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# Effect of Glass Beads on Permeability of Sand

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***Abstract*: Permeability is also known as hydraulic conductivity which is the property that represents the ease with which water flows through porous media it is one of the most important physical properties of soil used in geotechnical engineering. It is essential for calculating the quantity of underground seepage under various hydraulic conditions, in common practice, the permeability coefficient is usually obtained by constant head permeability test, and is utilized in settlement, and stability calculations. In the field of geotechnical engineering, permeability has a significant influence on the consolidation characteristics of soil and as a consequence of drainage, on the mobilization of shear strength of soils. Glass is a material composed of amorphous silica and the main chemical composition of glass is the same as natural sand, so the chemical properties of glass are similar to those of sand. Glass and sand are similar in single-grained structure and natural density. Corrosion resistant and acid-resistant glass can therefore be used in civil engineering. The permeability performance of glass can be inferred to be ahead of sand through the analysis. This project report presents a comparison of hydraulic conductivities of different sand such as calcareous sand, river sand and manufacturing sand and the effect of glass beads on the hydraulic conductivity of calcareous sand, river sand and manufacturing sand. The permeability value or hydraulic conductivity is estimated by constant head method in laboratory. The addition of glass beads into the sand results in decreasing the value of permeability. It seems to have a decrease in the permeability value and attaining a constant value even when percentage of glass beads added. While comparing, the river sand has low permeability value with respect to the permeability value of manufacturing sand and calcareous sand. Maximum permeability value obtained for calcareous sand on addition of 30% of glass beads is $5.02 \times 10^{-4}$ cm/s. Maximum permeability value for river on addition of 25% glass beads is $5.88 \times 10^{-4}$ cm/s and for M sand on addition of 35% glass beads is $5.20 \times 10^{-4}$ cm/s. The permeability value depends on the structure of soil mass, grain size etc. Hence the hydraulic conductivity of sand can be reduced by increasing the amount of glass beads.**

***Keywords*: Calcareous sand, Glass beads, Hydraulic conductivity, Msand.**

## 1. Introduction

The capacity of a soil to permit the passage of fluids through its inter connecting voids, is one of the most important soil engineering properties. The study of the permeability of soils is important in soil mechanics. Permeability is also known as hydraulic conductivity which is the property that represents the ease with which water flows through porous media it is one of the most important physical properties of soil used in geotechnical engineering. The rate of settlement of saturated soils under load, the stability of slopes and retaining structures, the design of filters made of soil, and the design of earth dams are some of the examples of applications of permeability in geotechnical engineering. It is essential for calculating the quantity of underground seepage under various hydraulic conditions, in common practice, the permeability coefficient is usually obtained by constant head permeability test, and is utilized in settlement, and stability calculations. These problems are extremely important for environmental aspects such as waste water management, slope stability control, erosion, and structural failure related with the ground settlement issues. The drainage and water movement in fine-grained soils are of primary importance to geotechnical engineering, soil science, and hydrology. In the field of geotechnical engineering, permeability has a significant influence on the consolidation characteristics of soil and as a consequence of drainage, on the mobilization of shear strength of soils. Glass is a material composed of amorphous silica and the main chemical composition of glass is the same as natural sand, so the chemical properties of glass are similar to those of sand. Glass and sand are similar in single-grained structure and natural density. Corrosion resistant and acid-resistant glass can therefore be used in civil engineering. In addition, recycled glass waste particles are nearly the same as glass; Particles of glass are free of acute angles, and the surface of glass particles is smoother than sand, so that it is easier for glass particles to overcome friction resistance in fluid. The permeability performance of glass can be inferred to be ahead of sand through the analysis.

This report presents a comparison of hydraulic conductivities of different sand such as calcareous sand, river sand and manufacturing sand and the effect of glass beads on the hydraulic conductivity of calcareous sand, river sand and manufacturing sand. The permeability value or hydraulic conductivity is estimated by constant head method in laboratory. The addition of glass beads into the sand results in decreasing the value of permeability. While comparing, the river sand has low permeability value with respect to the permeability value of manufacturing sand and calcareous sand.

## 2. Methodology

The materials such as river sand, calcareous sand, M sand and glass beads are collected prior to the experiment. The engineering properties of river sand, calcareous sand and Msand was found using sieve analysis, specific gravity test, relative density test, permeability tests and direct shear test.

The experimental test conducted was permeability test. Permeability of river sand is determined and the permeability test was done for river sand after addition of 2 % of glass beads. Then the test was repeated on addition of 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20%, 25%, 30%, 35%, 40% of glass beads and corresponding permeability value is determined.

Permeability of calcareous sand is determined and the permeability test was done for calcareous after addition of 2 % of glass beads. Then the test was repeated on addition of 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20%, 25%, 30%, 35%, 40% of glass beads and corresponding permeability value is determined.

Permeability of calcareous sand is determined and the permeability test was done for calcareous after addition of 2 % of glass beads. Then the test was repeated on addition of 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, 20%, 25%, 30%, 35%, 40% of glass beads and corresponding permeability value is determined.

### A. *Permeability test/hydraulic conductivity test*

The test conducted was constant head permeability test to determine the hydraulic conductivity of various sand like river sand, calcareous sand, M sand and the effect of glass beads at different percentage on hydraulic conductivity value. Permeameter apparatus is used for this test. Mould is placed on the base plate, first porous plate is placed up on the base plate and filter paper over it, Sand is filled in three layers by tamping. Level the top surface place a filter paper and a porous plate above it. Cover it with top lid and connect to water reservoir. Allow the water to flow and measure the quantity of water collected for a fixed time interval. Repeat the procedure by placing the glass beads layer of different percentage at bottom and top of sand specimen in the mould. Fig.1 shows the permeameter apparatus used

Fig. 1. Permeameter apparatus

## 3. Results and discussion

Permeability is the property that represents the ease with which water flows through porous media it is one of the most important physical properties of soil used in geotechnical engineering. The rate of settlement of saturated soils under load, the stability of slopes and retaining structures, the design of filters made of soil, and the design of earth dams are some of the examples of applications of permeability in geotechnical engineering. It is essential for calculating the quantity of underground seepage under various hydraulic conditions, in common practice, the permeability coefficient is usually obtained by constant head permeability test, and is utilized in settlement, and stability calculations.

### A. *River sand*

By conducting a series of laboratory experiments such as sieve analysis, specific gravity, relative density, permeability and direct shear test the properties of the sand was determined. The specific gravity obtained was 2.66, which points out that it is a slightly silty sand. The particle size distribution analysis obtained from sieve analysis is shown below.

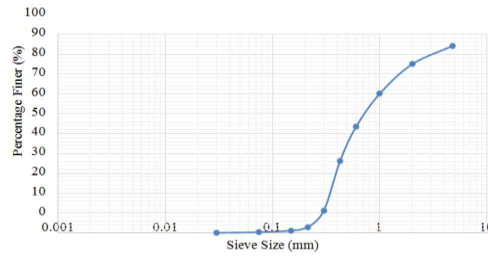


Fig. 2. Particle size

From the particle size distribution graph, the coefficient of uniformity obtained was 2.37 and the coefficient of curvature obtained was 0.72.

The relative density test in the sand was done using the vibrating table apparatus. The dry density in medium condition is obtained as 1.587 g/cc and it is taken for further calculations. The permeability of the parent soil was found using the permeameter apparatus. The coefficient of permeability is obtained as $9.17 \times 10^{-4}$cm/s.

Table 1
River sand properties

| **Index Properties** | **Value** |
|---|---|
| Specific gravity | 2.66 |
| Uniform coefficient | 2.37 |
| Coefficient of curvature | 0.72 |
| Relative density | 1.58 |
| Permeability value | 9.17x10-4 |
| Direct shear strength(ø) | 26° |

### B. *Calcareous sand*

By conducting a series of laboratory experiments such as sieve analysis, specific gravity, relative density, permeability and direct shear test the properties of the sand was determined. The specific gravity obtained was 2.73, which points out that it is a slightly silty sand. The particle size distribution analysis obtained from sieve analysis is shown below.

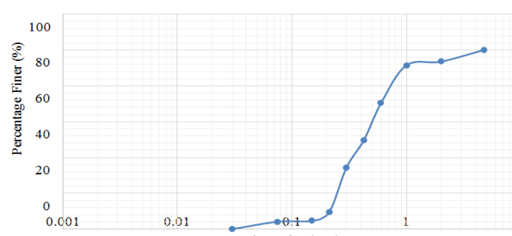


Fig. 3. Particle size

From the particle size distribution graph, the coefficient of uniformity obtained was 2.33 and the coefficient of curvature obtained was 0.73.

The relative density test in the sand was done using the vibrating table apparatus. The dry density in medium condition is obtained as 1.48 g/cc and it is taken for further calculations. The permeability of the parent soil was found using the permeameter apparatus. The coefficient of permeability is obtained as $9.24x10^{-4}$ cm/s.

Table 2
Calcareous sand properties

| Index Properties | Value |
|---|---|
| Specific gravity | 2.73 |
| Uniform coefficient | 2.33 |
| Coefficient of curvature | 0.73 |
| Relative density | 1.48 |
| Permeability value | 9.24x10-4 |
| Direct shear strength(ø) | 36° |

### C. *M sand*

By conducting a series of laboratory experiments such as sieve analysis, specific gravity, relative density, permeability and direct shear test the properties of the sand was determined. The specific gravity obtained was 2.63, which points out that it is a slightly silty sand. The particle size distribution analysis obtained from sieve analysis is shown below.

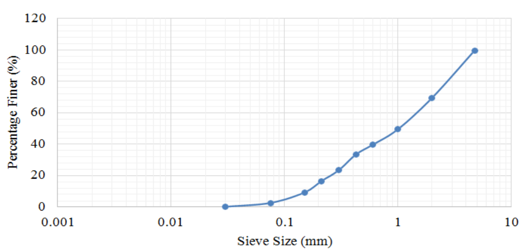

Fig. 4. Particle size

From the particle size distribution graph, the coefficient of uniformity obtained was 9.06 and the coefficient of curvature obtained was 0.63.

The relative density test in the sand was done using the vibrating table apparatus. The dry density in medium condition is obtained as 1.80 g/cc and it is taken for further calculations The permeability of the parent soil was found using the permeameter apparatus. The coefficient of permeability is obtained as $9.37x10^{-4}$ cm/s.

Table 3
M sand properties

| Index Properties | Value |
|---|---|
| Specific gravity | 2.63 |
| Uniform coefficient | 9.06 |
| Coefficient of curvature | 0.63 |
| Relative density | 1.80 |
| Permeability value | $9.37x10^{-4}$ |
| Direct shear strength(ø) | 29° |

### D. *Test results*

The constant head permeability test was conducted to obtain the hydraulic conductivity or permeability value. Constant head permeability tests series were conducted to examine the hydraulic conductivity of the sand composite, starting with the pure sand specimen, progressing to the sand containing various percentages of glass beads. The percentages of glassbeadsintroducedtothesandspecimenswere2%,4%,6%,8%, 10%,12%,14%, 16%,18%,20%,25%,30%,35%and40%.

The graph obtained for percentage of glass beads and hydraulic conductivity of river sand.

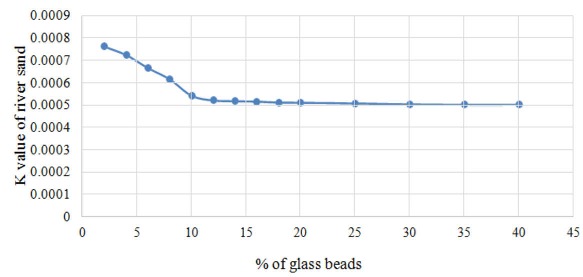

Fig. 5. % of glass beads vs. K value

In Fig. 5, represents the K value of river sand with respect to the addition of percentage of glass beads added. It seems that the K value decreases and found to be constant on addition of 30% of glass beads addition. Maximum permeability value obtained for calcareous sand on addition of 30% of glass beads is $5.02x10^{-4}$cm/s.

The graph obtained for percentage of glass beads and hydraulic conductivity of calcareous sand.

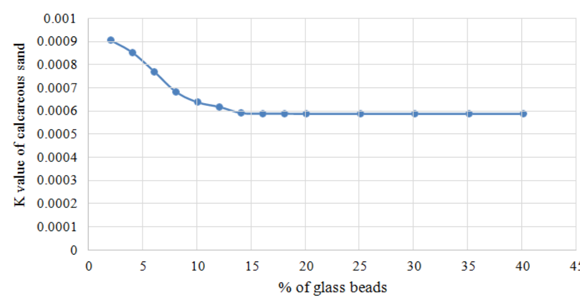

Fig. 6. % of glass beads vs. K value

In Fig. 6, represents the K value of calcareous sand with respect to the addition of percentage of glass beads added. It seems that the K value decreases and found to be constant on addition of 20% of glass beads addition. Maximum permeability value for river on addition of 25% glass beads is 5.88 $x10^{-4}$ cm/s.

The graph obtained for percentage of glass beads and hydraulic conductivity of M sand

In Fig. 7, represents the K value of M sand with respect to the addition of percentage of glass beads added. It seems that the K value decreases and found to be constant on addition of 35% of glass beads addition and Maximum permeability value for M sand on addition of 35% glass beads is 5.20 $x10^{-4}$cm/s.

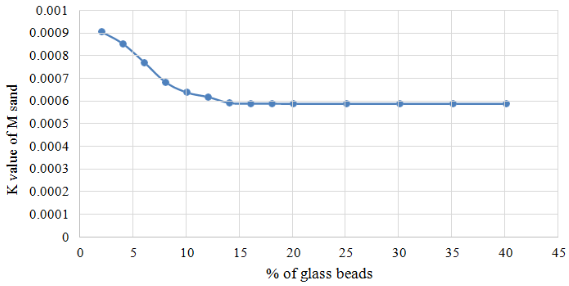


Fig. 7. % of glass beads vs. K value

### *E. Comparison*

The combined graph obtained for percentage of glass beads and hydraulic conductivity of M sand, Calcareous sand and River sand.

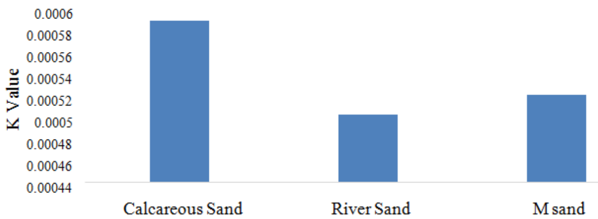


Fig. 8. Variation in K value

Graph describes that calcareous sand has highest hydraulic conductivity value and river sand has lowest hydraulic conductivity value when compared between calcareous sand – glass beads mixture, river sand glass beads mixture and M sand –glass beads mixture. Calcareous sand taken for test contains grains of larger diameter compared to river sand and M sand therefore it has greater K value. When M sand particles are considered it has some larger particles along with finer particles therefore the K value for Msand seems to be slightly greater than river sand. River sands taken for the test are fine particles and it results to have a lower K value when compared to other types of sand. Hence, K value of coarse grained soil is very large as compared to that of fine grained sand.

## 4. Conclusion

- Index properties and engineering properties were determined.
- Addition of glass beads in sands reduces the permeability value K.
- In calcareous sand, addition of 30%, 35%, and 40% of glass beads shows constant K value.
- In river sand, addition of 35% and 40% of glass beads shows constant K value.
- In M sand, addition of 35% and 40% of glass beads shows constant K value.
- Comparing the 3 sands, river sand shows less K value on addition of glassbeads.
- K value depends on the shape of particles, structure of soil mass, grain size etc.

## References

[1] Mojtaba G. Mahmoodlua, Martinus Thvan Genuchten, “Unsaturated hydraulic properties of heterogeneously packed sands: A porescale computational study,” Journal of hydrology, 2018.
[2] F. C. Wang, X. N. Feng, H. Gong, H. Y. Zhao, “study of permeability of glass-sand soil” Archives of civil engineering, vol. 63, no. 3, 2017.
[3] Gang Li, Xiao-Sen, Chai Li, “Measurement of Permeability and Verification of Kozeny-Carman Equation Using Statistic Method” Science Direct, 2017.
[4] Kapil Panwar, Ankit Laddha, D. G. M. Purohit, “Enhance the Performance of Permeability of Fine Sand Using Ceramic Tiles Waste and Plastic Waste as Admixture,” Journal of Engineering Research and Application, vol. 7, no. 11, 2017.
[5] Jagdish Prasad, D. G. M. Purohit, “The Permeability Influence of Dune Sand Mixed with Bentonite,” International Research Journal of Engineering and Technology, 2017.
[6] A. Barnhoorn, Menaf Alsafi, “Permeability of layered glass bead Samples,” Journal of hydrology, 2017.