Effect of Clay Content on Permeability and Compaction Parameters of Sand

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Abstract - The permeability is an important engineering property of soils. A knowledge of permeability is essential in a number of soil engineering problems, such as settlement of buildings, yields, seepage through and below the earth structure. It controls the hydraulic stability of soil masses. The permeability of a soil depends upon many factors like particle shape and size, void ratio, degree of saturation, adsorbed water etc. In the present experimental study, the effect of clay content on the permeability of sand has been studied. Moreover, the effect of clay content on the compaction parameters of sand viz optimum moisture content and maximum dry density has also been determined experimentally. The result shows the permeability of sand decreases with the increase of clay content and the relation is non-linear. Moreover, the variation of compaction parameters with change in clay content have also been presented.

Keywords: clay content, permeability, optimum moisture content, maximum dry density, grain size analysis, bentonite.

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I. INTRODUCTION

Permeability of soil is an important parameter for the engineering projects like reservoirs, canals, earthen dams etc. to control the loss of precious water through soil by seepage and for the safety of projects (Arora, 1992). In general, when the earthen dam or other water retaining structure is built on pervious foundation, the loss of water by seepage are very high and impervious layers or other means like diaphragm walls, concrete grouts etc. are provided to check the loss of water through the foundation. Similarly when a canal passes through a pervious strata, the loss of water through seepage needs to be controlled (Singh and Chowdhary, 1994). In the present experimental study, the effect of clay content on the permeability of sand has been studied (Noor and Singh, 2012). Moreover, the effect of clay content on the compaction parameters viz optimum moisture content and maximum dry density has also been determined experimentally.

II. MATERIALS AND EXPERIMENTAL PROGRAMME

In the present study, the sand used was fine sand from Yamuna river and bentonite was used as clay material having the clay content of 89.2% by mass. The liquid limit and plastic limit of bentonite were 332% and 37.9%. The differential free swell index of bentonite was 1050%. The sand and bentonite were classified as SP (Poorly Graded Sand) and CH (Clay of High Compressibility) (IS:1498 -1970). The grain size curve of sand and bentonite are presented in Figure 1. The bentonite was mixed with sand in different proportions viz. 5%, 10%, 15% and 20% and each mix was subjected to standard proctor test (IS 2720 Part VII: 1980) for determining the maximum dry density.
and optimum moisture content. The permeability test was carried out on sand-bentonite mixes at 98% MDD by falling head method (IS 2720 Part XVII: 1986).

The results of MDD and OMC are presented in Table 1 and relation between dry density and moisture content for sand-bentonite mixes are shown in Figure 2.
III. RESULTS AND DISCUSSIONS

(a) Effect of Clay on Dry Density

Table 1 summaries the effect of bentonite on the dry density of sand. The maximum dry density increases with increase of the clay content from 0% to 10% and further increase in the clay content reduces the maximum dry density. The increase in the dry density can be attributed to the fact that clay particles fills the voids of sand and increases the dry density. But further addition of clay increases the water requirements of soil and reduces the dry density of sand – bentonite mix. The effect of clay content on dry density is shown in Figure 3.

(b) Effect of Clay on Optimum Moisture Content

Table 1 summaries the effect of clay content on the optimum moisture content of sand. The optimum moisture content increases with the increase of clay content from 0% to 20% in the sand. The increase in the water content
The permeability of sand decreases with the increase of clay content. The relation between permeability and percentage clay content is presented in Figure 5. The decrease in the permeability of sand can be attributed to the fact that the clay reduces the void ratio of sand. The curve between permeability and clay content percentage is nonlinear. The relation can be represented by the equation,

$$k = 0.001e^{-0.58c}$$  \hspace{1cm} (1)

Where,

\[ C = \text{Percentage of Clay Content in percent} \]
IV. CONCLUSIONS

The following conclusions can be drawn from the experimental study,

1. The addition of clay in sand increases the maximum dry density up to 10% clay content and further addition of clay decreases the maximum dry density.
2. The addition of clay in sand increases the optimum moisture content.
3. The addition of clay reduces the hydraulic conductivity of sand. The effect is very prominent up to 10% clay content and beyond that reduction in permeability is gradually decreases.

V. ACKNOWLEDGEMENT

The authors are grateful to Shri Murari Ratnam, Director, CSMRS for his kind support and encouragement at all stages of the present work.

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