```
diary on         % begin recording

% FEMA appeal for The Town of Harpswell, Cumberland county, Maine
% TRANSECT ID: CM-140
% calculation by SJH, Ransom Consulting, Inc. 20-Feb-2020
% 100-year wave runup using TAW methodology
% including berm and weighted average with foreshore if necessary
%
% chk nld 20200220
%
% This script assumes that the incident wave conditions provided
% as input in the configuration section below are the
% appropriate values located at the end of the foreshore
% or toe of the slope on which the run-up is being calculated
% the script does not attempt to apply a depth limit or any other
% transformation to the incident wave conditions other than
% conversion of the peak wave period to the spectral mean wave
% as recommended in the references below
%
% references:
%
% Van der Meer, J.W., 2002. Technical Report Wave Run-up and
% Wave Overtopping at Dikes. TAW Technical Advisory Committee on
% Flood Defence, The Netherlands.
%
% FEMA. 2007,  Atlantic Ocean and Gulf of Mexico Coastal Guidelines Update
%
%
%

%-------------------------------------------------------------------------
% CONFIG
%-------------------------------------------------------------------------
fname='inpfiles/CM-140sta_ele_include.csv';   % file with station, elevation, include
                                    % third colunm is 0 for excluded points
imgname='logfiles/CM-140-runup';
SWEL=8.7522;  % 100-yr still water level including wave setup.
H0=10.9296;    % significant wave height at toe of structure
Tp=14.4675;    % peak period, 1/fma,
T0=Tp/1.1;

gamma_berm=0.93231;   % this may get changed automatically below
gamma_rough=0.8;
gamma_beta=1;
gamma_perm=1;

setupAtToe=1.4979;
maxSetup=2.5278;   % only used in case of berm/shallow foreshore weighted average

plotTitle='Iterative TAW for CM-140'

plotTitle =

Iterative TAW for CM-140



% END CONFIG
%------------------------------

SWEL=SWEL+setupAtToe

SWEL =

                   10.2501

SWEL_fore=SWEL+maxSetup

SWEL_fore =

                   12.7779



% FIND WAVELENGTH USING DEEPWATER DISPERSION RELATION
% using English units
L0=32.15/(2*pi)*T0^2

L0 =

          885.121154693792


% Find Hb (Munk, 1949)
%Hb=H0/(3.3*(H0/L0)^(1/3))
%Db=-Hb/.78+SWEL;  % depth at breaking

% The toe elevation here is only used to determine the average
% structure slope, it is not used to depth limit the wave height.
% Any depth limiting or other modification of the wave height
```

```
% to make it consitent with TAW guidance should be performed
% prior to the input of the significant wave height given above.
Ztoe=SWEL-1.5*H0

Ztoe =

                    -6.1443


% read the transect
[sta,dep,inc] = textread(fname,'%n%n%n%*[^\n]','delimiter',',','headerlines',0);

% remove unselected points
k=find(inc==0);
sta(k)=[];
dep(k)=[];

sta_org=sta;  % used for plotting purposes
dep_org=dep;


% initial guess at maximum run-up elevation to estimate slope
Z2=SWEL+1.5*H0

Z2 =

                    26.6445


% determine station at the max runup and -1.5*H0 (i.e. the toe)
top_sta=-999;
toe_sta=-999;
for kk=1:length(sta)-1
    if ((Z2 > dep(kk)) & (Z2 <= dep(kk+1)))    % here is the intersection of z2 with profile
       top_sta=interp1(dep(kk:kk+1),sta(kk:kk+1),Z2)
    end
    if  ((Ztoe > dep(kk)) & (Ztoe <= dep(kk+1)))    % here is the intersection of Ztoe with profile
       toe_sta=interp1(dep(kk:kk+1),sta(kk:kk+1),Ztoe)
    end
end

top_sta =

          99.8477064220183

% check to make sure we got them, if not extend the end slopes outward
S=diff(dep)./diff(sta);
if toe_sta==-999
   dy=dep(1)-Ztoe;
   toe_sta=sta(1)-dy/S(1)
end

toe_sta =

         -21.3297045101089

if top_sta==-999
   dy=Z2-dep(end);
   top_sta=sta(end)+dy/S(end)
end

% just so the reader can tell the values aren't -999 anymore
top_sta

top_sta =

          99.8477064220183

toe_sta

toe_sta =

         -21.3297045101089




% check for case where the toe of slope is below SWL-1.5*H0
% in this case interpolate setup from the setupAtToe(really setup as first station), and the max setup
% also un-include points seaward of SWL-1.5*H0
if Ztoe > dep(1)
   dd=SWEL_fore-dep;
   k=find(dd<0,1); % k is index of first land point
   staAtSWL=interp1(dep(k-1:k),sta(k-1:k),SWEL_fore);
   dsta=staAtSWL-sta(1);
   dsetup=maxSetup-setupAtToe;
   dsetdsta=dsetup/dsta;
   setup=setupAtToe+dsetdsta*(toe_sta-sta(1));
   sprintf('-!!- Location of SWEL-1.5*H0 is %4.1f ft landward of toe of slope',dsta)
   sprintf('-!!- Setup is interpolated between setup at toe of slope and max setup')
```

```
   sprintf('-!!-       setup is adjusted to %4.2f feet',setup)
   SWEL=SWEL-setupAtToe+setup;
   sprintf('-!!-       SWEL is adjusted to %4.2f feet',SWEL)
   k=find(dep < SWEL-1.5*H0)
   sta(k)=[];
   dep(k)=[];
else
   sprintf('-!!- The User has selected a starting point that is %4.2f feet above the elevation of SWEL-1.5H0\n',dep(1
   sprintf('-!!- This may be reasonable for some cases.  However the user may want to consider:\n')
   sprintf('-!!-   1) Selecting a starting point that is at or below %4.2f feet elevation, or\n', Ztoe)
   sprintf('-!!-   2) Reducing the incident wave height to a depth limited condition.\n')
end

ans =

-!!- The User has selected a starting point that is 5.30 feet above the elevation of SWEL-1.5H0



ans =

-!!- This may be reasonable for some cases.  However the user may want to consider:



ans =

-!!-   1) Selecting a starting point that is at or below -6.14 feet elevation, or



ans =

-!!-   2) Reducing the incident wave height to a depth limited condition.




% now iterate converge on a runup elevation
tol=0.01;  % convergence criteria
R2del=999;
R2_new=3*H0; %initial guess
R2=R2_new;
iter=0;
R2_all=[];
topStaAll=[];
Berm_Segs=[];
TAW_ALWAYS_VALID=1;
while(abs(R2del) > tol && iter <= 25)
    iter=iter+1;
    sprintf ('!----------------- STARTING ITERATION %d -----------------!',iter)
    % elevation of toe of slope
    Ztoe
    % station of toe slope (relative to 0-NAVD88 shoreline
    toe_sta
    % station of top of slope/extent of 2% run-up
    top_sta
    % elevation of top of slope/extent of 2% run-up
    Z2
    % incident significant wave height
    H0
    % incident spectral peak wave period
    Tp
    % incident spectral mean wave period
    T0

    R2=R2_new
    Z2=R2+SWEL
    % determine slope for this iteration
    top_sta=-999;
    for kk=1:length(sta)-1
       if ((Z2 > dep(kk)) & (Z2 <= dep(kk+1)))    % here is the intersection of z2 with profile
          top_sta=interp1(dep(kk:kk+1),sta(kk:kk+1),Z2)
          break;
       end
    end
    if top_sta==-999
       dy=Z2-dep(end);
       top_sta=sta(end)+dy/S(end)
    end

    % get the length of the slope (not accounting for berm)
    Lslope=top_sta-toe_sta

    % loop over profile segments to determine berm factor
    % re-calculate influence of depth of berm based on this run-up elevation
    % check for berm, berm width, berm height
    berm_width=0;
    rdh_sum=0;
```

```
Berm_Segs=[];
Berm_Heights=[];
for kk=1:length(sta)-1
   ddep=dep(kk+1)-dep(kk);
   dsta=sta(kk+1)-sta(kk);
   s=ddep/dsta;
   if  (s < 1/15)     % count it as a berm if slope is flatter than 1:15 (see TAW manual)
      sprintf ('Berm Factor Calculation: Iteration %d, Profile Segment: %d',iter,kk)
      berm_width=berm_width+dsta;   % tally the width of all berm segments
      % compute the rdh for this segment and weight it by the segment length
      dh=SWEL-(dep(kk)+dep(kk+1))/2
      if  dh < 0
          chi=R2;
      else
          chi=2* H0;
      end
      if (dh <= R2 & dh >=-2*H0)
         rdh=(0.5-0.5*cos(3.14159*dh/chi)) ;
      else
         rdh=1;
      end
      rdh_sum=rdh_sum + rdh * dsta
      Berm_Segs=[Berm_Segs, kk];
      Berm_Heights=[Berm_Heights, (dep(kk)+dep(kk+1))/2];
   end
   if dep(kk) >= Z2  % jump out of loop if we reached limit of run-up for this iteration
      break
   end
end
sprintf ('!------- End Berm Factor Calculation, Iter: %d ---------!',iter)
berm_width
rB=berm_width/Lslope
if (berm_width > 0)
   rdh_mean=rdh_sum/berm_width
else
   rdh_mean=1
end
gamma_berm=1- rB * (1-rdh_mean)
if gamma_berm > 1
   gamma_berm=1
end
if gamma_berm < 0.6
   gamma_berm =0.6
end
% Iribarren number
slope=(Z2-Ztoe)/(Lslope-berm_width)
Irb=(slope/(sqrt(H0/L0)))
% runup height
gamma_berm
gamma_perm
gamma_beta
gamma_rough
gamma=gamma_berm*gamma_perm*gamma_beta*gamma_rough

% check validity
TAW_VALID=1;
if (Irb*gamma_berm < 0.5 | Irb*gamma_berm > 10 )
   sprintf('!!! - - Iribaren number: %6.2f is outside the valid range (0.5-10), TAW NOT VALID - - !!!\n', Irb*gam
   TAW_VALID=0;
else
   sprintf('!!! - - Iribaren number: %6.2f is in the valid range (0.5-10), TAW RECOMMENDED - - !!!\n', Irb*gamma_
end
islope=1/slope;
if (slope < 1/8 | slope > 1)
   sprintf('!!! - - slope: 1:%3.1f V:H is outside the valid range (1:8 - 1:1), TAW NOT VALID - - !!!\n', islope)
   TAW_VALID=0;
else
   sprintf('!!! - - slope: 1:%3.1f V:H is in the valid range (1:8 - 1:1), TAW RECOMMENDED - - !!!\n', islope)
end
if TAW_VALID == 0
   TAW_ALWAYS_VALID=0;
end

if (Irb*gamma_berm < 1.8)
   R2_new=gamma*H0*1.77*Irb
else
   R2_new=gamma*H0*(4.3-(1.6/sqrt(Irb)))
end


% check to see if we need to evaluate a shallow foreshore
if berm_width > 0.25 * L0;
   disp ('!   Berm_width is greater than 1/4 wave length')
   disp ('!   Runup will be weighted average with foreshore calculation assuming depth limited wave height on ber
   % do the foreshore calculation
   fore_H0=0.78*(SWEL_fore-min(Berm_Heights))
   % get upper slope
   fore_toe_sta=-999;
   fore_toe_dep=-999;
   for kk=length(dep)-1:-1:1
```

```
          ddep=dep(kk+1)-dep(kk);
          dsta=sta(kk+1)-sta(kk);
          s=ddep/dsta;
          if s < 1/15
             break
          end
          fore_toe_sta=sta(kk);
          fore_toe_dep=dep(kk);
          upper_slope=(Z2-fore_toe_dep)/(top_sta-fore_toe_sta)
       end
       fore_Irb=upper_slope/(sqrt(fore_H0/L0));
       fore_gamma=gamma_perm*gamma_beta*gamma_rough;
       if (fore_Irb < 1.8)
          fore_R2=fore_gamma*fore_H0*1.77*fore_Irb;
       else
          fore_R2=fore_gamma*fore_H0*(4.3-(1.6/sqrt(fore_Irb)));
       end
       if berm_width >= L0
          R2_new=fore_R2
          disp ('berm is wider than one wavelength, use full shallow foreshore solution');
       else
          w2=(berm_width-0.25*L0)/(0.75*L0)
          w1=1-w2
          R2_new=w2*fore_R2 + w1*R2_new
       end
    end % end berm width check

    % convergence criterion
    R2del=abs(R2-R2_new)
    R2_all(iter)=R2_new;

    % get the new top station (for plot purposes)
    Z2=R2_new+SWEL
    top_sta=-999;
    for kk=1:length(sta)-1
       if ((Z2 > dep(kk)) & (Z2 <= dep(kk+1)))    % here is the intersection of z2 with profile
          top_sta=interp1(dep(kk:kk+1),sta(kk:kk+1),Z2)
          break;
       end
    end
    if top_sta==-999
       dy=Z2-dep(end);
       top_sta=sta(end)+dy/S(end);
    end
    topStaAll(iter)=top_sta;
end
ans =
!----------------- STARTING ITERATION 1 -----------------!
Ztoe =
                    -6.1443
toe_sta =
         -21.3297045101089
top_sta =
           99.8477064220183
Z2 =
                    26.6445
H0 =
                    10.9296
Tp =
                    14.4675
T0 =
           13.1522727272727
R2 =
                    32.7888
Z2 =
                    43.0389
top_sta =
           180.974533106961
Lslope =
            202.30423761707
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 19
dh =
                  5.178725
rdh_sum =
          0.132213086059303
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 20
dh =
                  5.471775
rdh_sum =
          0.279014055197672
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 21
dh =
                  5.766525
rdh_sum =
          0.441119367123881
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 22
```

```
dh =
                6.062975
rdh_sum =
         0.619228745219761
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 23
dh =
                6.285275
rdh_sum =
         0.809724079427069
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 24
dh =
                6.433425
rdh_sum =
          1.0086501388518
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 25
dh =
                6.574375
rdh_sum =
          1.21572395172742
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 26
dh =
                6.708125
rdh_sum =
          1.43064051481211
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 27
dh =
                 6.75495
rdh_sum =
          1.64832781697004
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 28
dh =
                 6.71485
rdh_sum =
          1.8636415221749
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 71
dh =
               -7.576175
rdh_sum =
          1.98968881175755
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 72
dh =
               -7.516525
rdh_sum =
          2.11384531590662
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 73
dh =
                -7.47525
rdh_sum =
          2.23670066796553
ans =
Berm Factor Calculation: Iteration 1, Profile Segment: 74
dh =
                -7.45235
rdh_sum =
          2.35883666374227
ans =
!------- End Berm Factor Calculation, Iter: 1 ---------!
berm_width =
    14
rB =
        0.0692027026467919
rdh_mean =
         0.168488333124448
gamma_berm =
         0.942457145369873
slope =
         0.261190085907772
Irb =
          2.35047650587334
gamma_berm =
         0.942457145369873
gamma_perm =
     1
gamma_beta =
     1
gamma_rough =
                      0.8
gamma =
         0.753965716295898
ans =
!!! - - Iribaren number:   2.22 is in the valid range (0.5-10), TAW RECOMMENDED - - !!!
```

```
ans =
!!! - - slope: 1:3.8 V:H is in the valid range (1:8 - 1:1), TAW RECOMMENDED - - !!!
R2_new =
          26.8343489573177
R2del =
          5.95445104268234
Z2 =
          37.0844489573177
ans =
!----------------- STARTING ITERATION 2 -----------------!
Ztoe =
                   -6.1443
toe_sta =
         -21.3297045101089
top_sta =
          147.276451371351
Z2 =
          37.0844489573177
H0 =
                    10.9296
Tp =
                    14.4675
T0 =
          13.1522727272727
R2 =
          26.8343489573177
Z2 =
          37.0844489573177
top_sta =
          147.276451371351
Lslope =
          168.606155881459
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 19
dh =
                   5.178725
rdh_sum =
         0.132213086059303
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 20
dh =
                   5.471775
rdh_sum =
         0.279014055197672
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 21
dh =
                   5.766525
rdh_sum =
         0.441119367123881
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 22
dh =
                   6.062975
rdh_sum =
         0.619228745219761
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 23
dh =
                   6.285275
rdh_sum =
         0.809724079427069
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 24
dh =
                   6.433425
rdh_sum =
           1.0086501388518
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 25
dh =
                   6.574375
rdh_sum =
          1.21572395172742
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 26
dh =
                   6.708125
rdh_sum =
          1.43064051481211
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 27
dh =
                    6.75495
rdh_sum =
          1.64832781697004
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 28
dh =
                    6.71485
```

```
rdh_sum =
          1.8636415221749
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 71
dh =
                -7.576175
rdh_sum =
           2.047759303445
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 72
dh =
                -7.516525
rdh_sum =
          2.22917816923362
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 73
dh =
                 -7.47525
rdh_sum =
           2.4087385990719
ans =
Berm Factor Calculation: Iteration 2, Profile Segment: 74
dh =
                 -7.45235
rdh_sum =
          2.58727116476533
ans =
!------- End Berm Factor Calculation, Iter: 2 ---------!
berm_width =
    14
rB =
       0.0830337417208116
rdh_mean =
          0.184805083197524
gamma_berm =
          0.932311315826105
slope =
          0.279605612796312
Irb =
           2.51619973056755
gamma_berm =
          0.932311315826105
gamma_perm =
     1
gamma_beta =
     1
gamma_rough =
                        0.8
gamma =
          0.745849052660884
ans =
!!! - - Iribaren number:   2.35 is in the valid range (0.5-10), TAW RECOMMENDED - - !!!
ans =
!!! - - slope: 1:3.6 V:H is in the valid range (1:8 - 1:1), TAW RECOMMENDED - - !!!
R2_new =
          26.8304003337378
R2del =
       0.00394862357985915
Z2 =
          37.0805003337378
% final 2% runup elevation
Z2=R2_new+SWEL
Z2 =
          37.0805003337378
diary off
-1.000000e+00
-1.000000e+00
```