```
      PROGRAM EPWPGOOD
*
* Modifications of EPWP started on June 22, 2011
* completed July 2, 2011
* October 30th 2011: change calculation of Percent contributions of Pressure and
Cohesion
* to be a percentage of SFBOX rather than percentages of themselves
*

      DIMENSION DSIZEMM(100),PRCPASS(100),VOLPART(100),SURFAREA(100)
      DIMENSION ADSIZE(100),RETAIND(100),VISCFORC(100),WVISCF(100)

      DIMENSION FRSPACE(100),VPPLUSV(100),GRAINS(100),DFFRACT(100)
      DIMENSION WPRESSF(100),EPWPFORC(100),PCFFF(100),PCRET(100)
      DIMENSION PCVISC(100),PCBOTH(100)

      REAL L(100)
      REAL K

      CHARACTER ANS*1

      OPEN(5,FILE='EPWP.IN',STATUS='OLD')
      OPEN(6,FILE='EPWP.OUT',STATUS='OLD')

      GRAVITY = 9.81
      RHO     = 1000.
      SPECGRAV= 2.65
      PI      = 3.1416
      PIOVER4 = PI/4.
      PIOVER6 = PI/6.

      C=1./72.
      IFLAG=0

      WRITE(*,*)
      WRITE(*,*)
      WRITE(*,1004)
      WRITE(6,1004)
 1004 FORMAT( 5X,'EXCESS PORE WATER PRESSURE',/)
      WRITE(*,1005)
      WRITE(6,1005)
 1005 FORMAT( 5X,'Code written by W.E. Hodge as a design tool for his ow
     &n work.')
      WRITE(*,1006)
      WRITE(6,1006)
 1006 FORMAT( 5X,'Based on a mainly theorietical method published in a s
     &eries of')
      WRITE(*,1007)
      WRITE(6,1007)
 1007 FORMAT( 5X,'Geotechnical News articles, starting December 2010.',/
     &/)
      WRITE(6,1008)
 1008 FORMAT(5X,'CONFIRMING INPUT DATA',/)

*
* Read Input from File EPWP.IN
*

      READ(5,*) NS
        DO 35 MS=1,NS
      READ(5,*) DSIZEMM(MS),PRCPASS(MS)
      WRITE(6,32) MS,DSIZEMM(MS),PRCPASS(MS)
   32 FORMAT(10X,I2,5X,'Grain Size :',F9.3,' mm',4X,'Passing',F10.1,' %'
```

```
     &)
    35 CONTINUE

*
* Read Input from the Screen
*

       WRITE(*,21)
    21 FORMAT(10X,'Input Element Length, Width, Height in metres  :  ',\)
       READ(*,*) BOXLNG,BOXWDT,BOXHGT
       WRITE(*,*)

       WRITE(*,25)
    25 FORMAT(10X,'Deformation Rate, mm/s         :  ',\)
       READ(*,*) RATEDEFM
       WRITE(*,*)

       WRITE(*,26)
    26 FORMAT(10X,'Void Ratio                     :  ',\)
       READ(*,*) VOIDRTO
       WRITE(*,*)

       WRITE(*,27)
    27 FORMAT(10X,'Water Temperature, C           :  ',\)
       READ(*,*) TEMPDC
       WRITE(*,*)

       VISCDYN  = 0.0017413*EXP(-0.0276*TEMPDC)
       RGOVERV  = RHO*GRAVITY/VISCDYN

*
* Print Mirror Input to File "EPWP.OUT"
*

       WRITE(6,6001) RATEDEFM
 6001 FORMAT(/,6X,' Deformation Rate       ',F8.3,' mm/s',/)

       VELAPP=RATEDEFM/1000

       WRITE(6,6003) VOIDRTO
 6003 FORMAT(6X,' Void Ratio      ',F15.3,/)
       WRITE(6,6005)BOXLNG
 6005 FORMAT(6X,' Element Size - Length',F10.3,' m')
       WRITE(6,6007)BOXWDT
 6007 FORMAT(6X,'              - Width ',F10.3,' m')
       WRITE(6,6009)BOXHGT
 6009 FORMAT(6X,'              - Height',F10.3,' m',//)

* Calculations related to Particle sizes and numbers in Prism/Box

       BOXVOL = BOXLNG*BOXHGT*BOXWDT
       BVMM   = BOXVOL*1000*1000*1000

         DO 45 MSA=1,NS-1
       ADSIZE(MSA)=0.5*(DSIZEMM(MSA)+DSIZEMM(MSA+1))
       RETAIND(MSA)=(PRCPASS(MSA+1)-PRCPASS(MSA))/100.
    45 CONTINUE

         DO 55 MVA=1,NS-1
       FRSPACE(MVA) = BVMM * RETAIND(MVA)
       SURFAREA(MVA)= PI*ADSIZE(MVA)*ADSIZE(MVA)
       VOLPART(MVA) = PIOVER6*(ADSIZE(MVA)**3)
       VPPLUSV(MVA) = VOLPART(MVA)*(1+VOIDRTO)
```

```
      GRAINS(MVA)  = FRSPACE(MVA)/VPPLUSV(MVA)
   55 CONTINUE

      TOTVOL = 0.0
      TOTSUR = 0.0

        DO 90 MVA=1,NS-1
      TOTVOL = TOTVOL + (VOLPART(MVA)*GRAINS(MVA))
      TOTSUR = TOTSUR + (SURFAREA(MVA)*GRAINS(MVA))
   90 CONTINUE

* Introduce DS into computations for Permeability

      DS       = 6*TOTVOL/(TOTSUR*1000)
      TUBEDIAM = 2*VOIDRTO*DS/3
      TUBEAREA = PIOVER4*TUBEDIAM*TUBEDIAM
      UNITVOL  = PIOVER6*(DS**3)*(1+VOIDRTO)
      UNITSIDE = UNITVOL**(1./3.)
      SOILAREA = UNITSIDE**2
      RTOAREAS = TUBEAREA/SOILAREA
      VELTUBE  = VELAPP/RTOAREAS
      RET      = VELTUBE*TUBEDIAM*RHO/VISCDYN

* RET is Tube Reynolds Number for Permeability computations

* Laminar flow in pipe
      PERMLAMR = C*RGOVERV*(VOIDRTO**2)*(DS**2)*RTOAREAS

* Hazen estimate from equivalent particle diameter Ds
* maybe later add Hazen as one of the choice for user
      PERMHAZN = 10000.*DS*DS

*
*  Write Output to File "EPWP.OUT"
*
      WRITE(6,1100)
 1100 FORMAT(5X,'COMPUTED OUTPUT VALUES',//)

*
* OPPORTUNITY OFFERED TO INPUT USER'S OWN PERMEABILITY VALUE
*

 1234 FORMAT(15X,'                                Re ',E10.3,/)

      WRITE(*,41)
   41 FORMAT(10X,'Would you like to use built-in Permeability or your ow
     &n ?')
      WRITE(*,42)
   42 FORMAT(10X,'To use your own value, answer: Y, to use the built-in,
     & answer: N    ',\)
      READ (*,43) ANS
   43 FORMAT(A1)

      IF((ANS.EQ.'N').OR.(ANS.EQ.'n')) GOTO 1444

      IF((ANS.EQ.'Y').OR.(ANS.EQ.'y')) THEN
      WRITE(*,44)
   44 FORMAT(/,10X,'Input value for permeability in m/s units :  ',\)
      READ(*,*)USERPERM
      HYDRGRAD = VELAPP/USERPERM
      WRITE(6,1223)USERPERM
 1223 FORMAT(10X,'PERMEABILITY : User Input   ',E10.3,' m/s',/)
      WRITE(6,1234)RET
```

```
      GOTO 1555
      END IF

* Laminar value of permeability

 1444 IF(RET.LE.2000.) THEN
      HYDRGRAD    = VELAPP/PERMLAMR
      WRITE(6,1233)PERMLAMR
 1233 FORMAT(10X,'PERMEABILITY : Laminar calculate ', E10.3,' m/s',/)
      WRITE(6,1234)RET
      GOTO 1555
      END IF

*************************************************************************
      CALL PERM (RHO,GRAVITY,VISCDYN,PERMLAMR,PTTSOIL,VELAPP,RTOAREAS,TU
     &BEDIAM,HGTT)
*************************************************************************

* PERM subroutine only entered if RET is greater than 2000

      IF(RET.GT.2000.) THEN
      HYDRGRAD     = VELAPP/PTTSOIL
      WRITE(6,1243)PTTSOIL
 1243 FORMAT(10X,'PERMEABILITY : Non-Laminar calculated', E10.3,' m/s'/)
      WRITE(6,1234)RET
      GOTO 1555
      END IF

*
*  Write Permeability Output to File "EPWP.OUT"
*

 1555 CONTINUE

   60 WRITE(*,24)
   24 FORMAT(//,20X,'Input now complete !',//)

*      WRITE(*,*)
*      WRITE(*,*) PERMHAZN, PERMLAMR, USERPERM, PTTSOIL

*********************************************************************
* Hydraulic Gradient now known for any permeability choice or Re
* Therefore end of permeability calculation
* Now get into calculation of Seepage Force and Drag Forces & K
*********************************************************************

      SFBOX = RHO*GRAVITY*HYDRGRAD*BOXVOL

        DO 501 NK=100,100000

      K = NK*0.01
      VELVOID = K*VELAPP
      DFTOTAL = 0.0

        DO 888 MMM=1,NS-1

      PARTDIAM = ADSIZE(MMM)/1000.
      AREA = PIOVER4*PARTDIAM*PARTDIAM

      REDRAG   = VELVOID*PARTDIAM*RHO/VISCDYN

*************************************************************************
      CALL CDSUB (CD,REDRAG)
```

```
**************************************************************************

      DRAGFPP = CD*RHO*AREA*VELVOID*VELVOID/2
      DFFRACT(MMM) = DRAGFPP*GRAINS(MMM)
      DFTOTAL = DFTOTAL + DFFRACT(MMM)

* Calculation of Drag Force components

      COHESION  = 2*VISCDYN*VELVOID/PARTDIAM
      FBC       = COHESION*6*AREA
      PP        = RHO*VELVOID*VELVOID/2
      FPP       = PP*AREA

* Calculation of the L-factor

      L(MMM)    = (DRAGFPP-FBC)/FPP
      EPWPFORC(MMM)  =  L(MMM)*FPP
      VISCFORC(MMM)  =  FBC

  888 CONTINUE

      SFOVERDR = SFBOX/DFTOTAL
      IF(SFOVERDR.LT.1.0) GOTO 899
  501 CONTINUE

  899 CONTINUE

      TOTFEPWP=0.0
        DO 65 MW=1,NS-1
      WPRESSF(MW) = EPWPFORC(MW)*GRAINS(MW)
      TOTFEPWP=TOTFEPWP+WPRESSF(MW)
   65 CONTINUE

      TOTFVISC=0.0
        DO 67 MW=1,NS-1
      WVISCF(MW) = VISCFORC(MW)*GRAINS(MW)
      TOTFVISC=TOTFVISC+WVISCF(MW)
   67 CONTINUE

        DO 75 MSA=1,NS-1
*      PCFFF(MSA)  = 100*WPRESSF(MSA)/TOTFEPWP
*      PCVISC(MSA) = 100*WVISCF(MSA)/TOTFVISC
      PCFFF(MSA)  = 100*WPRESSF(MSA)/SFBOX
      PCVISC(MSA) = 100*WVISCF(MSA)/SFBOX
      PCBOTH(MSA) = 100*(WPRESSF(MSA)+WVISCF(MSA))/SFBOX
   75 CONTINUE

        DO 88 MSA=1,NS-1
      PCRET(MSA)= 100*RETAIND(MSA)
   88 CONTINUE

      FTOGRAD=1./(BOXLNG*BOXHGT*BOXWDT*GRAVITY*RHO)

      PRESFACE=TOTFEPWP/(BOXHGT*BOXWDT)
      DRAGFACE=SFBOX/(BOXHGT*BOXWDT)

      HGSEEP=SFBOX*FTOGRAD
      HGEPWP=TOTFEPWP*FTOGRAD

      PHGVCRIT = 100.*HGEPWP*(1+VOIDRTO)/(SPECGRAV-1)
      HGCRITIC = (SPECGRAV-1)/(1+VOIDRTO)

      WRITE(6,177)K
```

```
  177 FORMAT(10X,'K-factor  :',F10.2,//)

      WRITE(6,1200)
 1200 FORMAT(5X,'Fraction',2X,' Average','    Retnd','      Number','
     &    L','     Visc','    Press','  Visc %','  Pres %','  Both %')
      WRITE(6,1202)
 1202 FORMAT(5X,'       #',2X,'    Size','     Part','   of Grains','  f
     &actor','    Force','    Force','  of Tot','  of Tot','  of Tot')
      WRITE(6,1204)
 1204 FORMAT(5X,'        ',2X,'      mm','        %','            ','
     &         ','    N','         N',/)

        DO 80 M=1,NS-1
      WRITE(6,72) M,ADSIZE(M),PCRET(M),GRAINS(M),L(M),WVISCF(M),WPRESSF(
     &M),PCVISC(M),PCFFF(M),PCBOTH(M)
   72 FORMAT(11X,I2,F10.3,F9.1,E12.3,F8.2,2F9.1,2F9.3,2F8.1)
   80 CONTINUE

      WRITE(6,115)
  115 FORMAT(/,10X,'ELEMENT FORCES PARALLEL TO MOVEMENT')
      WRITE(6,116)SFBOX
  116 FORMAT(/,15X,'Seepage             :  ',F10.3,' N')
      WRITE(6,117)DFTOTAL
  117 FORMAT(/,15X,'Drag                :  ',F10.3,' N')
      WRITE(6,118)TOTFVISC
  118 FORMAT(/,15X,'-    Viscosity      :  ',F10.3,' N')
      WRITE(6,119)TOTFEPWP
  119 FORMAT(/,15X,'-    Water Pressure :  ',F10.3,' N',/)

      WRITE(6,125)
  125 FORMAT(/,10X,'PRESSURE ON UPSTREAM FACE OF ELEMENT',/)
      WRITE(6,121)DRAGFACE
  121 FORMAT(15X,'Seepage               :',F10.3,' Pa'/)
      WRITE(6,122)PRESFACE
  122 FORMAT(15X,'Pore Water            :',F10.3,' Pa'/)

      WRITE(6,130)
  130 FORMAT(/,10X,'GRADIENTS ALONG DIRECTION OF MOVEMENT')
      WRITE(6,132)HGSEEP
  132 FORMAT(/,15X,'Seepage or Drag      :  ',F10.3)
      WRITE(6,134)HGEPWP
  134 FORMAT(/,15X,'Pore Pressure        :  ',F10.3)
      WRITE(6,136)HGCRITIC
  136 FORMAT(/,15X,'Reference Critical   :  ',F10.3)


*        1         2         3         4         5         6         7
*23456789012345678901234567890123456789012345678901234567890123456789012
**************************************************************************

  999 WRITE(*,1090)
 1090 FORMAT(//,5X,'COMPUTED OUTPUT VALUES WRITTEN TO "EPWP.OUT"',////)

      STOP'                   Program successfully completed !'
      END


**************************************************************************
      SUBROUTINE CDSUB (CD,REDRAG)
**************************************************************************

      DIMENSION A(7),B(7)
```

```
      A(1)=25.9183
      B(1)=-0.8970
      A(2)=24.9985
      B(2)=-0.7572
      A(3)=19.1082
      B(3)=-0.6269
      A(4)= 7.8208
      B(4)=-0.4314
      A(5)= 1.3586
      B(5)=-0.1586
      A(6)= 0.0818
      B(6)= 0.1753
      A(7)= 0.1343
      B(7)= 0.1298

      RE = REDRAG

        IF(RE.LT.0.6) GOTO 400
        IF((RE.GE.0.6).AND.(RE.LT.1.0)) M=1
        IF((RE.GE.1.0).AND.(RE.LT.10.0)) M=2
        IF((RE.GE.10.0).AND.(RE.LT.100.0)) M=3
        IF((RE.GE.100.0).AND.(RE.LT.600.0)) M=4
        IF((RE.GE.600.0).AND.(RE.LT.2500.0)) M=5
        IF((RE.GE.2500.0).AND.(RE.LT.7000.0)) GOTO 410
        IF((RE.GE.7000.0).AND.(RE.LT.40000.0)) M=6
        IF((RE.GE.40000.0).AND.(RE.LT.100000.0)) M=7
        CD=A(M)*RE**B(M)
        IF((RE.GE.100000.0).AND.(RE.LT.200000.0)) GOTO 420
        IF((RE.GE.200000.0).AND.(RE.LT.260000.0)) GOTO 430
        IF(RE.GT.260000.0) WRITE(*,*)'Reynolds Number out of range'
        GOTO 444
  400   CD=24.0/RE
        GOTO 444
  410   CD=0.39
        GOTO 444
  420   CD= 3.36-0.2385*LOG(RE)
        GOTO 444
  430   CD=11.04-0.8677*LOG(RE)
        GOTO 444
  444   CONTINUE

      RETURN
      END
*************************************************************************
      SUBROUTINE PERM (RHO,GRAVITY,VISCDYN,PERMLAMR,PTTSOIL,VELAPP,RTOAR
     &EAS,TUBEDIAM,HGTT)
*************************************************************************

      EOVERD   = 0.050
      SOILLNGT = 1.0
      CURVLNGT = 1.0

      SPGRM0 = VELAPP/PERMLAMR

         DO 333 M=1,100

      IF(M.EQ.1)CHEKGRAD = SPGRM0
      IF(M.GT.1)CHEKGRAD = RETHG

***** find pipe friction factor

      FIRSTTRM=SQRT(2*CHEKGRAD*TUBEDIAM*GRAVITY)
      SQFMAX=SQRT(0.08)
```

```
      SQFMIN=SQRT(0.008)
      VTUBEMIN=FIRSTTRM/SQFMAX
      VTUBEMAX=FIRSTTRM/SQFMIN
      VRANGE=VTUBEMAX-VTUBEMIN

      NN=10000
      VSTEP=VRANGE/NN

        DO 100 N=1,NN

      VELTUBE=VTUBEMIN+N*VSTEP
      RE=VELTUBE*TUBEDIAM*RHO/VISCDYN
      FFLAMNR= 64./RE
      FFLMIN = 0.032
      FASSUM = 0.08

        DO 500 N1=1,100

        VALUE=-2*LOG10((EOVERD/3.7)+(2.51*FASSUM/RE))
        DIFF=ABS(VALUE-FASSUM)
        FASSUM=VALUE
        FFTURB=1/(FASSUM*FASSUM)
        IF(DIFF.LT.0.000001)GOTO 510
  500   CONTINUE

  510 FFTURB=1/(FASSUM*FASSUM)
      FTRANS = 0.032+(0.044*(RE-2000))/2000
      IF(RE.LE.2000.)F=FFLAMNR
      IF((RE.GT.2000.).AND.(RE.LT.4000.))F=FTRANS
      IF(RE.GE.4000.)F=FFTURB

******** "f factor" now known ********

      TUBELNGT = SOILLNGT*CURVLNGT
      V2OVER2G = VELTUBE*VELTUBE/(2*GRAVITY)
      HEADLOSS = F*V2OVER2G*TUBELNGT/TUBEDIAM
      HGTT     = HEADLOSS/SOILLNGT
      IF(HGTT.GE.CHEKGRAD) GOTO 799

  100 CONTINUE

  799 CONTINUE

*      AGREEK   = 100*HGTT/CHEKGRAD
      PTTSOIL  = VELTUBE*RTOAREAS/HGTT
      CALVAPP  = PTTSOIL*HGTT
      RETHG    = VELAPP/PTTSOIL
      RATVS    = CALVAPP/VELAPP

      IF(RATVS.GE.0.9999)GOTO 777

  333 CONTINUE

  777 CONTINUE

  900 RETURN
      END
→
```