International Workshop on Seismic Stability of Tailing Dams

Some Issues Regarding Run-out Evaluations

By

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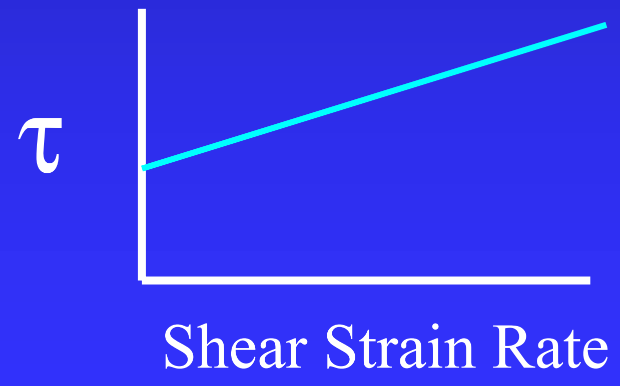
Simplified <u>Static</u> Run-out Analysis Methodology

- Lucia et al. (1981)
  - Estimates of **end configuration** using only **static equilibrium forces**.
  - 2-D static modeling of a complicated dynamic process.

Simplified
Dynamic "Fluid"
Run-out Analysis Methodology

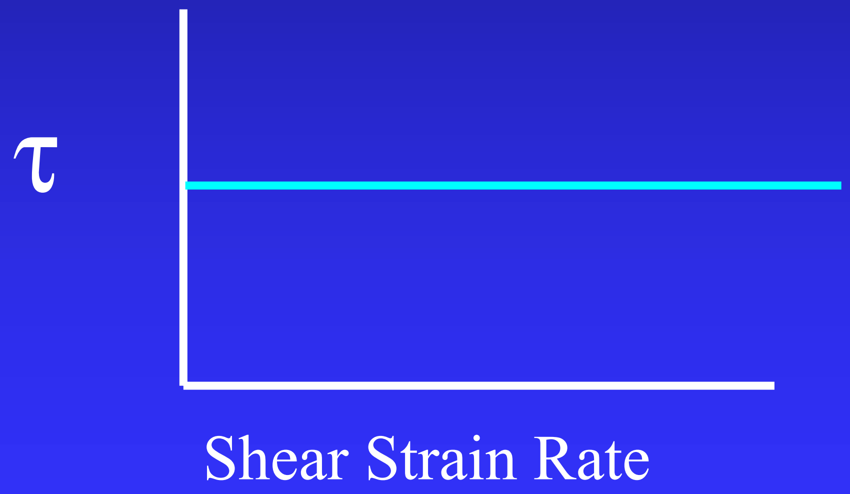
- Jeyapalan et al. (1983)
  - Estimates of end configuration using simplified **dynamic fluid flow equations**
  - **Bingham plastic fluid**



Simplified

Dynamic "Soil"

Run-out Process



1. Initiation of Flow Slide

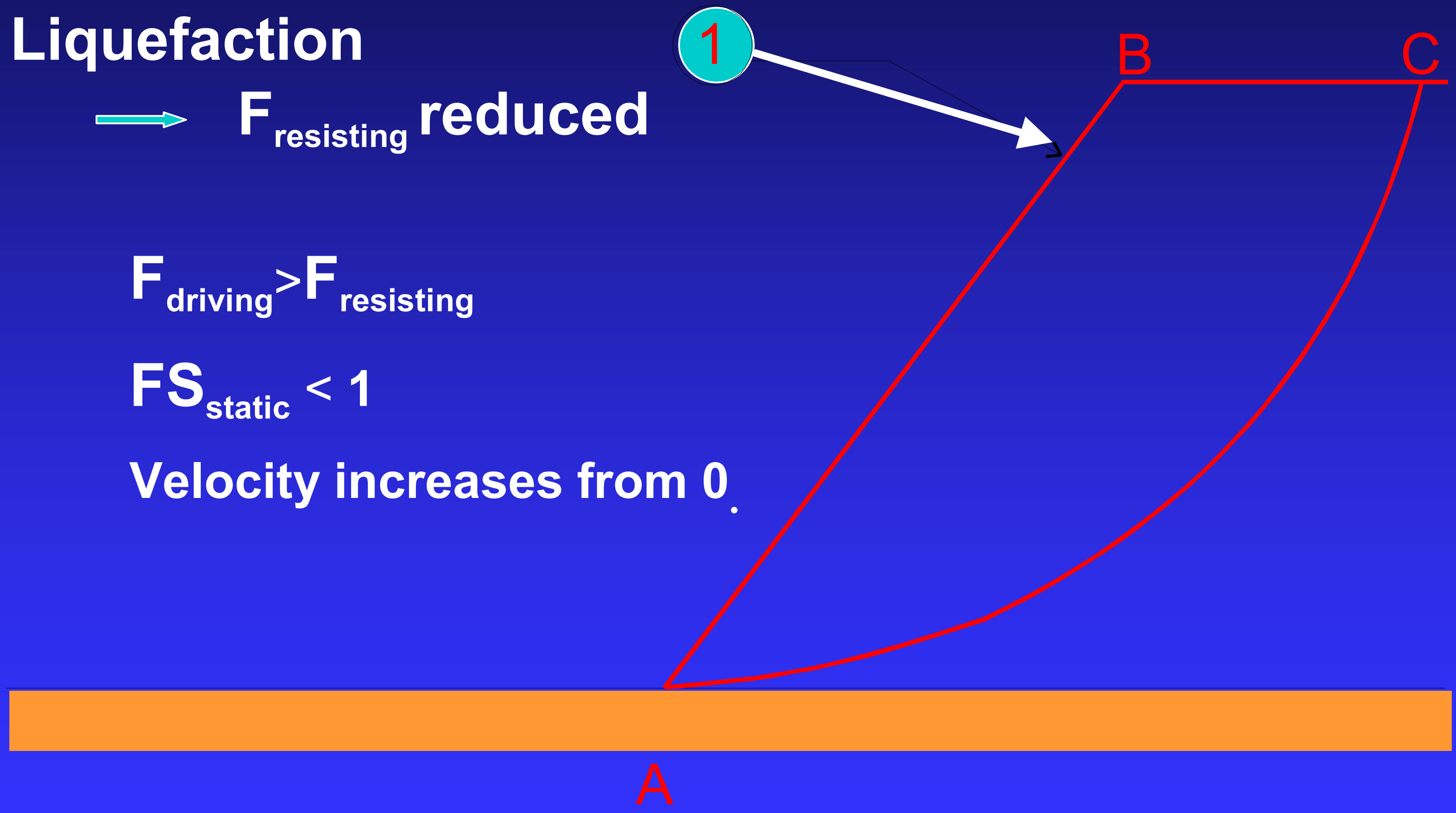
Liquefaction

→ $F_{resisting}$ reduced

$F_{driving} > F_{resisting}$

$FS_{static} < 1$

Velocity increases from 0

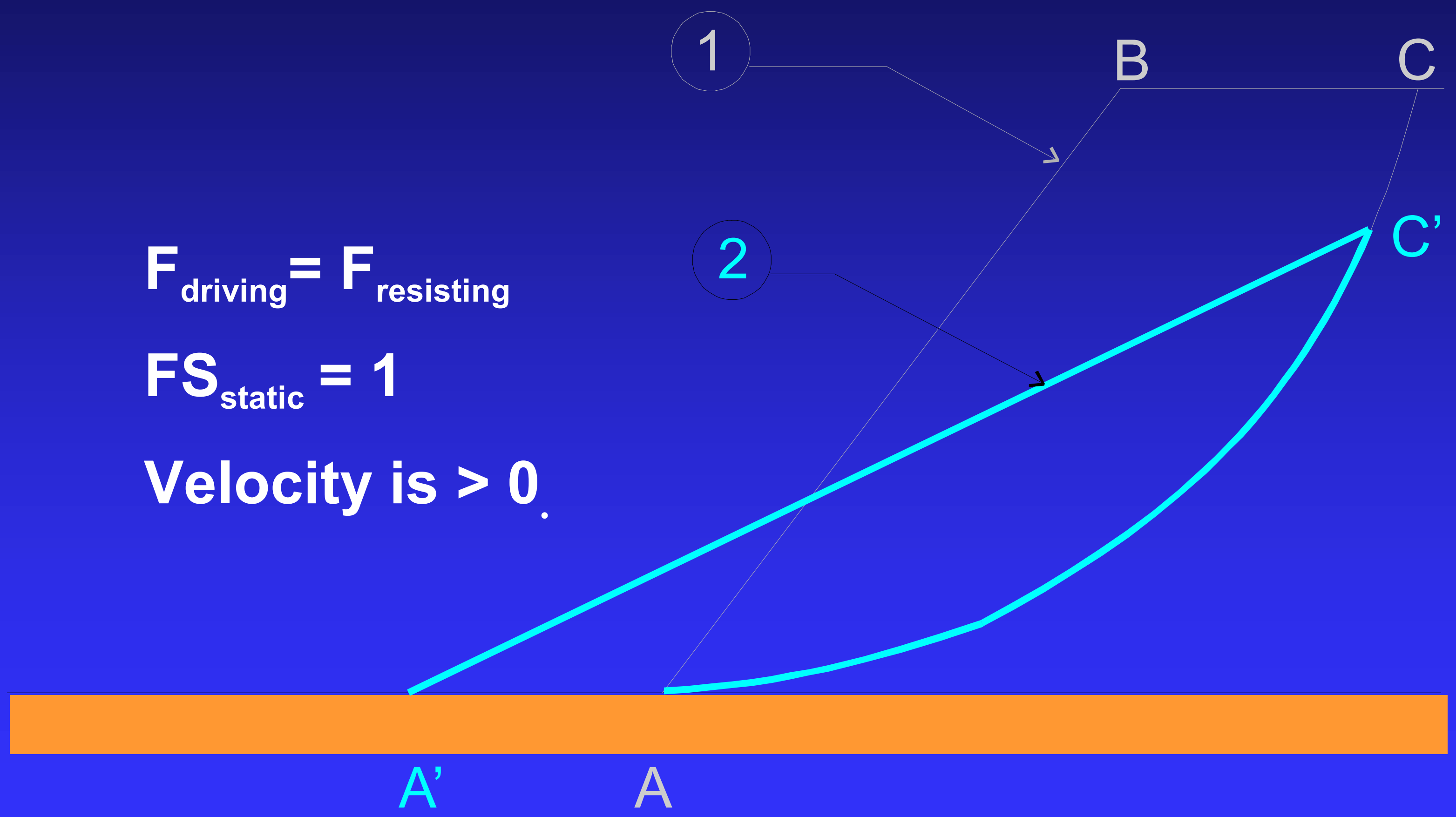


2. "Statically Stable" State

$F_{driving} = F_{resisting}$

$FS_{static} = 1$

Velocity is > 0.

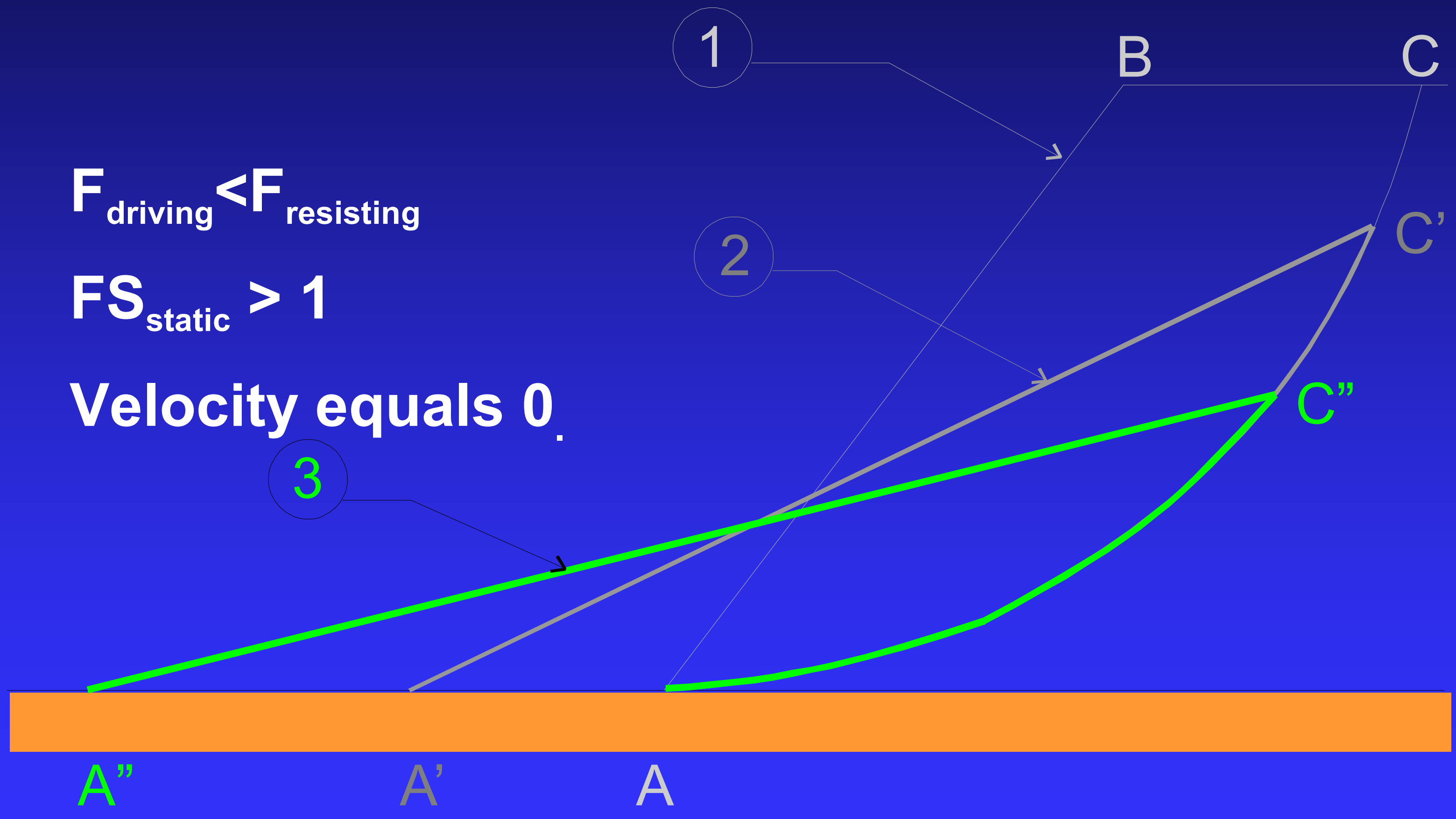


3. "Dynamically" Stable State

$F_{driving} < F_{resisting}$

$FS_{static} > 1$

Velocity equals 0.



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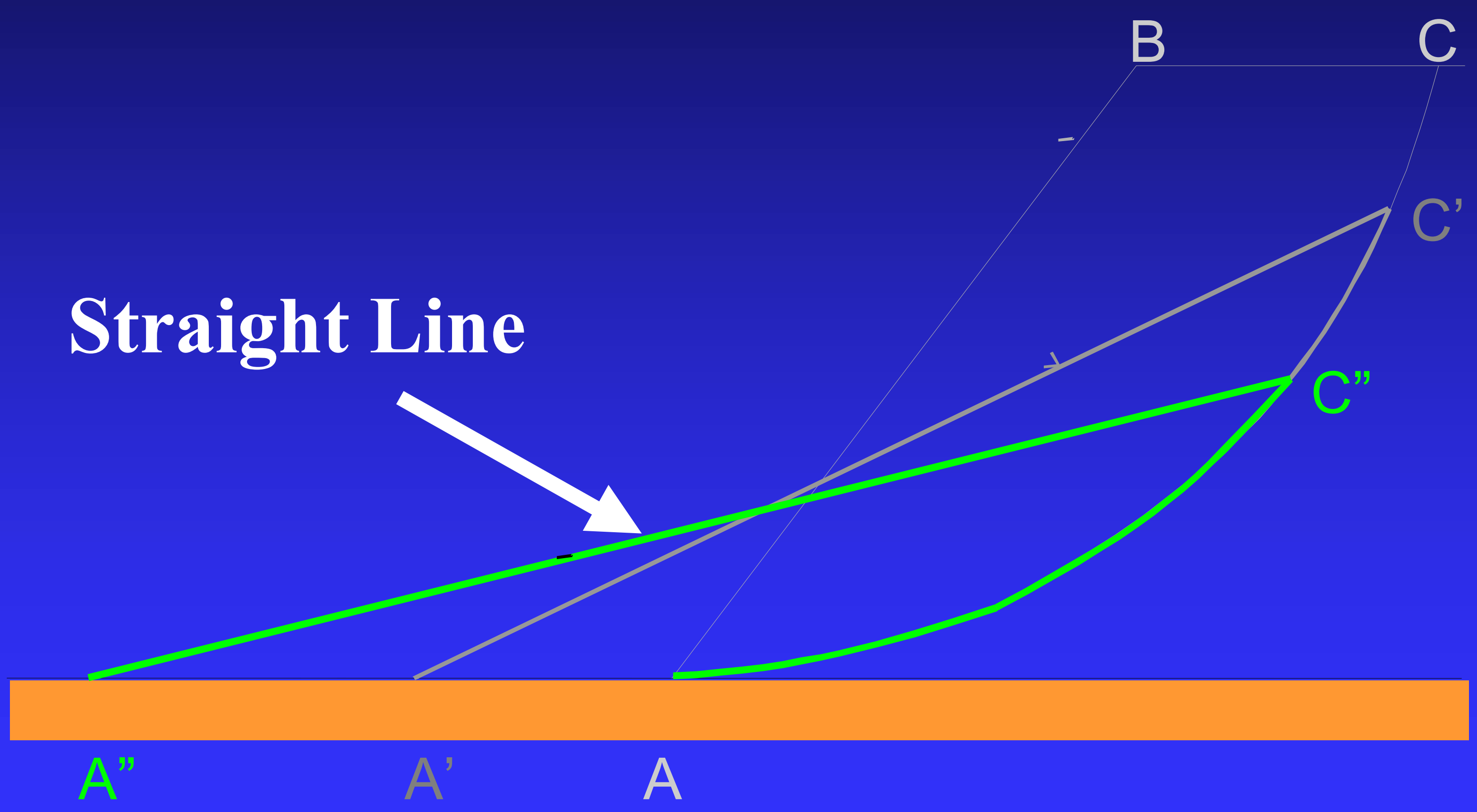
Assumptions

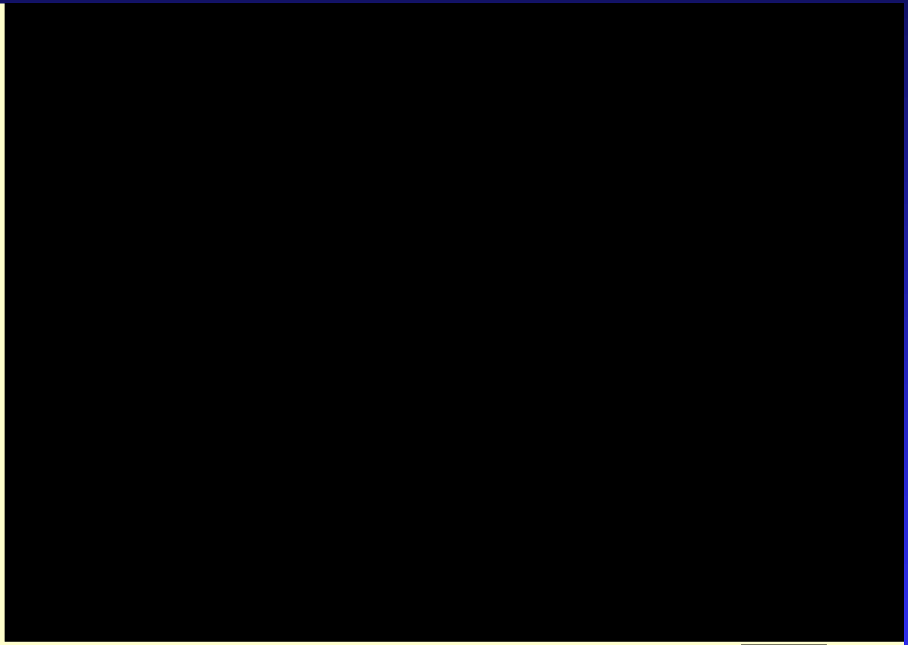
- F = ma *in the direction of the movement*
- Neglect the effects of shaking-induced inertia forces.
- Driving force = gravity force.
- Resistance force = assigned shear strength summed over the base of the sliding plane.
- Plane strain conditions.
- Slide mass volume remains constant.
- Geometry of run-out mass must be specified (Surface of run-out slope remains straight).

Straight Surface of Run-out Mass



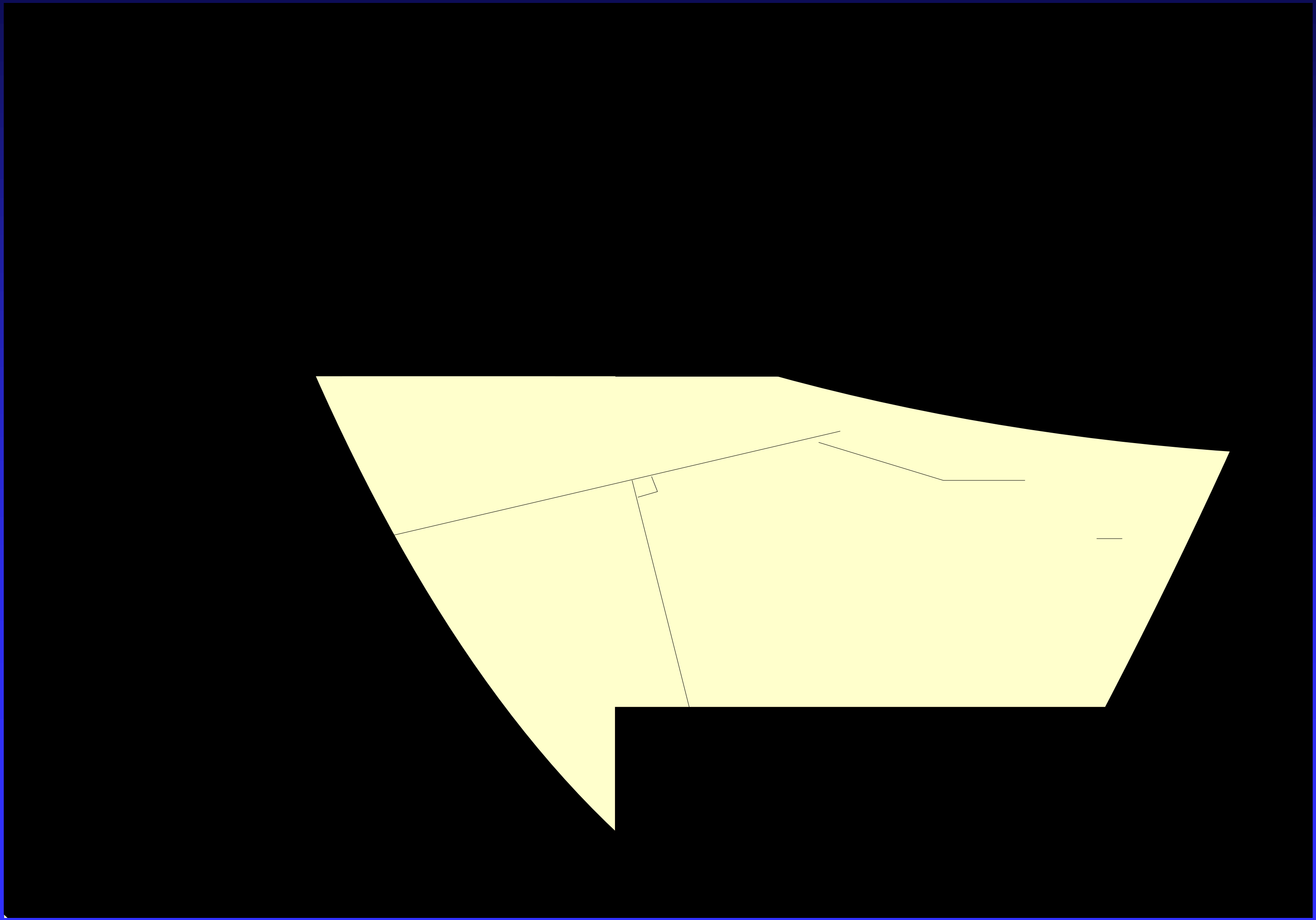
DRUM Program

$t = t_i$



$t = t_{i+1}$

$F = ma$ for t_i to t_{i+1}

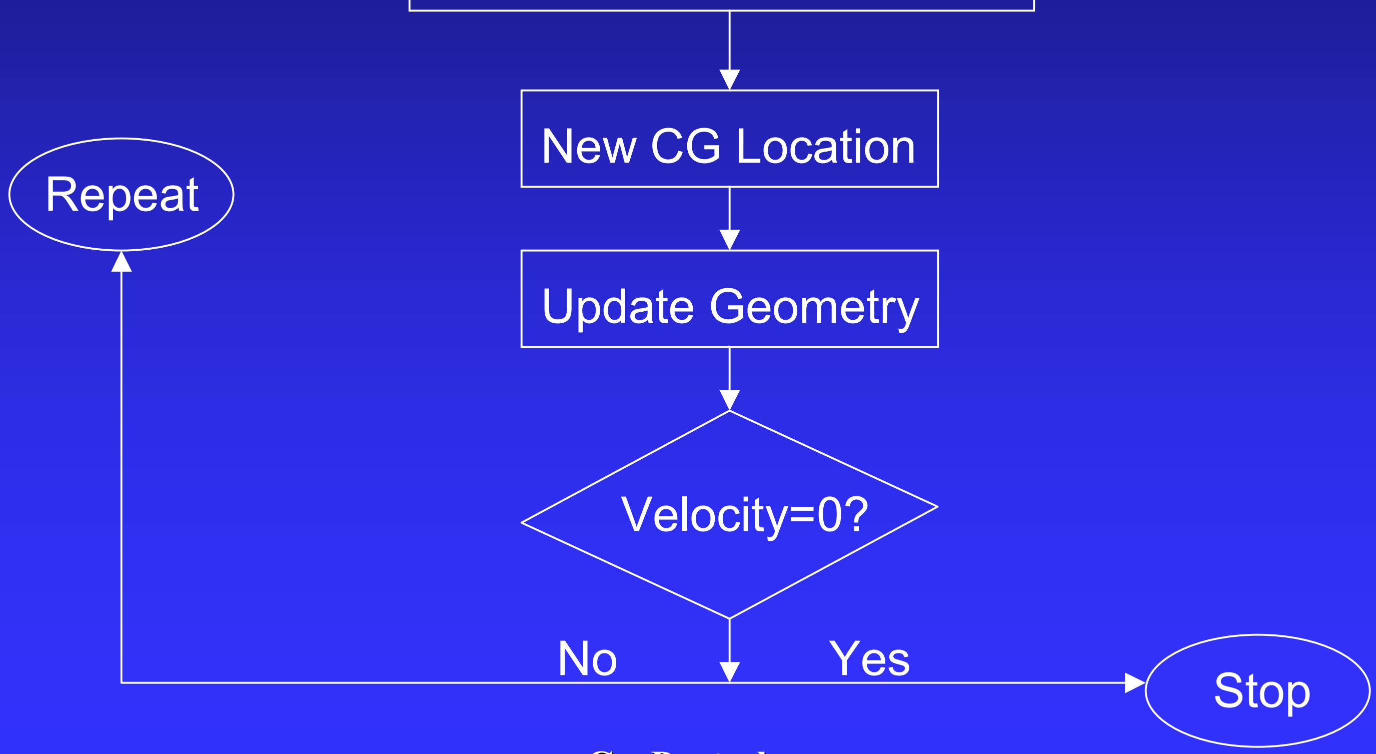


Analysis Methodology

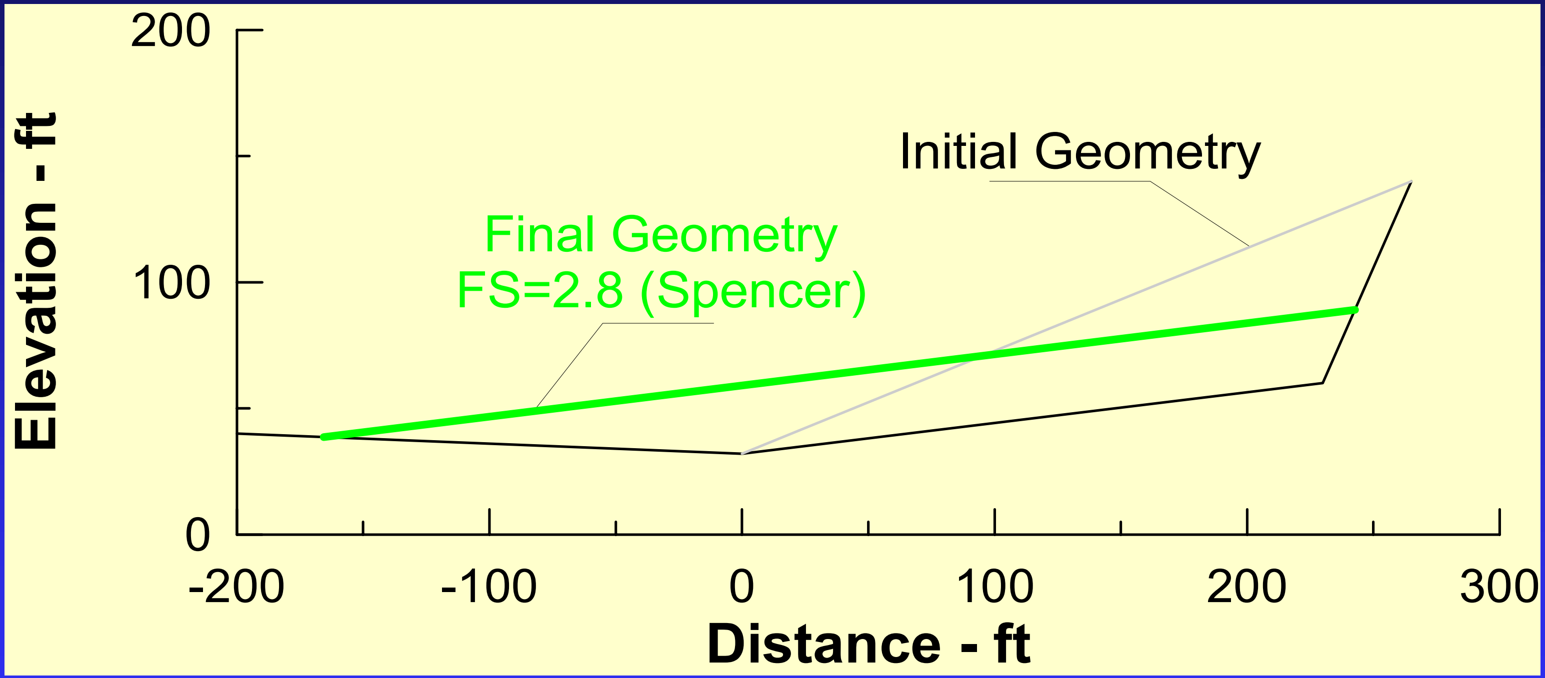
$$v_{i+1} = \frac{(a_i + a_{i+1}) \cdot \Delta t}{2}$$

$$d_{i+1} = d_i + v_{i+1} \cdot \Delta t$$

(Iteration)

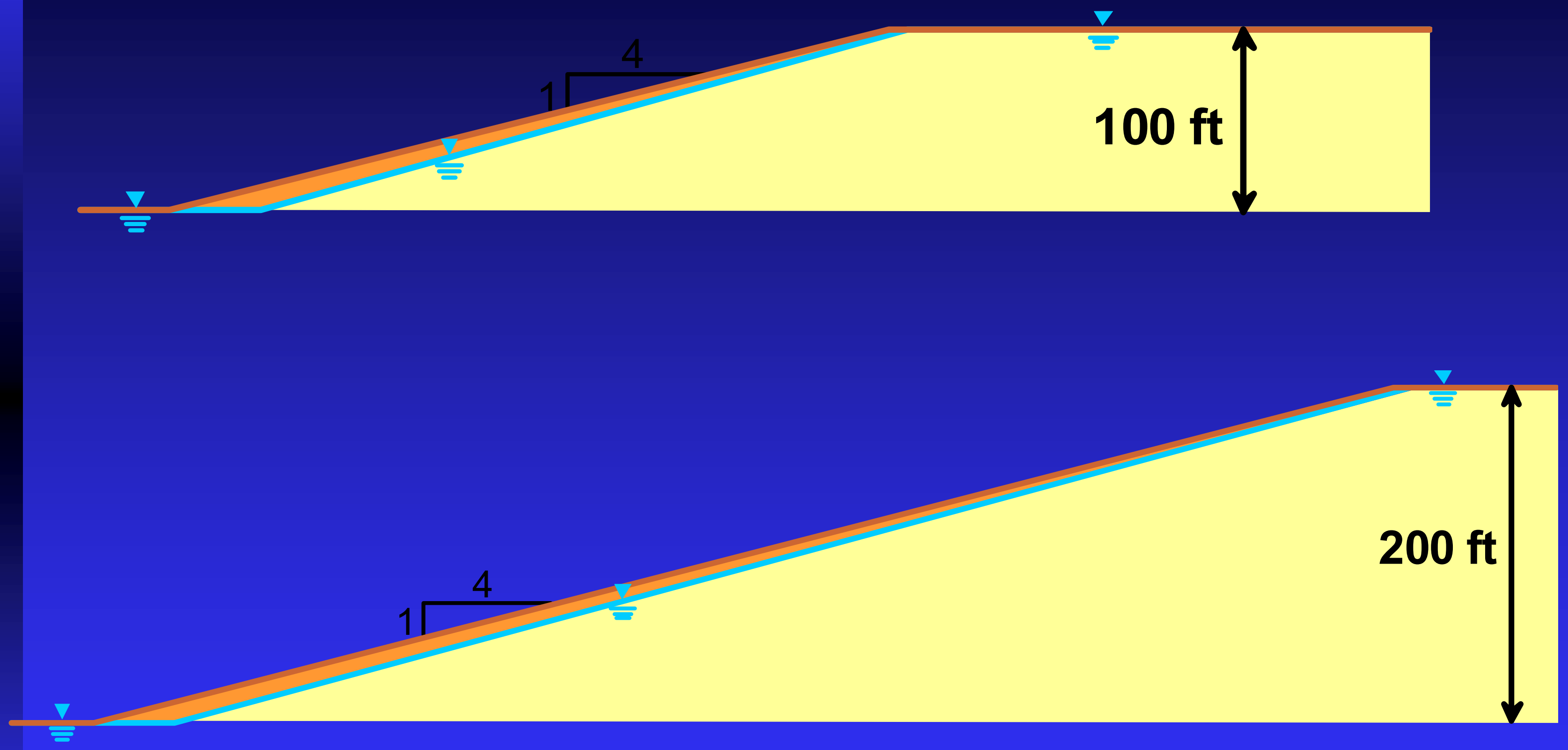


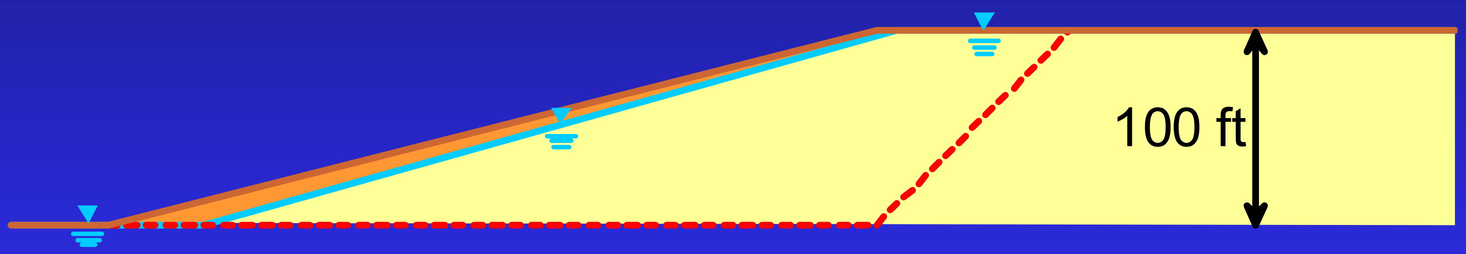
Lower San Fernando Dam



Run-Out Analysis Results: Initial and Final Geometry

Example Calculations


4
1
100 ft
4
1
200 ft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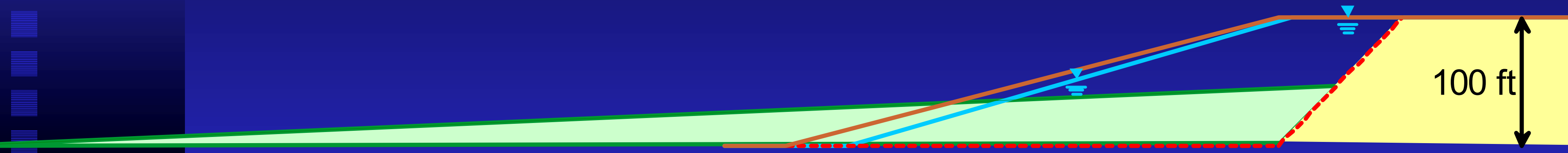
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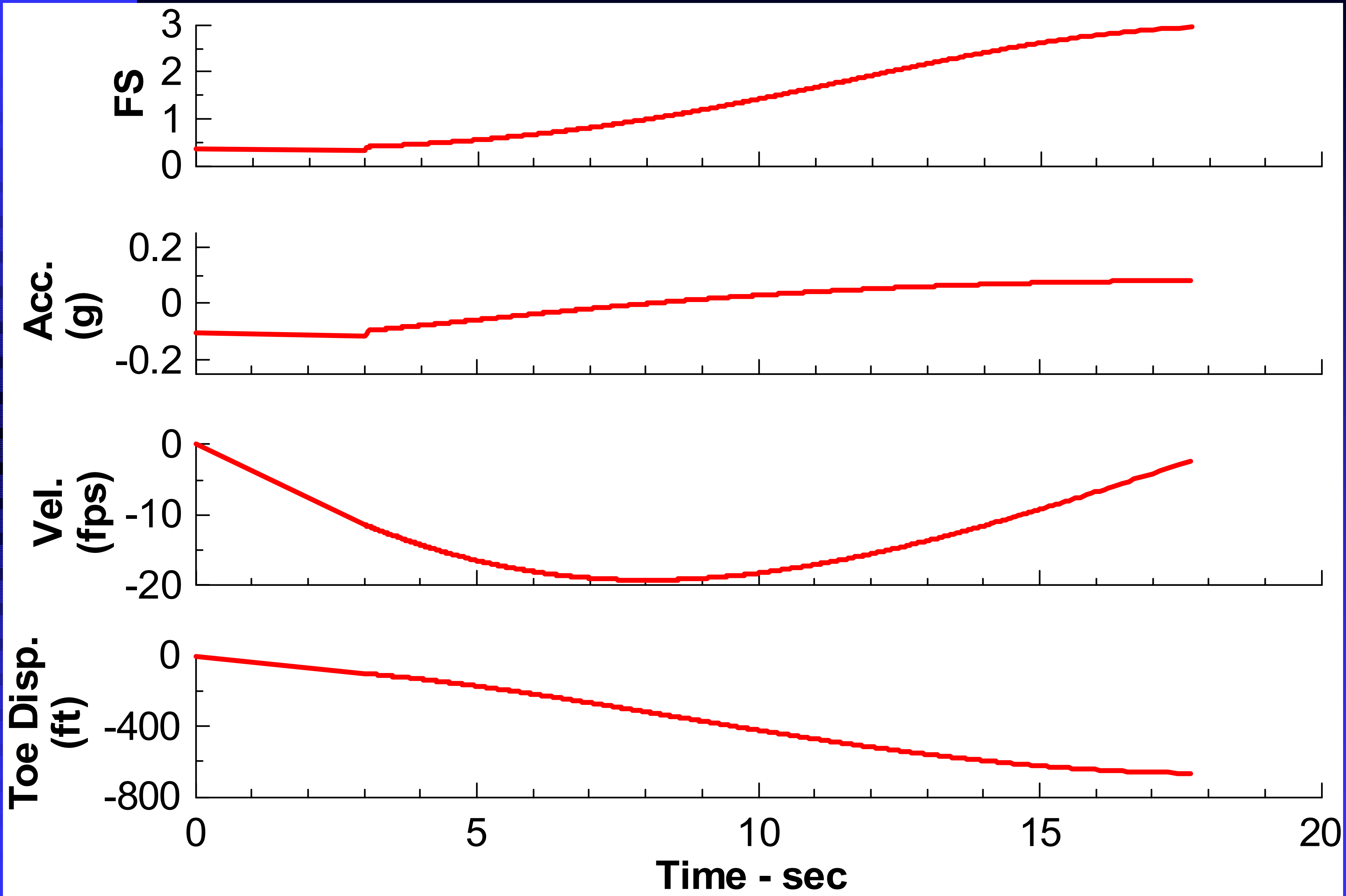

FS
3
2
1
0
Acc.
(g)
0.2
0
-0.2
Vel.
(fps)
0
-10
-20
Toe Disp.
(ft)
0
-400
-800
0
5
10
15
20
Time - sec

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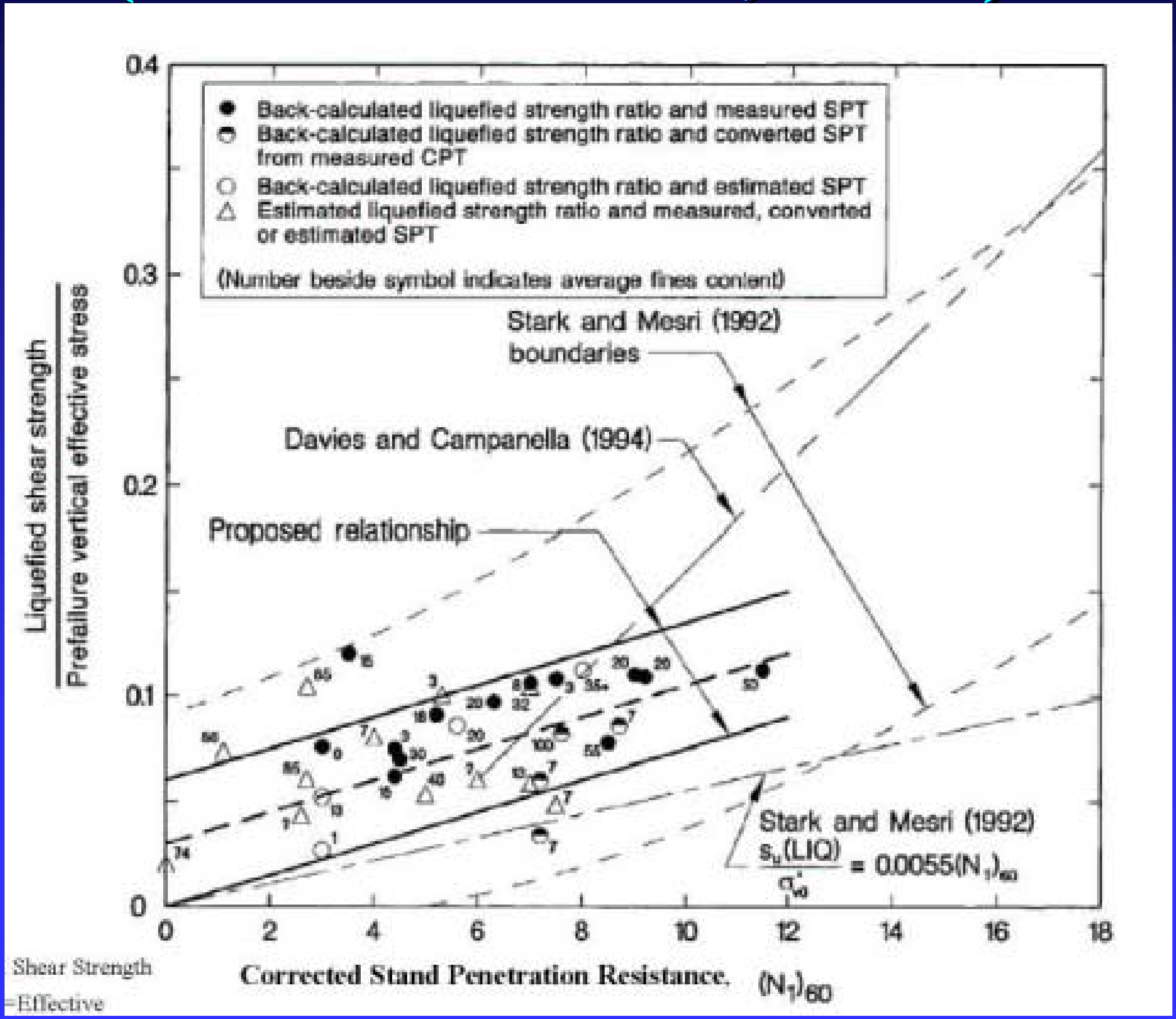
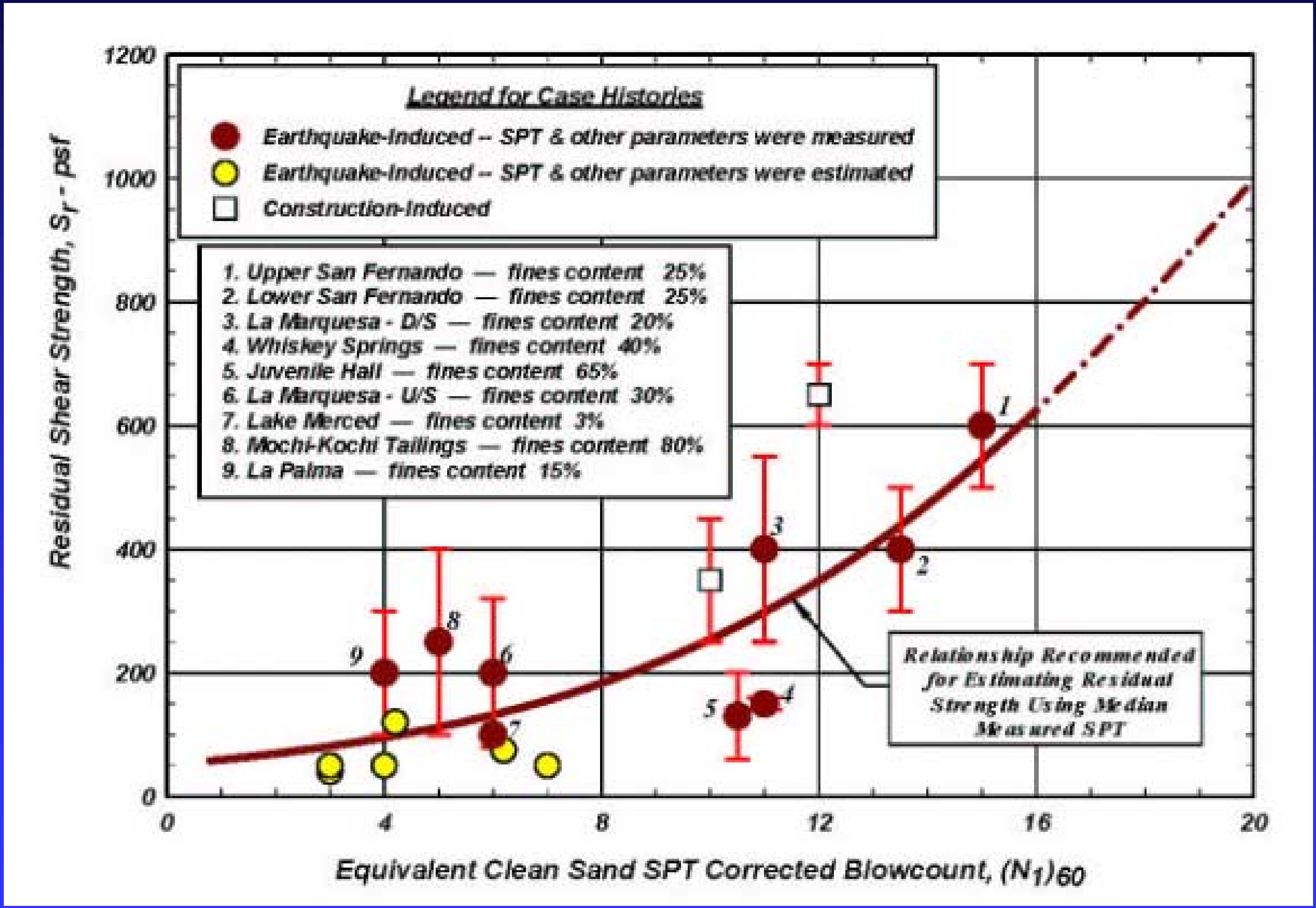
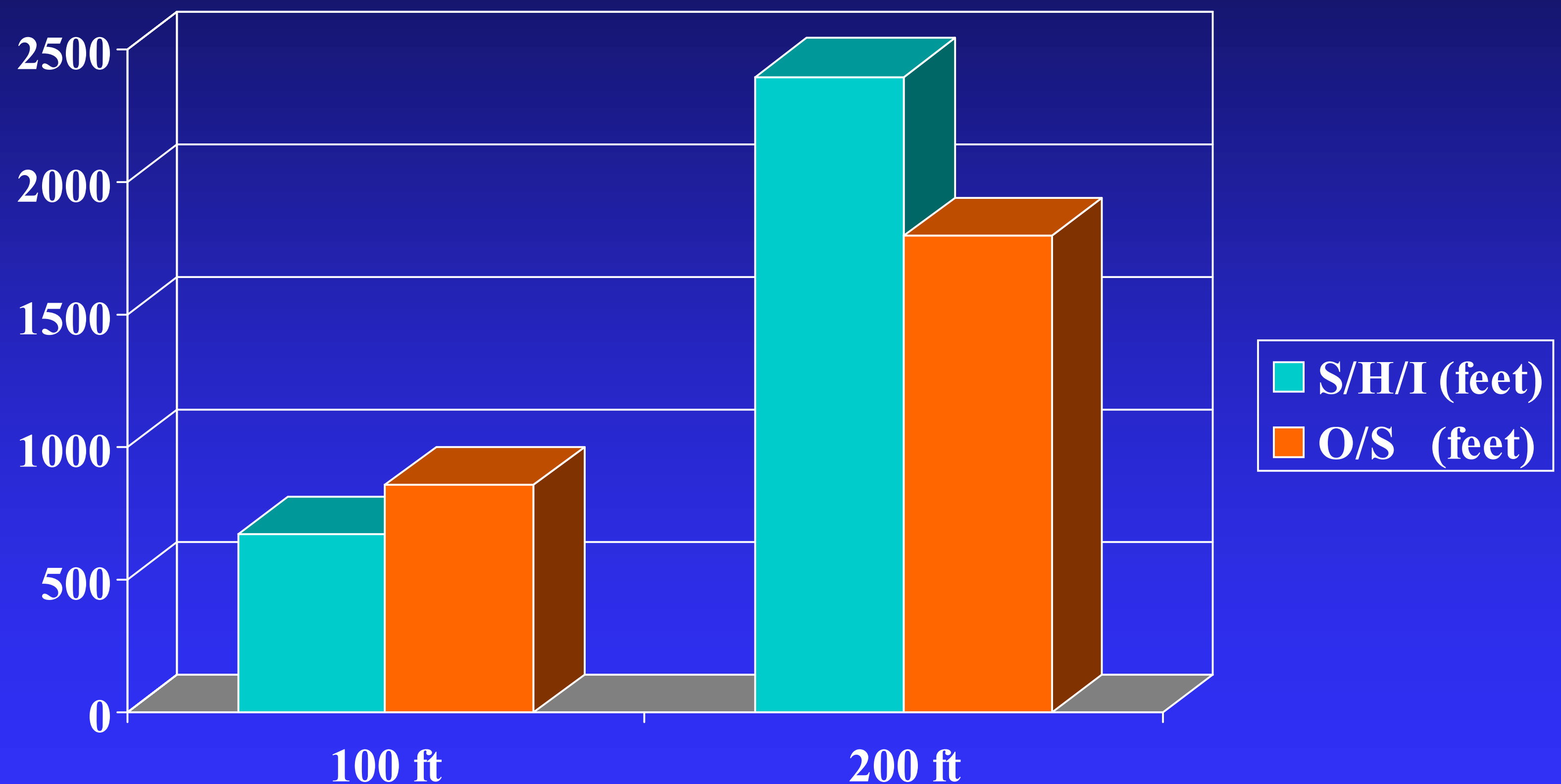
Residual Shear Strength (Olson & Stark, 2002)



Residual Shear Strength
(Seed & Harder, 1990; Idriss, 2002)



Example Run-Out Analysis Results



SOME OBSERVATIONS

- Simplified Dynamic "Soil" Run-out Method Is One Reasonable Way to Evaluate the Site-Specific Run-out Distance of Liquefied Tailings.
- Shear Strength Characterization of Liquefied Tailings Introduces Big Uncertainty.
- Run-out Estimates Should be Based on:
  - Use of Multiple-analysis/characterization Approaches
  - Results of Parametric analyses
  - Judgment