Effect of Salinity on Consolidation of Peat

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ABSTRACT: Peat is a problematic geotechnical material, which could cause large settlements when subjected to loading because of the consolidation effect. Other than the well known factors which can have an impact on consolidation of peat, according to Zhang and O'Kelly (2013) addition of salt grains also improves the primary consolidation rate of peat specimens. In this research, the impact of salinity of water for the rate of consolidation was analyzed. The samples were mixed prior to and after addition of salt to achieve identical samples. Kaolin clay samples were used as a control specimen and those samples had no considerable effect on consolidation rate with the addition of salt grains. It was found that under similar conditions of one dimensional loading, consolidation rate of peat can be increased with the addition of salt. For quantitative analysis further experiments are required.

1 INTRODUCTION

1.1 *Consolidation of peat*

Peat is a problematic geotechnical material, which causes large settlements when subjected to loading. It consists of decayed organic matter and therefore the characteristics are very different from ordinary soils. It has an extremely high water content, low shear strength and high compressibility. (O'Kelly, 2009) The permeability is also very high in peat and it has a higher secondary consolidation compared to other clayey soils.

1.2 *Factors affecting consolidation of peat*

Compressibility or consolidation of a soft soil depends on the structure and fabric, stress path, temperature, and the rate of loading. (Lerueil, 1996) That means the strain rate can be expressed as a function of stress, temperature and total strain. (Stolle, D.F.E., 1999) It is difficult to express the actual relationship of these parameters with consolidation and material parameters in a laboratory. However the effect of above mentioned factors on compressibility of a soil is well recognized. (Crawfard, 1965)

According to the Terzaghi's theory of consolidation, the time for primary consolidation is proportional to H^2, where H is the drainage length of the soil under consolidation. However interpreting on field soil behavior from laboratory experiments on consolidation is complicated when viscosity of the soil structure is taken into account. (Joseph, 2014).

Other than these well known factors, according to Zhang and O'Kelly (2013) addition of salt grains also improves the primary consolidation rate of peat specimens. They state that more than one third of the salt additives were removed from the treated peat by the way of expelled pore water and because of this the amount of creep or secondary consolidation was also reduced. But due to possible environmental and groundwater pollution, using this method is problematic and they suggest that further research should be done on suitable additives.

Since the composition of peat is mostly organic, there can be reactions with chemical elements and even the composition of peat can be altered. Then compressibility characteristics of peat could also vary with the different elements in water. Hence, consolidation rate of peat may change with the quality of water of which the peat is saturated.

1.3 *Salinity*

Salinity is the measure of all the salt content, usually measured in parts per thousand (ppt) or asa percentage of weight. Salts in the presence of water, are divided into ions. Therefore, water can be easily dissipated when it comes to consolidation, hence an impact can be expected in consolidation rate of peat, with the addition of salt.

In this research the consolidation rate of peat with salinity or in other words with addition of salt is investigated.

2 METHODOLOGY

As mentioned earlier, peat has very high water content which leads to higher settlements when dissipated during the consolidation process. Salt grains consist of Na cations and Cl anions. When they are added into peat, this ionization of salt grains induces the movement of nearby pore water towards them. Dissolving salt grains also release a

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high ion concentration water layer around them, producing electrostatic potential and concentration potential fields that can attract counter ions could be visible in the water on a microscope scale (Zhang and O'Kelly, 2015).

Then the water can easily be removed with loading, with the help of the effect of these ions. Hence the coefficient of permeability is increased and so is the rate of consolidation.

For the process sodium chloride salt was selected to accelerate consolidation since sodium chloride solution has neutral pH. Increases in pH values of the pore water in peat are likely to cause an increase in the rate of decomposition of constituent organic matter. (Pichan and O'Kelly, 2013).

In this research also sodium chloride salt was used for experiments.

2.1 *Materials used in experiments*

Laboratory experiments were performed on saturated peat material and saturated kaolin clay material. Kaolin clay samples were used as the control experiment. Peat material was subjected to wet sieve analysis, hydrometer test, Organic content test and specific density test in order to find the properties of the sample and they are shown in Table 1 and Figure 1.

Table 1.Materialproperties of peat

Property	Value
Sulphate content (%)	25
Chloride content (%)	0
Water content (%)	185
Organic content (%)	32
Specific gravity	2.2

Oedometer test was carried out for the peat sample and kaolin clay sample under similar conditions. Hereafter the sample sets will be identified as P sample and K sample respectively.

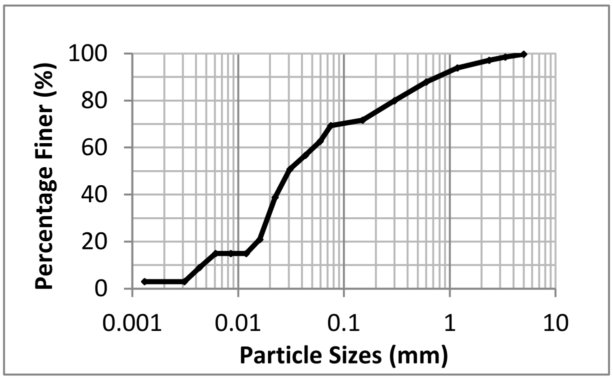

Fig.1 Particle size distribution of peat sample

2.2 *Specimen preparation*

Preparation of sample sets with identical conditions (P and K) was done as described below.

First sufficient amount from soil was selected and then the harder particles such as stones, decayed tree particles, etc. were removed from itmanually. Then the sample was mixed well, for five minutes and was kept for air drying for three days. After that the air dried sample was divided into 5 equal parts, each was 450g in weight. The salt amount added was defined as 2%, 4%, 8% and 16% of weight of initial sample, for the varying concentration of salinity, while all other parameters were maintained constant. One sample was kept in its original condition without adding salt. To prepare the oedometer samples following procedure was followed for each sample.

First the soil sample was mixed with required amount of salt. Since the water content in the soil was not sufficient for mixing, 11 ml of distilled water was also mixed. This water amount added was found by a trial and error method since Atterberg tests were not successfully completed to obtain a liquid limit of peat sample.

This was followed by four minutes of mechanical mixing. After that the soil samples were carefully prepared in pans, avoiding formation of air bubbles inside the sample. Then it was covered with a wet filter paper to protect moisture loss and then wrapped in polythene cover to ensure no moisture would be lost. Then the sample was kept for two days. After two days the samples were used to prepare 50 mm diameter oedometer samples. At the beginning of the tests, water content of all peat samples was between 166%-170%.

K samples were prepared using same procedure. At the beginning of the tests, water content of all kaolin samples was between 66%-77%.

2.3 *Experimental programme*

The sample sets P and K were submerged with distilled water in order to avoid additional salinity concentration changes due to water addition for submerging. They were kept submerged for one day before the oedometer tests were conducted.

Oedometer tests were carried out starting from 5 kN/m^2 to 40 kN/m^2 in loading stages. Unloading was carried out in two stages. Then the results were recorded as per the standards (BS 1377:5) of the oedometer test.

Organic content was found as per the standards of ASTM D 2974, in P sample set and the oedometer samples were used for that after the consolidation test procedure.

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3 TEST RESULTS AND ANALYSIS

3.1 *Test results of oedometer test*

The settlement vs. time taken for settlement graphs of sample sets P, K are shown in Figures 2 and 3, respectively.

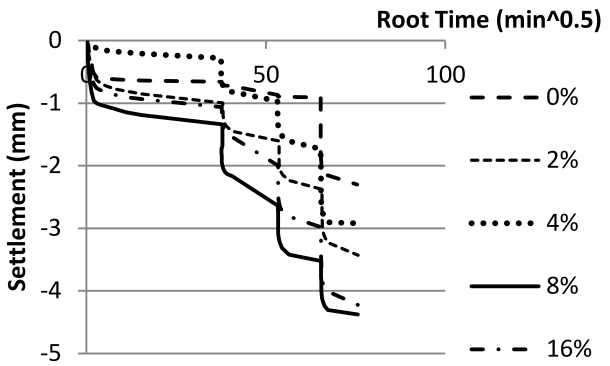

Fig.2 Oedometer test results of sample set P

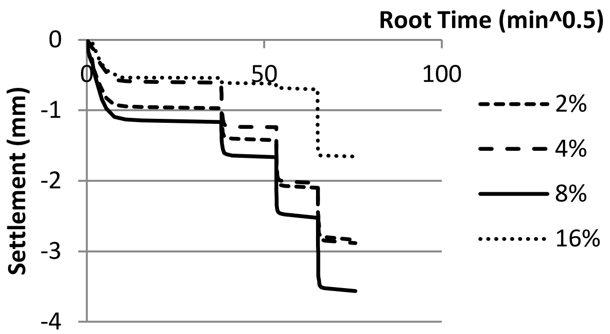

Fig.3 Oedometer test results of sample set K

Coefficient of consolidation c_v from square root time method, Coefficient of Volume Compressibility m_v, Compression index c_c and Secondary compression index c_α of above sample sets were determined for each sample for each loading stage. Results of sample set P are shown in Table 2, 3, 4 and 5.Results of sample set K are shown in Tables 6, 7, 8 and 9.

Table 2.Coefficient of Consolidation c_v (m^2/year)

Sample	Salt added	Loading stages			
		0-5 kPa	5-10 kPa	10-20 kPa	20-40 kPa
1	0%	7	43	67	11
2	2%	10	14	27	1
3	4%	11	10	10	5
4	8%	19	27	9	6
5	16%	13	18	17	9

Table3.Coefficient of Volume Compressibility m_v (m^2/kNx 10^{-3})

Sample	Salt added	Loading stages			
		0-5 kPa	5-10 kPa	10-20 kPa	20-40 kPa
1	0%	7	2	2	4
2	2%	10	6	4	3
3	4%	3	7	4	3
4	8%	13	14	5	3
5	16%	11	10	5	4

Table 4.Compression index c_c

Sample	1	2	3	4	5
Salt added	0%	2%	4%	8%	16%
c_c	1	0.6	0.6	0.6	0.4

Table 5.Secondary compression index c_α x 10^{-3}

Sample	Salt added	Loading stages			
		0-5 kPa	5-10 kPa	10-20 kPa	20-40 kPa
1	0%	6	-	-	7
2	2%	-	-	-	-
3	4%	-	-	-	5
4	8%	-	-	-	-
5	16%	18	19	-	-

Table 6.Coefficient of Consolidation c_v (m^2/year)

Sample	Salt added	Loading stages			
		0-5 kPa	5-10 kPa	10-20 kPa	20-40 kPa
1	2%	2	1	2	2
2	4%	1	1	2	3
3	8%	1	2	4	1
4	16%	1	19	19	3

Table 7.Coefficient of Volume Compressibility m_v (m^2/kNx 10^{-3})

Sample	Salt added	Loading stages			
		0-5 kPa	5-10 kPa	10-20 kPa	20-40 kPa
1	2%	10	5	4	2
2	4%	6	7	4	2
3	8%	12	5	5	3
4	16%	5	8	4	2

Table 8. Secondary compression index c_α x 10^{-3}

Sample	Salt added	Loading stages			
		0-5 kPa	5-10 kPa	10-20 kPa	20-40 kPa
1	2%	3	5	5	6
2	4%	5	3	7	7
3	8%	4	5	8	7
4	16%	0.5	-	-	2

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Table 9. Compression index c_c

Sample	1	2	3	4
Salt added	2%	4%	8%	16%
c_c	0.3	0.5	0.4	0.4

Table 2 and 6 describes the impact of addition of salt on coefficient of consolidation. With the results it can be clearly seen that the addition of salt has not created a considerable impact in K (kaolin clay) sample while there is a considerable impact in P (peat) sample. Also, the addition of salt has increased the consolidation rate. Though the impact cannot be confirmed since sample 4 (8% salt added) sample has higher consolidation rate than sample 5 (16% salt added) sample, it can be only concluded that the impact on coefficient of consolidation seems to be increasing with the addition of salt in peat samples.

Table 3 and 7 describes the impact of addition of salt on volume compressibility. In both samples, it has been reduced with increase of loading; hence the results cannot used to conclude the effect on m_v of peat. Table 4, 5 and 6, 7 describe the impact of addition of salt on secondary compression and compression index. It can be clearly seen that c_c has been decreased with the increasing of the salt amount added to the samples. Here also there cannot be seen an identifiable alteration in sample set K and sample set P, since both show this impact. However, the compression index c_c values are higher in sample set P than sample set K. Therefore, these comparisons confirm the effect of salinity on consolidation is higher in peaty soil types while it has a low impact in non-organic soils like kaolin clay.

Furthermore, Figure 2 shows that the creep effect is also increased compared to Figure 3, with the addition of salt. That means the creep consolidation in peat samples is also affected by the salt addition, since kaolin clay sample does not show any creep consolidation.

Calculated sulfate, chloride and organic contents of five samples of sample set P are shown in Table 10 to identify the end condition of samples.

Table 10.Chloride, Sulphate and organic contents of sample set P

Sample	Salt added by weight	Sulphate content (%)	Chloride content (%)	Organic content (%)
1	0%	0.6	0.02	40
2	2%	0.7	0.4	42
3	4%	0.7	0.6	42
4	8%	0.6	1	44
5	16%	0.6	1.7	47

It can be seen that the sulfate condition is identical in all samples but the chloride content has increased with addition of salt, which is anticipated. Also the organic content of all samples are similar and that confirms that the 5 samples are identical to a greater extent.

4 SUMMARY AND CONCLUSION

Under similar conditions of one dimensional loading, consolidation rate of peat can be increased with the addition of salt grains. That means the coefficient of permeability also change with addition of salt grains compared to the original condition. Since the secondary consolidation is higher than normal, creep consolidation effect can be expected to be minimized since higher settlements have occurred at the beginning. However, quantitative analysis cannot be done with this experiments and further research should be done in order to find a measurable impact.

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