A SIMPLE METHOD FOR ESTIMATING THE NON-STRUCTURAL FINES CONTENT OF GRANULAR MATERIALS

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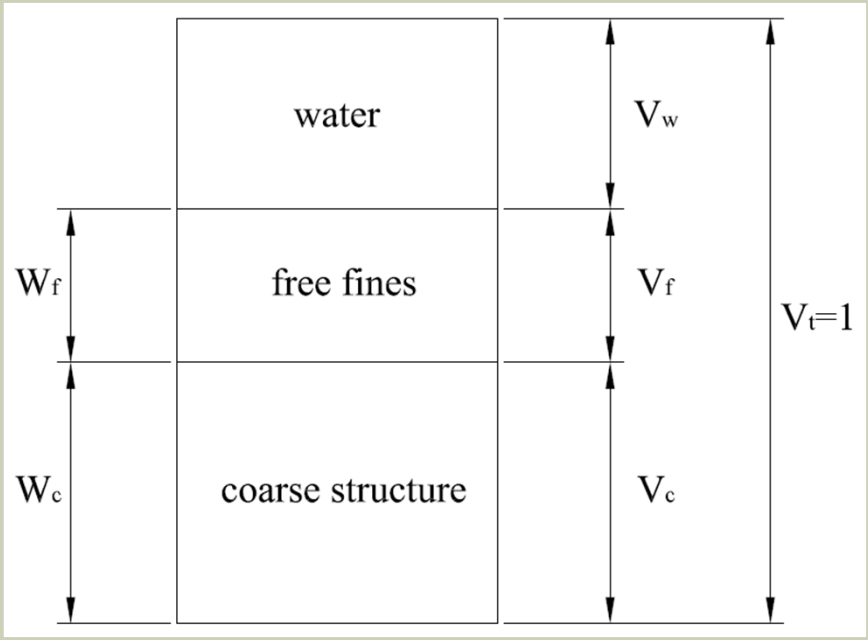
INTRODUCTION

- Determining the structural vs. non structural fractions in soil is necessary for internal erosion assessment: Suffusion and filter compatibility
- The mass ratio of the fraction of the soil that does not contribute to the load carrying skeleton is referred to as the free fines content
- Three ways of determining: Laboratory testing, Analytical methods, and Phase relations

PHASE RELATIONS

Weight fraction of the coarse structure: $S_c = W_c \Big/ \left(W_c + W_f \right)$

Weight fraction of free fines: $S_f = W_f \Big/ \left(W_c + W_f \right)$



$$e_c = \frac{V_w + V_f}{V_c} \qquad e_c = \frac{n_c}{1 - n_c}$$

$$e_f = \frac{V_w}{V_f} \qquad e_f = \frac{n_f}{1 - n_f}$$

$$n_c = n + (1 - n) S_f$$

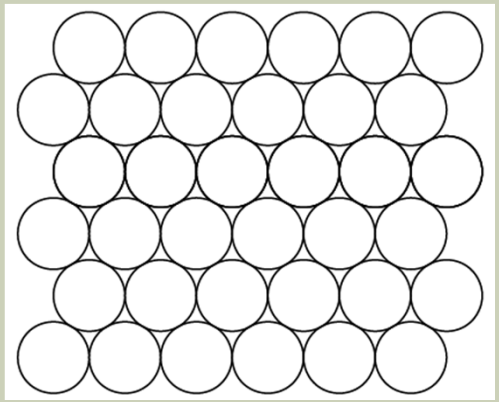
ESTIMATION OF MAXIMUM FREE FINES CONTENT

Reference		n	n_c	n_f	e	e_c	e_f	S_f (%)
Kenney and Lau (1985)	Narrowly graded	0.16	0.41	**0.38**	0.19	**0.69**	0.62	30
	Widely graded	0.10	0.28	**0.36**	0.11	**0.39**	0.56	20
Skempton and Brogan (1994)		**0.20**	**0.45**	0.44	0.25	0.82	0.80	35 (31?)
Wan and Fell (2004)		0.12	0.48	0.26	0.14	**0.91**	**0.35**	41

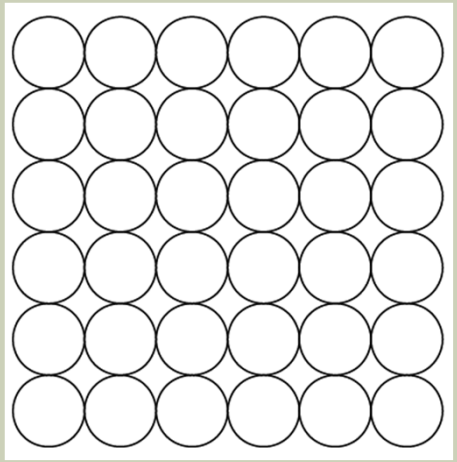
- Particle shape is assumed to be spherical
- Gradation is assumed to be bimodal
- Limit porosities are assumed for coarse and fine fractions
- Each estimation method prescribes a constant porosity

ESTIMATION OF MAXIMUM FREE FINES CONTENT

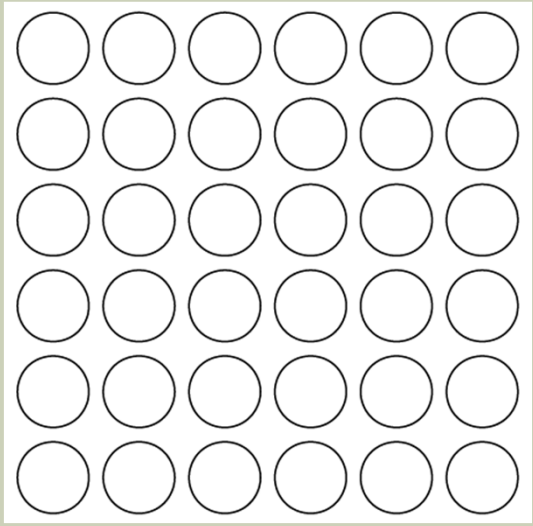
Schematic assembly of uniform particles at three porosities:



Minimum porosity n^*_{min}



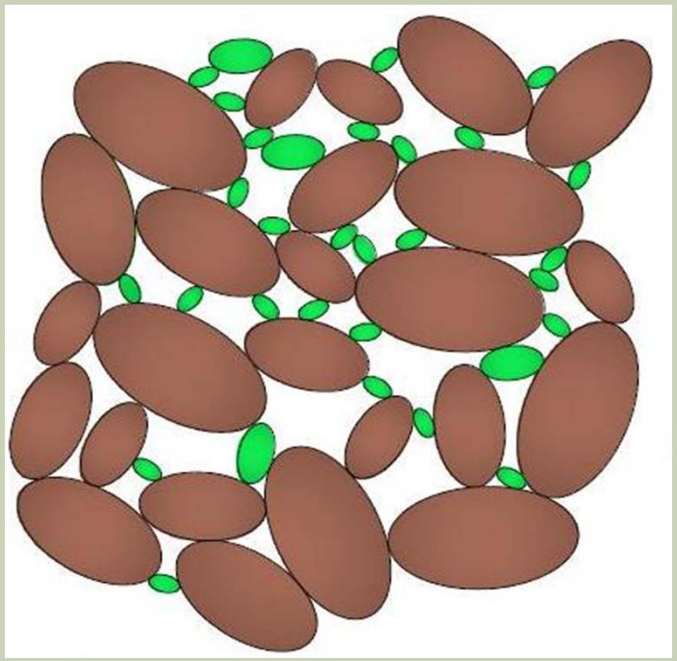
Maximum porosity n^*_{max}



Porosity more than n^*_{max}

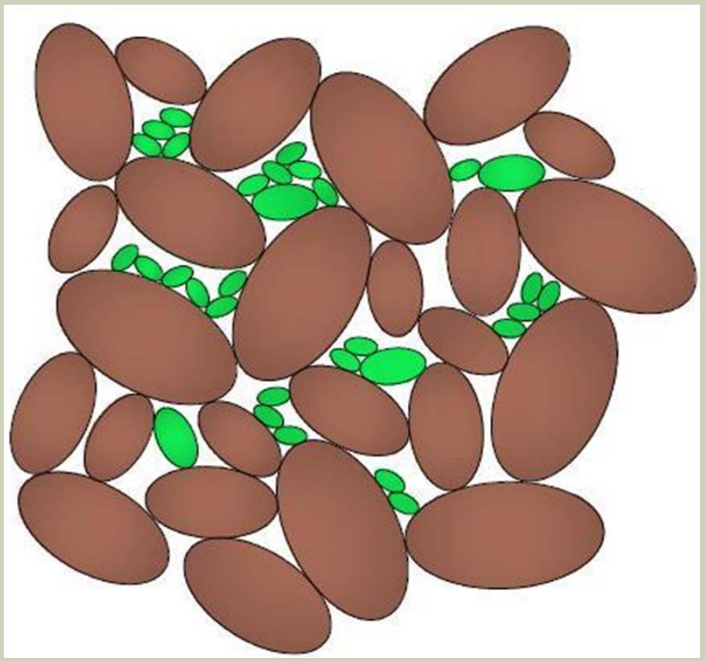
ESTIMATION OF MAXIMUM FREE FINES CONTENT

Schematic assembly of random particles:



$n = n^*_{max}$

All particles carry the load



$n \leq n^*_{max}$, $n_c = (n^*_{max})_c$

The fine fraction is non-structural

METHOD SUMMARY

- Split the gradation to its coarse and fine fractions at an arbitrary number of particle diameters
- Calculate the $(n^*_{max})_c$ of the coarse fractions and plot against their associated splitting particle diameter
- Calculate n_c for the coarse fractions from $n_c = n + (1 - n)S_f$ and plot against the associated splitting particle diameters
- The boundary between the free fines and the structural coarse particles is where the n_c plot intersects the $(n^*_{max})_c$ plot
- Use the original gradation curve to calculate the mass ratio of the free fines

DETERMINING n^*_{max} OF A SOIL

- In practice we can replace the theoretical n^*_{max} with experimental values based on the problem at hand
- Can use standard and non-standard laboratory tests to determine n_{max} (or e_{max})
- Can include the effects of stress by performing compression tests on loose specimens
- Can use existing correlations; e.g. Youd (1973)

$$e_{\max} = \left(\frac{7.2R + 0.4}{12R - 1.0}\right) C_u^{\left(\frac{0.65 - 5.49R}{18R - 1.8}\right)}$$

EXAMPLE: DETERMINING THE FREE FINES CONTENT FOR AN ARBITRARY SOIL

3/8” **#4** **#10**

***n*=0.22 and *R*=0.35**

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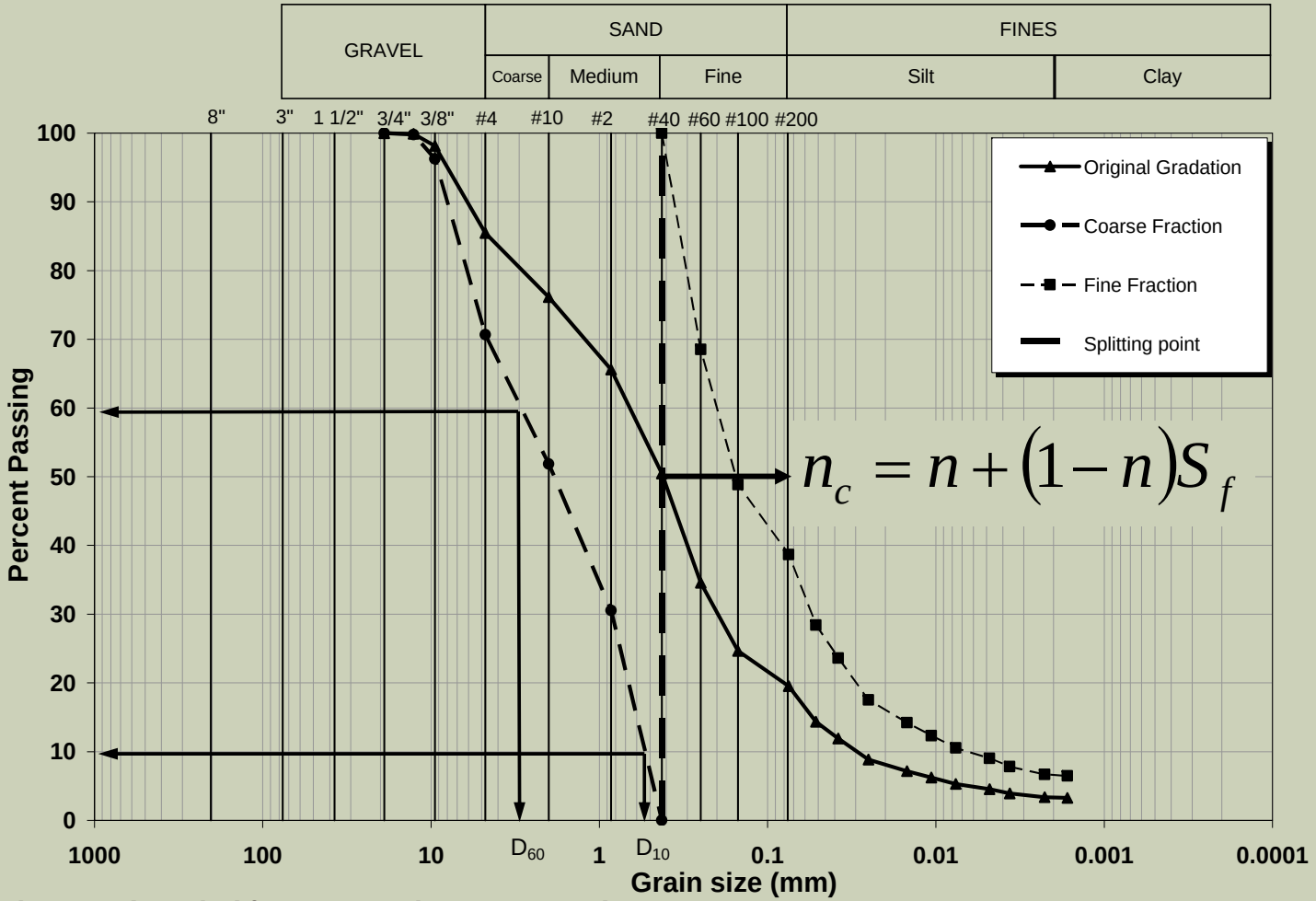

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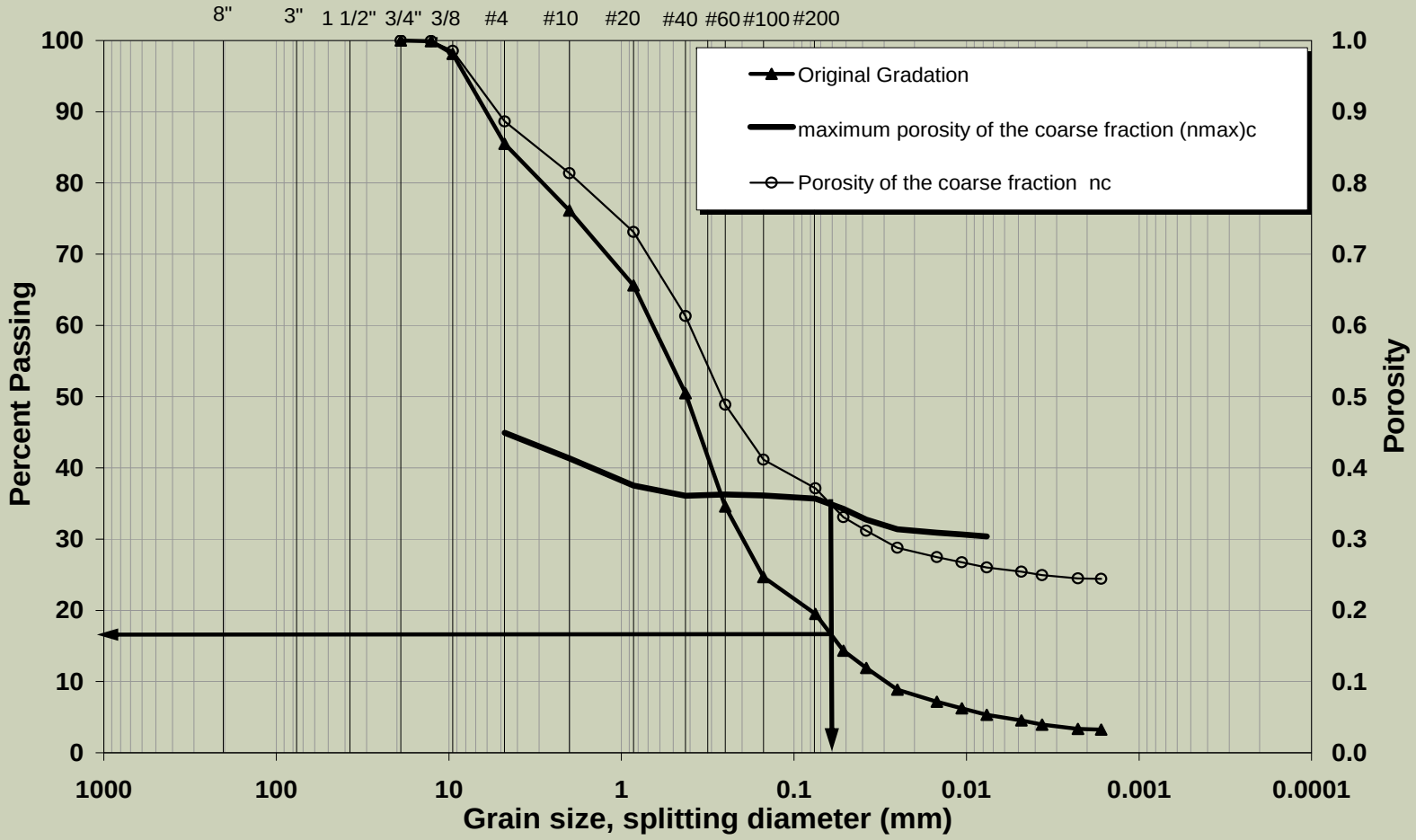

CONCLUSIONS

- A simple method is proposed for estimating the free fines content of soils using their maximum porosity (or maximum void ratio e_{max}) and gradation curve as input.
- A graphical representation of the method uses plots of the porosity of the coarse fractions of arbitrarily selected sub-gradations of a soil , and their estimated maximum porosities , against particle diameters to identify the free fines content of the soil at a certain density.
- Further work is required to verify the method and investigate the appropriate methods of estimating the maximum porosities of different fractions of a soil gradation.

MERCI!

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