Evaluation of Stabilised Red Sand for use as a Highway Embankment Material

By
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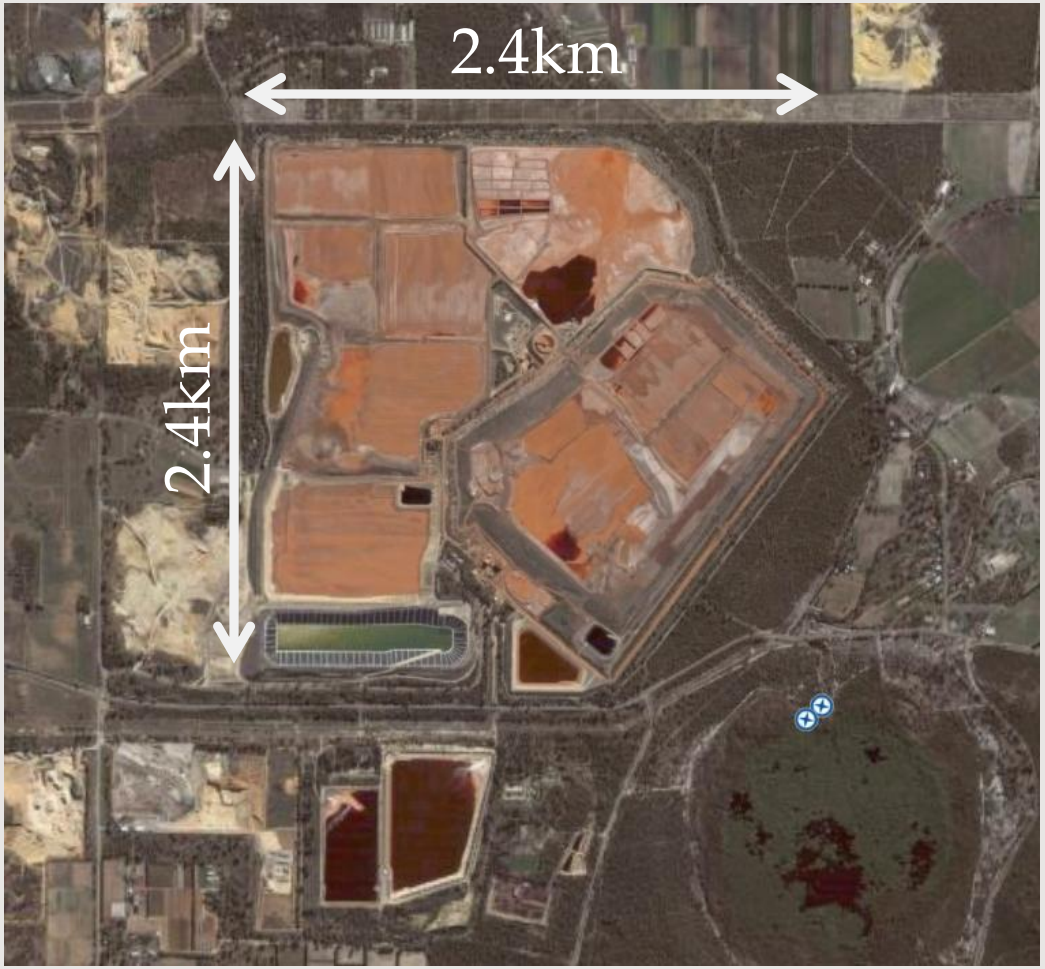
Presentation Overview

1. **Problem Statement**
2. **Aim of the study**
3. **Laboratory Results**
   a) **Optimisation Program**
   b) **Evaluation of Engineering Properties Program**
4. **Theoretical Analysis**
5. **Conclusions**

1. Problem Statement

Bauxite Residue Stockpiles



1. Problem Statement

Current Issues

- Environmental issues
  - Storage of highly caustic materials
  - Potential leaching of residue into the groundwater system
- Economic issues
  - High cost of managing and maintaining stockpiles
  - Purchase of additional land for new stockpiles
- Sustainability issues
  - Stockpiled red sand has no long term use

1. Problem Statement

A Possible Solution

Stockpiled Residual Red Sand

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Washed Carbonated Red Sand **(WCRS)**

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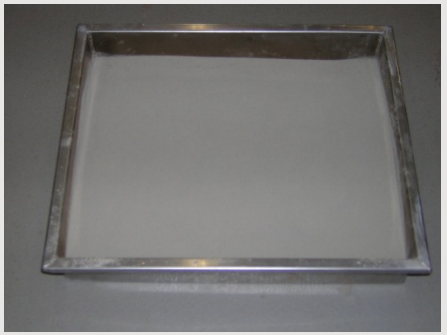
Stabilise and use as an highway embankment fill

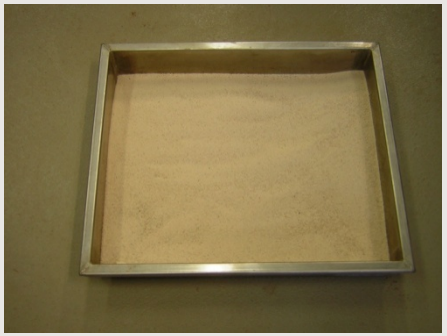
1. Problem Statement

Definitions

- Lime Stabilisation
  - Pozzolanic Reaction which produces a cementitious product
  - Strengthens soil considerably
- Combination of:
  - Red Lime
    - Residual lime from Bayer Process
  - Fly Ash
    - Finest Fraction of coal ash from coal power plants



Fly Ash

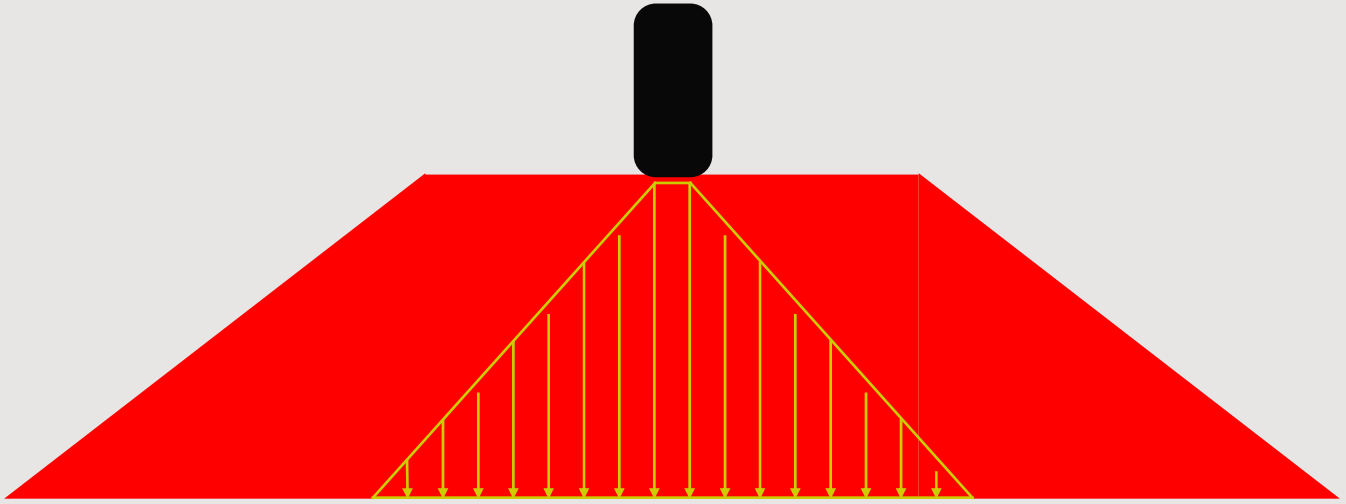


Red Lime

1. Problem Statement

Definitions

- Embankments
  - Maintain Road & Rail Level
  - Reduces load intensity on sub-grade



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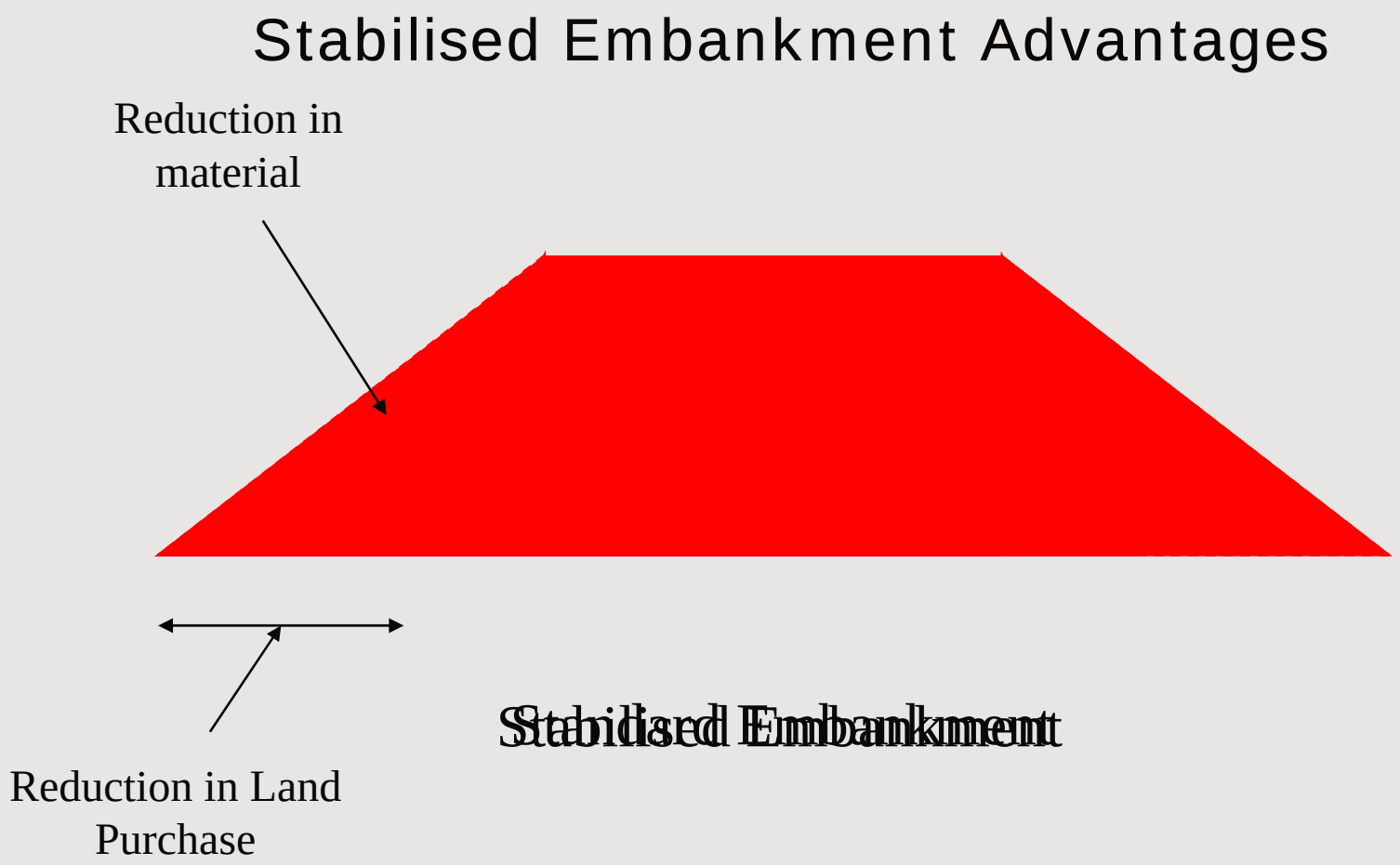
Definitions



2. Aim of the Study

Investigate the potential use of washed & carbonated red sand as a highway embankment material

- ❑Optimisation Program
  - •Determines the optimum mix ratio
- ❑Evaluation of Engineering Properties Program
  - •Determines engineering characteristics embankment materials need to possess
    - •Gradation, specific gravity, moisture-density characteristics, shear strength, compressibility, collapsibility and permeability
- ❑Theoretical Analysis
  - •Determines stable embankment geometries based on laboratory results

3. Optimisation Program

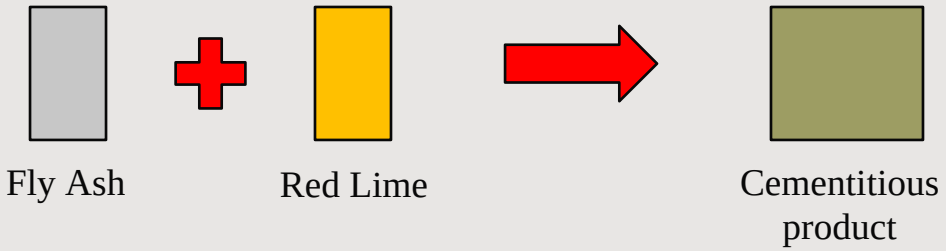
Purpose:
To determine the optimum mix ratio of washed and carbonated red sand, red lime and fly ash

3. Optimisation Program

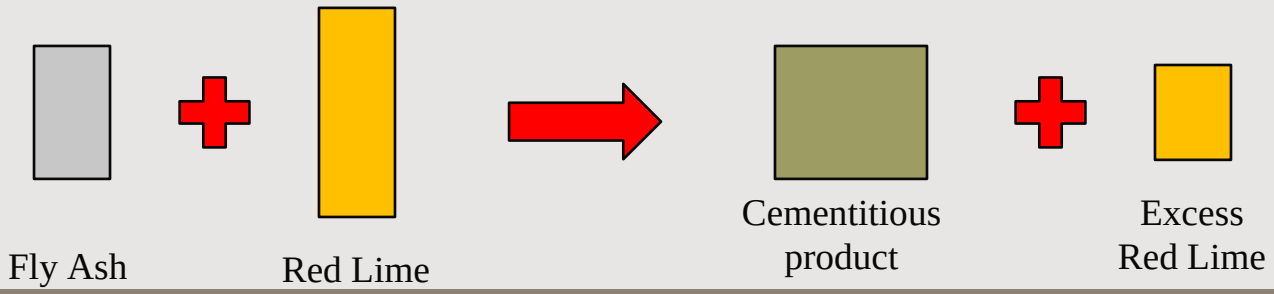
Governing Ratios

Ratio of Fly Ash to Red Lime

Optimum Ratio: Complete reaction



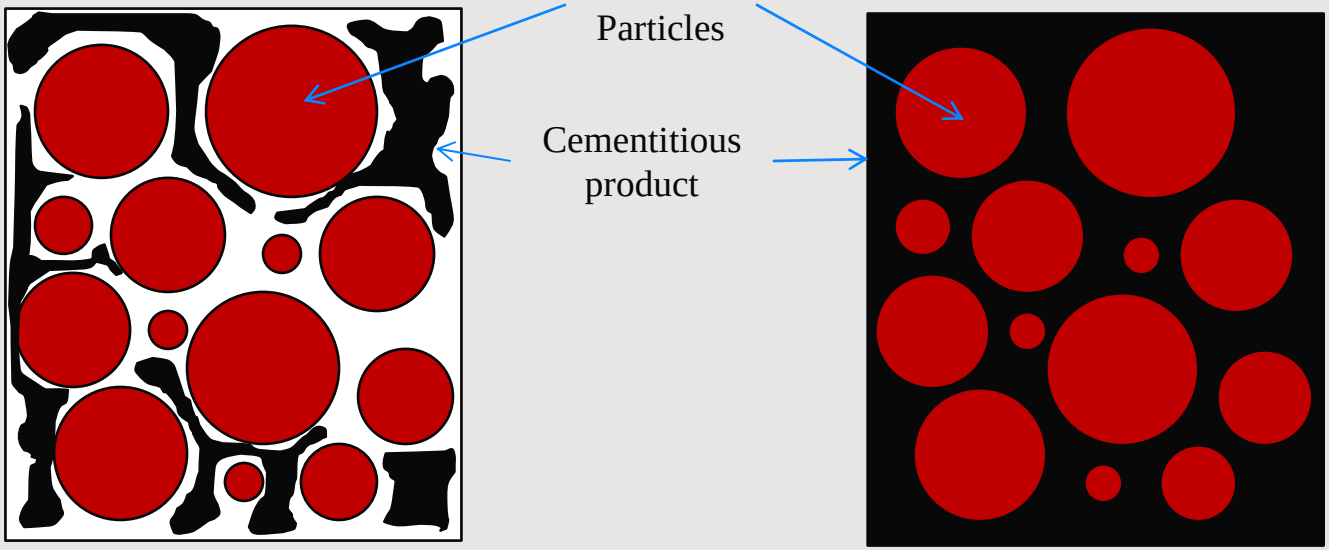
Non Optimum Ratio: Incomplete reaction



3. Optimisation Program

Governing Ratios

Ratio of WCRS to Red Lime and Fly ash



Non Optimum Ratio

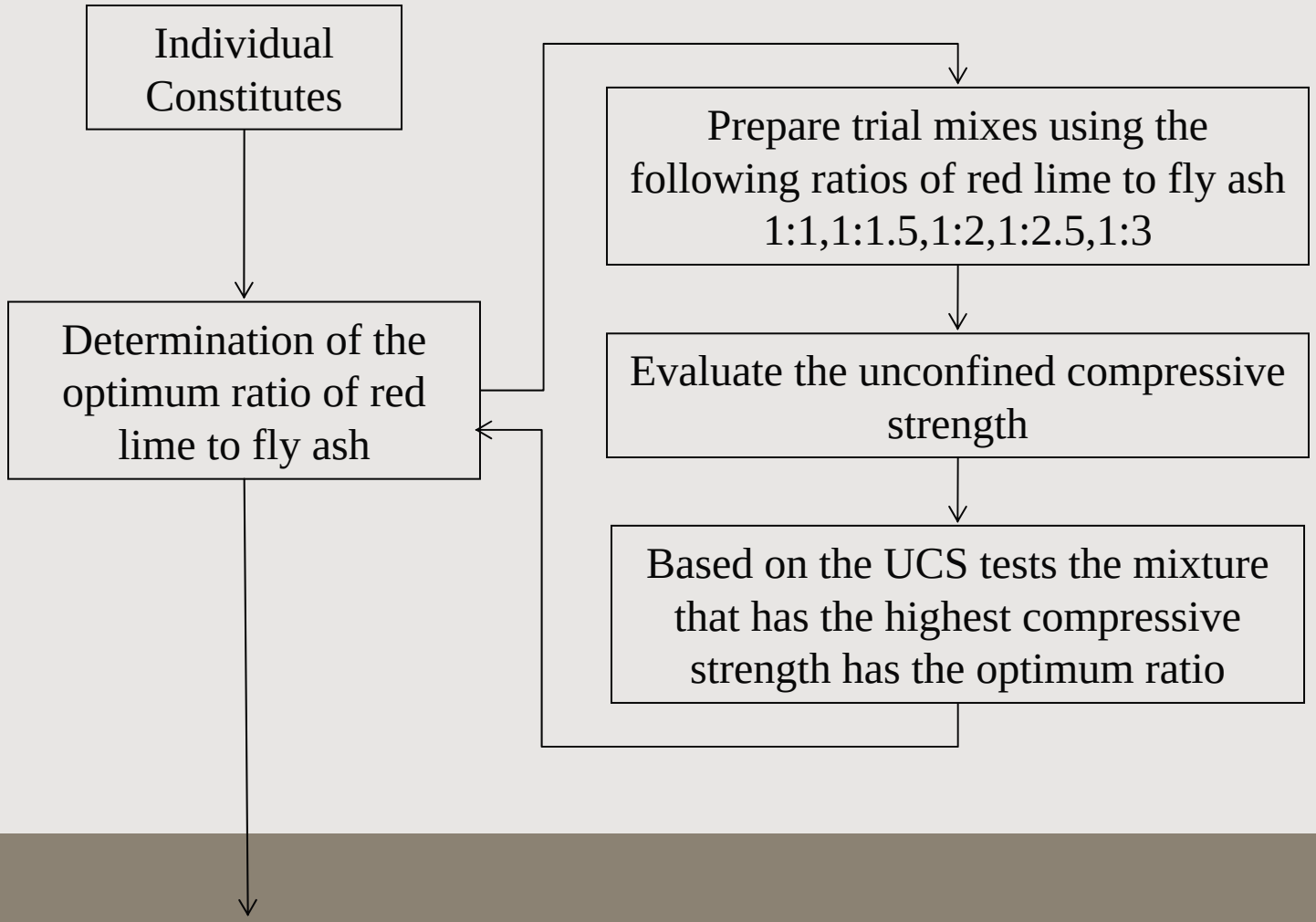
Partial filling of voids with cementitious product

Optimum Ratio

Almost complete filling of voids with cementitious product

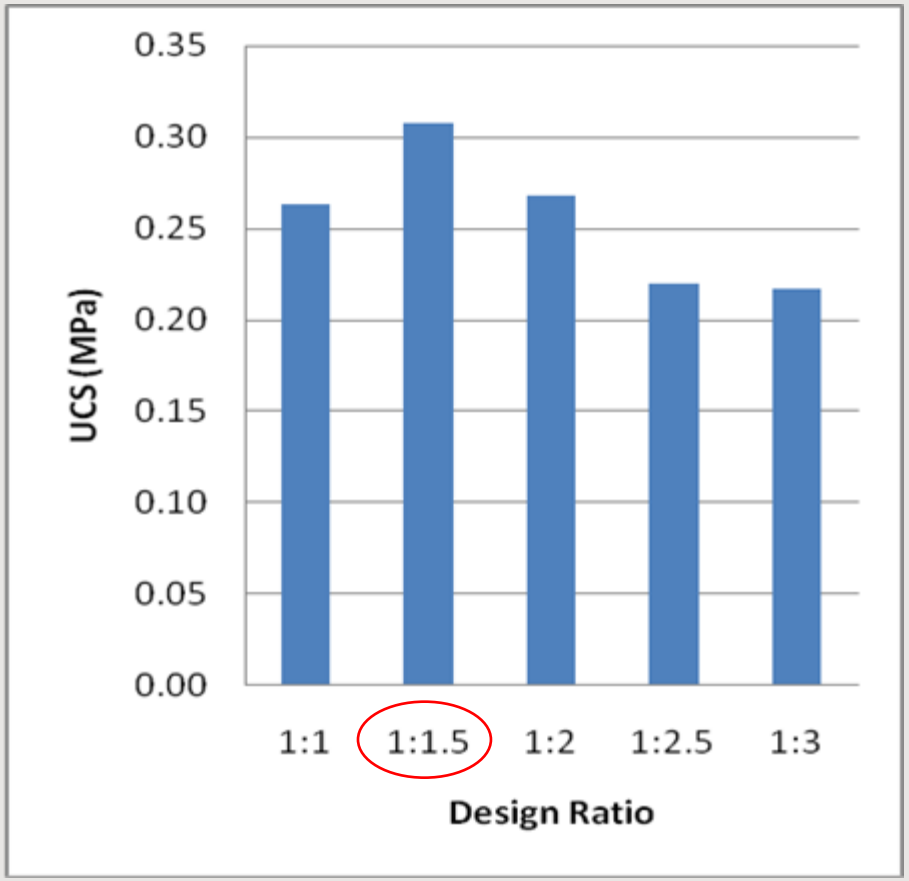
3. Optimisation Program

Experimental Program



3. Optimisation Program

Experimental Program



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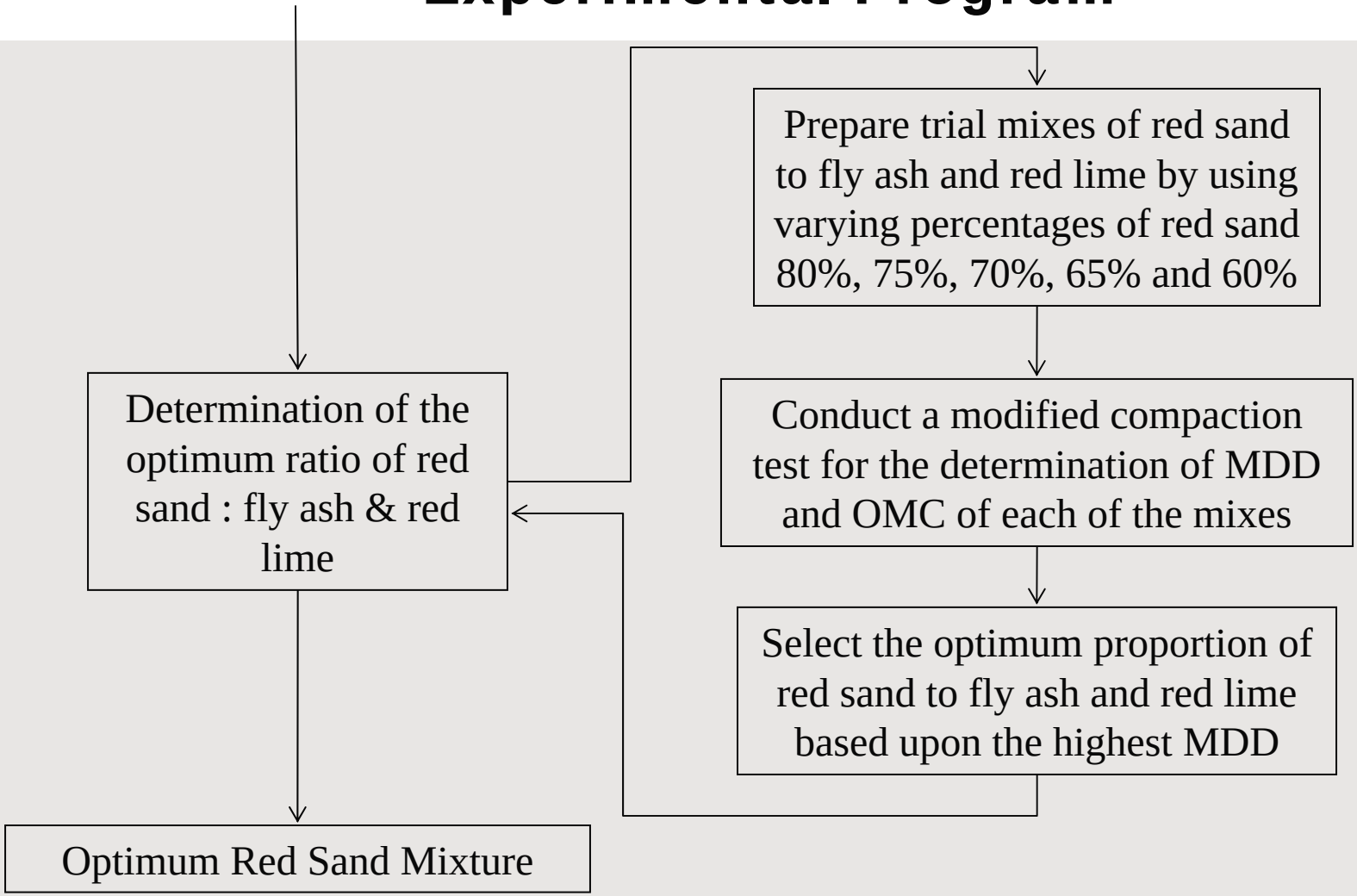
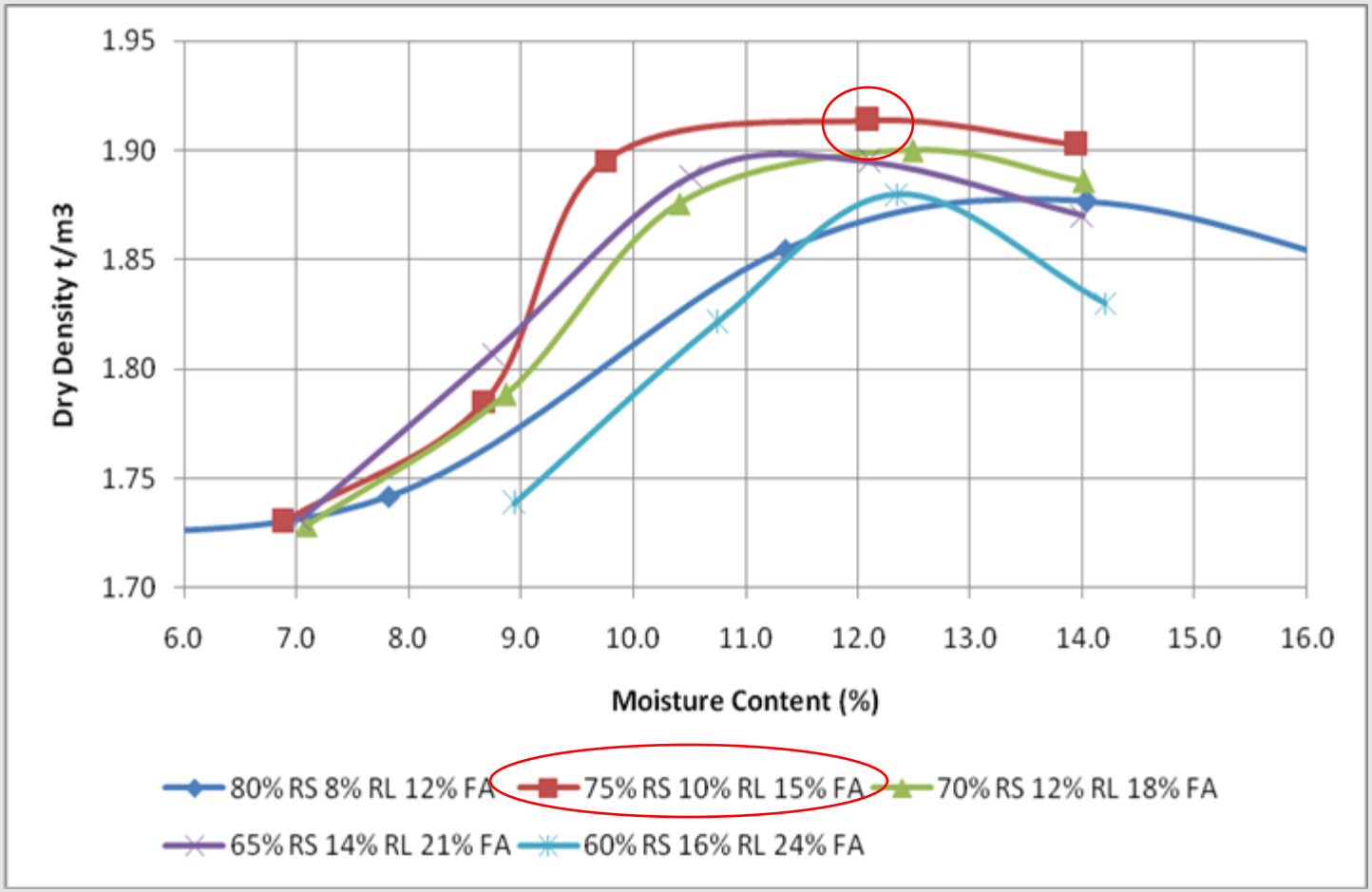
Experimental Program



3. Optimisation Program

Experimental Program



3. Optimisation Program

Summary

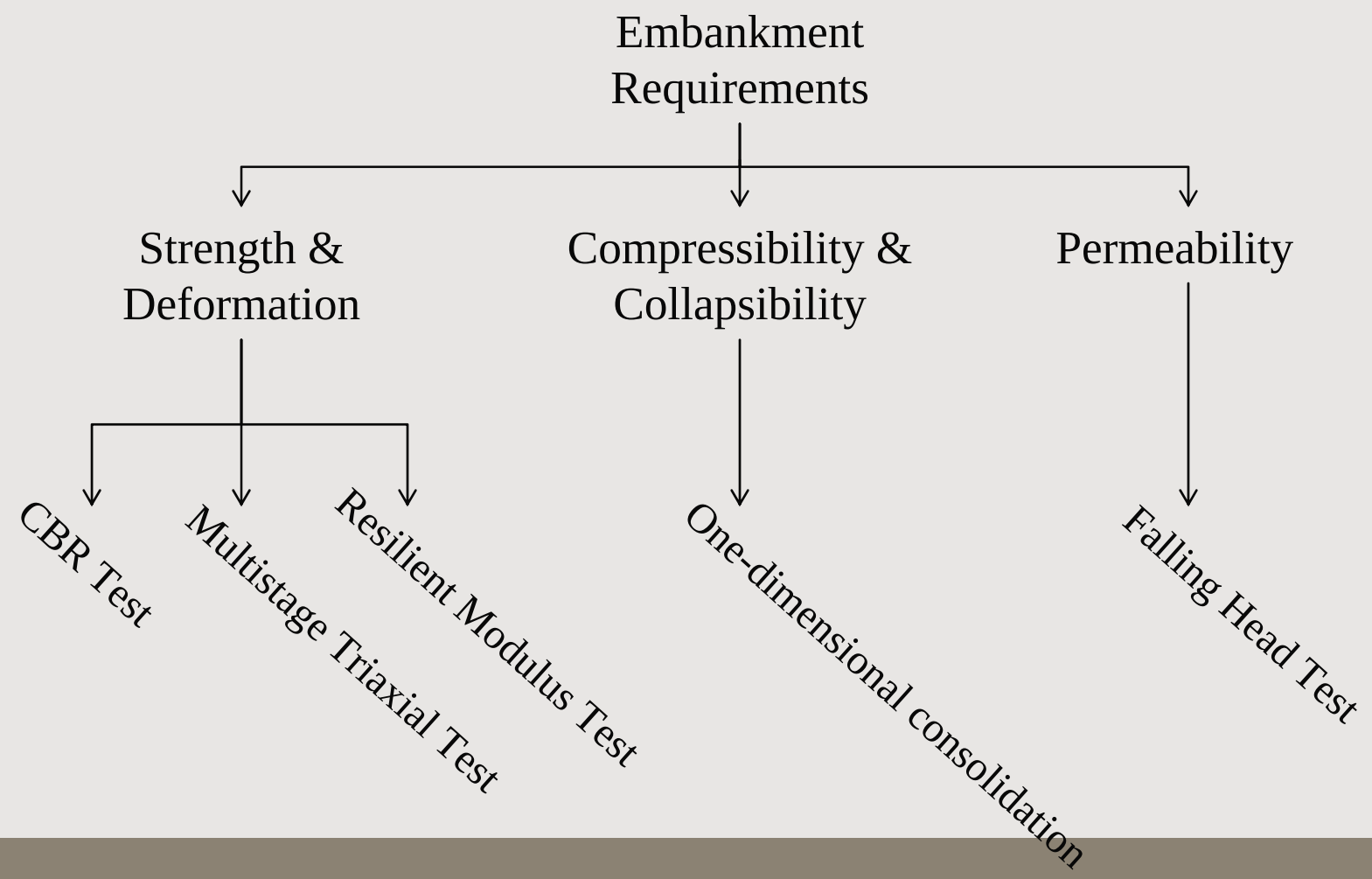
- Optimum stabilised red sand mixture (by dry weight) was
  - 75% Washed and Carbonated Red Sand
  - 15% Fly Ash
  - 10% Red Lime

4. Evaluation of Engineering Properties Program

Purpose:
To experimentally determine the engineering properties of the optimum stabilised red sand mixture required for embankment construction

4. Evaluation of Engineering Properties

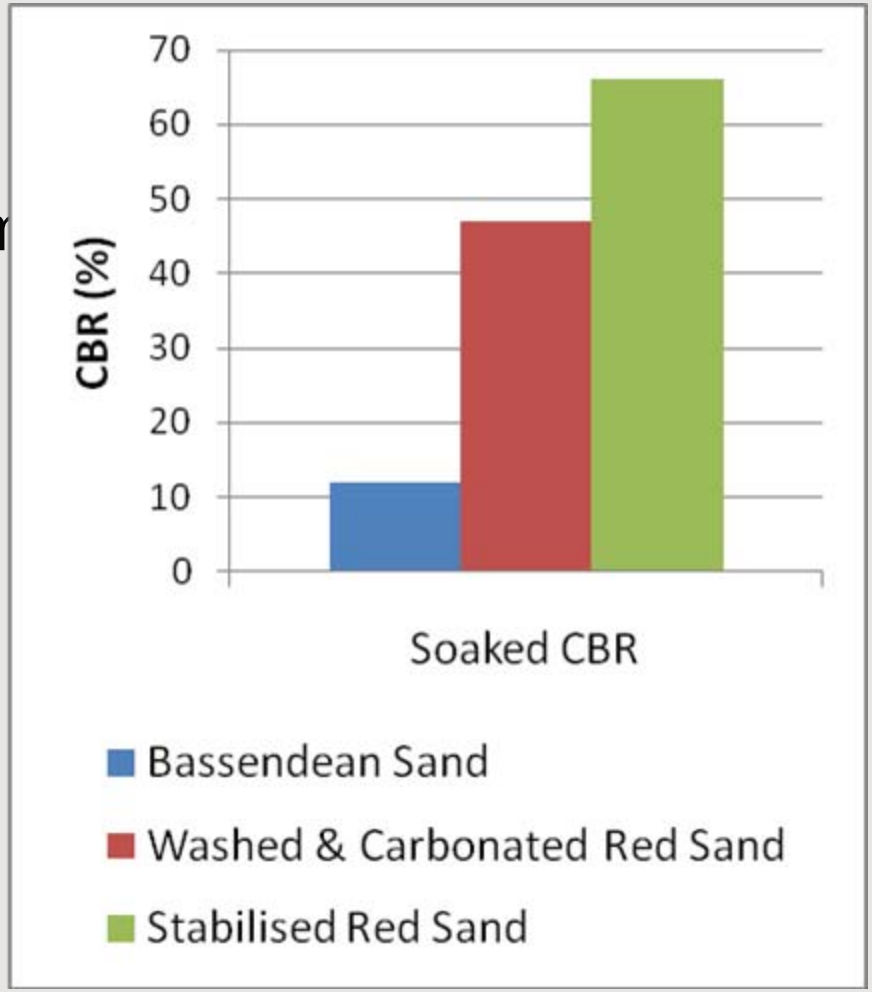
Embankment Requirements



4. Evaluation of Engineering Properties

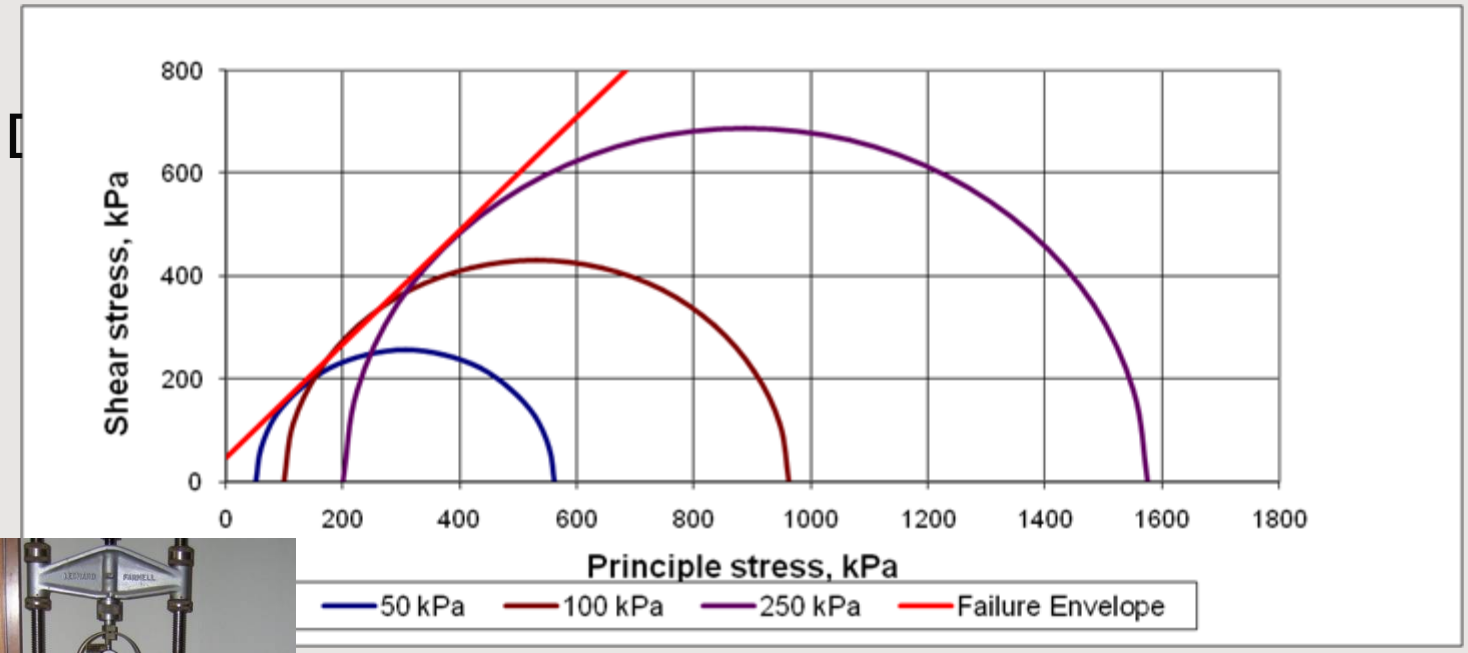
Strength & Deformation Requirements

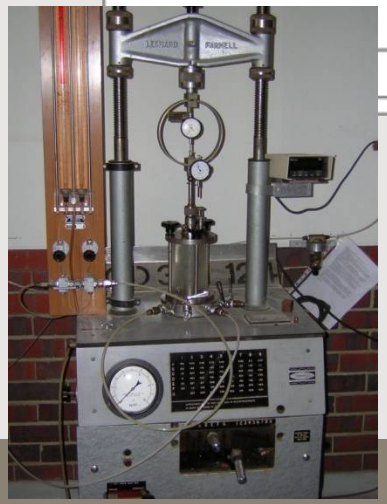
Determ soil



4. Evaluation of Engineering Properties

Strength & Deformation Requirements





$\phi_d = 47.5^O$

$c_d = 48$ kPa

4. Evaluation of Engineering Properties

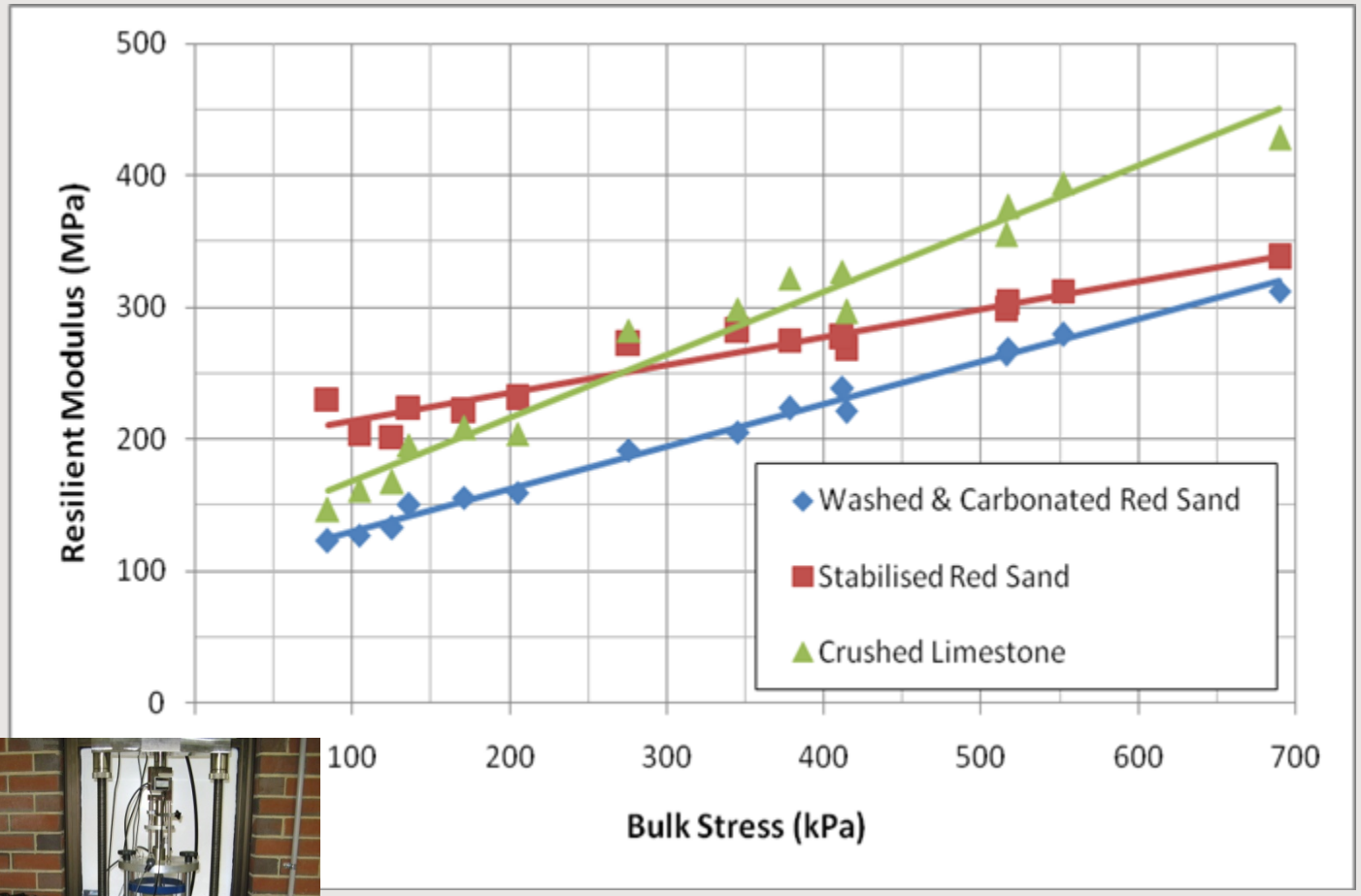
Strength & Deformation Requirements

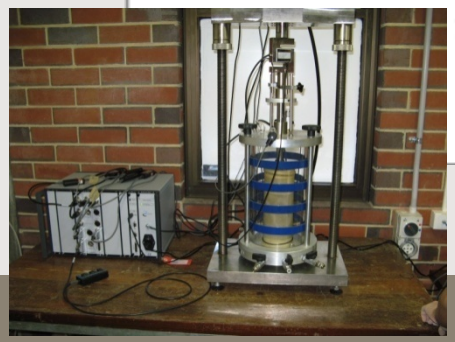
- Resilient Modulus
  - A measure of a soils resistance to cyclic loading
  - A high resilient modulus prevents excessive deformations from damaging overlying pavement layers

A example of a poor quality pavement material with a low resilient modulus

4. Evaluation of Engineering Properties

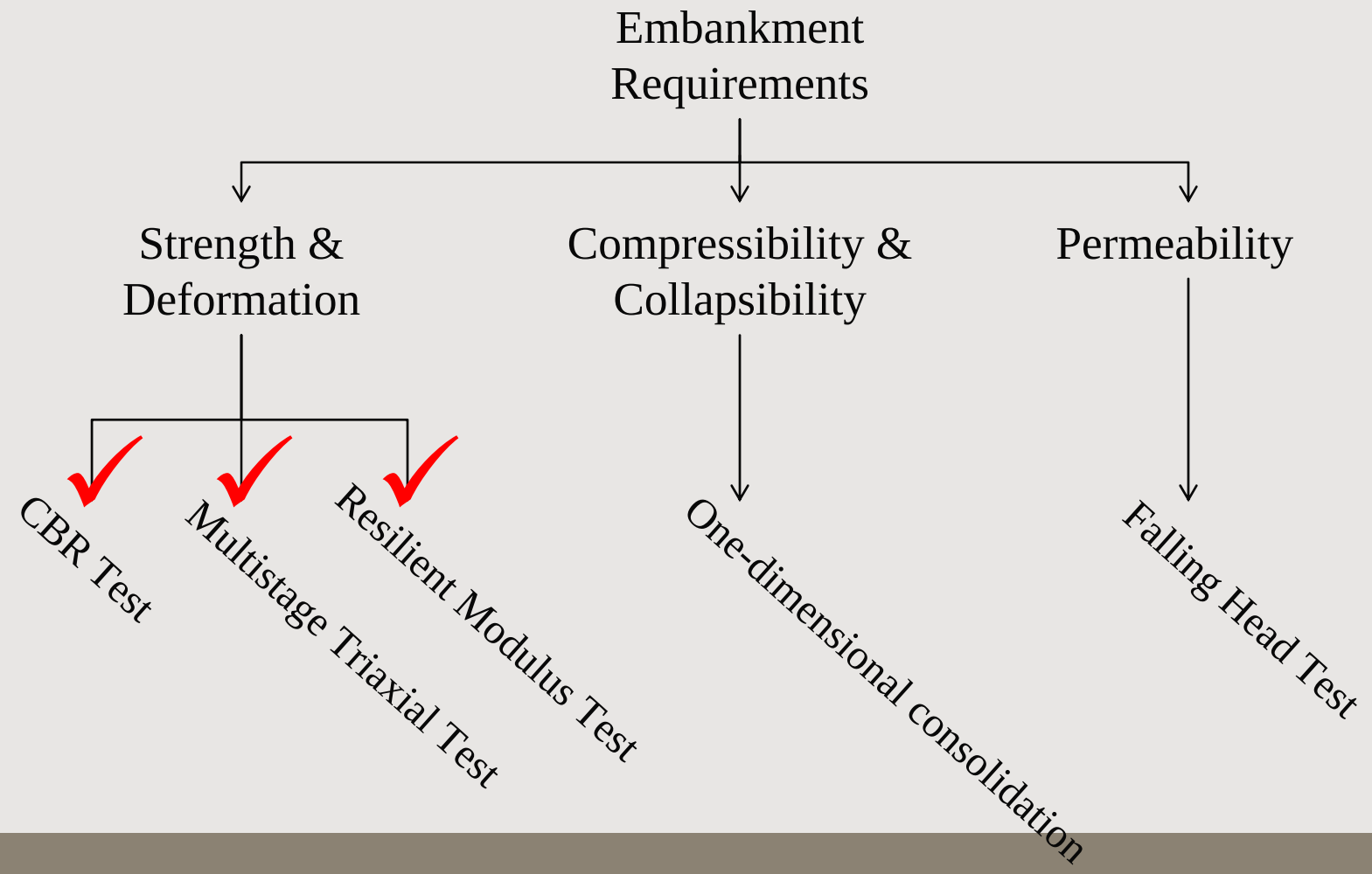
Deformation Requirements





4. Evaluation of Engineering Properties

Embankment Requirements



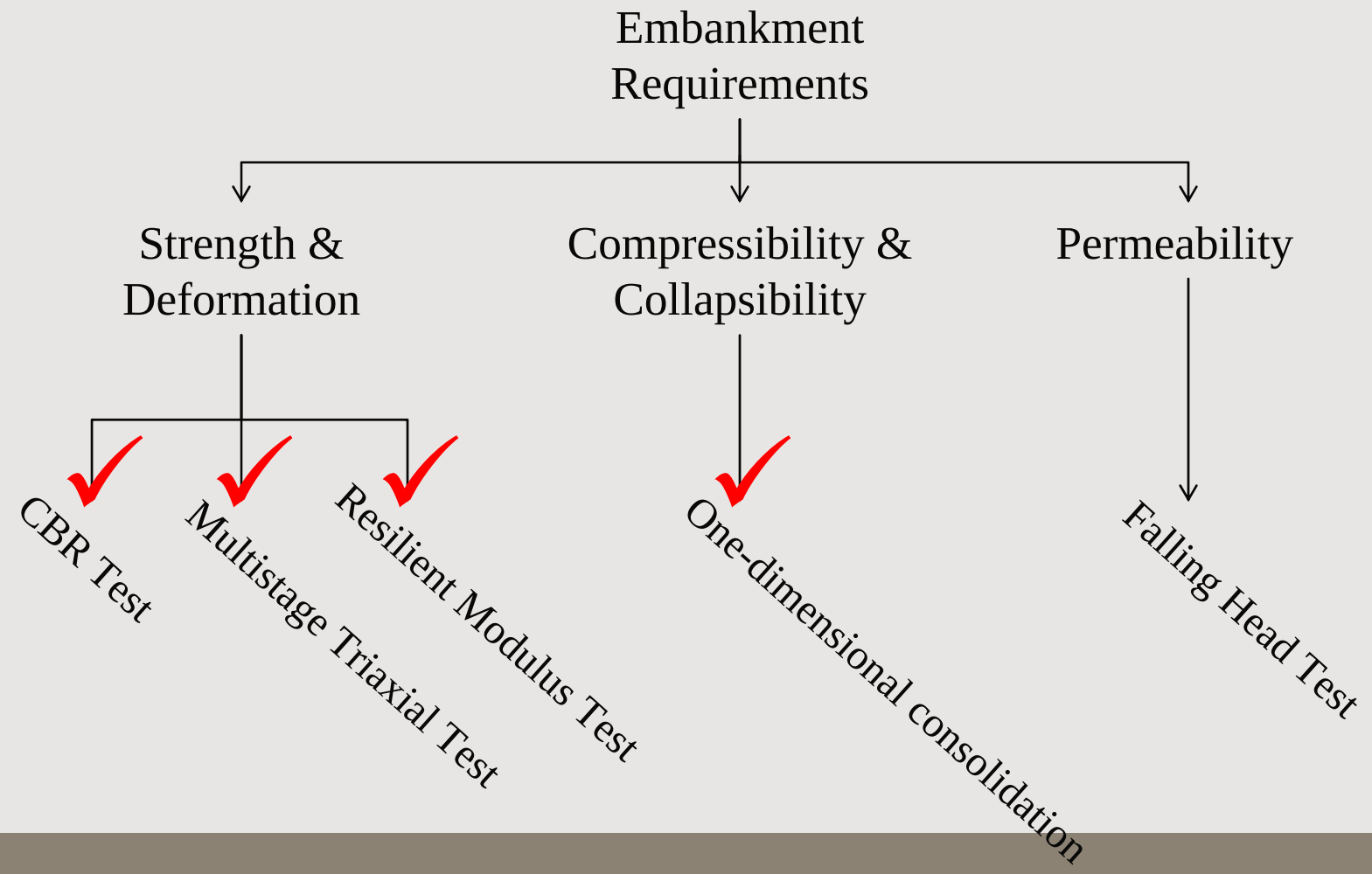
4. Evaluation of Engineering Properties

Compressibility & Collapsibility

- Compressibility
  - Consolidation characteristics of a material under long-term loading conditions.
  - Stabilised red sand exhibited ‘immediate’ settlement
- Collapsibility
  - The potential to decrease in volume when induced by water permeation
  - Testing indicated red sand had a collapse potential of 0.2% (Slight)

4. Evaluation of Engineering Properties

Embankment Requirements



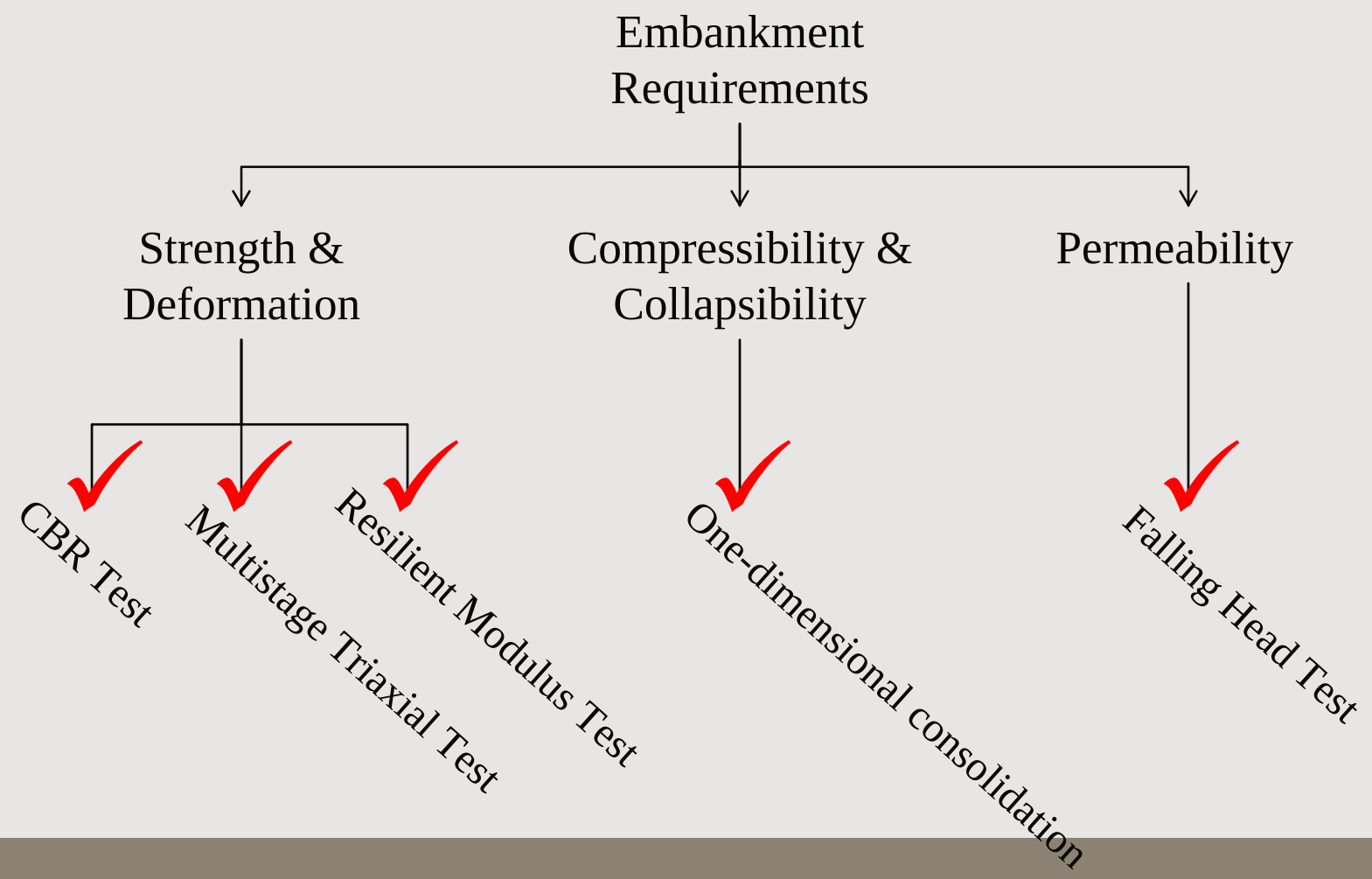
4. Evaluation of Engineering Properties

Permeability Requirements

- Embankments should be free draining to prevent excessive moisture from building up
- Stabilised red sand has a very low permeability 5.5×10^{-8} m/s which presents a potential problem
- This can be countered by good design by the utilisation of subsurface drains

4. Evaluation of Engineering Properties

Embankment Requirements



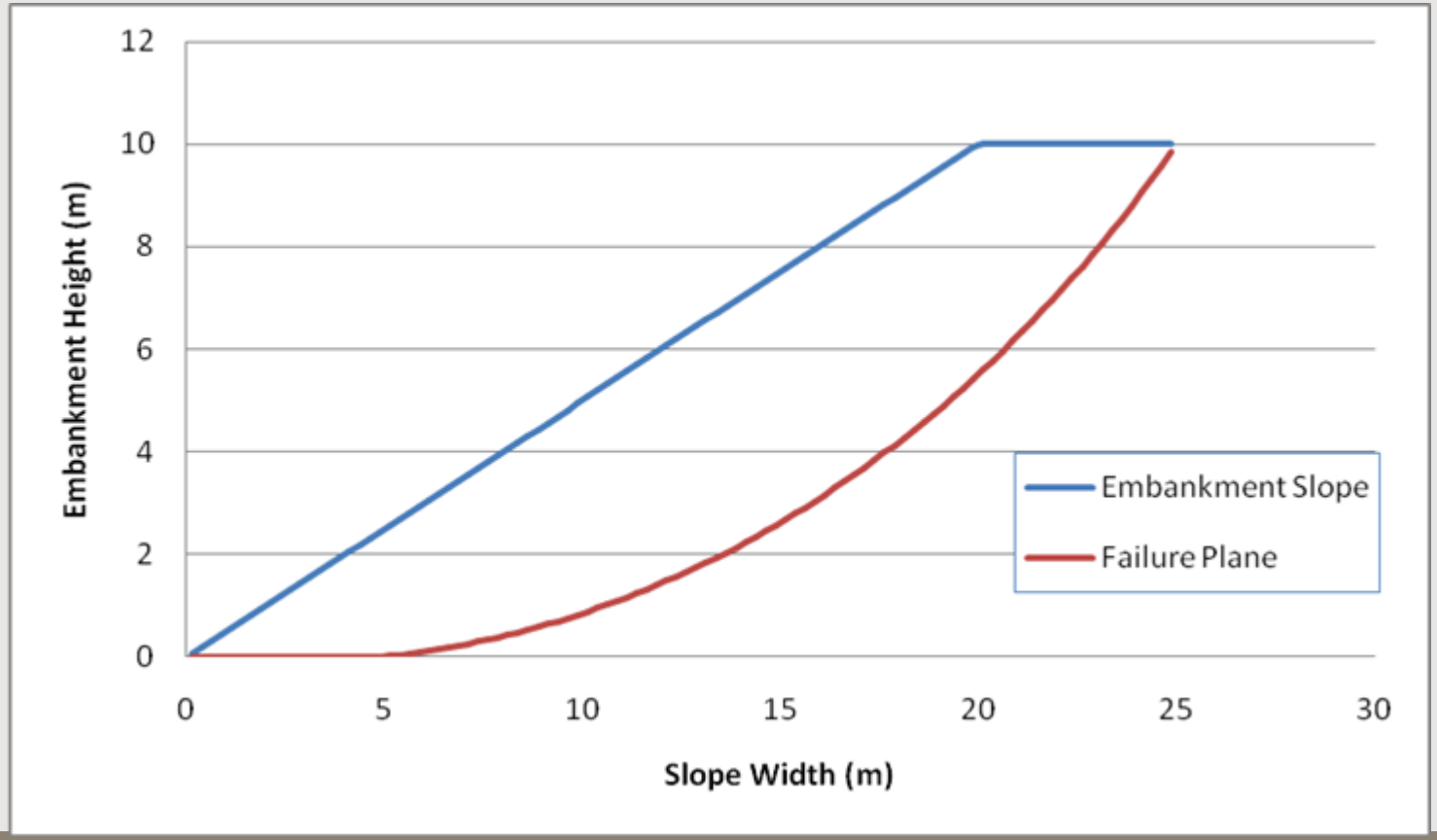
5. Theoretical Analysis

Purpose:
To conduct a simple slope stability analysis to investigate the stability of WCRS and stabilised WCRS embankments in order to determine stable embankment geometries based on the laboratory results.

5. Theoretical Analysis

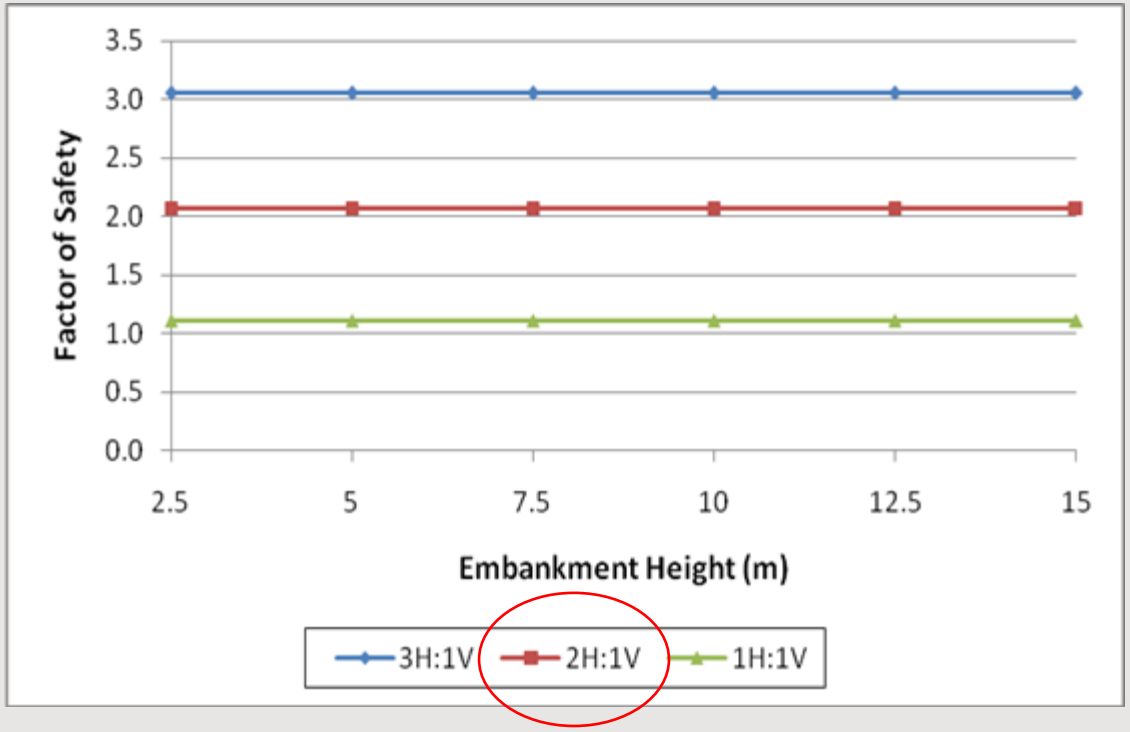
Analysis Method

Bishop's Simplified Method of Slices



5. Theoretical Analysis

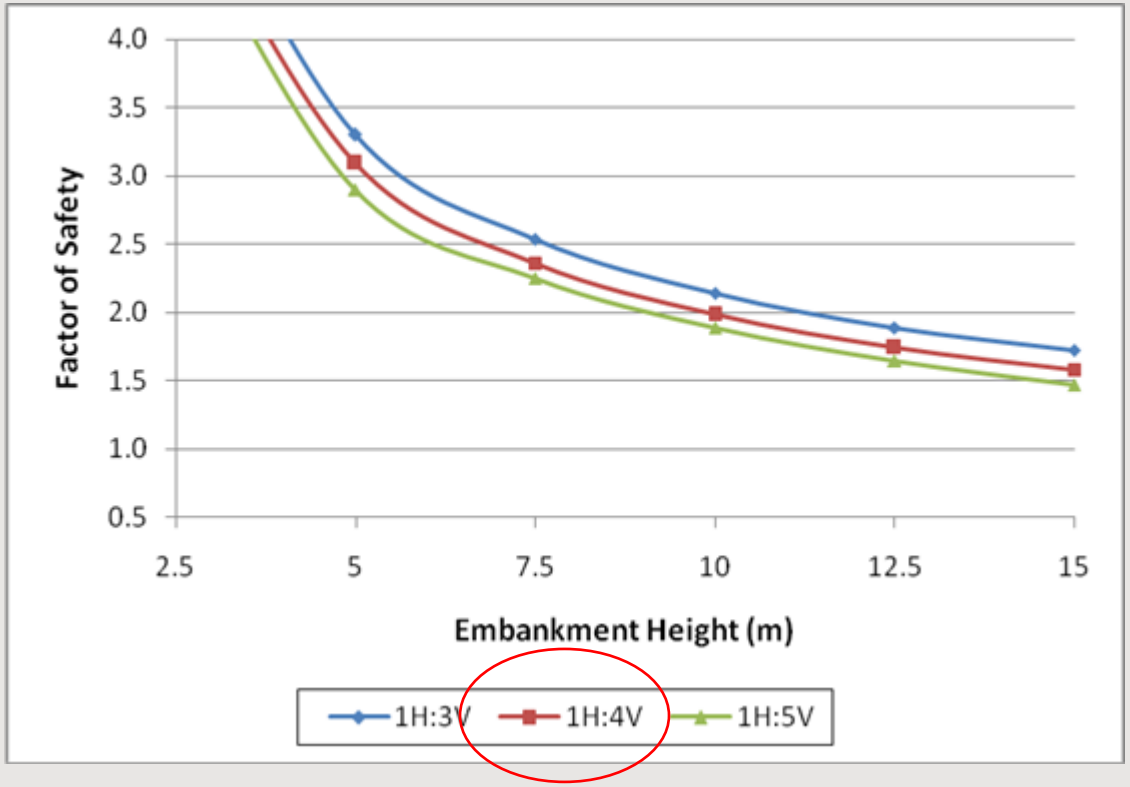
Slope Stability Results



Washed and Carbonated Red Sand

5. Theoretical Analysis

Slope Stability Results



Stabilised Red Sand

6. Conclusion

- The experimental program was a success
- There was a vast improvement in strength with the addition of fly ash and red lime
- For embankment heights less than 15m acceptable slopes were:
  - 2H:1V for WCRS
  - 1H:4V stabilised red sand

6. Conclusion

Based on the results of this study, it appears that both washed and carbonated red sand and the stabilised red sand mixtures are suitable for use in highway embankments, provided design and construction guidelines are followed.