# 1 DIMENSION CONSOLIDATION TEST

***Georgia Institute of Technology***

# Outline

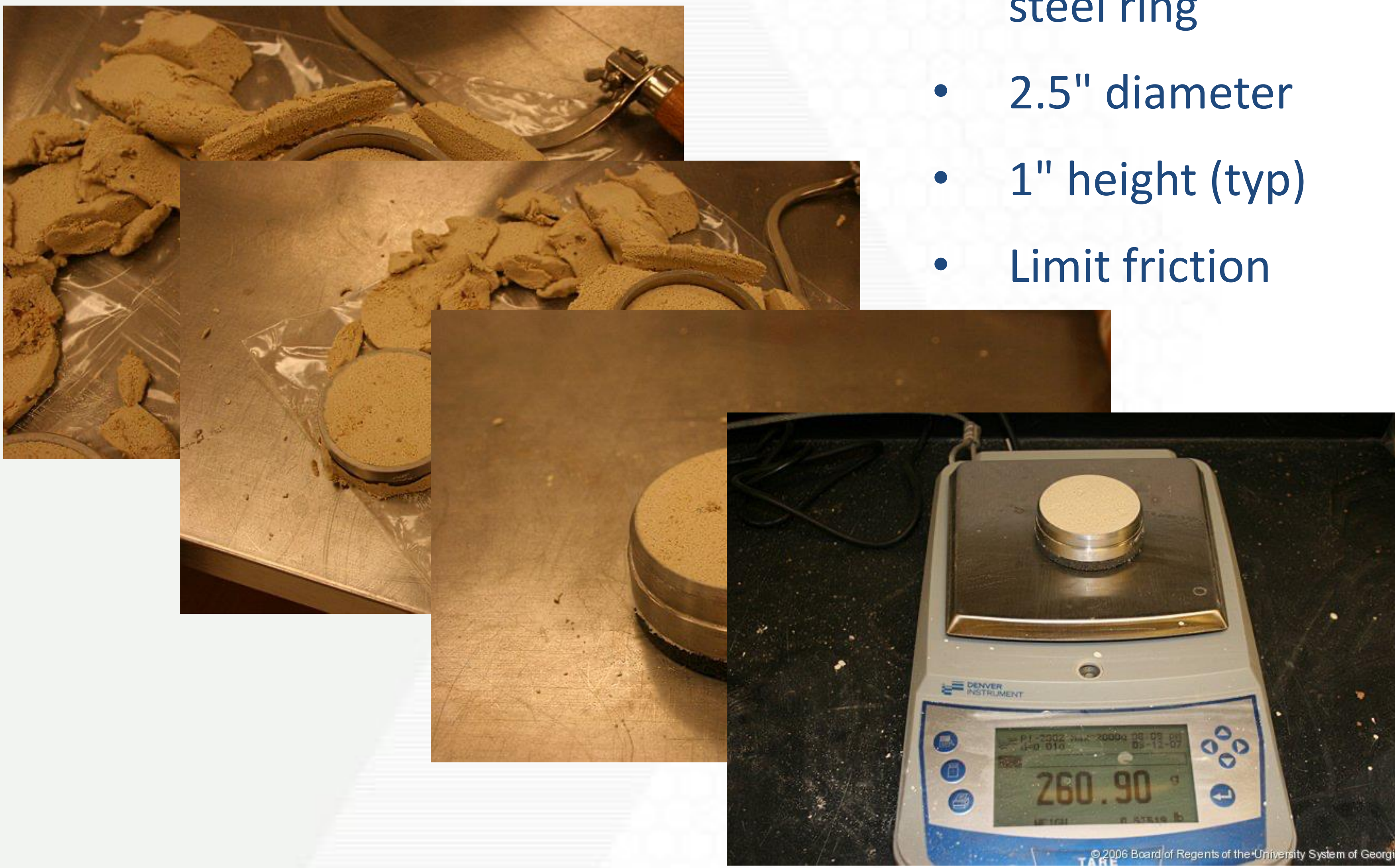
- 1D consolidation test
- Drainage
- Consolidation data
- Unload/reload
- Preconsolidation pressure
- Normally consolidated vs overconsolidated
- OCR, Cc, Cr, and modulus

# 1D Consolidation Test

- Determine amount of settlement that will result when soil deposit is loaded
- Perform small scale test to model field conditions
  - Confine soil in stainless steel ring
  - Apply vertical load
  - No lateral movement
  - All settlement is vertical
- Increase load in defined increments
- Measure settlement
- Increase load, measure settlement….
- Unload in measured increments

# Preparing sample

- Trim a soil specimen
- Place inside stainless steel ring
- 2.5" diameter
- 1" height (typ)
- Limit friction



# Preparing sample

Assumes saturated soil

# Load Frame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WYKEHAM FARRANCE ENG LTD
.0001"
0
10
20
30
40
50
60
70
80
90

# Vertical Deformation

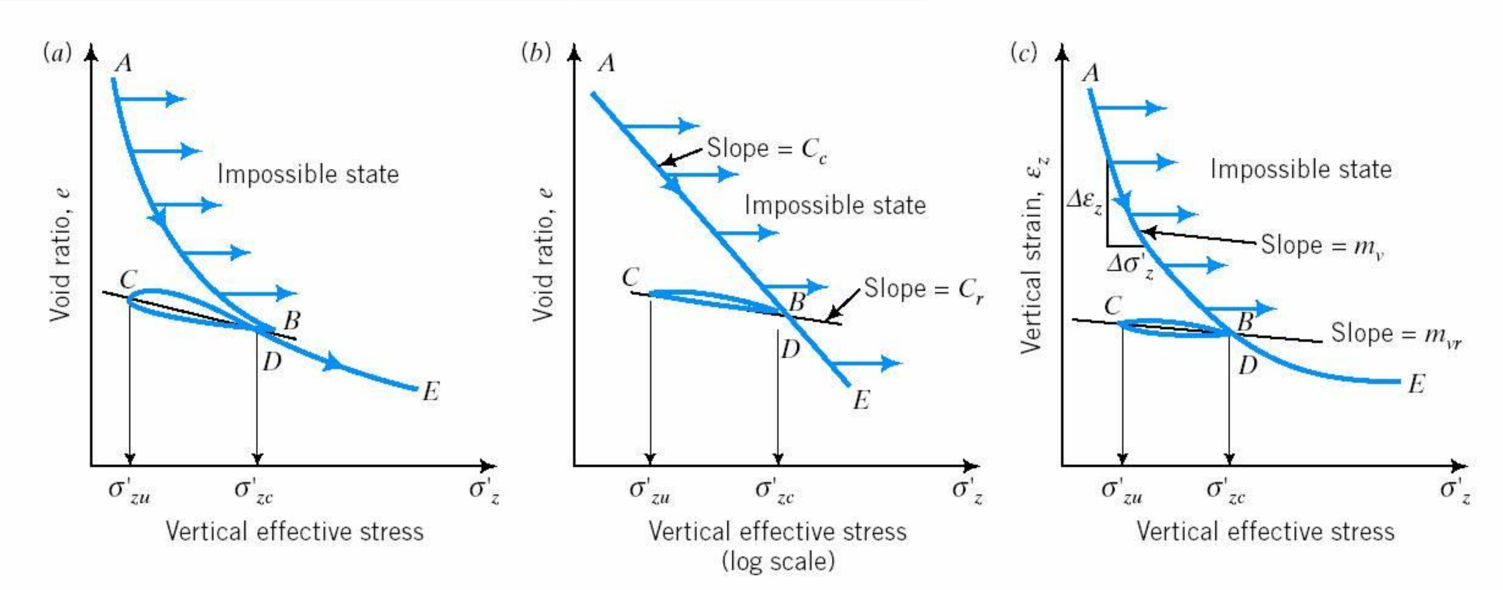
# Weight

# Test Procedure

- Apply load
- Measure rate and amount of settlement
  - Not linear
- Apply next load
  - Usually 2x previous load
- Measure rate and amount of settlement
- Continue until max desired load is reached
- Think about what happens if we drop a large load on the soil instantaneously?

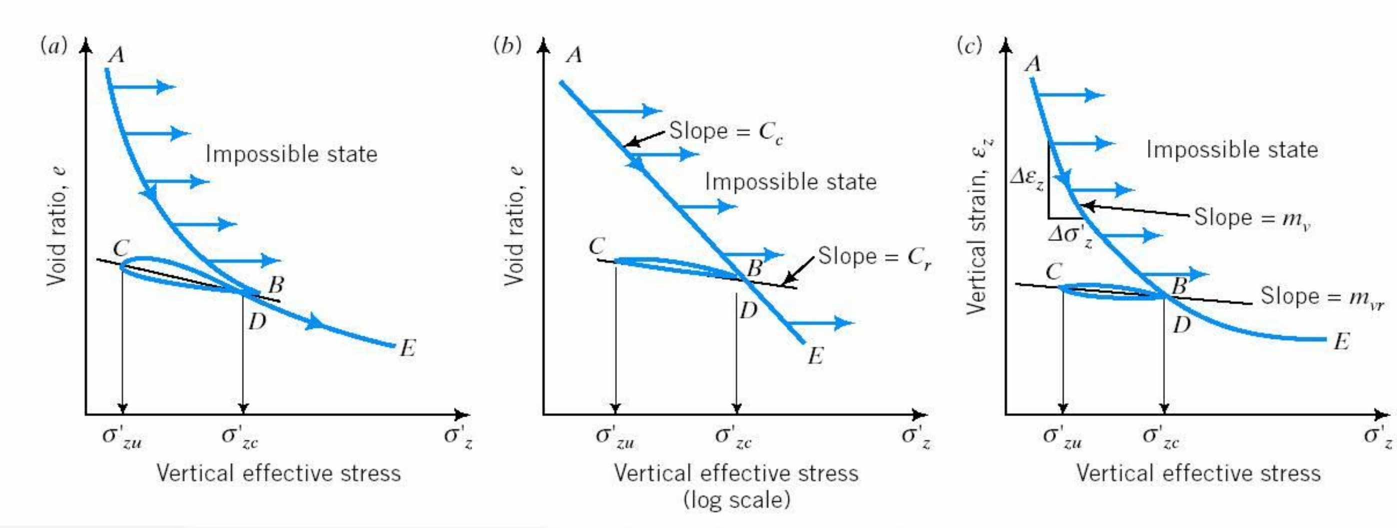
# Consolidation Data

- Continue to apply loads
- → Define a stress vs. deformation curve
- Essentially → defining a modulus for the soil with no lateral deformation
- Most often report the results of consolidation tests
  - Void ratio versus the effective stress on a log scale



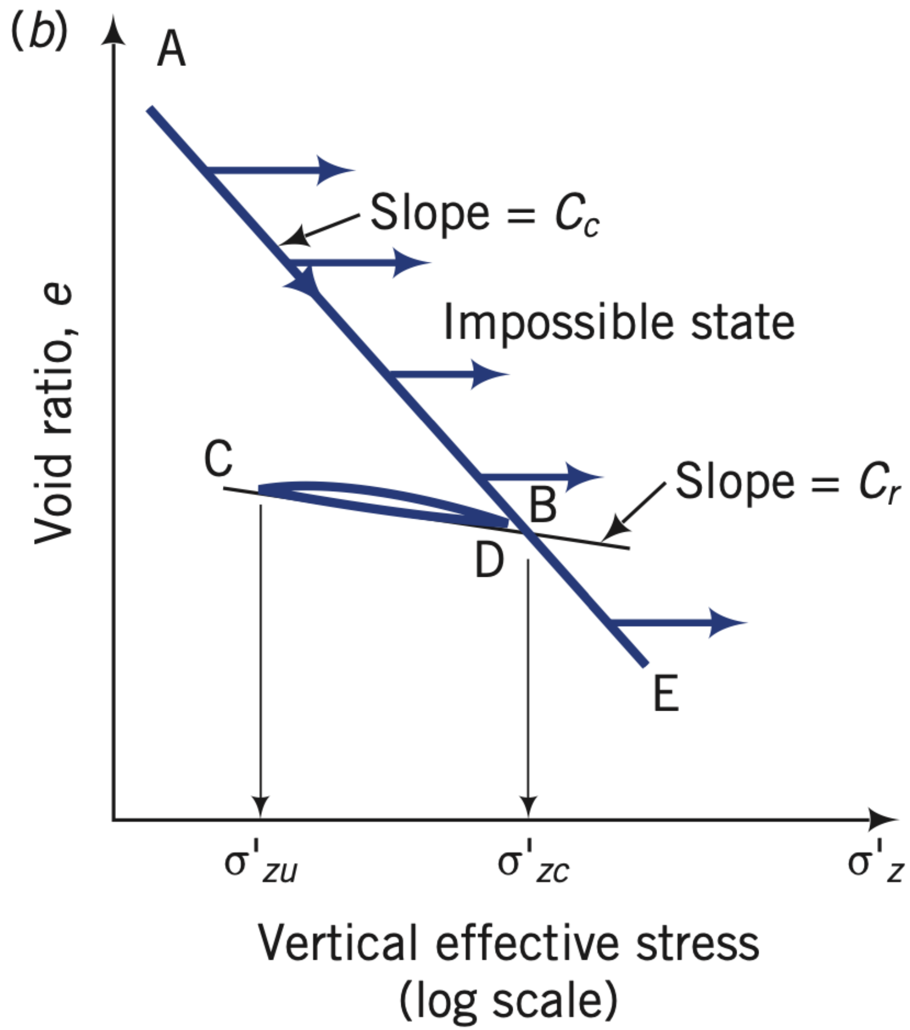
# Data Plots

- Can plot the data in a variety of ways
  - Void ratio versus effective vertical stress (arithmetic)
  - Void ratio versus effective vertical stress (logarithmic)
  - Vertical strain versus effective vertical stress (arithmetic)
- Remember that settlement is not linear
  - Soil is getting denser
  - Hydraulic conductivity is decreasing



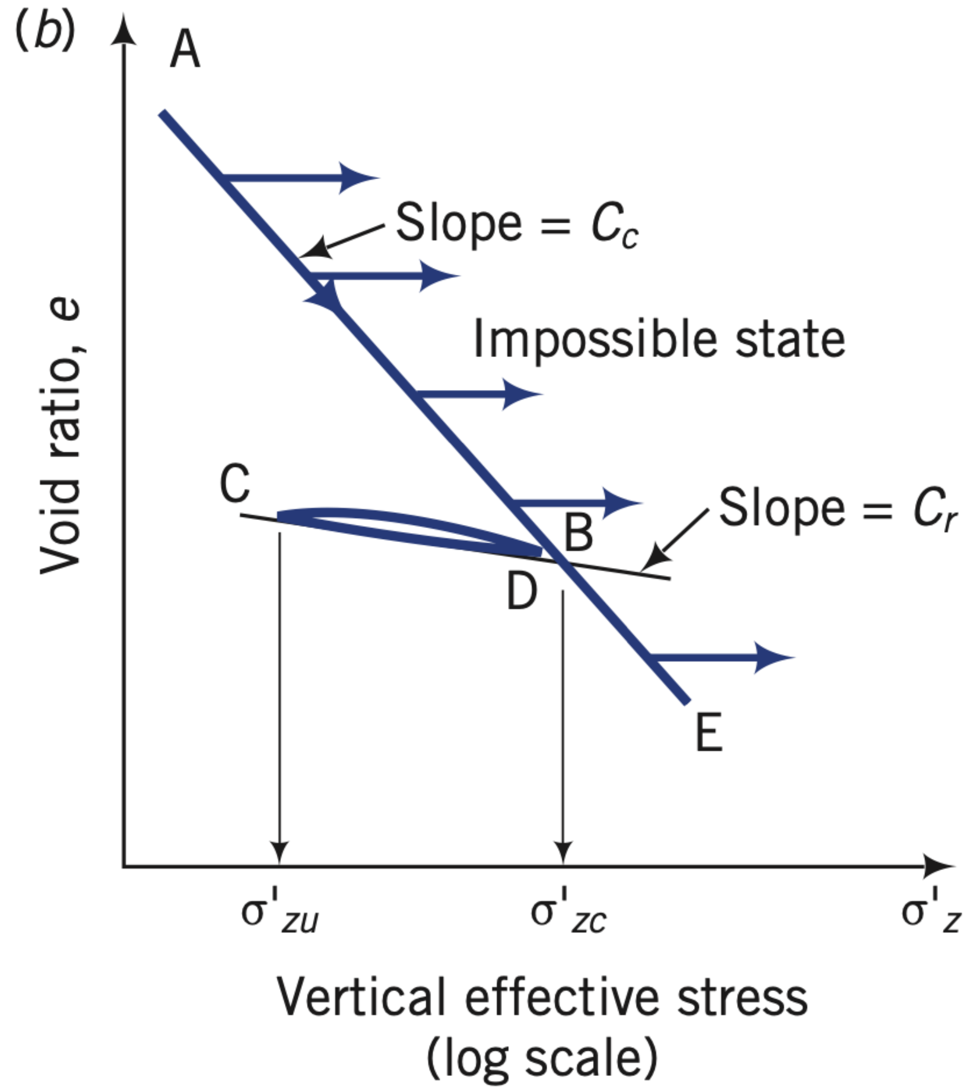
# Data Plots

- For a consolidation stress that is higher than the soil has ever experienced
- Settlement follows an approximately straight line on a log scale (vertical stress)
  - Known as virgin consolidation
  - Or the normal consolidation line
  - Elastic and plastic deformation components



# Unload Reload

- Unload the soil, it swells (sorbs water) and gains in volume, but some permanent deformation is retained (Unload-reload is elastic)
- When we reload past the past maximum stress, the soil will again follow the virgin compression line



# Preconsolidation Pressure

- Several important features:
  - Two straight lines connected by a smooth transition
- Intersection is known as the preconsolidation pressure $\sigma'_{zc}$
- Stress level at which the break occurs is an indication of the maximum past effective vertical stress that the soil has felt
- Soils have a "memory" for the amount of stress they have been subject to in past
- Preserved in the soil structure and is reflected in the way that the soil will deform under load
- When soil is loaded to a larger magnitude than it has experienced in the past, the structure starts to break down

# Normal vs Overconsolidation

- For some soils this is significant:
  - For the load levels less than the maximum past load, the soil is not very deformable
  - In levels greater than the maximum past load, many soils can deform significantly
- There are two main states for a soil:
  - Normally consolidated –
    current effective vertical stress = max past effective vertical stress
  - Overconsolidated –
    current effective vertical stress < max past effective vertical stress

# Overconsolidation Ratio

- Ratio of maximum past effective vertical stress / current effective vertical stress
- $OCR = \frac{\sigma'_{zc}}{\sigma'_{zo}}$ = Overconsolidation ratio
- $\sigma'_{zc}$ $=$ preconsolidation pressure
  - maximum stress soil has felt in the past
- $\sigma'_{zo}$ $=$ current effective vertical stress
  - stress soil feels currently
- Normally consolidated OCR = 1
- Overconsolidated OCR>1
- Soils become overconsolidated by erosion of soil (most commonly)

# Compressibility in Consolidation Test

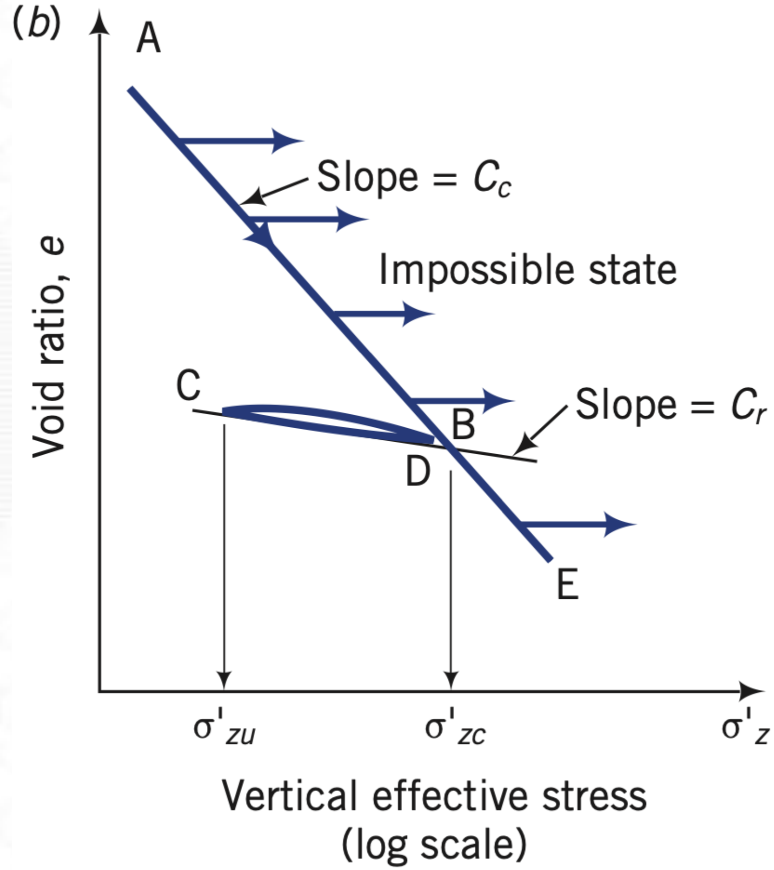
- Two distinct zones of behavior - recompression and virgin compression

- For compression, define Compression Index:

$$C_c = \frac{-Change in void ratio}{Change in stress} = \frac{-(e_2 - e_1)}{\log \frac{(\sigma_z')_2}{(\sigma_z')_1}} = \frac{|\Delta e|}{\log \frac{(\sigma_z')_2}{(\sigma_z')_1}}$$

- For recompression, define Recompression Index:

$$C_r = \frac{-Change in void ratio}{Change in stress} = \frac{-(e_2 - e_1)}{\log \frac{(\sigma_z')_2}{(\sigma_z')_1}} = \frac{|\Delta e_r|}{\log \frac{(\sigma_z')_2}{(\sigma_z')_1}}$$



# Modulus

- Modulus of volumetric compressibility – arbitrarily choose two points on the NCL line

$$m_v = -\frac{(\varepsilon_z)_2 - (\varepsilon_z)_1}{(\sigma_z^{'})_2 - (\sigma_z^{'})_1} = \frac{|\Delta\varepsilon_z|}{(\sigma_z^{'})_2 - (\sigma_z^{'})_1} \quad \left(\frac{m^2}{kN}\right)$$

- Modulus of volumetric REcompressibility – arbitrarily choose two points on the unload/reload line

$$m_{vr} = -\frac{(\varepsilon_z)_2 - (\varepsilon_z)_1}{(\sigma_z^{'})_2 - (\sigma_z^{'})_1} = \frac{|\Delta\varepsilon_{zr}|}{(\sigma_z^{'})_2 - (\sigma_z^{'})_1} \quad \left(\frac{m^2}{kN}\right)$$