Estimating Capacity of Offshore Foundations

The McClelland Lecture

A Tribute to Bram

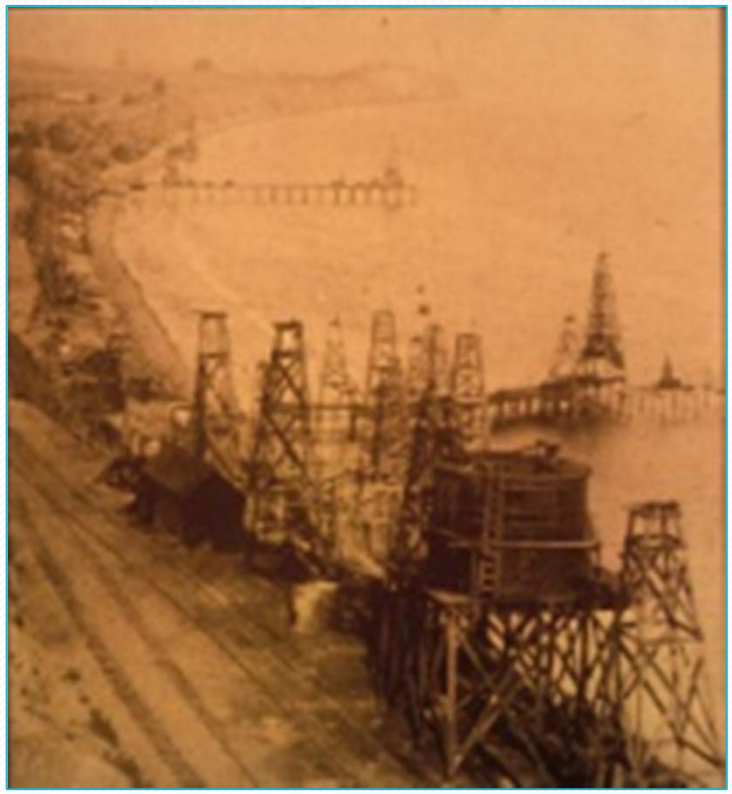
OBJECTIVES

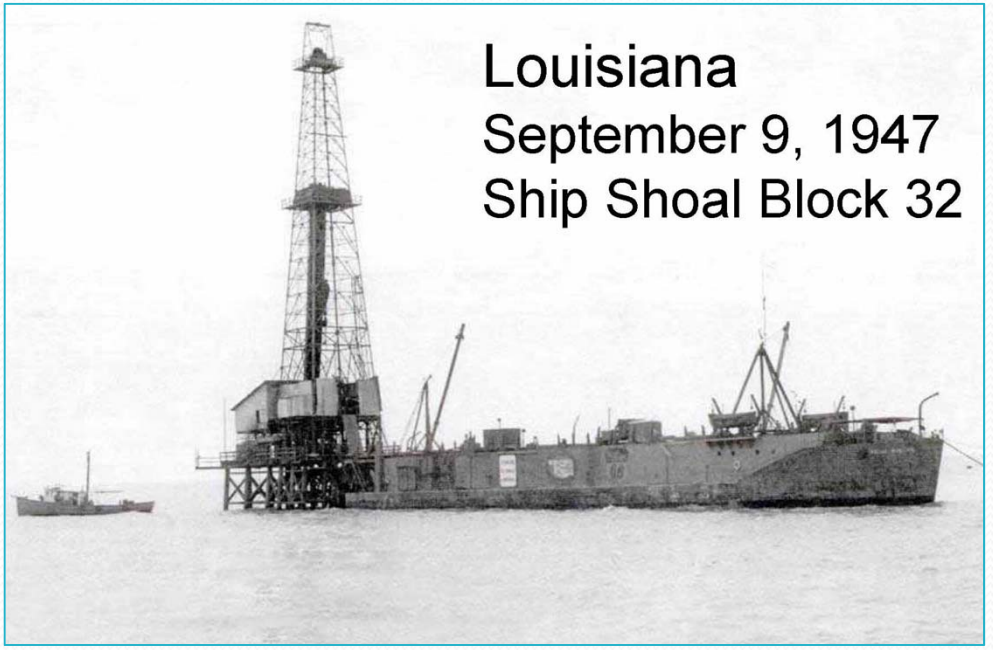
Demonstrate the techniques of plastic limit analysis (PLA) and the advantages of same for estimating foundation capacity

Outline

- Offshore Foundation - A Brief History
- Analysis of Typical Cases Including Individual and Systems of
  - Shallow Foundations
  - Pile Foundations
- Show Similarities and Differences in PLA and Limit Equilibrium Techniques

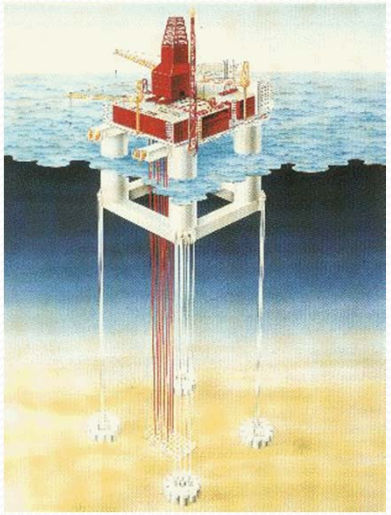
History- The Early days



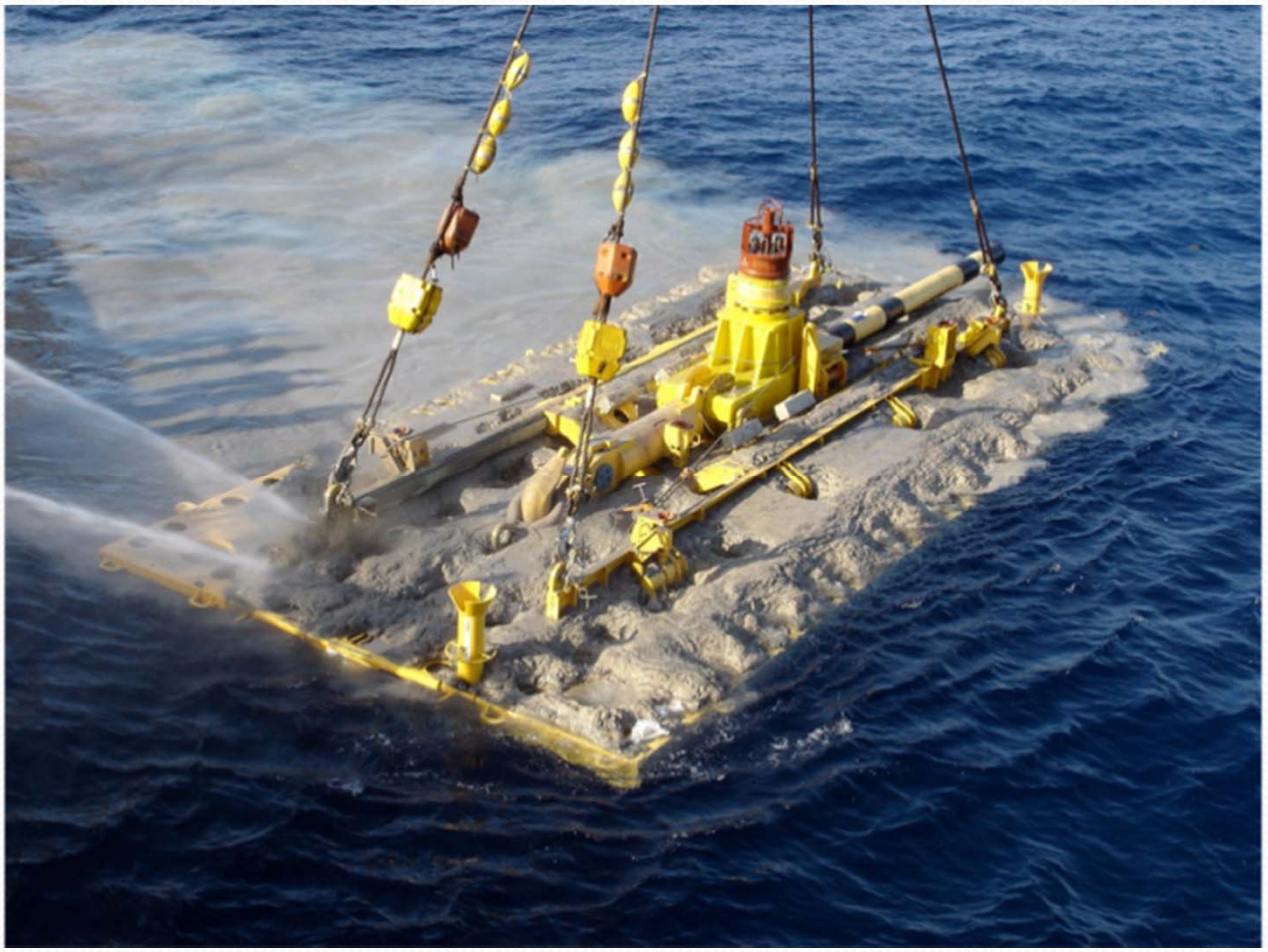


History- Shallow Water Structures

History- Deep Water Structures



History- Shallow Foundations



IDEALISATION

"...how can mathematics, which is so clear and precise, and in so many ways simple, be applied to the physical world which, although apparently consistent, is many sided and extremely complex? ...."

Calladine, 1969

COMPUTING

" The purpose of computing is insight, not numbers."

Richard Hamming

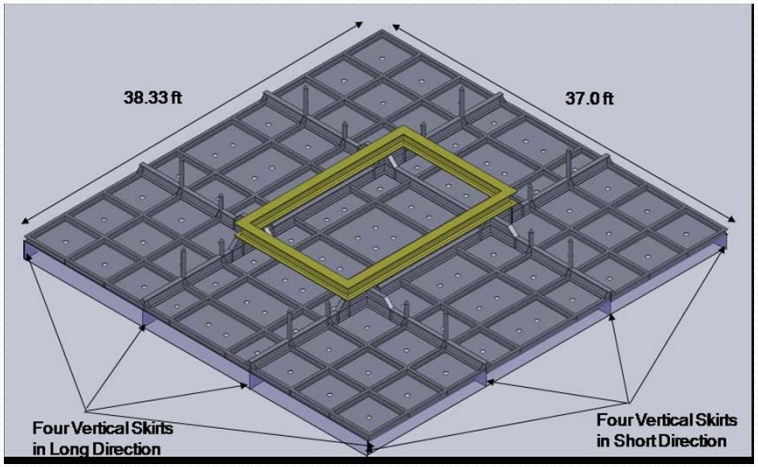
AN ASIDE

"… this solution was obtained using the analytical tools available to us…"

"… this solution was obtained using the analytical fools available to us…"

SHALLOW FOUNDATIONS

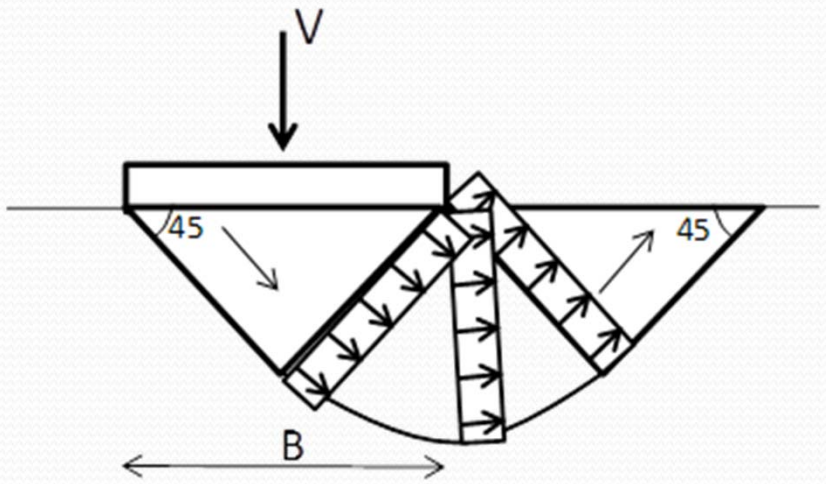
- Conventional Methods
- Plasticity Approach



Conventional Plane Strain Bearing Capacity Solution

$$V/A = cN_c + qN_q + 0.5\gamma BN_\gamma$$

Prandtl Reissner Terzaghi



Mechanism

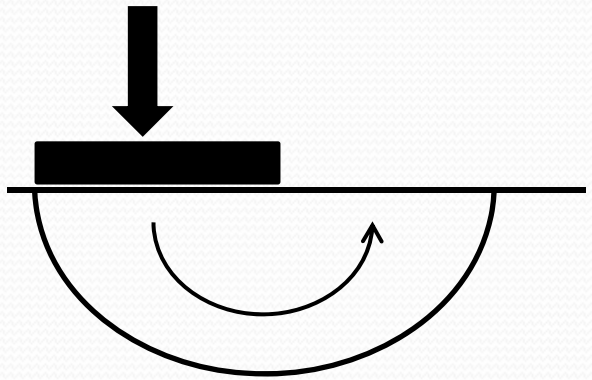
The Plasticity Approach with Some Words of Caution

"Mathematicians are useful animals who should be kept in golden cages and fed problems judiciously."

Karl Terzaghi

The Upper Bound Method of Plastic Limit Analysis

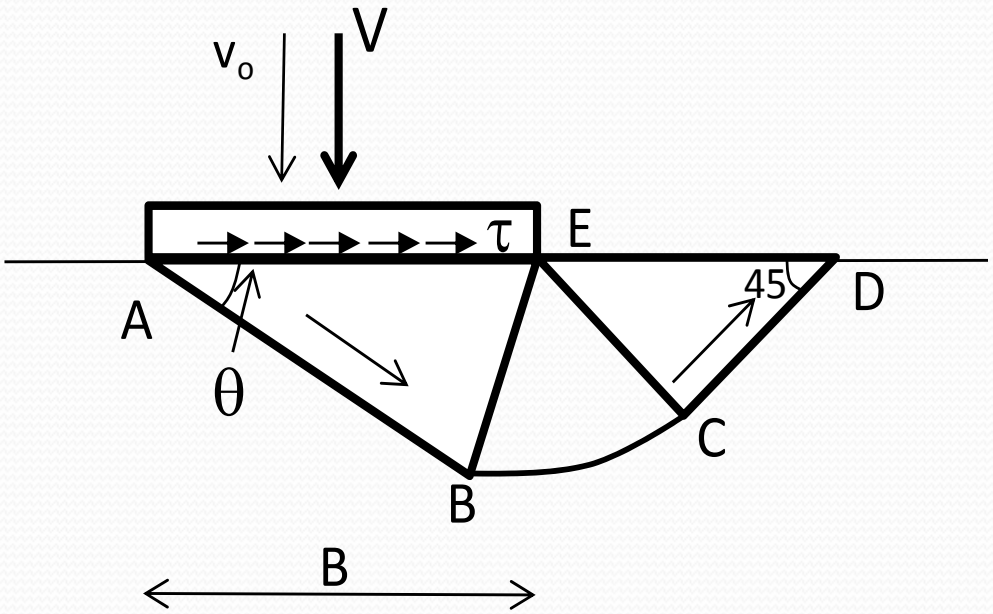
- Define an admissible mechanism
- Assume a virtual velocity of the unknown loads
- Set external work rates equal to internal energy dissipation rates
- Solve the resulting equation
- Optimize the mechanism



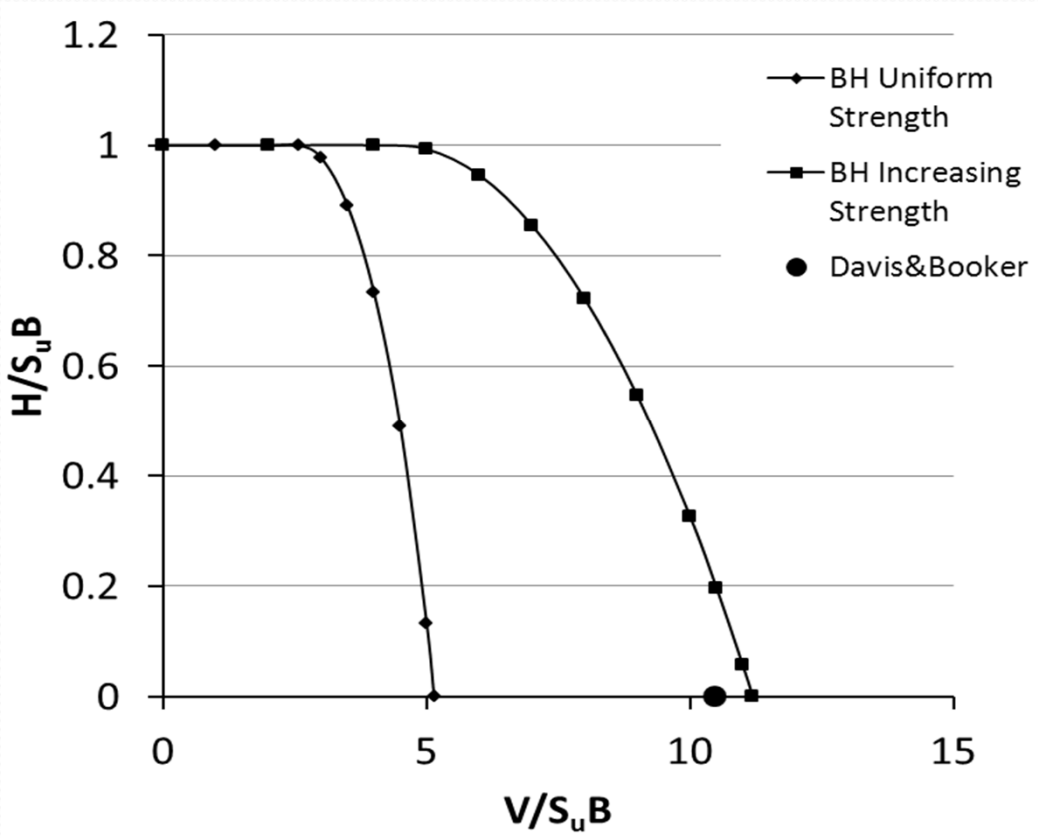
A Word of Encouragement

Remember --- no one ever really understands anything, we just get used to it.

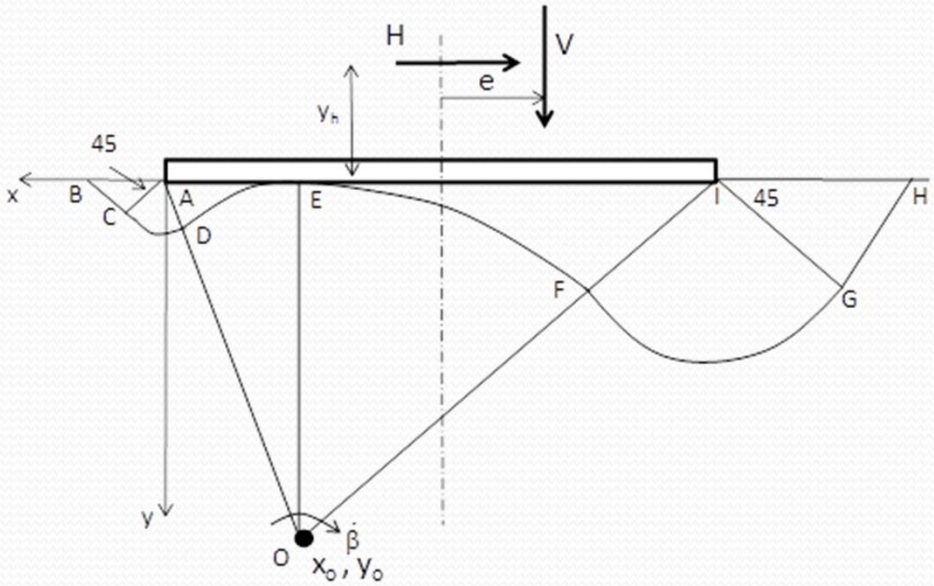
Example -- Inclined Load Mechanism



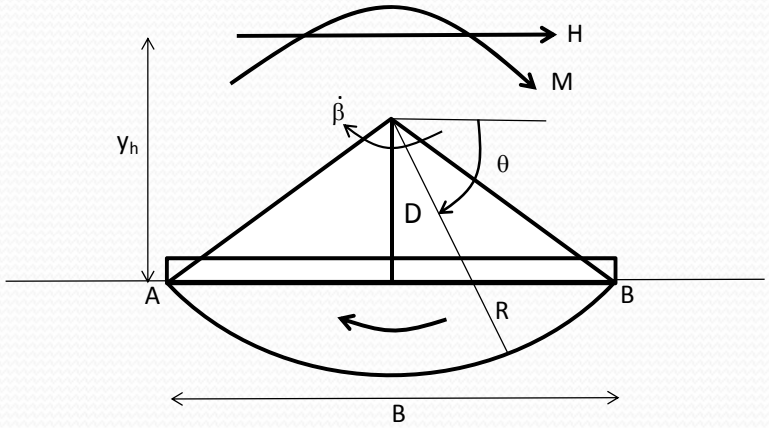
Example 1 – Solution



Eccentric Load Mechanism

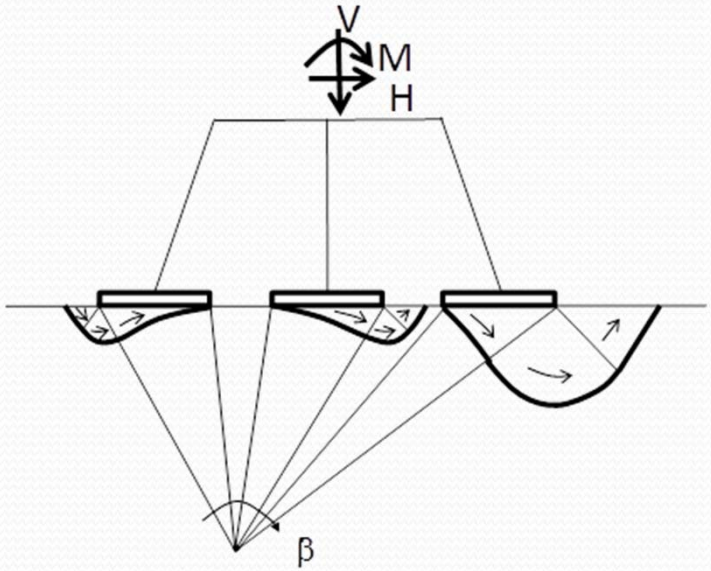


Brinch Hansen Mechanism

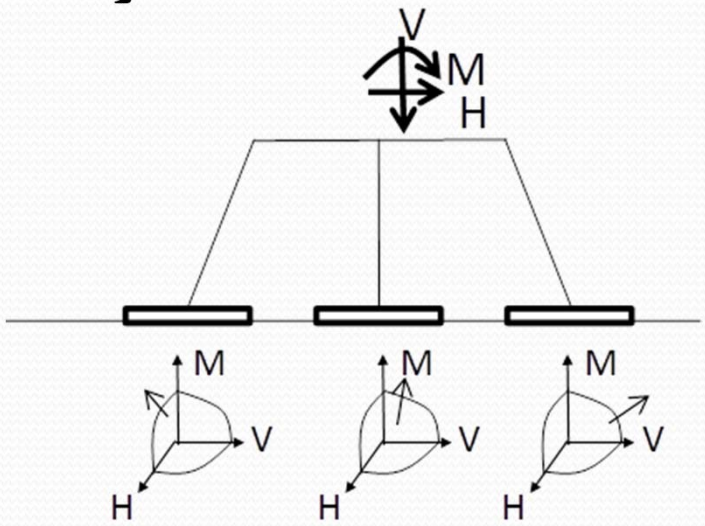


Scoop Mechanism
Randolph, et al

Alternative Formulations for Shallow Foundation System



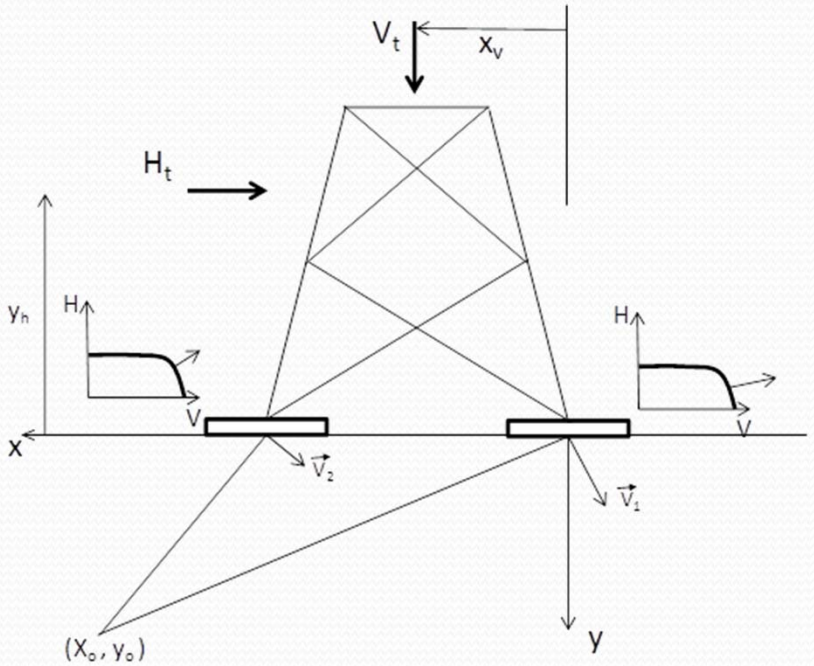
Detailed or Explicit Mechanism



Macro or Implicit Mechanism

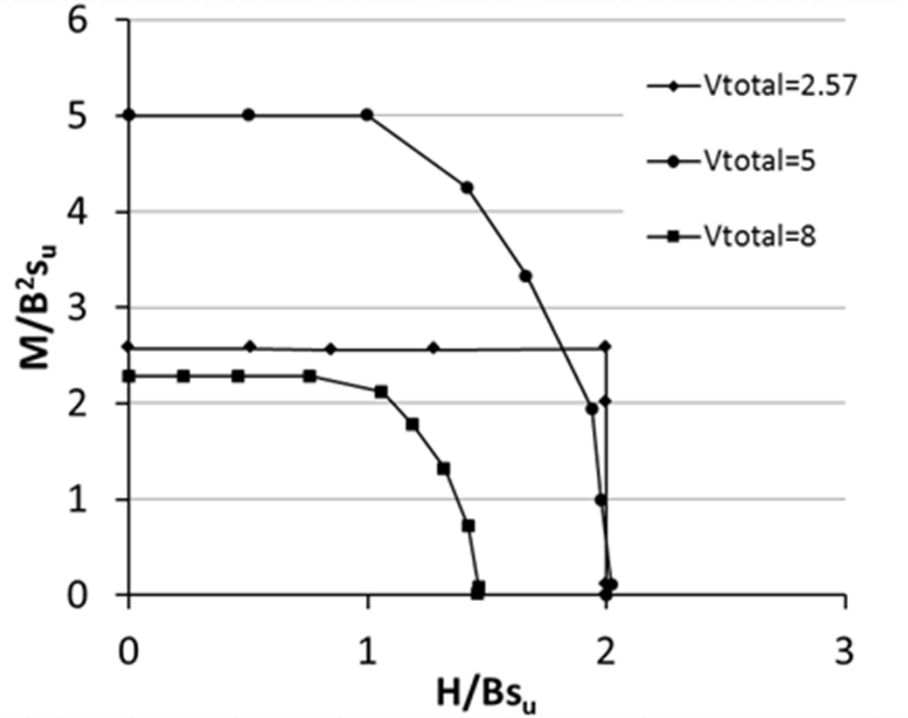
Step By Step Procedure for Macro PLA Planar Model (V&H) of System

1. Virtual rotation about X_o , Y_o
2. Find footing velocities v & h
3. Use normality to form ratios of velocities e.g v/h
4. Equate these to ratios from mechanism => 2 equations
5. Interaction surface => 3rd equation
6. Solve for V & H
7. Dissipation rate= Vv+Hh
8. Set dissipation= external work rate
9. Solve for unknown Force
10. Optimize e.g. wrt X_o , Y_o

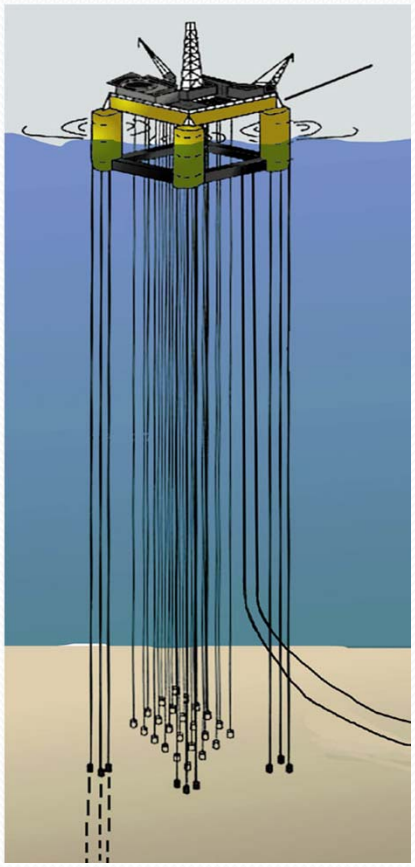


Macro Solutions of Two-Footing System

With Varying Vertical Load



Pile Foundations



AN ASIDE

These piles will have to be driven with considerable batter.

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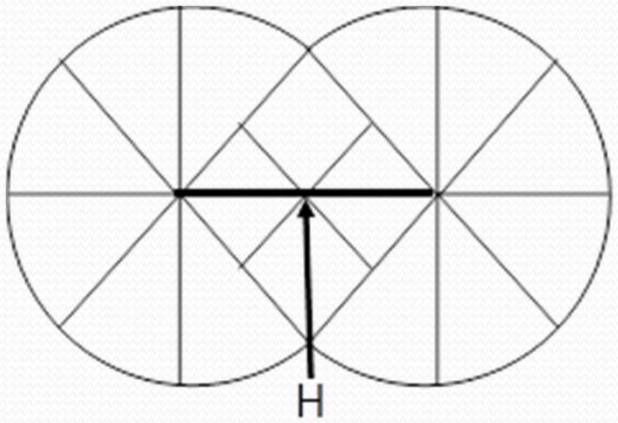
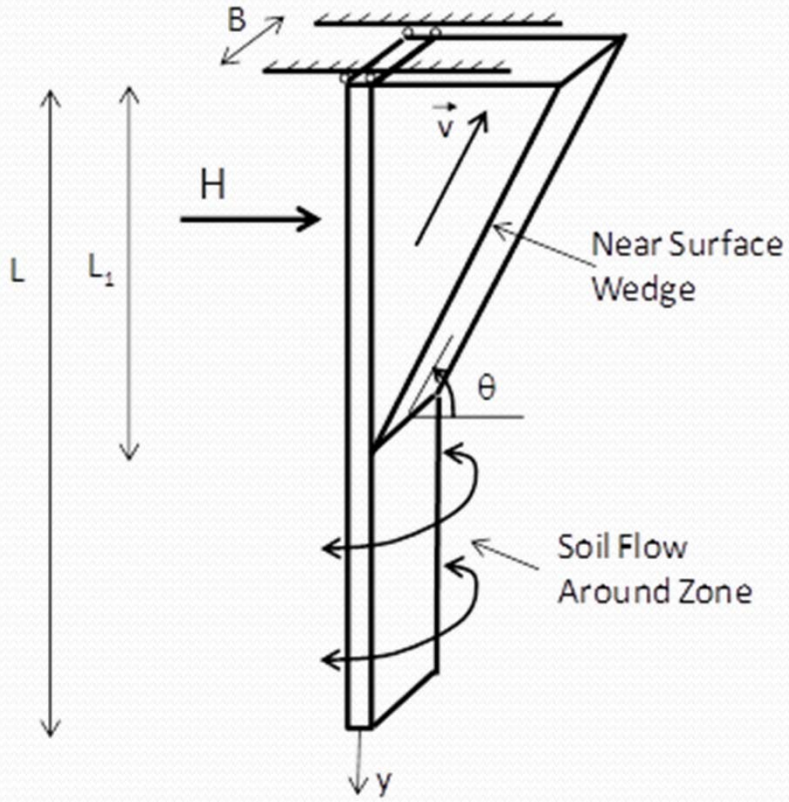
Pile Foundations – Lateral Capacity

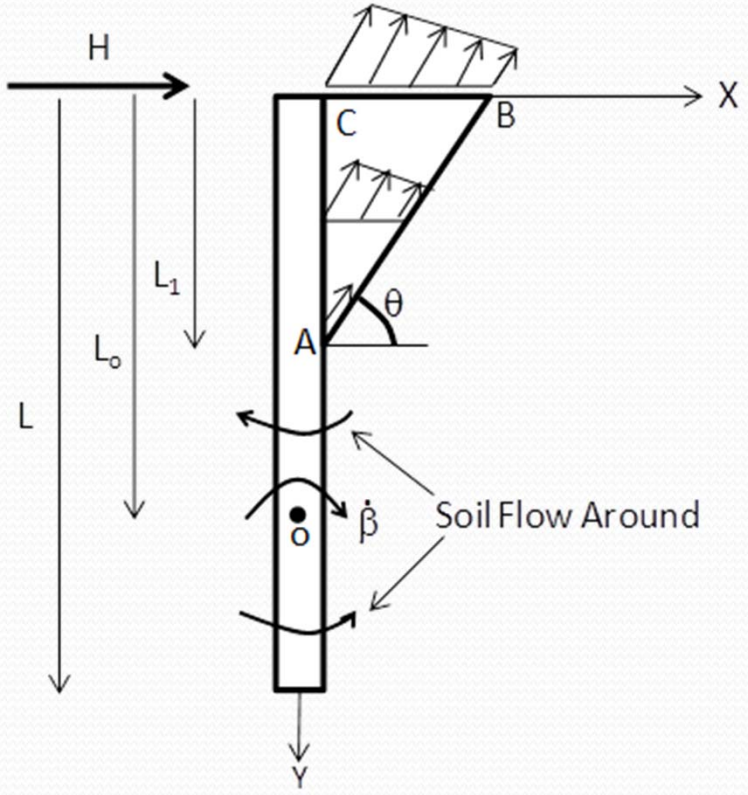


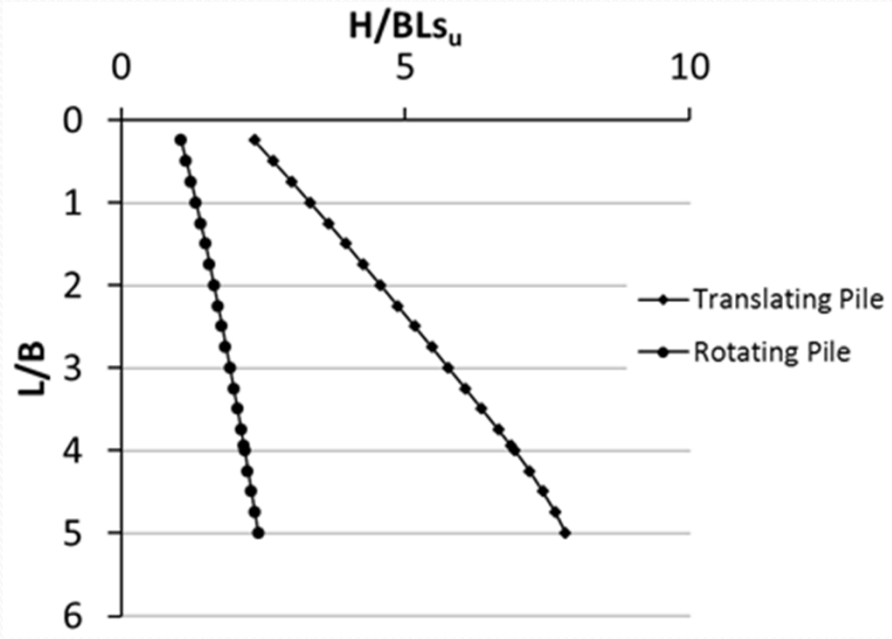
Deep flow-around of a flat plate
H= 11.42 SuB



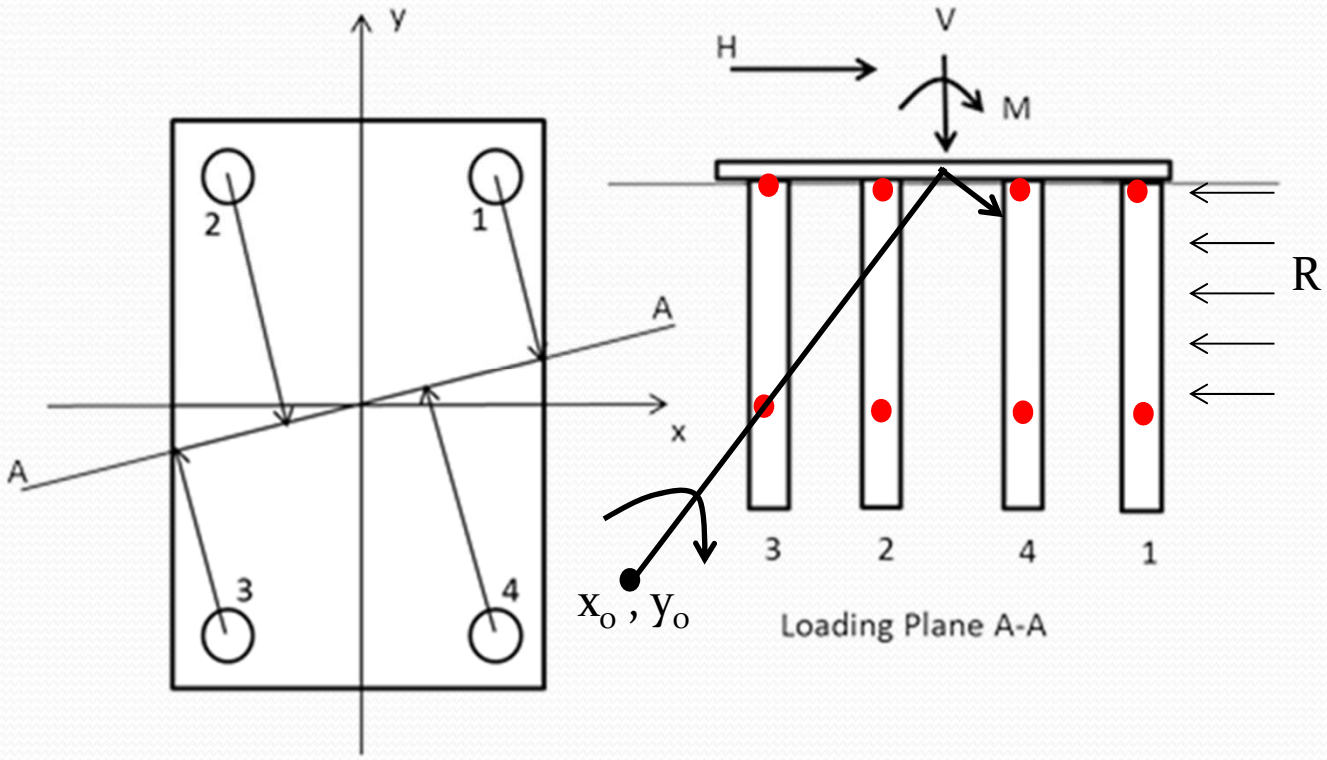
Lateral Mechanism for
Translation

Pile Foundations – Detailed Rotation Mechanism for Rigid Pile

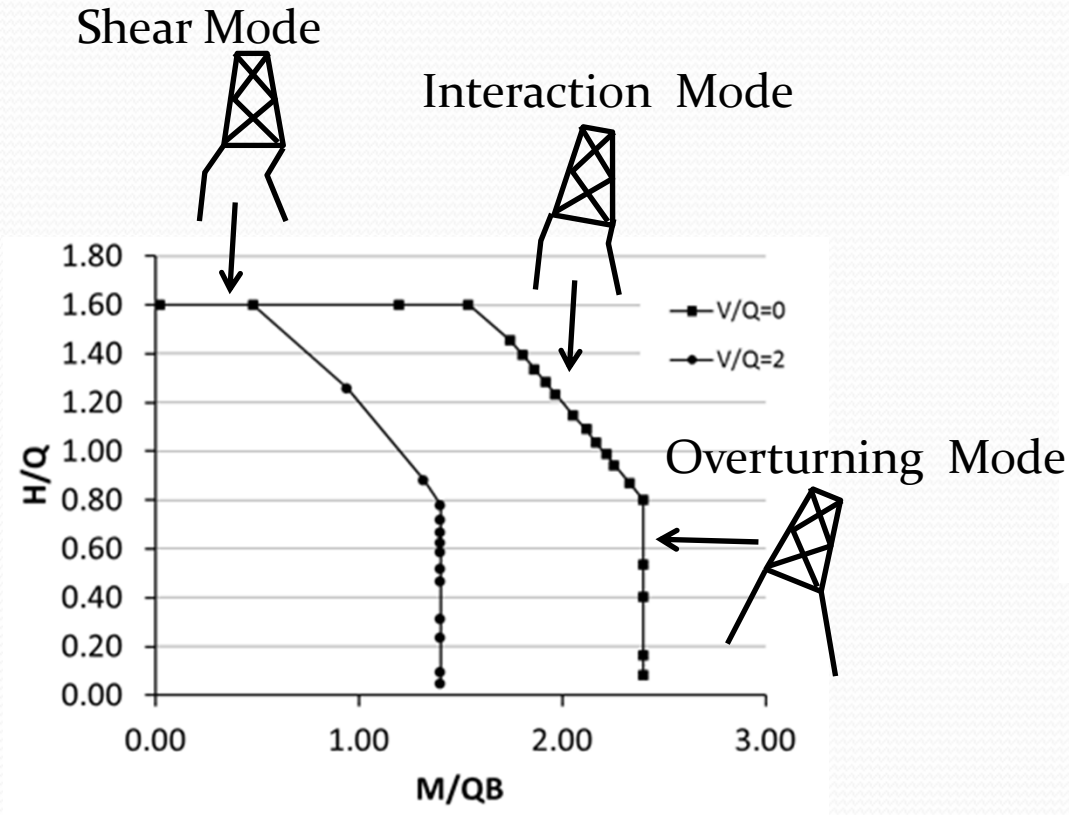




Pile Foundations – Analysis of a Four Pile Group



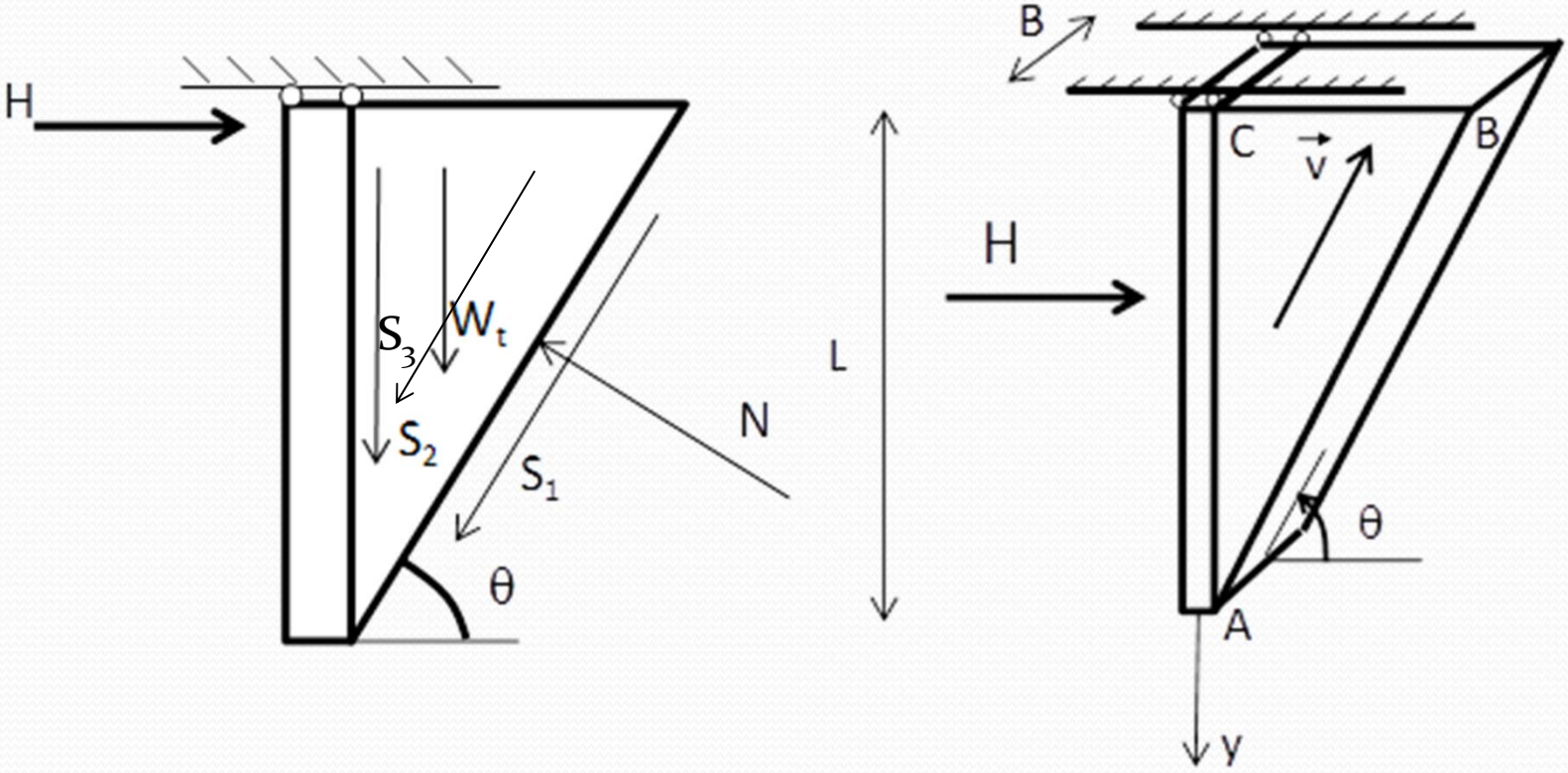
Typical Results--Moment vs. Lateral Load Interaction Diagram for a Four Pile Group



Parameter	Value
V/Q	0 and 2
M/QB	0.10
RB/Q	0.40

Upper Bound vs. Limit Equilibrium Concepts

Comparison of Upper Bound vs Limit Equilibrium Analysis



Closing Comments

Acknowledgements