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      PROGRAM PERMBLOO

* Using Fluid Mechnaics' pipe flow analogy, calculate soil permeabiliy for
* LOOSE array of uniformly sized perfect spheres for the critical gradient using
* hydraulic radius cf Reynolds Number to give friction factor for an equivalent
conduit.
* Coding finalized March 28th 2010.
* Corrected March 30th 2010, again April 15th 2010.

      OPEN(6,FILE='SOILPERM.OUT',STATUS='OLD')

      GRAVITY = 9.81
      RHO = 1000.
      SPECGRAV=2.65

*************** variables set constant pro tem *******

      VOIDRTO  = 0.91
      EOVERD   = 0.050
      SOILLNGT = 1.0
      CURVLNGT = 1.0

* temperature set to reflect laboratory conditions

      TEMPDC   = 20
      VISCDYN  = 0.0017413*EXP(-0.0276*TEMPDC)

* set gradient at critical as per void ratio

      SPECHYGR=(SPECGRAV-1)/(1+VOIDRTO)

***************************** READ INPUT *********************************

      WRITE(*,1020)
 1020 FORMAT(10X,'Input Particle Diameter mm : ',\)
      READ(*,*)PARTDMMM

      PARTDIAM = PARTDMMM/1000.
      TUBEDIAM = 2*VOIDRTO*PARTDIAM/3

      RGOVERV  = RHO*GRAVITY/VISCDYN

      VELTUBE=RGOVERV*TUBEDIAM*TUBEDIAM*SPECHYGR/32
      REL=VELTUBE*TUBEDIAM*RHO/VISCDYN
      C=1./72.
      PERMLAMR = C*RGOVERV*(VOIDRTO**3)*(PARTDIAM**2)/(1+VOIDRTO)

      IF(REL.LE.2000.)GOTO 800

************************************************************************

      FIRSTTRM=SQRT(2*SPECHYGR*TUBEDIAM*GRAVITY)

      SQFMAX=SQRT(0.08)
      SQFMIN=SQRT(0.008)
      VTUBEMIN=FIRSTTRM/SQFMAX
      VTUBEMAX=FIRSTTRM/SQFMIN
      VRANGE=VTUBEMAX-VTUBEMIN
      VSTEP=VRANGE/10000

*********** LOOP FOR RE > 2000 *********

        DO 100 N=0,10000
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      VELTUBE=VTUBEMIN+N*VSTEP

      RE=VELTUBE*TUBEDIAM*RHO/VISCDYN
      IF(RE.LE.2000.0)GOTO 100
*
*  DETERMINE "f factor" the PIPE FRICTION PARAMETER
*
      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=(FFLMIN+FFTURB)/2
      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
      HYDGRAD=HEADLOSS/SOILLNGT

      IF(HYDGRAD.GE.SPECHYGR) GOTO 799

  100 CONTINUE

  799 CONTINUE
      AGREEK=100*HYDGRAD/SPECHYGR
      PERMSOIL=VELTUBE*VOIDRTO/(HYDGRAD*(1+VOIDRTO))

      IF(RE.LE.2000.0)PERMSOIL=PERMLAMR

******************** WRITE RESULTS ************************************

  800 WRITE(6,5000)
 5000 FORMAT(/,15X,'         program PERMBLOO output   ',//)

      WRITE(6,5010)PARTDMMM
 5010 FORMAT(15X,'Particle Diameter    ',F10.2,' mm',/)
      WRITE(6,5025)VOIDRTO
 5025 FORMAT(15X,'Void Ratio            ',F9.3,//)
      WRITE(6,5030)REL
 5030 FORMAT(15X,'Reynolds # Laminar   ',E10.3,/)
      WRITE(6,5050)TUBEDIAM
 5050 FORMAT(15X,'Equivalent Diameter  ',E10.3,/)
      WRITE(6,5060)SPECHYGR
 5060 FORMAT(15X,'Required Hydr Grad   ',F10.3,/)
      WRITE(6,5080)PERMLAMR
 5080 FORMAT(15X,'Soil Perm Laminar    ',E10.3,' m/s',//)
      WRITE(6,6000)PARTDMMM,PERMLAMR,PERMSOIL
 6000 FORMAT(15X,F15.3,2E15.3,///)

      IF(RE.LE.2000.)GOTO 999

      WRITE(6,5035)RE
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                                        PERMBLOO
 5035 FORMAT(15X,'Reynolds Number      ',E10.3,/)
      WRITE(6,5040)F
 5040 FORMAT(15X,'Friction Factor      ',F10.4,/)
      WRITE(6,5090)AGREEK
 5090 FORMAT(15X,'Agreement on Gradient',F10.3,' %',/)
      WRITE(6,5070)PERMSOIL
 5070 FORMAT(15X,'Soil Permeability    ',E10.3,' m/s',//)

      WRITE(6,6000)PARTDMMM,PERMLAMR,PERMSOIL

  999 STOP'                     Program successfully completed !'
      END
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