
    yf(i) = sv4(i)
460 continue
  go to 500
480 do 490 i=1,16
    xf(i) = cn8(i)
    yf(i) = sv8(i)
490 continue
500 continue
if(ysig .gt. yf(1)) go to 520
  icn = 1
  cn = 1.8
go to 580
520 continue
  j = 1
  do 540 loop=1,15
  j = j+1
  if(yf(j) .gt. ysig) go to 560
540 continue
560 cn = xf(j-1) + (xf(j)-xf(j-1))*(ysig-yf(j-1))/(yf(j)-yf(j-1))
580 continue
bctmp = (bcmod-dbc)/cn
bc = bctmp/xshw
cpt = bctmp*xcpt
resu(1,ic) = z
resu(2,ic) = sum1
resu(3,ic) = sum2
resu(4,ic) = s3
resu(5,ic) = s4
resu(6,ic) = taur
resu(7,ic) = bcmod
resu(8,ic) = bc
resu(9,ic) = cpt
resu(10,ic) = rmk(1)
resu(11,ic) = rmk(1)
if(isilt .eq. 1) resu(10,ic)=rmk(3)
if(icn .eq. 1) resu(11,ic)=rmk(4)
if(kdpt .ne. 0) resu(11,ic)=rmk(5)
if(bc .gt. 80.0) go to 800
z = z+dz
if(z .lt. zlimit) go to 100
save results on designated file for printer output
800 continue
write(16,2) title
write(16,16) nlayer
write(16,18) ((i,depth(i),den(i)),i=1,nlayer)
write(16,26) rden
write(16,20) eqm, amax, zgw, zgwt
write(16,22)
write(16,23)
do 850 i=1,ic
write(16,24) i,(resu(j,i),j=1,11)
850 continue
write(16,28)
write(16,30)
check to see if new set of computation is needed
write(6,4)
write(6,*), ' enter integer>0 for a new set of computation'
read*, icont
if(icont .gt. 0) go to 1000

stop
end

subroutine getfac(eqm,fac,igrav,gfac)

subroutine to compute scaling factor, fac, for a
given earthquake magnitude, eqm, to establish the
reference liquefaction potential curve --
stress ratio versus modified penetration blow count

dimension sy(6),qx(6),cy(6)

digitized values of curve in fig. 56, ref. 1

data sy/1.6,1.32,1.13,1.0,0.89,0.80/
data qx/5.25,6.0,6.75,7.5,8.5,9.97/
data cy/3.0,6.0,10.0,15.0,26.0,100.0/

do 100 i=1,4
   if(eqm .le. qx(i+1)) go to 120
100 continue
120 cyn=cy(i)+(eqm-qx(i))*(cy(i+1)-cy(i))/(qx(i+1)-qx(i))
   if(igrav .ne. 0) cyn=cyn/gfac
   do 140 i=1,4
      if(cyn .le. cy(i+1)) go to 160
140 continue
160 continue
delx = cyn/cy(i)
dx = cy(i+1)/cy(i)
fac = sy(i)+(sy(i+1)-sy(i))*alog(delx)/alog(dx)
return
end

subroutine stress(z,s1,s2,s3,s4)
common /blka/den(9),th(9),depth(9),nlayer,zg,zgwt

iseq = 1
zgw = zg

100 continue
if(iseq .eq. 2) zgw=zgwt
sum1 = 0.0
sum2 = 0.0
if(z .gt. zgw) go to 220
j = 0
do 120 loop=1,nlayer

j = j+1
if(depth(j) .ge. z) go to 140
sum1 = sum1+th(j)*den(j)
sum2 = sum1
120 continue
140 if(j .gt. 1) go to 160
sum1 = z*den(j)
sum2 = sum1
go to 400
160 sum1 = sum1 + (z-depth(j-1))*den(j)
sum2 = sum1
go to 400
220 continue
j = 0
do 240 loop=1,nlayer
j = j+1
if(depth(j) .ge. zgw) go to 250
sum1 = sum1 + th(j)*den(j)
sum2 = sum2 + th(j)*den(j)
240 continue
250 continue
idry = j
if(idry .gt. 1) go to 280
if(z .gt. depth(1)) go to 260

z, zgw both in layer 1
sum1 = zgw*den(1) + (z-zgw)*(den(1)-62.4)
sum2 = z*den(1)
go to 400

260 sum1 = zgw*den(1) + (depth(1)-zgw)*(den(1)-62.4)
sum2 = depth(1)*den(1)
go to 320
280 if(z .gt. depth(idry)) go to 300
sum1 = sum1 + (zgw-depth(idry-1))*den(idry)
& + (z-zgw)*(den(idry)-62.4)
sum2 = sum2 + (z-depth(idry-1))*den(idry)
go to 400
300 sum1 = sum1 + (zgw-depth(idry-1))*den(idry)
& + (depth(idry)-zgw)*(den(idry)-62.4)
sum2 = sum2 + th(idry)*den(idry)
320 continue
do 340 loop=idry,nlayer
j = j+1
if(depth(j) .gt. z) go to 360
sum1 = sum1 + th(j)*(den(j)-62.4)
sum2 = sum2 + th(j)*den(j)
340 continue
360 sum1 = sum1 + (z-depth(j-1))*(den(j)-62.4)
sum2 = sum2 + (z-depth(j-1))*den(j)
400 continue
if(iseq .eq. 2) go to 500
s1 = sum1
s2 = sum2
iseq = 2
go to 100
500 s3 = sum1
s4 = sum2
return
end