STUDY ON MECHANICAL AND EROSION PROPERTIES OF AGGREGATED SOIL

団粒化土の力学特性と侵食性に関する研究

Aggregated soil is a chemically stabilized soil, to increase the permeability and water retention capacity of natural soil. The geotechnical properties of aggregated soil is not yet properly understood to be used as a major construction material. In this study mechanical and erosion properties of aggregated sand with natural sand and cement treated sand were compared. Masado was used as natural sand. Basic soil tests, unconfined compressive strength test(7 & 28 curing days), and permeability test were conducted for each type of soils. A new permeability apparatus was used to evaluate internal erosion of the soil. Turbidity of the outflow was measured to evaluate the degree of internal erosion. The microstructure of the treated soil was observed using scanning electron microscope (SEM) images.

団粒化土とは自然土の透水性や保水性を向上させるために化学的に安定化させた土として知られていますが、その地盤工学的な特性は未だ理解されておらず、主要な建設材料として用いられる段階にはいたっていません。本研究では団粒化土と自然土である真砂土やセメント処理を施した土の工学的性質や侵食性を比較しました。物理試験、一軸圧縮試験(養生期間7日間・28日間)、及び透水試験を各試料について行いました。新しい透水試験装置を使用し、流出水の濁度を測定することで土の内部侵食を評価しました。また、団粒化土の微小構造をSEM(走査型電子顕微鏡)を用いて観察しました。

(1)Introduction on aggregated soil

Aggregated soil is a chemically stabilized natural soil, made by mixing cement (Hexavalent Chromium Soluble cement), polymeric liquid called crumb agent, and water to create three dimensional meshes like structure by attaching fine particles to larger particles.

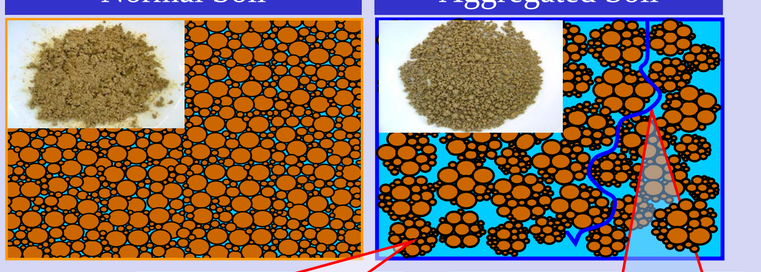
Cement treated soil
Natural soil
Cement
Water

Crumb agent
GB-2000

- **High permeability**
- **High water retention capacity**
- **Resistance against erosion**

Aggregated soil

Normal Soil	Aggregated Soil

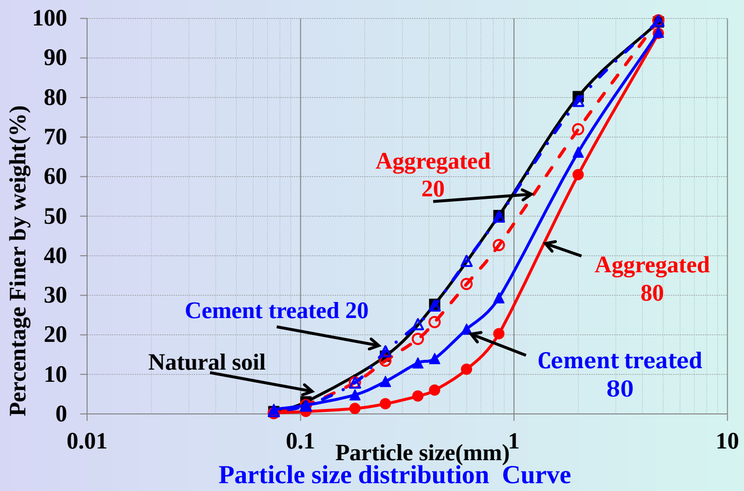


http://www.cimaconsul.co.jp

(2) Tests, Apparatus and testing method

Materials and mix proportions

Test set	Cement (by volume)	Crumb agent (by volume)	Water (by weight)	Dense condition
SET 1	80kg/m^3	1.5l/m^3	16.5%	Dense **DC>95%**
SET 2	20kg/m^3	1.5l/m^3	14.5%	Dense **DC>95%**
SET 3	20kg/m^3	1.5l/m^3	14.5%	Loose **DC<85%**

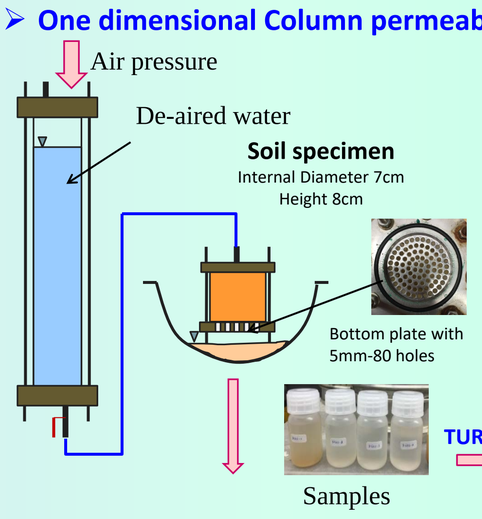


Particle size distribution Curve

- Addition of crumb agent of aggregated soil has caused to formation of larger sized clusters than in natural soil and cement treated soil
- When increase cement content flocculation ability is increased in both cement treated and aggregated soils

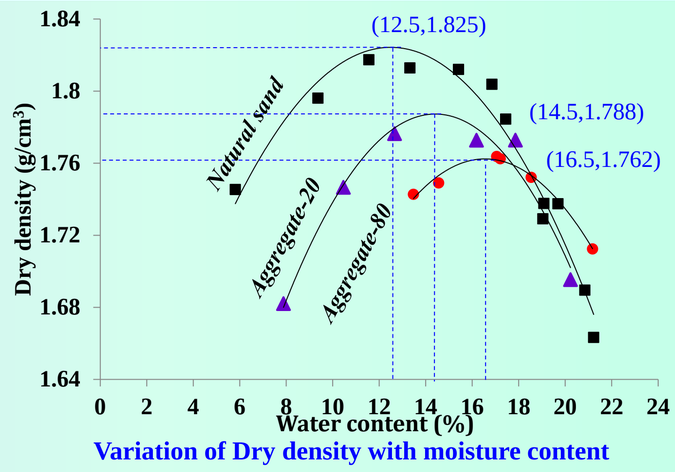
・セメントや土壌団粒促進剤を加えた団粒化土は自然土に比べ、大きい塊を形成し、透水性が向上した。
・セメント量を増加させると、どちらの試料についても凝集力が増加した。

One dimensional Column permeability test and Turbidity test



-Out flow of water collected for checking turbidity

- Time duration to complete each water cycle was also measured



Variation of Dry density with moisture content

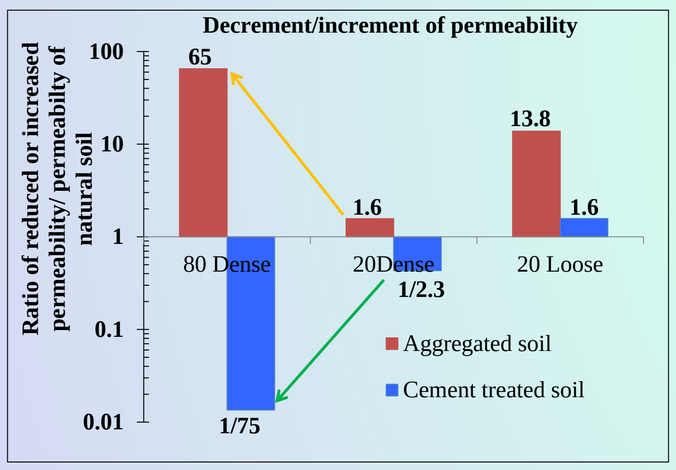
- When increase the cement content of aggregated soil, the increase of voids reflects the decrease in maximum dry density

・団粒化土のセメント量を増加させると、最大乾燥密度の減少が空隙量の増加に反映された。

(3)Test results

Permeability test results

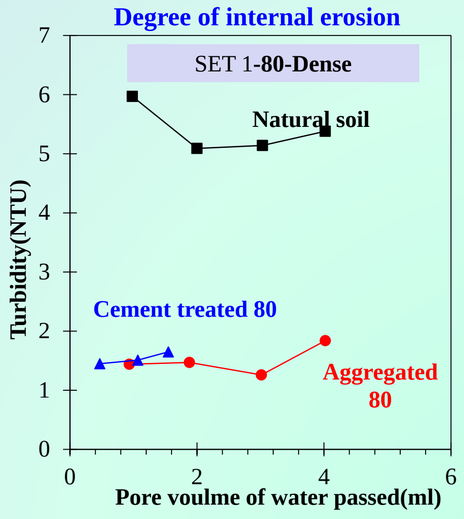
	Soil type	Coefficient of permeability (cm/s)
SET 1 **80kg/m^3 Dense**	Natural soil	3.12E-5
	Cement treated soil	4.20E-7
	Aggregated soil	2.03E-3
SET 2 **20kg/m^3 Dense**	Natural soil	2.51E-4
	Cement treated soil	1.08E-4
	Aggregated soil	3.94E-4
SET 3 **20kg/m^3 Loose**	Natural soil	7.48E-4
	Cement treated soil	1.17E-3
	Aggregated soil	1.03E-2



- Aggregated soil shows higher permeability in all three conditions due to larger amount of interconnected pores

団粒化土は全ての条件において空隙の相互連結によって透水性が向上した。

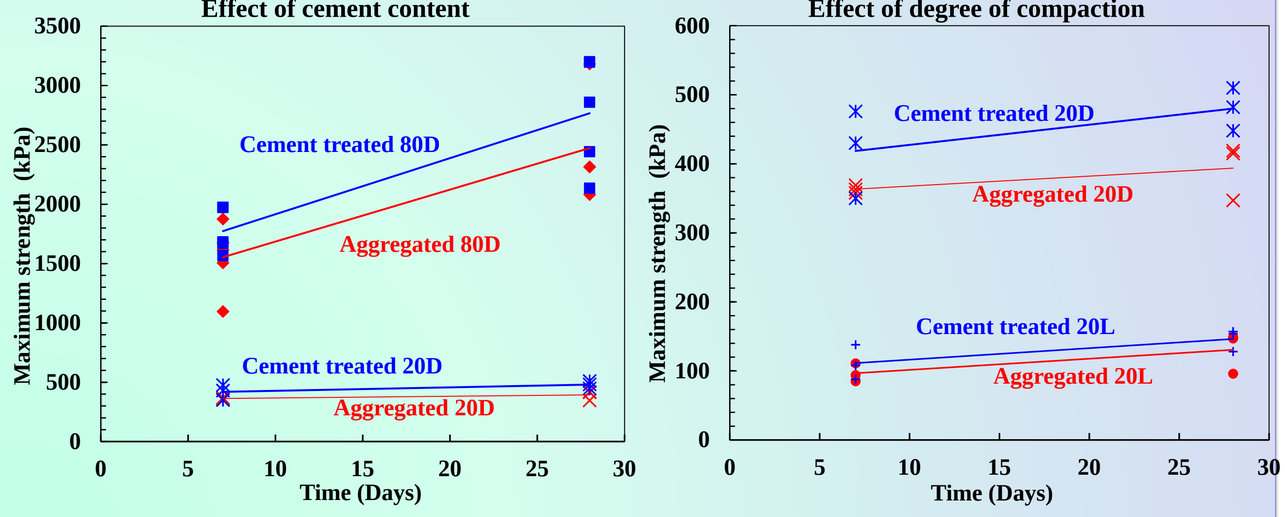
Degree of internal erosion

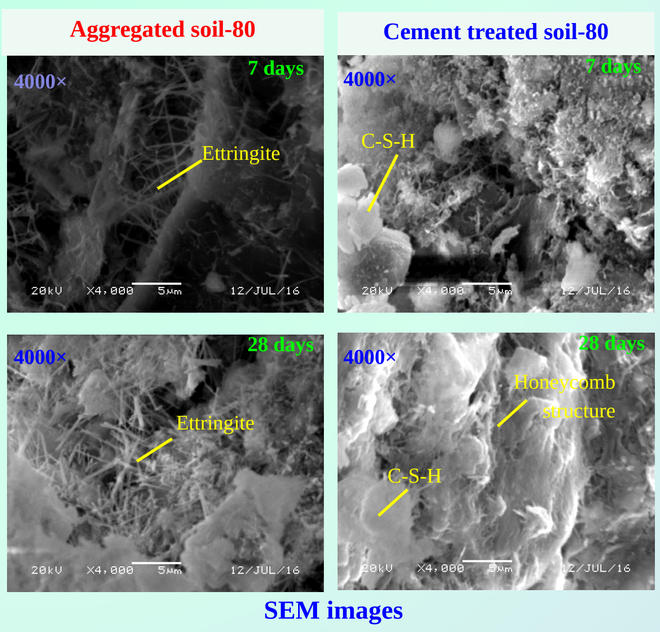


- When increasing the cement content permeability of aggregated soil is increased and the permeability of cement treated soil is decreased
- Aggregated soil has severe condition to erode with higher water flow velocity due to higher coefficient of permeability
- But it shows lower turbidity values which reflect higher erosion resistance even with higher flow velocity

・セメント量を増加させると、団粒化土の場合は透水性が向上し、セメント処理をした土の場合は低下した。
・団粒化土は透水係数が高いめ、間隙の水の流速がくなるが、濁度の数値は低く、高い侵食抵抗が見られた。

Behavior of Strength with curing time of aggregated soil and cement treated soil





SEM images

- Maximum strength of the aggregated soil depended on the cement content and the degree of compaction and enhance when increasing the curing time
- But the strength increment rate of aggregated soil with curing time was a little bit lower than cement treated soil
- As shown in SEM images, a stabilized honeycomb structure has formed in the cement treated soil with 28 curing days, than in aggregated soil
- As a result, it shows a higher strength gain rate and lower permeability in cement treated soil

・団粒化土の最大強度はセメント量と締固め度に依存し、養生期間を長くすると増加した。
・しかし、強度発現率はセメント処理をした土に比べて低かった。
・SEM画像から、養生期間28日において、セメント処理をした土の方が団粒化土に比べてより安定したハニカム構造を形成することが確認された。
・その結果、セメント処理をした土は高い強度増加率と低い透水性を見せた。

本研究に関する担当研究室は桑野研究室です.
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