iv) CPT

- Schmertmann(1970)
  ; modified later by Schemertmann and Hartman(1978)

- Using strain influence factor (I_Z)

$$\text{Settlement} = \int \varepsilon_z dz$$

$$\varepsilon_z = \frac{p}{E_s} I_z$$

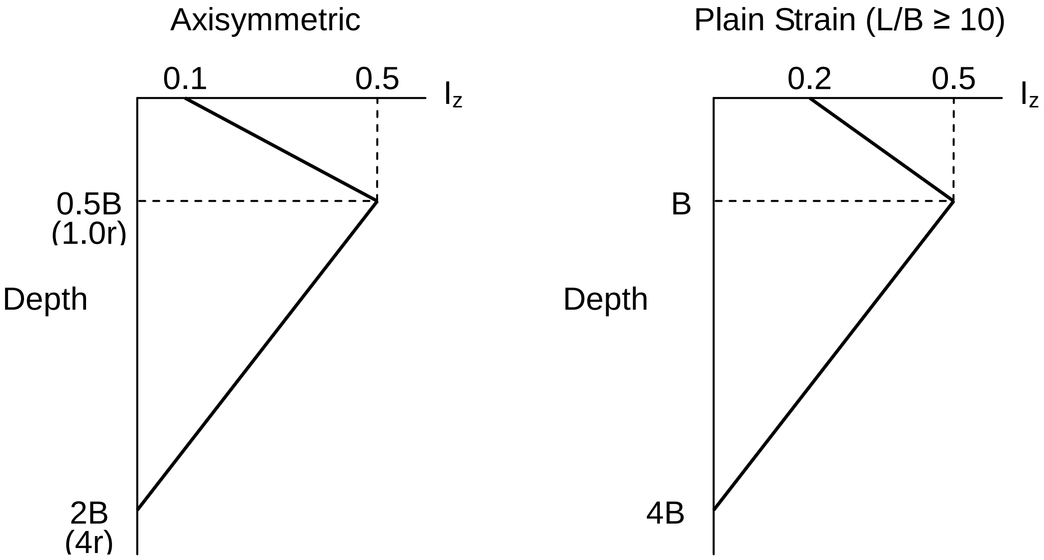
I_z = f(footing geometry, ν)

→ Fig. 2-13 and 2-14 in page 2-33 (based on theoretical, experimantal and numerical results)
((ε_z or I_z)$_{max}$ occurs not immediately under the footing but between 0.6r to 1.5r for circular footing) (r : radius of footing)

→ Vertical strains in sand deposits depend not only on the level of existing and added vertical stress but also on the existing and added shear stress.

→ Horizontal stress increment under the ground decreases more rapidly than vertical stress increment.

- Recommended simplified form
  (modified by Schmertmann and Hartman(1978))



For $1 < B/L < 10$, linearly incorporate the stressed depth and the point of $I_{Z(\max)}$.

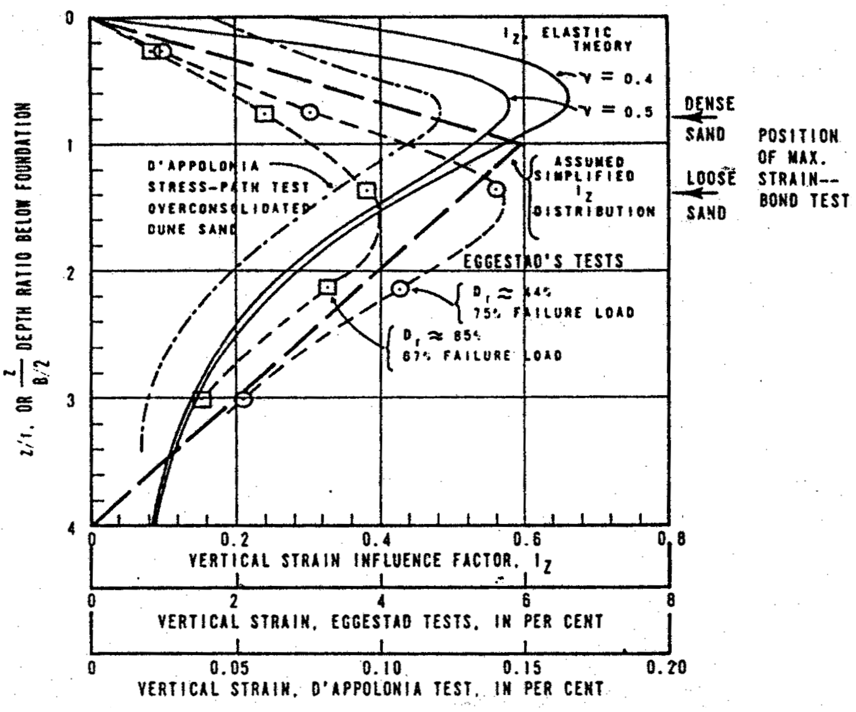


Fig. 2-13 Theoretical and experimental distributions of vertical strain below center of loaded area.

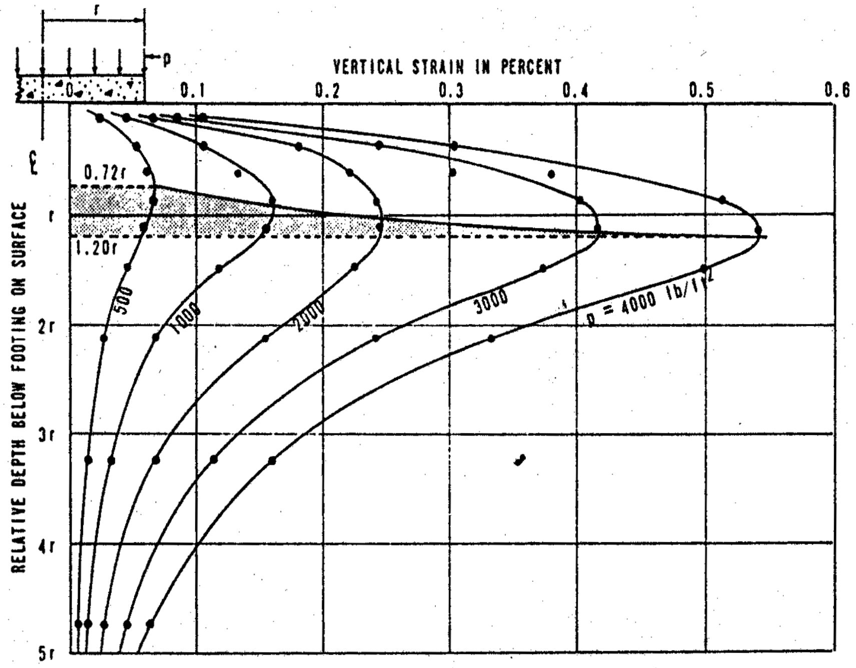
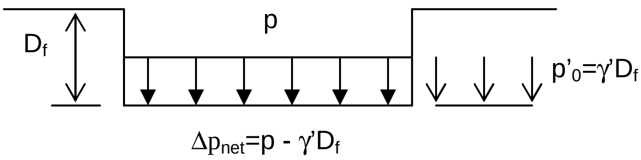


Fig. 2-14 Nonlinear, stress dependent finite element model prediction of vertical strains under center of 10-ft diam. 1.25ft thick. concrete footing loaded on surface of normally consolidated sand with $=37^{o}$

Thus,



- Computation of immediate settlements.

- $S_e = \int_0^{\infty} \varepsilon_z dz = \int_0^{2B \text{ or } 4B} \frac{\Delta p_{net}}{E_s} I_z dz$

$$= C_1 C_2 \Delta p_{net} \sum_{i=1}^{n} \frac{I_{z(i)}}{E_{s(i)}} \Delta z_i \quad \text{- - - -}\mathbf{(1)}$$

where n = no. of layers in 2B or 4B.

C_1 = coefficient for depth of embedment.

$= 1 - 0.5 \frac{p'_0}{\Delta p_{net}} \geq 0.5$

C_2 = creep coefficient.

$= 1 + 0.2 \log \frac{t(yrs)}{0.1}$

t ≡ time when the value of settlement is desired.

- E_s determination with q_c values from CPT

→ Continuous set of readings of q_c. → E_s.

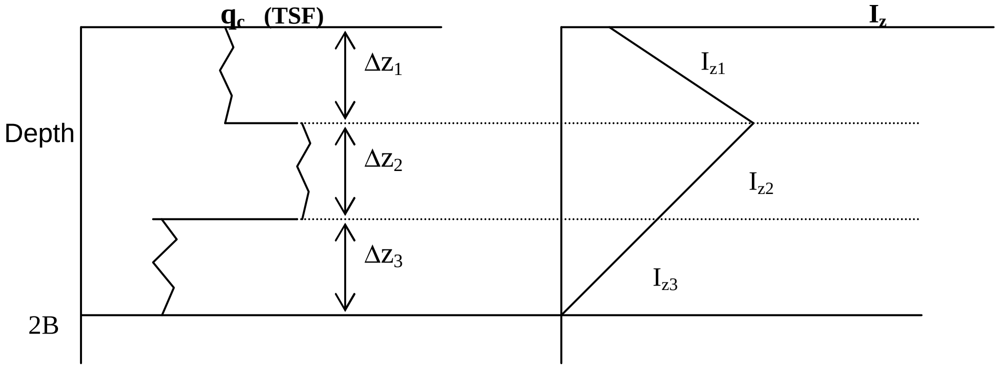
→ Correlating q_c with E_s from screw plate tests.

$E_s = 2.5 q_c \quad (L/B = 1)$ **(Axi - symmetry)**

$E_s = 3.5 q_c \quad (L/B \geq 10)$ **(Plane strain)**

- Procedure.

1. Develop static core profile and divide into layers.



2. Fill in chart.

Layer	Δz	q_c	$2.5q_c(B/L=1)$ $E_s = 3.5q_c(B/L>10)$	I_z	$\frac{I_z}{E_s}\Delta z$
1					
2					
3					

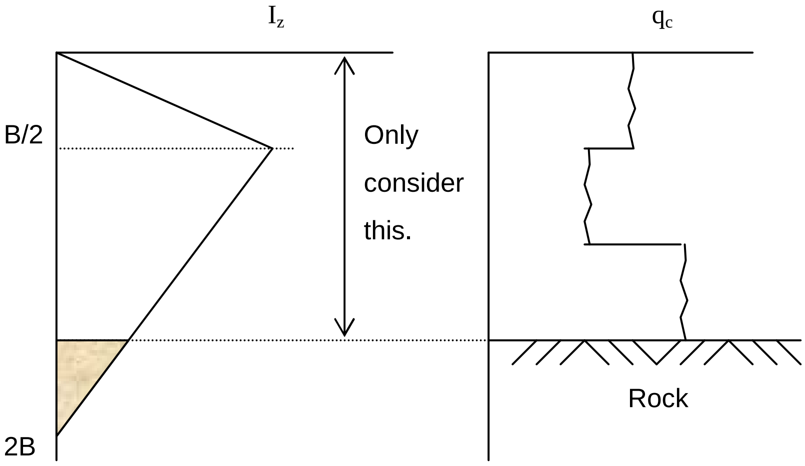
$\sum_{i=1}^{3}$ .....

3. Compute C_1, C_2

4. $S_e = C_1 C_2 \Delta p \sum_{i=1}^{n} \frac{I_{z(i)}\Delta z_i}{E_{s(i)}}$

- <u>Comments</u>.

① If rigid boundary is close to foundation level, it can be accounted for by :



② If you have only N values, you can use the following correlations with CPT results.

(but best to get a site specific N - q_c correlations).

Soil type	$q_c(kg/cm^2)/N$	E_s/N ($q_c/N \times$ (2.5 or 3.5))
i) Silts, sandy silts and slightly cohesive mixtures.	2	5 ~ 7
ii) Fine-medium grained clean sand.	3.5	9 ~ 12
iii) Coarse sand.	5	12 ~ 18
vi) Sandy gravels & gravels	6	15 ~ 21

③ Method is valid for first loading cases with adequate bearing capacity.

④ Results are conservative, if the sand has been preload.
  - Geologic O.C. state.
  - Roller compaction.
    (As much as 100% lager than observed).

⑤ Any values of E (i.e. pressuremeter E) can be used, if site specific correlations are made.

- Long – Term Performance. → (Settlement by creep).

  - Constant load. → Not significant.
  - Slightly fluctuating load → might be 1.5 × $S_{immediate}$ after 30 years.
  - Heavily fluctuating load → might be 2.5 × $S_{immediate}$ after 30 years.