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Reduction of Seepage Velocity of Sand using Polypropylene fibre

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Abstract:

Piping is a problem that commonly occurs downstream of hydraulic structure under the influence of upward seepage. Piping is considered as the main mechanism of hydraulic structure failures. In this work an experimental programme was set for determining the seepage velocity and piping resistance for both unreinforced and randomly distributed sand sample. The experimental test is proposed to be carried out for different fibre content (0%, 0.5%,1%,1.5%,2%).Discharge velocity and seepage velocity of water flow through unreinforced and reinforced samples will calculate. Seepage velocity of reinforced sample is compared with unreinforced sample. The expected result is that the inclusion of fibres will reduce the seepage velocity and improve the piping resistance

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Keywords — **PP fibre, piping resistance, seepage velocity, randomly distributed, one dimensional piping test**

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I. INTRODUCTION

Piping is a problem that commonly occurs downstream of hydraulic structure under the influence of upward seepage. Piping is considered as the main mechanism of hydraulic structure failures. In this work an experimental programme was set for determining the seepage velocity and piping resistance for both unreinforced and randomly distributed sand sample.The experimental test is proposed to be carried out for different fibre content(0%,0.5%,1%,1.5%,2%).Discharge velocity and seepage velocity of water flow through unreinforced and reinforced samples will calculate. Seepage velocity of reinforced sample is compared with unreinforced sample. The expected result is that the inclusion of fibres will reduce the seepage velocity and improve the piping resistance

Continuous piping phenomena on hydraulic structures causes structural damage.From 1970s investigators such as Gray and Ohashi (1983), Maher and Gary (1990), Woods (1990),Yetimoglu et.al. (2003) and Yetimoglu and Salbas (2005) studied the mechanical behavior of soil reinforcement that doing the various tests on the sandy soil samples randomly reinforced and show that adding fiber on soil increasing the soil strength.

The fibers effectively restrict soil particles movement. Polypropylene fibers are effective in controlling seepage and improving the piping resistance of soils. The inclusion of fibers reduced the seepage velocity, increased the piping resistance and increased the critical hydraulic gradient hence, delaying the occurrence of piping

II. MATERIALS

A.Sand

The sand used for the test was collected from the campus of Marian Engineering College, Kazhakuttom, Trivandrum. Sand particles passing through 4.75 mm sieve were used for the experimental investigation. Fig 1 and TABLE 1 shows the particle size distribution curve and properties of sand respectively. The sand have specific gravity 2.6 with uniformity coefficient, C_u 1.5 and coefficient of curvature C_c 0.99.

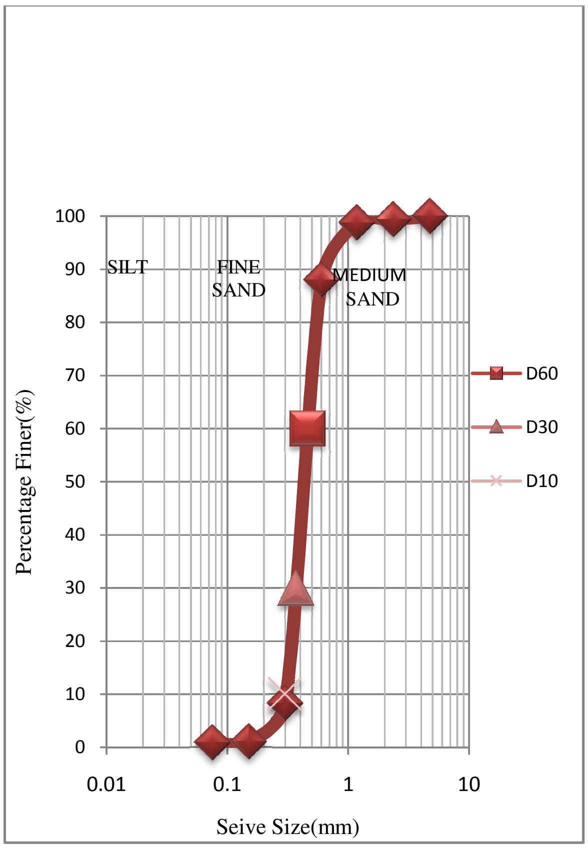

Fig 1 Particle size distribution of sea sand

TABLE 1

PROPERTIES OF SEA SAND

Sl. No.	Properties	Result
1.	Percentage of gravel	0
2.	Percentage of sand	99.5
3.	Percentage of clay and silt	0.5
4.	Uniformity Coefficient, C_U	1.5
5.	Coefficient of Curvature, C_C	0.99
6.	Specific Gravity	2.6
11.	Angle of Shearing Resistance	39^o
12.	Cohesion (kg/cm^2)	0.2
13.	Classification of soil	SP

B.Polyropylene fibre (PP fibre)

Polypropylene (PP) fibre was used in this study. PP fibre is the most widely adopted synthetic fibre for soil reinforcement. TABLE 2 summarises the physical and mechanical properties of the test fibre

TABLE 2

PHYSICAL PROPERTIES OF POLYPROPYLENE FIBRE

Properties	Value
Type	Polypropylene fibre (PP)
Cross-section type	circular
Equivalent diameter (mm)	0.0557
Length Lf(mm)	20mm

III. METHODOLOGY

Piping behavior sea sand was studied and compared with that of specimen prepared by mixing polypropylene fibre. The experimental setup used in this study is shown in Fig. 2. It consisted of a tank 25 cm in diameter and 40 cm in height with an attached graduated scale to measure the level of water. The mould for the soil specimen has a diameter of 10cm and height of 11.7cm.The soil mixture was filled in the cylindrical mould and then the mould was connected to the water tank. Water was connected to the water tank. Water was permitted to flow through the sample in an upward direction and discharge was collected in measuring jar. The experiments were conducted for different fibre content (0, 0.5%, 1%, 1.5%, 2%) and fibre length 20mm. When the hydraulic head reached a certain level, small bubbles and local boiling were observed and finally the specimen failed by piping. A schematic illustration of upward seepage test system is shown in Fig 3

Fig. 2 piping test setup

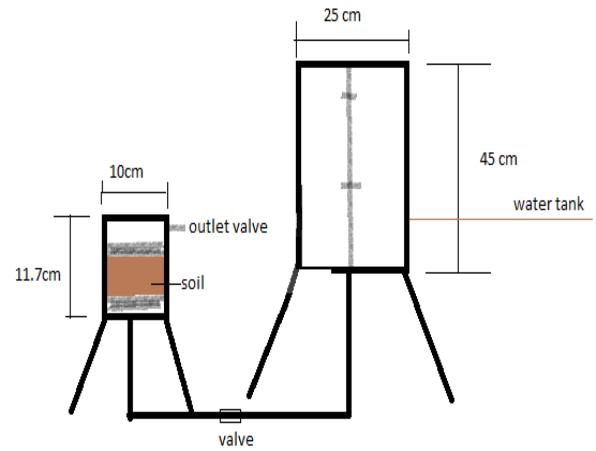

Fig. 3 schematic illustration of upward seepage test

Seepage velocity was obtained by the following relationships,

Vs=v/n, (1)

Where, Vs, v, n, seepage velocity, discharge velocity, porosity respectively and v is obtained by,

Q=Axv (2)

Where, Q = V/t, (3)

V is the volume of discharge, t, time of discharge (cm^3/s) and A, area of the specimen.

IV. RESULTS AND DISCUSSIONS

A. Variation of permeability

The result of variable head permeability test is shown in Fig 4. The test is conducted for the fibre content 0.5%, 1%, 1.5%, 2% and for fibre length 20mm. The results shows that the permeability decreases for sand as fibre content increases. TABLE 3 shows the permeability test. This is because an interlocking between sand and fibre is formed in turn reduces the void space.

TABLE 3

SUMMARY OF PERMEABILITY TEST

Fibre content(%)	Permeability (cm/s)
0	$6.1X10^{-3}$
0.5	$4.5X10^{-3}$
1	$3X10^{-3}$
1.5	$2.7X10^{-3}$
2	$1.9x10^{-3}$

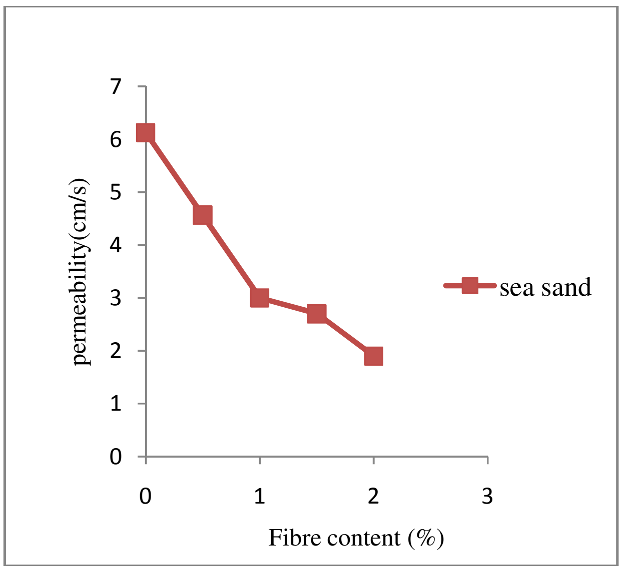

Fig 4 Variation of permeability with fibre content

B. Seepage velocity- fibre content

Fig 5 shows the hydraulic seepage velocity-fibre content plot for sea sand. The seepage velocity decreases with increase in fibre content. Similar trend also shown by Yang.et.al (2017).Table 4 shows the summary of seepage test. The seepage velocity decrease as fibre content increases due to decrease in void ratio and blocking of pore space of sand by fibres replacing sand solids.

TABLE 4

SUMMARY OF SEEPAGE TEST

Fibre content(%)	Seepage velocity(cm/s)
0	$1.4x10^{-5}$
0.5	$8.3x10^{-6}$
1	$3.23x10^{-6}$
1.5	$1.5x10^{-6}$
2	$2.1x10^{-7}$

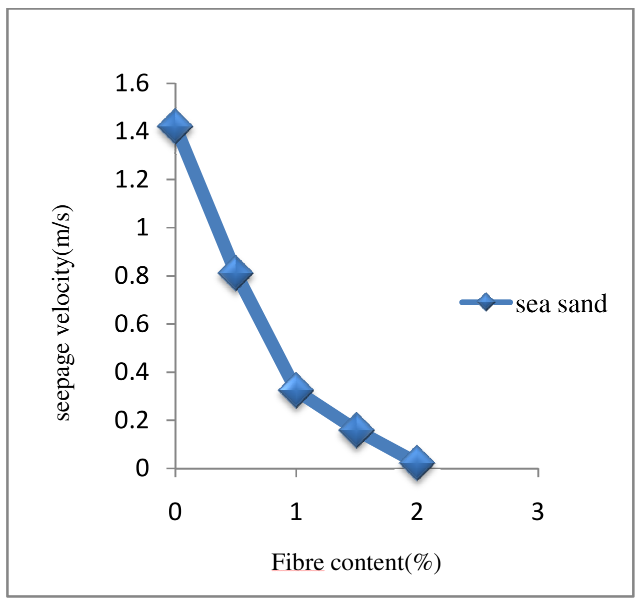

Fig. 5 Seepage velocity-fibre content plot

V.CONCLUSION

Experimental studies have been carried out on sand mixed with fibers and their effect on the seepage and piping resistance is studied. The study shows that the addition of fibres in sand is an effective method in improving the piping resistance of sand. Inclusion of fibres in sand reduced the lifting of individual soil particles. Sand mixed with polypropylene fibre shows an improved resistance to the piping due to higher shear resistance offered by the fibre.

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