



ITASCA

Automatic remeshing logic in large strain continuum simulations

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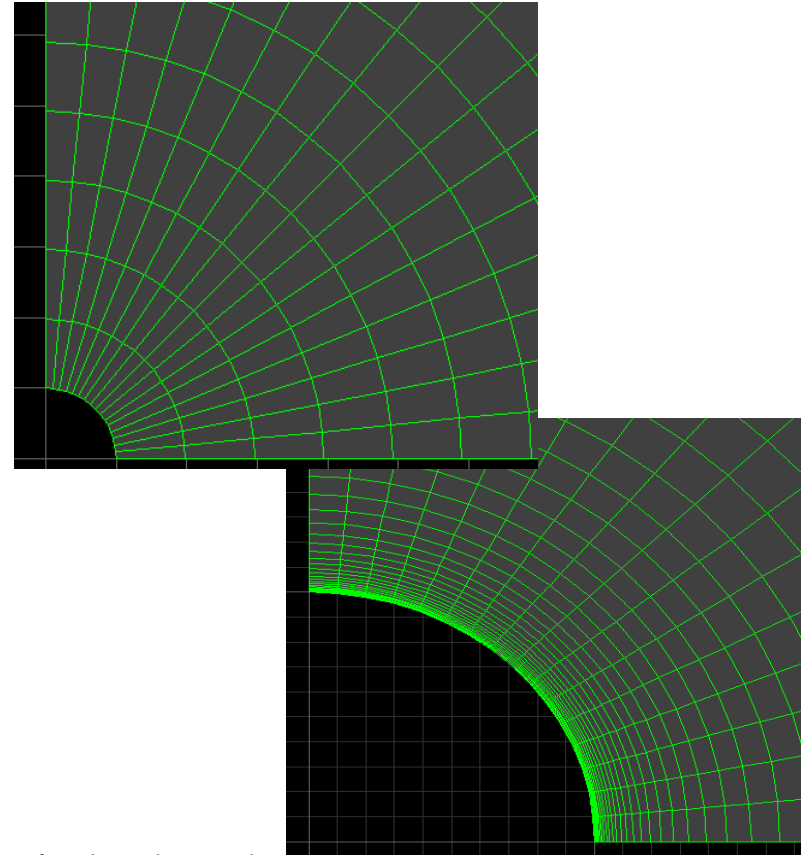
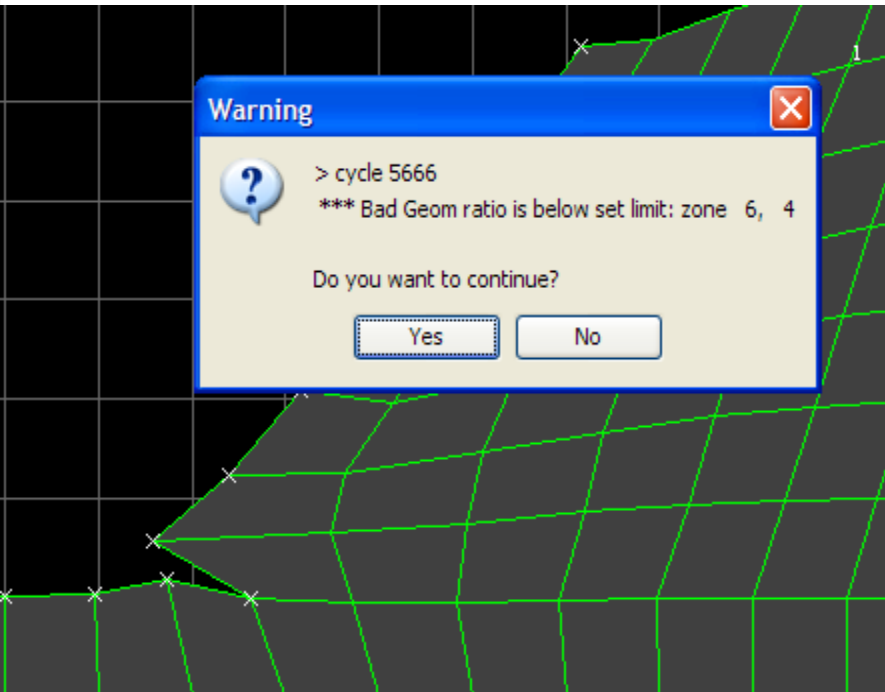
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Topics

- Motivations
- Logic description
- Validation
- Examples
- Summary

Motivations



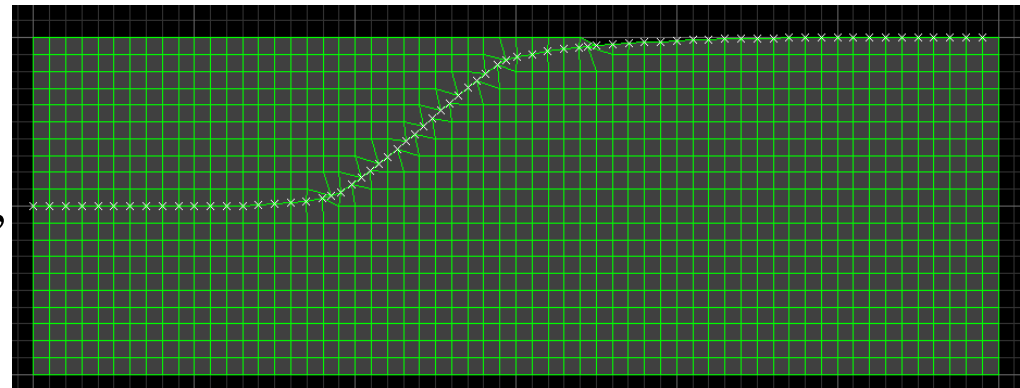
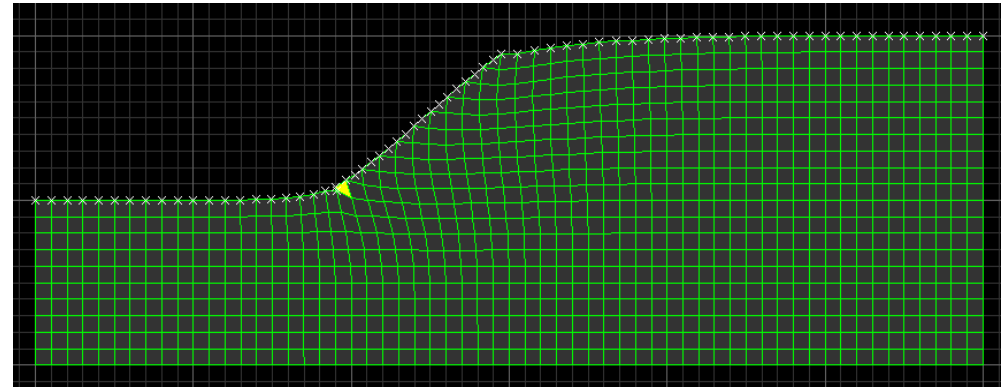
- The mesh has to be rezoned in order to continue the run
- It might be desirable to rezone some area at intermediate stages

Logic description

Typical remeshing process

Three Steps

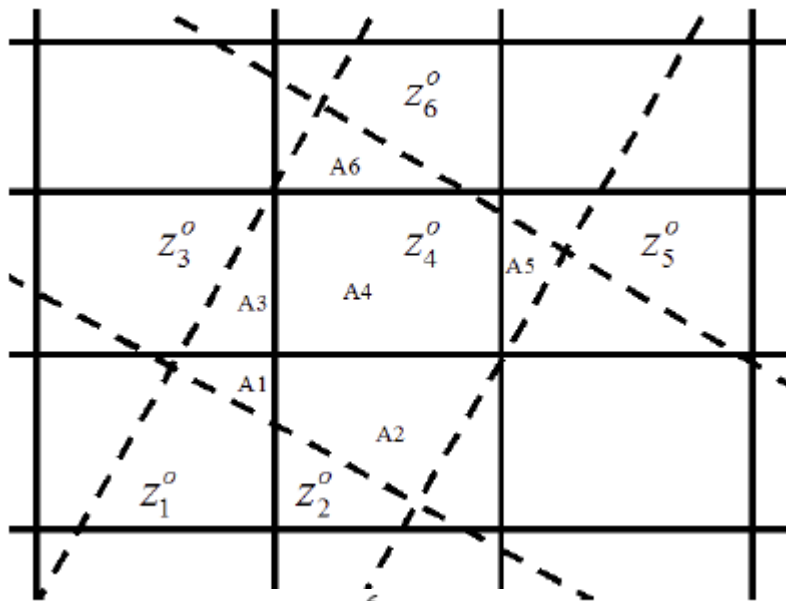
- Step 1: to trigger remeshing operation, e.g., bad geom. event
- Step 2: to generate a new, regular mesh
- Step 3: to transfer model information (stresses, velocities, etc) from the old, distorted mesh to the new mesh



Logic description

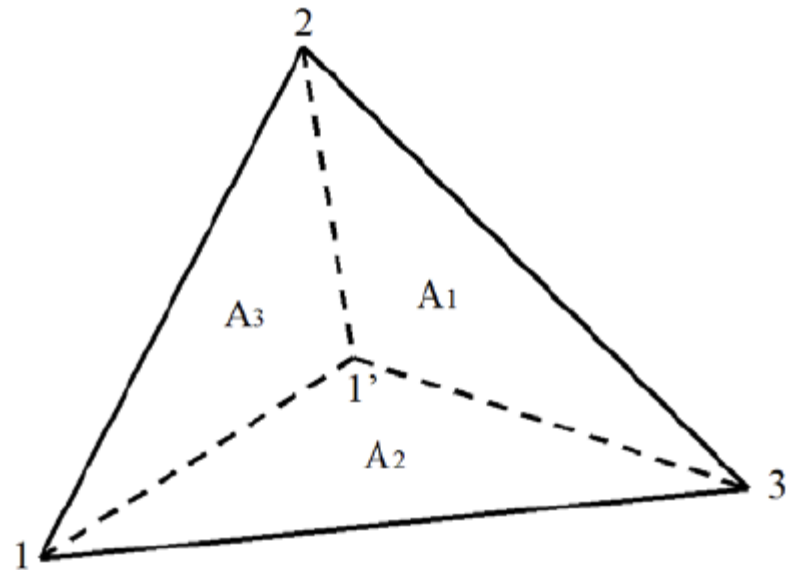
Mathematical formulations (at stage 3)

Mapping in volume/area



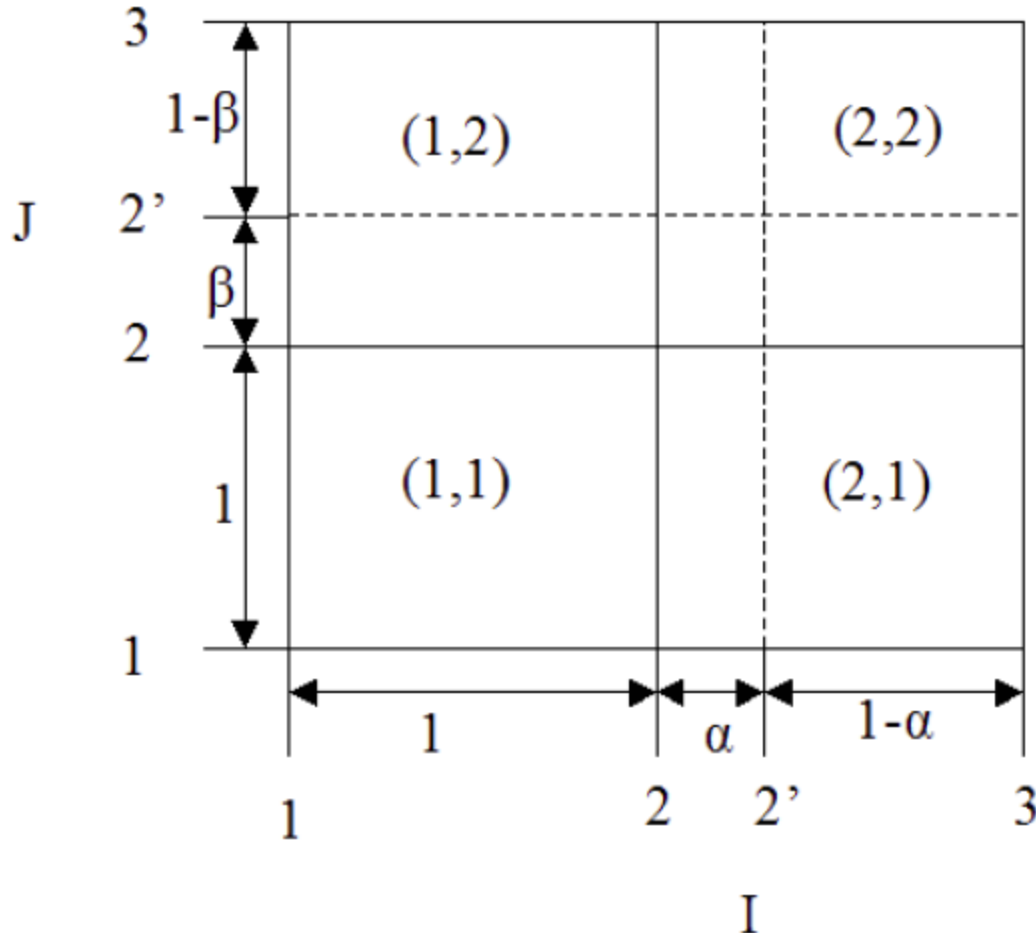
$$z^N = \frac{\sum_{i=1}^6 A_i z_i^o}{\sum_{i=1}^6 A_i}$$

Interpolation at point



$$g^N = (A_1 g_1^o + A_2 g_2^o + A_3 g_3^o) / (A_1 + A_2 + A_3)$$

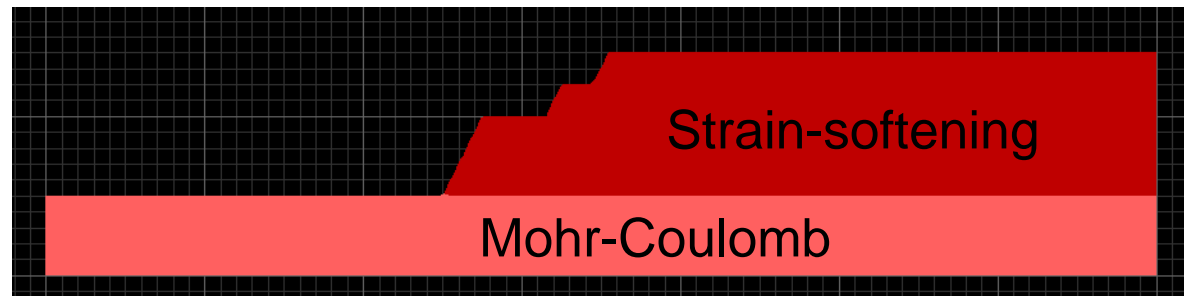
Validation



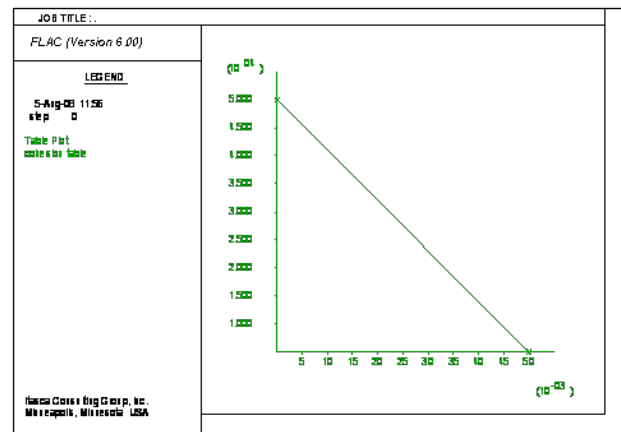
- solid lines – original grid
- translate $i=2$ in x-dir
- translate $j=2$ in y-dir
- dash lines + bound = new grid
- evaluate overlapping area fractions analytically
- compute zone and gridpoint variables analytically
- compare with FLAC's printout values

Example 1: Collapsed open pit slope

- Clay properties
 $K = 1700 \text{ KPa}$
 $G = 625 \text{ KPa}$
 $C = 425 \text{ KPa}$
- Two different materials, M-C is represented by SS with constant cohesion



Bench slope



Softening table for cohesion

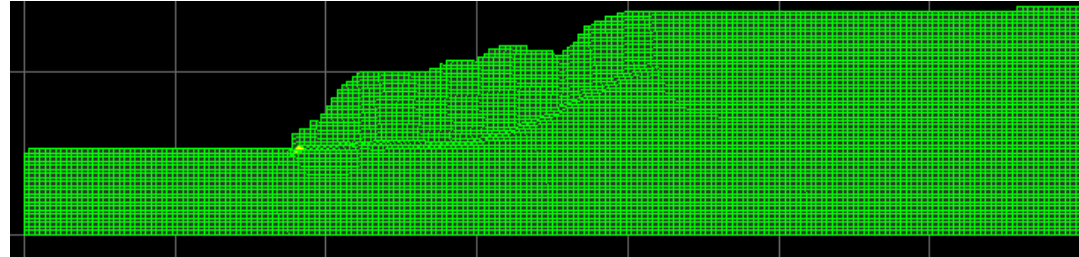
Example 1: Bench slope collapse

- Remeshing steps

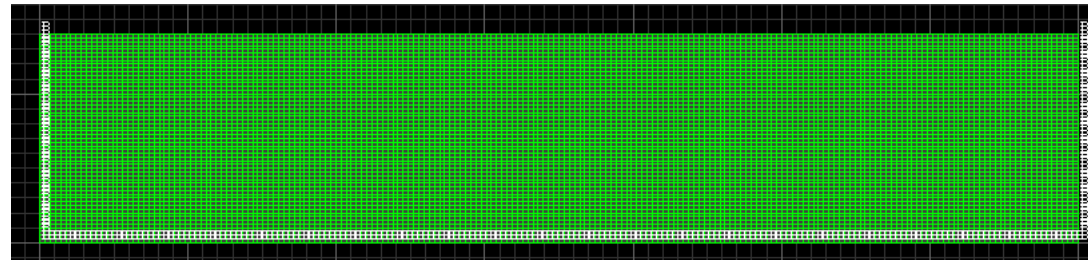
Step 1: store the surface of the old mesh to a table

Step 2: generate a new block mesh, remove the upper-left corner above the surface table

Step 3: info transfer by issuing 'rezone' cmd



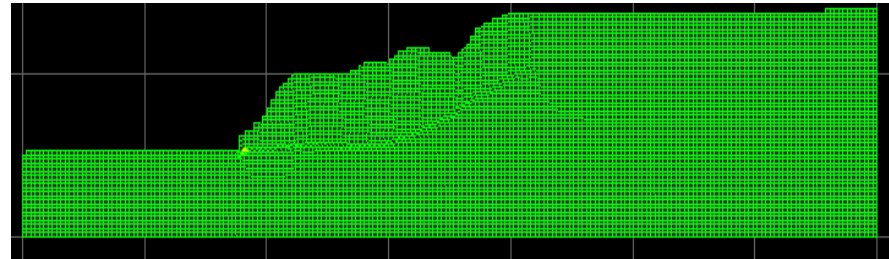
Old, distorted mesh



New, regular mesh

Example 1: Bench slope collapse

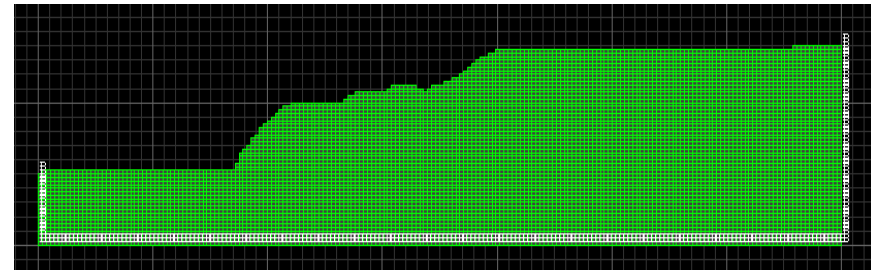
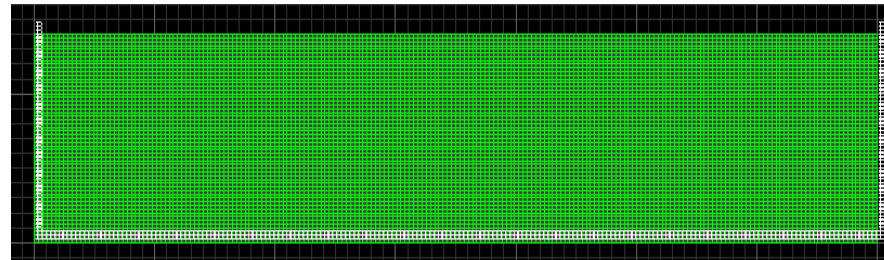
```
def _rezone
  command
    rez set sep meth=_remesh
    rez set smooth from _ib,_jb to _ie,_je
    rez set surfac from _ib,_jb to _ie,_je table 4
  rezone
endcommand
end
```



Example 1: Bench slope collapse

```
def _gentab4
  loop ii (1,izones)
    loop jj (1,jzones)
      if model(ii,jj) # 1
        _x = (x(ii,jj)+x(ii+1,jj)+x(ii,jj+1)+x(ii+1,jj+1))/4.
        _y = (y(ii,jj)+y(ii+1,jj)+y(ii,jj+1)+y(ii+1,jj+1))/4.
        _yt = table(4,_x)
        if _y > _yt
          oo = rez_exe('model null i=ii j=jj')
        endif
      endif
    endloop
  endloop
end
```

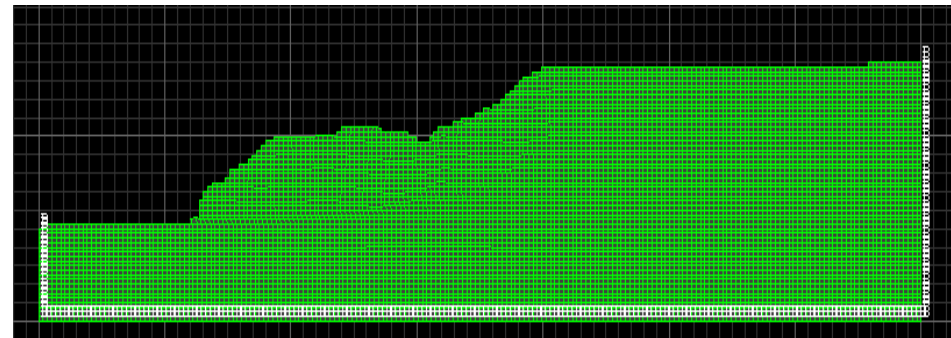
```
def _remesh
  _nrez = _nrez + 1
  oo=rez_exe('gen _xmin,_ymin _xmin,_ymax
    _xmax,_ymax _xmax,_ymin')
  oo=rez_exe('model ss')
  _gentab4
End
```



Example 1: Bench slope collapse



On site picture of the failed slope



Shape of the failed slope shape predicted in FLAC

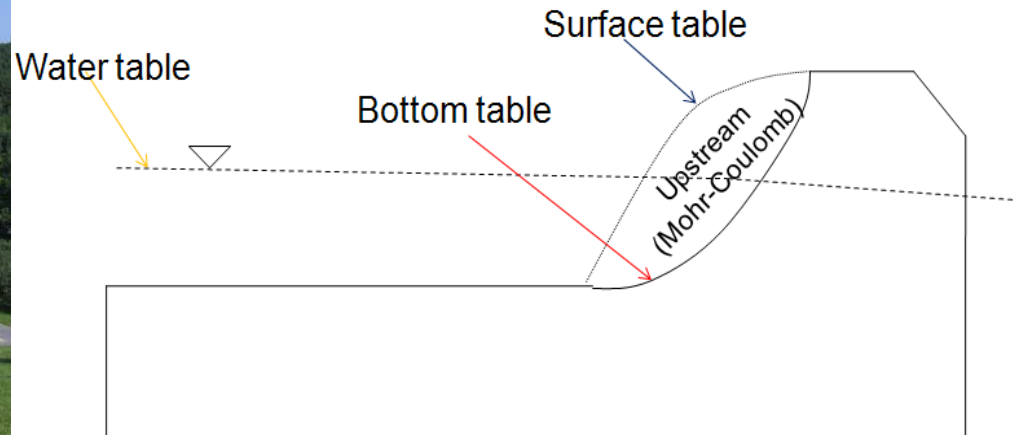
After 20 remeshing operations (25000 steps)

Example 2: North Dike of Wachusett Dam



Wachusett Dam (today)

<http://en.wikipedia.org/wiki/Image:Wachusett-dam.jpg>



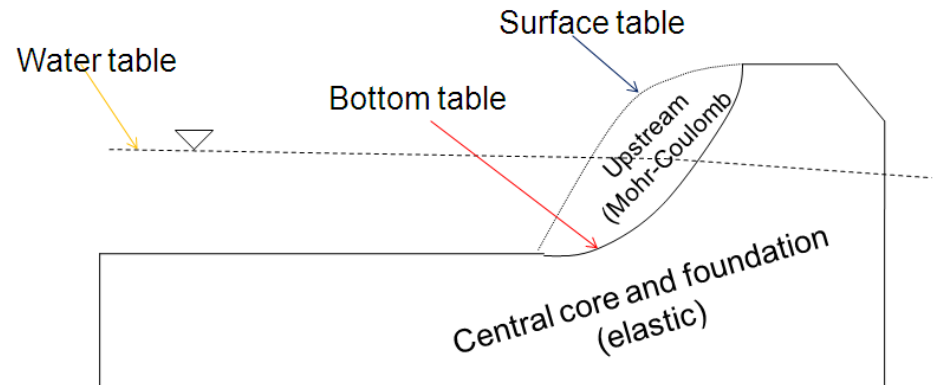
Cross-section of the dam when constructed

- constructed on south branch of Nashua River in Clinton, Massachusetts
- sandy silt to silty sand in the central core
- fine sand in the upstream shell
- failed due to strength loss in the upstream shell during the first reservoir filling

Example 2: North Dike of Wachusett Dam

Remeshing steps

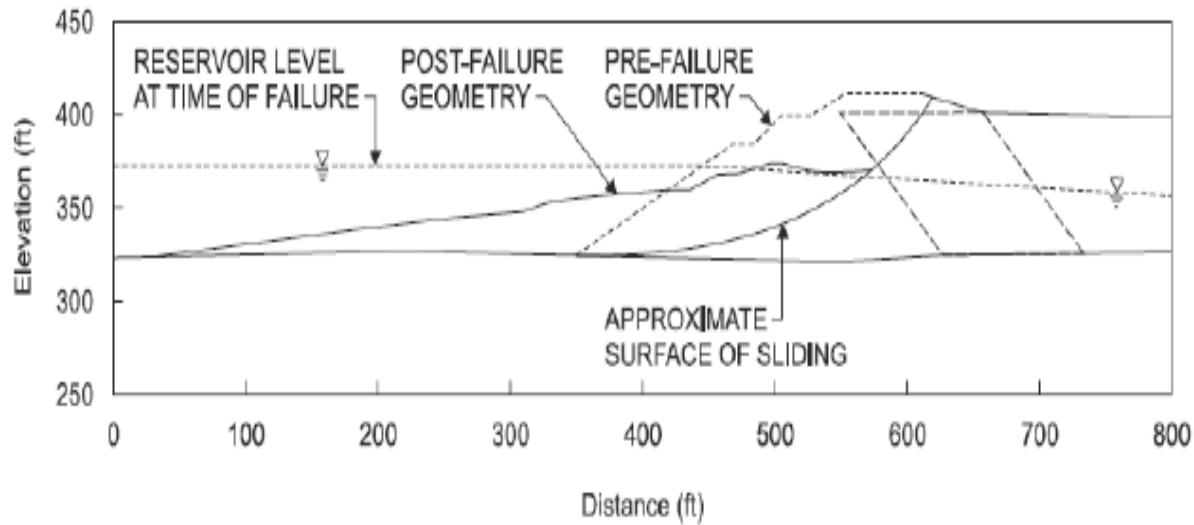
- Step 1: store the surface line to a table
- Step 2: generate a new block mesh; remove the mesh above the surface table
- Step 3: transfer info from old, distorted mesh to the new, regular mesh



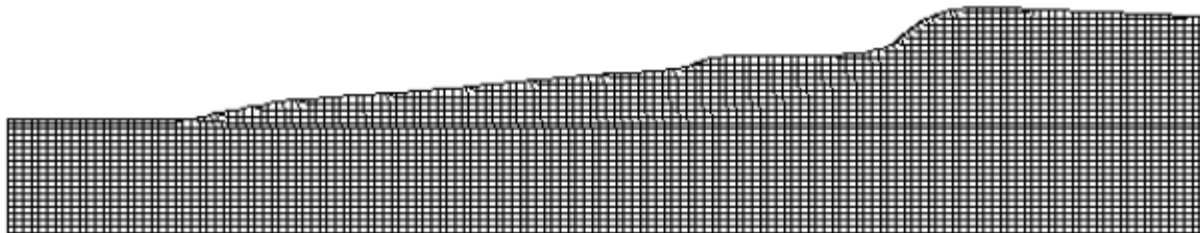
Additional work

- Search the grid-point at the point crossing water table and surface table in order to renew pressure BC
- Adjust density for zones newly moving below water table

Example 2: North Dike of Wachusett Dam

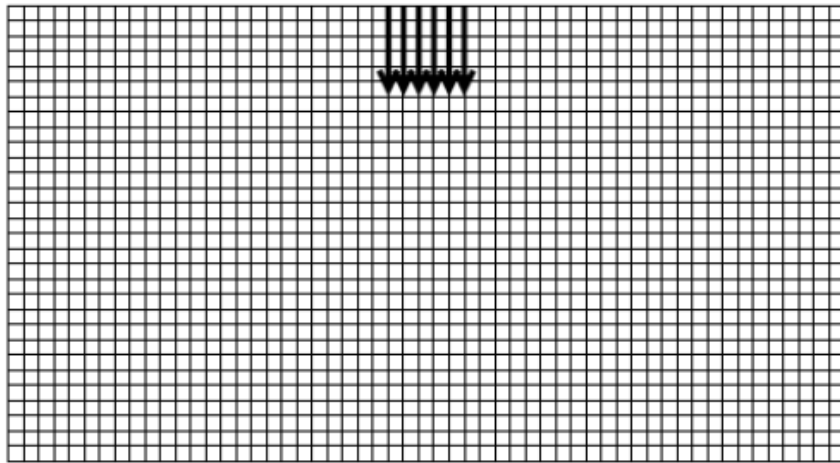


Olson, S. 2000. 1907 Static Liquefaction Flow Failure of the North Dike of Wachusett Dam. *Journal of Geotechnical and Geoenvironmental Engineering*, Dec. 2000.

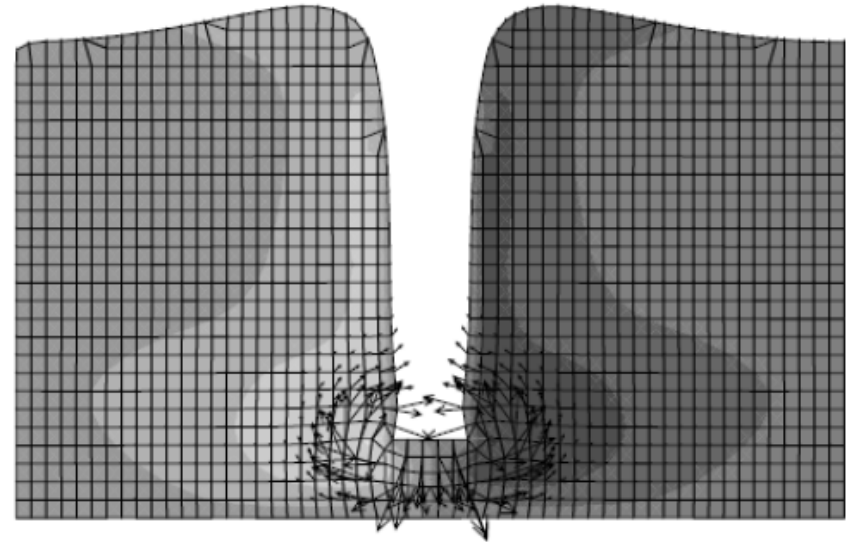


After 46 operations (about 80,000 steps)

Example 3: Punch Problem



Initial mesh



Mesh after 13 rezonings

- Punch downward at the center with a constant velocity
- Roller condition at laterals and bottom
- Able to punch through the whole model with assistance of remeshing logic

Summary

- Mesh generation takes advantage of FISH, the embedded programming language in FLAC
- Information transfer is automatic
- The logic is still under development, although most modules/models covered; not well tested
- Not applicable to models with interfaces and attaches at current stage