Sand color due to water content

Visual-based observation of a physical property

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20241022_v1| https://osf.io/gv8h5/

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Outline

Intro

Aetherial, “Sand digital color palette procreat”, Etsy, url https://www.etsy.com/uk/listing/1223534541 [20241022].

Moisture content and sand color relation

- It is a well-known phenomenon that the color of sand changes due to moisture.
- As moisture content increases, sand will be typically darker.
- The change in soil moisture content can be clearly distin-guished both in the visible (380–700 nm) and in the near-infrared range (750–1400 nm).
- A HE73 moisture meter was used to determine the moisture content of the sandy soil.

György Pillinger, Ahmed Elawad Eltayeb Ahmed, Kornél Bessenyei, Péter Kiss, "Correlations between moisture content and color spectrum of sandy soils", Journal of Terramechanics, vol 108, p 39-45, Aug 2023, url https://doi.org/10.1016/j.jterra.2023.05.002.

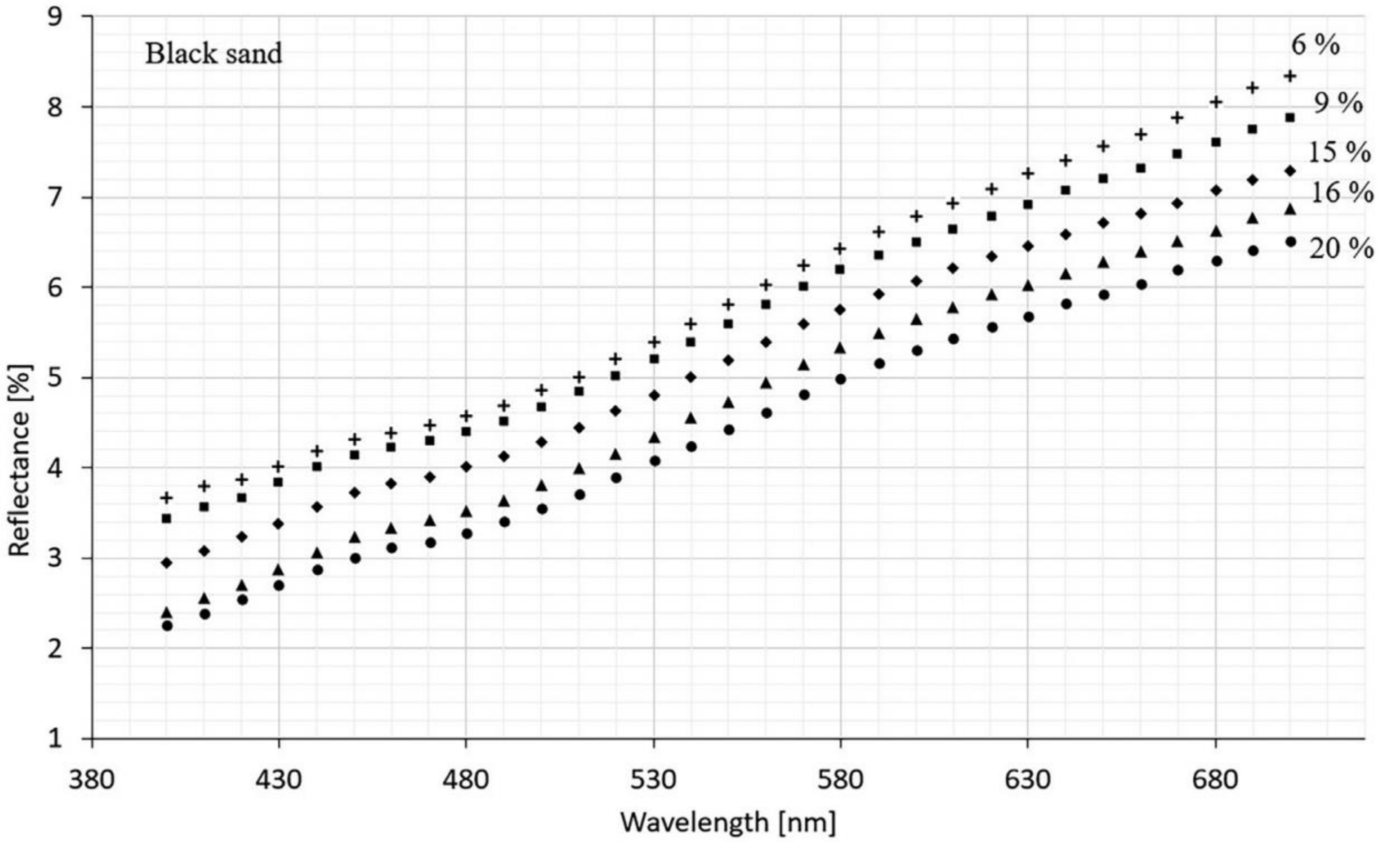


Fig. 4. Some raw reflectance curves of black sand at different moisture contents.

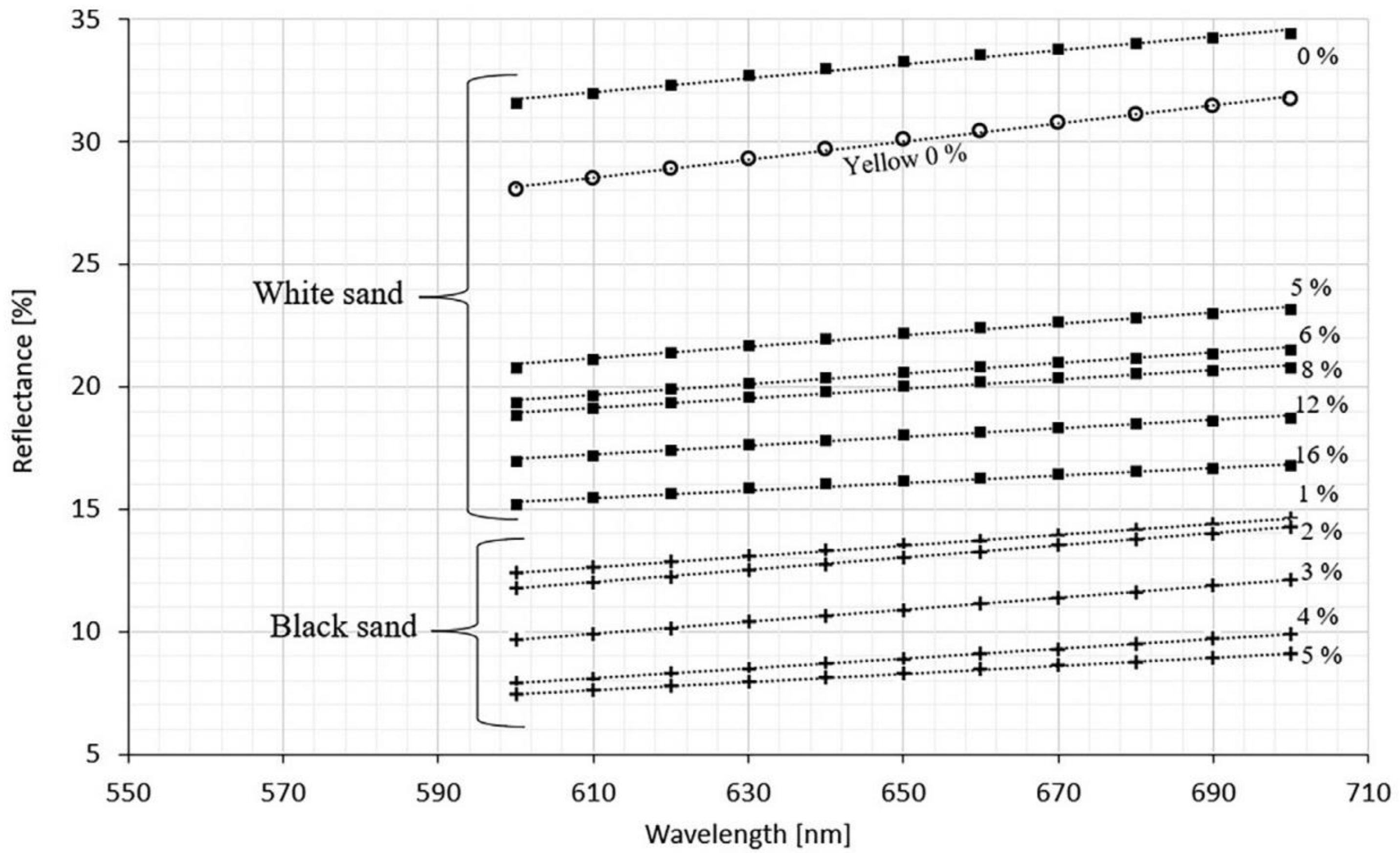
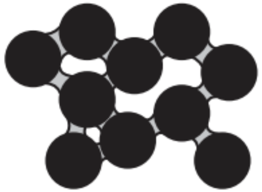
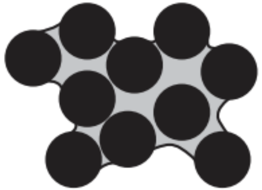
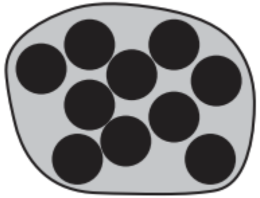


Fig. 5. Some raw reflectance curves of black and white sand in the 600–700 nm range.

Various water content of granular media

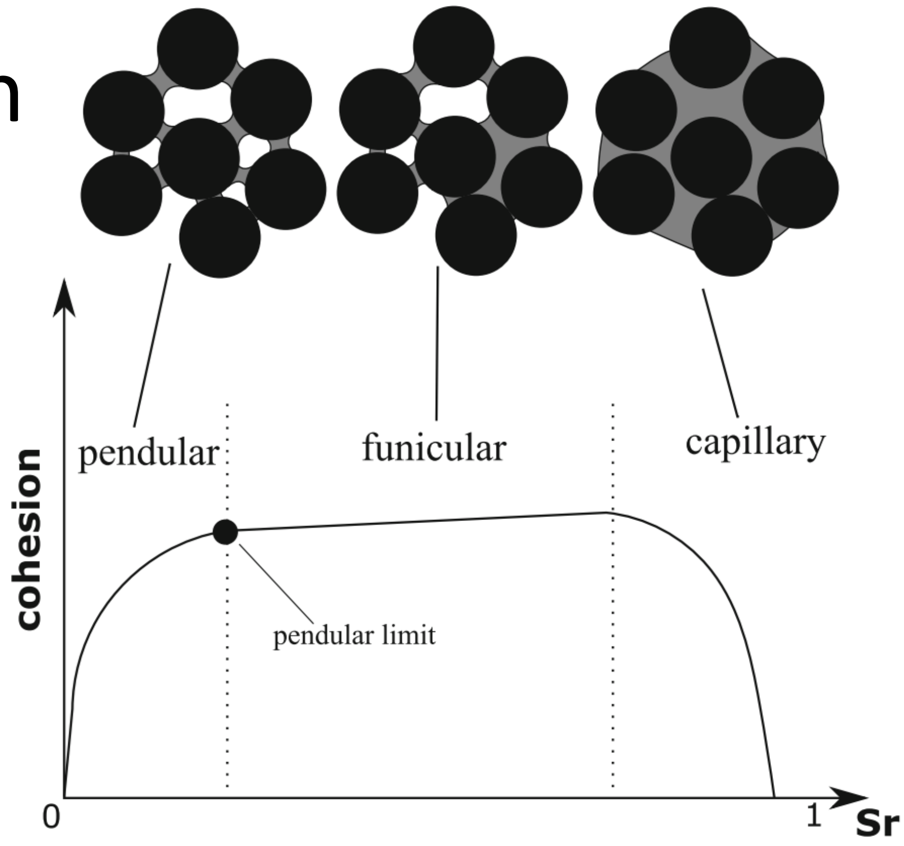
Liquid content	State	Schematic diagram	Physical description
No	Dry		Cohesion between grains is negligible.
Small	Pendular		Liquid bridges are formed at the contact points of grains. Cohesive forces act through the liquid bridges.

Namiko Mitarai, Franco Nori, "Wet granular materials", Advances in Physics, vol 55, no 1-2, p 1-45, 2006, url https://doi.org/10.1080/00018730600626065.

Middle	Funicular		Liquid bridges around the contact points and liquid-filled pores coexist. Both give rise to cohesion between particles.
Almost saturated	Capillary		Almost all the pores are filled with the liquid, but the liquid surface forms menisci and the liquid pressure is lower than the air pressure. This suction results in a cohesive interaction between particles.
More	Slurry		The liquid pressure is equal to, or higher than, the air pressure. No cohesive interaction appears between particles.

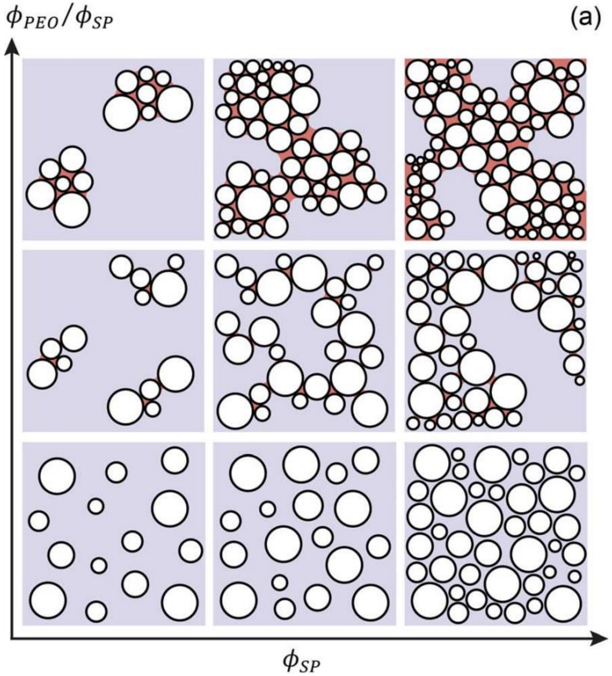
Cohesion vs saturation

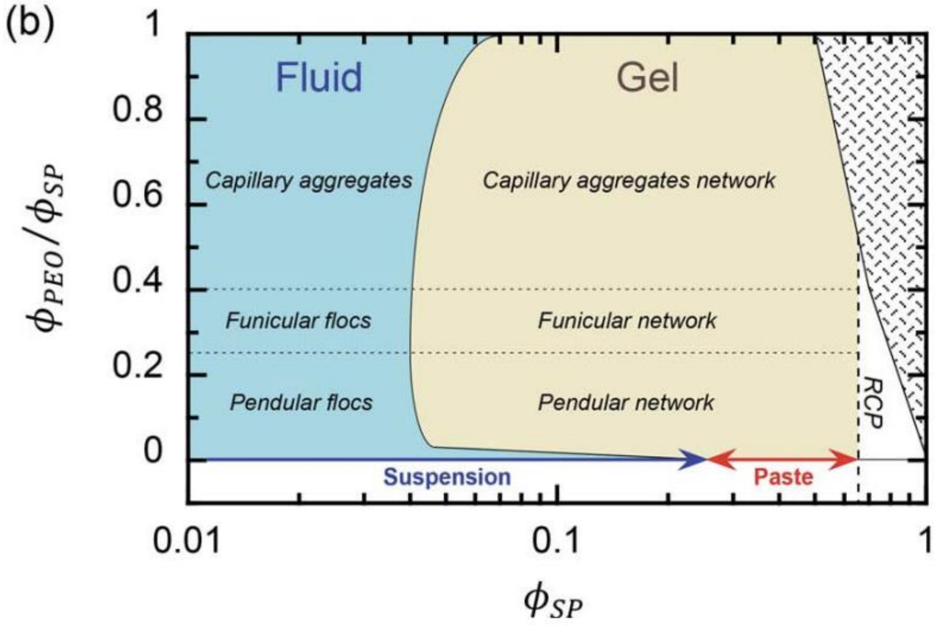
- There is some values of saturation that give higher cohesion.



Ji-Peng Wang, Xia Li, Hai-Sui Yu, "A micro–macro investigation of the capillary strengthening effect in wet granular materials", Acta Geotechnica, vol 13, p 513-533, Jun 2018, url https://doi.org/10.1007/s11440-017-0619-0.

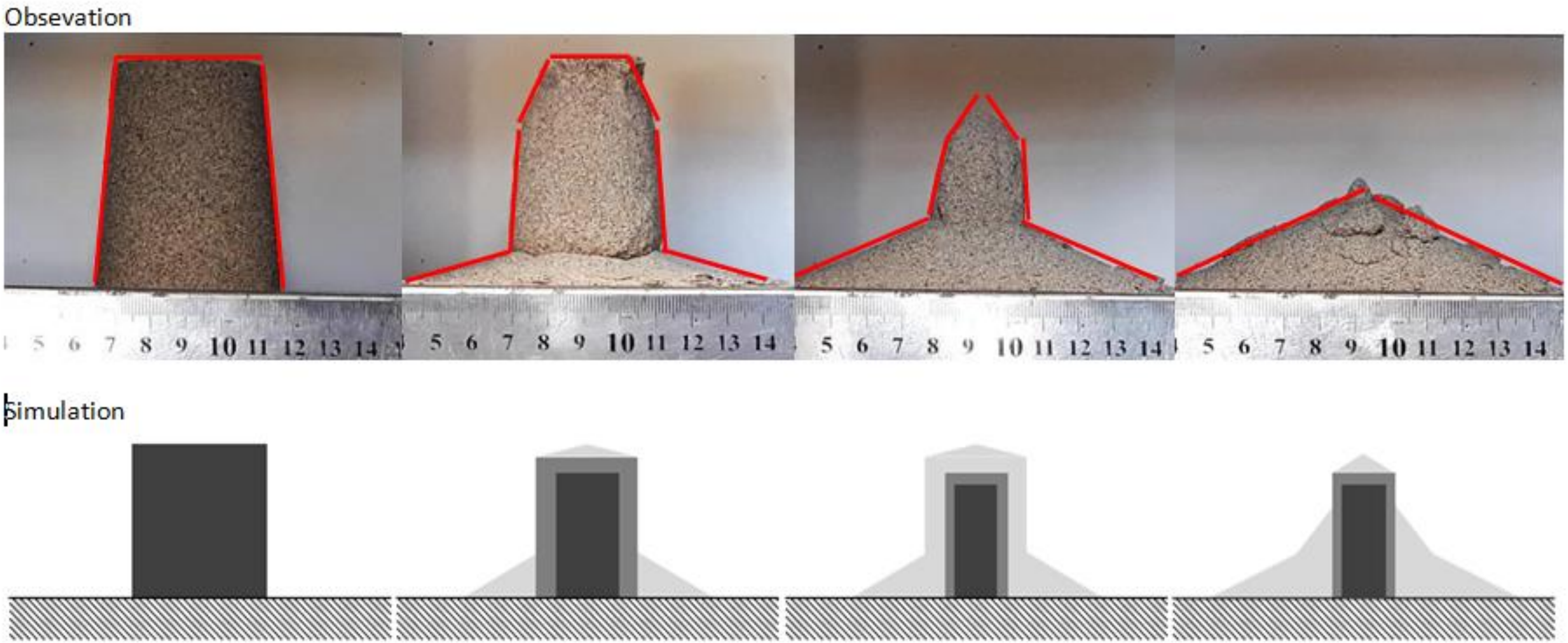
Capillary attraction on ternary system





Trystan Domenech, Sachin S. Velankar, "On the rheology of pendular gels and morphological developments in paste-like ternary systems based on capillary attraction", Soft Mater, vol 11, no 8, p 1500-1516, Feb 2015, url https://doi.org/10.1039/c4sm02053g.

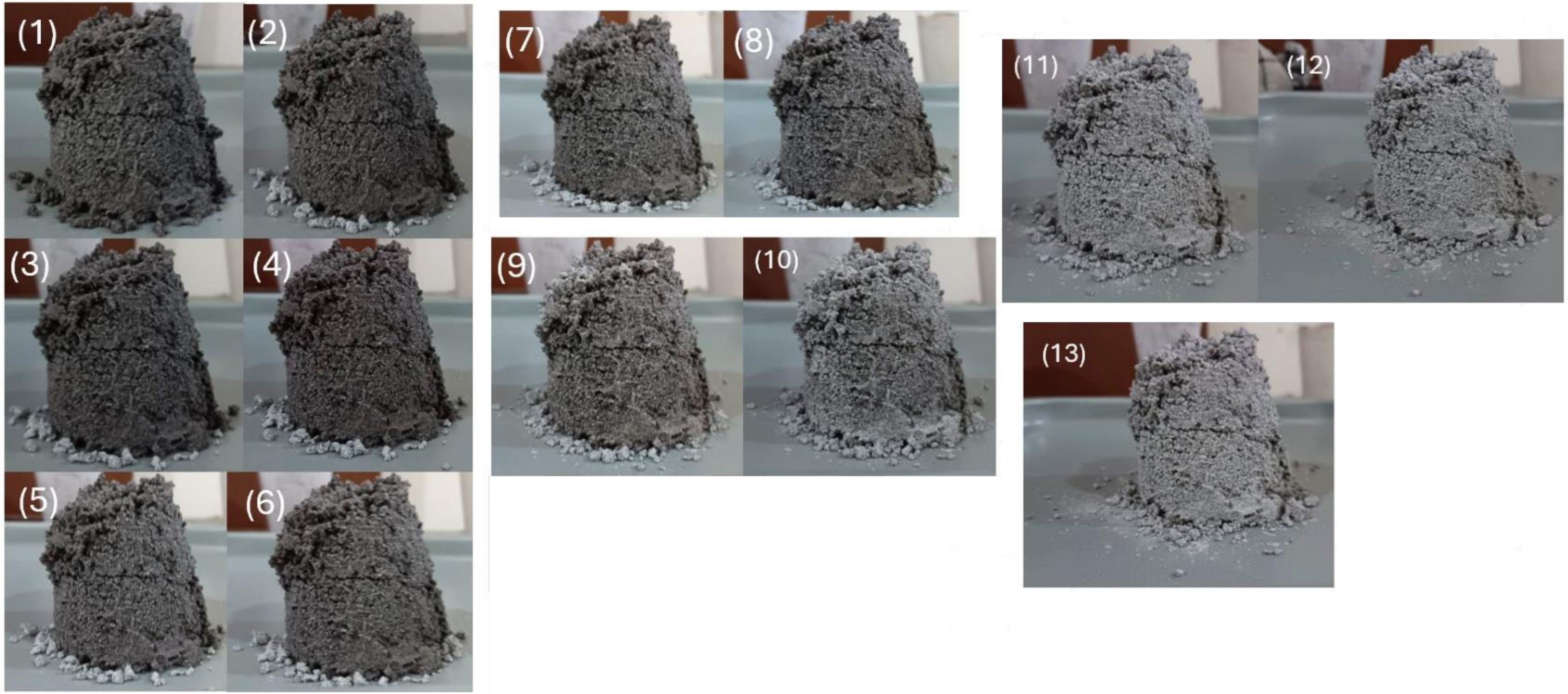
Observation and modeling



Sparisoma Viridi, Zahrotul Firdaus Tri Wahyu Lestari, Triati Dewi Kencana Wungu, Suprijadi, "Simple grid-based model of sandpile avalanche due to heating process", Presentation for International Workshop on Computational Science, 30 June 2018, Kanazawa University, Japan, url https://osf.io/nker6/ [20241022].

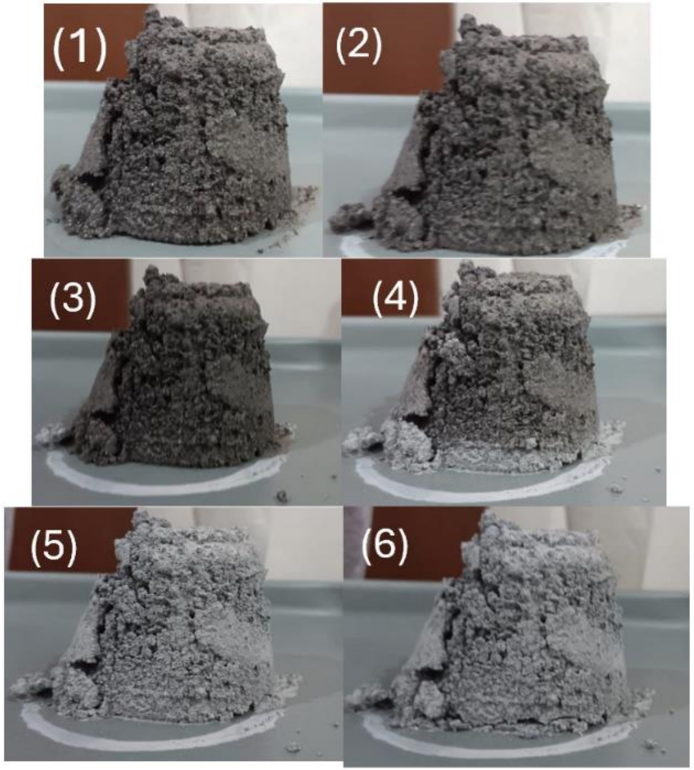
Preliminary study

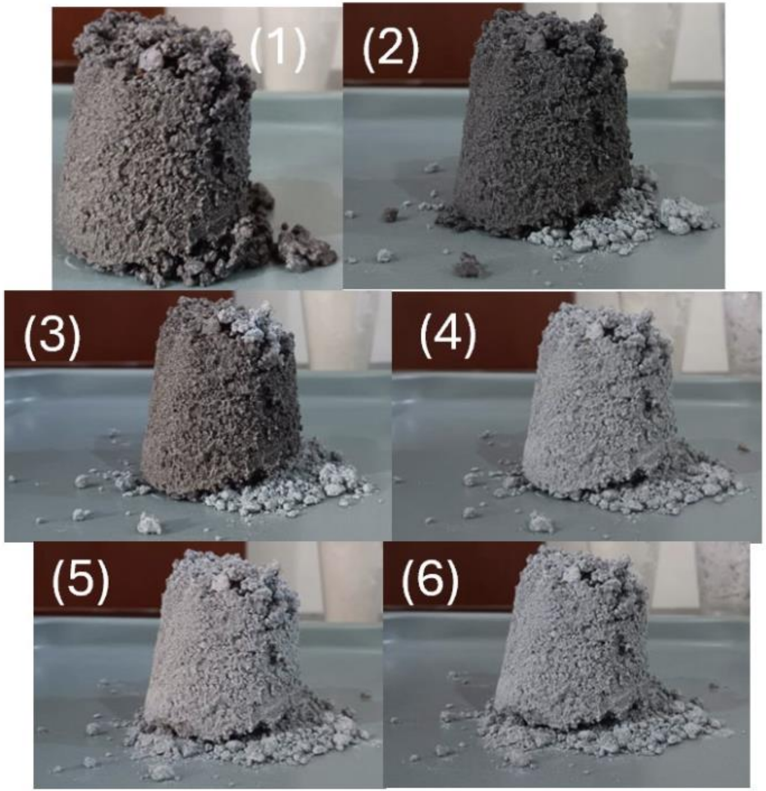
Heating temperature 100 °C



Revanka Mulya, "Prediksi Konsentrasi Air pada Material Granular dengan Pengamatan Citra", Tugas Akhir 1, Prodi Fisika, Fakultas Matematika dan Ilmu Pengetahuan Alam, Institut Teknologi Bandung, 2024, url https://osf.io/k783r [20241022].

Heating temperature 200 °C and 150 °C





Challenges

- Observation: There should be relation between sand color and pile stability.

- The relation is complex and could be investigated throung
  - Relation between sand color and water content.
  - Relation between water content and grains cohesion.
  - Relation between pile stability and grains cohesion.

To-do List

References

- Obtain references used in this slide.
- Try to understand them deeper.
- Find new insights.

Color palette

- Create color palette from C_0 to C_N with $N > 9$.
- The C_0 is for dry sand.
- The C_N is for sand still with funicular state but with most saturation, so it can still build a steep slope.
- Relate RGB (or BW) colors with water content.

Color palette illustration

C_N	% water	Color
C_{00}	0	
C_{01}	2	
C_{02}	4	
C_{03}	6	
C_{04}	8	
C_{05}	10	

CN	% water	Color
C_{06}	12	
C_{07}	14	
C_{08}	16	
C_{09}	18	
C_{10}	20	
C_{11}	22	

Procedure

- Design a procedure to obtain the relation between sand color and water content.
- Assure the procedure also works with several types of sands.
- Report color palette for several types of sand obtained from the procedure.

Time schedule

- The procedure should be obtained before the end of November 2024.
- The color palette data for several types of sands should be finished before mid of December 2024.
- In parallel discuss how to observe pile stability during heating using the color palette data.

Equations

- Try to make empirical equations from slide 6 – 7.
- Repeat that for slide 10.
- Relate above equations to obtain the relation between color and cohesion. Is it possible? Or it requires other relation?

GitHub repository

- Create a GitHub repository for this study.
- Share link of the repository in next progress meeting.

Thank you

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