CAPILLARY CHARACTERISTICS AND SALTWATER PROPAGATION IN FINE AGGREGATE RELATED TO CLIMATE CHANGE INDUCED BY SEA LEVEL RISE

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Introduction

In the context of climate change, sea level rise leads to the expansion of saline soil. Meanwhile, the demand for urban and infrastructure development in coastal cities on saline soils is still a big question. Buildings on the saline ground are faced with the capillary phenomenon. Groundwater contains salt absorbs into materials and concrete and then capillaries on other parts of the building. Salt that chemically interacts with material components causes them to lose the strong bonds, breaking down building's structures. Besides, the capillary is also the reason for the strong growth of mold, which not only affects the quality and life of the building but also causes the loss of its aesthetics. The study of capillary characteristics of the materials that are applicable in geotechnical aspect and numerical simulation of saline transport in those materials are the basis for proposing solutions to design the foundation bed against saline intrusion.

The study of "capillary characteristics and numerical simulation of saltwater propagation in fine aggregate" contributes to satisfying the demand of the infrastructure development on saline soil and also is an urgent, scientific and highly practical issue.

Methodology

Sample preparation:

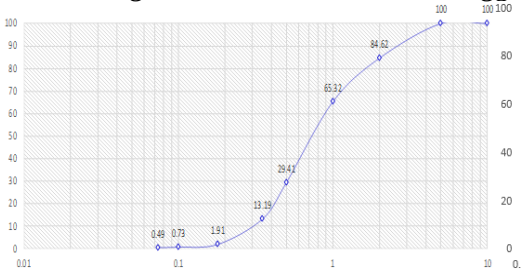
- Field survey and sampling to collect samples, including: 1) natural sand, 25kg; 2) bottom ash from thermal power plant, 25kg; and 3) granulated blast furnace slag (GBFS), 25kg. In the laboratory, the materials were dried and sieved into four grain size groups, i.e. gravel (5 - 2mm), coarse (1-2mm), medium (1 - 0.5mm), fine (0.5 - 0.1mm). Total of 84 specimens were prepared for studying.
- The saltwater solution is prepared for determination of capillary height with salt concentrations are 0.0, 4.95, 9.9, 14.75, 19.8, 24.75, and 33.0 g/L, respectively. These are salt concentrations corresponding to 0, 15, 30, 45, 60, 75 and 100% salinity of natural seawater, if the average salinity of seawater is considered equal 33.0g / L.

Studied methods:

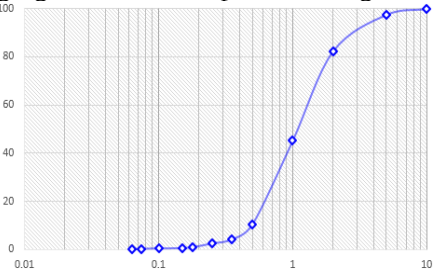
- The method of determining the capillary capacity of fine aggregate (ASTM C1585 - 13),
- The method of determining coefficient of permeability (hydraulic conductivity) by constant head method.

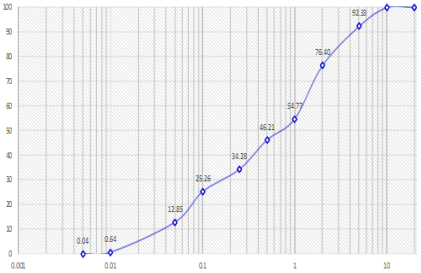
Results

- The grain size distribution of the aggregate used for experiment is given below:



Grain size of natural sand


Grain size of GBFS



Grain size of bottom ash of thermal plant

- Hydraulic conductivity of the aggregate:
+ Permeability coefficient of natural sand and gravel range between $1.39x10^{-5}$–$5.86x10^{-4}$, average: $8.76x10^{-5}$
+ Permeability coefficient of GBFS: $4.36x10^{-5}$ – $7.28x10^{-4}$, average: $1.38x10^{-4}$
+ Permeability coefficient of of bottom ash of thermal plant: $1.86x10^{-5}$-$1.117x10^{-3}$, average: $1.04x10^{-4}$.

- Capillary height of aggregate corresponds to 7 salt concentrations:

+ Natural sand and gravel

Grain size	**Salinity (g/L)**						
	0.0	4.95	9.9	14.85	19.8	24.75	33.0
Fine	39,0	37,0	32,0	31,0	34,5	33,5	31,4
Medium	32.0	30.0	28.0	27.0	22.0	24.0	22.4
Coarse	10,8	9.0	8,5	8.0	6,8	7,2	7,4
Gravel	5,1	4,8	4,60	4,0	4,2	3,8	4,3

+ Granulated blast furnace

Grain size	**Salinity (g/L)**						
	0.0	4.95	9.9	14.85	19.8	24.75	33.0
Fine	27,5	26,5	22,5	23.0	24,8	23,9	20,8
Medium	14.0	13.0	10.0	10,5	11,9	11.0	9.0
Coarse	7,5	7,0	5,8	5,5	6,0	6,3	5,0
Gravel	3,8	3,0	2,3	2,1	3,2	2,6	3,5

+ Bottom ash

Grain size	**Salinity (g/L)**						
	0.0	4.95	9.9	14.85	19.8	24.75	33.0
Fine	36.5	34.0	27.5	29.8	31.2	32.8	26.0
Medium	26.9	25.2	24.5	21.2	20.0	23.2	22.7
Coarse	9.5	7.2	6.0	6.3	5.1	8.8	8.2
Gravel	4.8	4.0	3.0	2.5	2.2	3.5	3.7

Discussion

In all 7 studied salinities, average capillary height gradually increases in the order of granulated blast furnace slag, bottom ash, and natural sand. The capillary height and grain size of aggregate are inversely proportional to each other. Similarly, capillary height is also inversely proportional to the salt concentration in saturated solution, i.e. the more salt concentration in the testing solution is, the less capillary height gets. Indeed, in the natural soil environment, capillary height depends on three dominant factors: grain size, uniformity, and chemical composition.

Conclusions

This study was carried out on 3 types of materials, including natural sand and gravel, granulated blast furnace slag, and bottom ash from thermal power plant including 84 specimens. Saline solutions with seven salt concentrations corresponding to naturally saline intrusion progress in the coastal area were prepared for the testing program. The tests were conducted including sieving analysis, permeability, and capillary experiments. The obtained results showed that the capillary height in the material block was inversely proportional to the salt concentration of the solution. It reached the maximum value when the solution did not contain salt and minimum value with solution at highest salinity tested, i.e. 33.0 g/L. The capillary height in sand is greatest, followed by that in bottom ash of thermal plant, and finally in GBFS. This study supplies the idea on design the civil construction foundation on saline subsoil in the area undergone sea level rise related to climate change.