SOIL STRUCTURE INTERACTION WITH BURIED PVC PIPES

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ABSTRACT

The Behavior of PVC (poly vinyl chloride) pipes has been studied in this paper with a view to explore its wide use in civil engineering constructions. The buried or the submerged pvc pipes in the soil plays a vital role in the applications of drainage systems, oil pipelines, sewages etc. Load on a buried pipe is not exactly equal to the weight of the soil over the pipe. Experimental investigations are carried out to find out the effect of diameter and flexibility of buried pvc pipe. The main objective of this research is to investigate load deformation behavior of pvc pipes at a depth of 5 cm, 10cm and 15 cm in loose and medium dense state of soil by performing model tests with automated data acquisition and graph is plotted between load Vs settlement. From the test results it is concluded that the deformation of pipe was reduced with the increase of soil height over the pipe. It was observed that the main reason of reduction in pipe deformation is due to the reduction in intensity of stress on pipe surface at greater depth. The deformation depends on the density of back fill and it also depends on diameter of the pipe with a proportional relationship . So when pipe is placed at larger depths the load intensity and settlement decreases.

Keywords: Soil interaction, pvc pipes, plate load test, load deflection behavior.

1.INTRODUCTION

The Behavior of underground structures is usually complicated in comparison with super structures. This is mainly due to the soil-structure interaction, which in many cases can hardly be predicted. PVC (poly vinyl chloride) pipes can be installed under roads in either the longitudinal or transverse direction. Many researchers have focused on this topic and developed different testing set ups to study the soil-pipe interaction. Although extensive tests in connection with single and double buried pipes under different conditions have been performed, and valuable information involving soil-pipe interaction was obtained in that piece of research, the testing system was only able to apply monotonic loads.

In general there are two methods in placing a pipe. The first method is to provide a backfill to hold the pipe firmly to protect it from mechanical damage. The second is to provide support against the pipe and earth where there is an live load pressure acts. In soil structure interaction with buried PVC pipes the soil density and pipe depth plays a vital role The main objective of this research is to investigate load deformation behavior of pvc pipes at a depth of 5 cm, 10cm and 15 cm in loose and medium dense state of soil by performing model tests with automated data acquisition. A series of test on the single buried pipes was performed, using this model to evaluate the role of different factors on the soil behavior such as soil density, pipe buried depth, load cycles and amplitudes, constraint conditions, etc. The description of the testing system, testing materials, and testing results are presented and discussed in the following sections.

2. MATERIALS

Fine Aggregate:

Locally available river sand is utilized in this study . The preliminary test was carried out and the test results are tabulated in table 1.

Table.1 Properties of Sand

Properties	Values
D_{60} ,mm	1.80
D_{30} ,mm	1.30
D_{10} ,mm	0.66
Cc	1.42
Cu	2.72
Classification	SP

Void ratio:

It is defined as the volume of voids to volume of solids.Void ratio for loose and compacted state are tested in an acrylic tank of size 25x25x25 cm and the results are tabulated in table 2.

Table 2: Void Ratio

Type of soil	Loose soil	Compacted soil
Wt of sand in (gms)	22485 g	26379g
Volume(V)	15625cm^3	15625cm^3
Γd	1.43 g/cc	1.68 g/cc
Specific Gravity(G)	2.6	2.6
e max	0.81	-
e min	-	0.54
$e = (e_{max} + e_{min})/2$	0.67	

PVC pipes:

A Rigid polyvinyl chloride pipes (PVC) of 50 mm diameter and 25 cm length is chosen in this study. These pipe posses a high flexural and compressive strength. The properties of PVC pipes are tabulated in table 3.

Fig 1: PVC pipe of 50 mm diameter

Table 3: Physical properties of Rigid PVC

Property	Rigid PVC
Density [g/cm3]	1.3–1.45
Thermal conductivity [W/(m•K)]	0.14–0.28
Yield strength [psi]	4500-8700
Young's modulus [psi]	490,000
Flexural strength (yield) [psi]	10,500
Compression strength [psi]	9500
Coefficient of thermal expansion	5×10^{-5}
Vicat B [°C]	65–100
Restivity [Ω m]	10^{16}
Surface restivity [Ω]	10^{13}–10^{14}

3.METHODOLOGY

Stabilisation of PVC in tank:

An Acrylic tank of size 25 x 25 x 25 cm is chosen for the study. The tank should be completely dry before sand filling. The sand is filled in three layers in medium dense state and the pipe is placed at different depths like 5 cm, 10 cm and 15 cm.

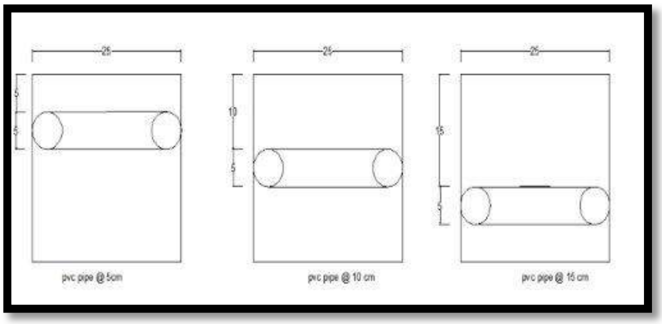

Fig 2: PVC Stabilisation

Plate load test:

The specimen is mounted on the axial loading machine which consists of linear variable displacement transformer (LVDT) to check the axial displacements, load cell to measure the load intensity for corresponding displacements. The load cell and the LVDT are connected to data logger and the readings are observed. The test setup of the loading frame is shown in Fig 3.

Fig 3 : Plate load test setup

Initially the test was carried out placing the pipe at a depth of 5 cm .The steel plate of size 8.5 x 8.5 cm was used above which load is distributed uniformly in axial compression. The load Vs Displacement readings are noted down and the graphs are plotted. Similarly test procedure was repeated by placing a pipe at 10 cm and 15 cm . The results are tabulated in table 4, 5 and 6 and the corresponding graphs in Fig. 4, 5 & 6 respectively.

Table 4: Load Vs Displacement with respect to pipe at 5-cm

Load intensity, kN/m^2 @ 5cm	Displacement, mm
0	0
0.1	2
0.2	5
0.3	6
0.4	9
0.5	11
0.6	13
0.7	15
0.8	18
0.9	22
1	26
1.1	32
1.2	36
1.3	42
1.4	49

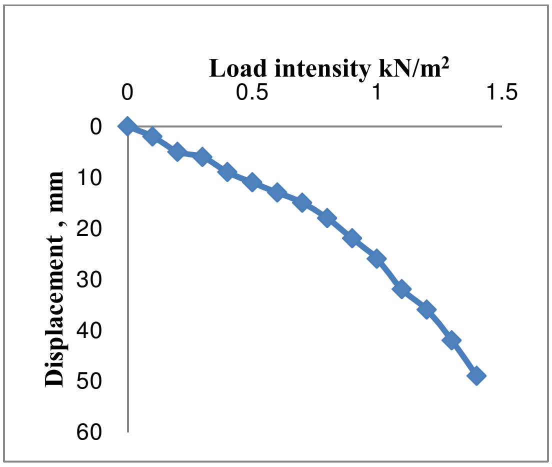

Fig 4: Graphical representation - Pipe @5cm depth

Table 5 :Load Vs Displacement with respect to PVC at 10-cm

Load intensity, kN/m^2 @10cm	Displacement, mm
0	0
0.1	2
0.2	3
0.3	4
0.4	6
0.5	7
0.6	8
0.7	11
0.8	14
0.9	17
1	21
1.1	32
1.2	47

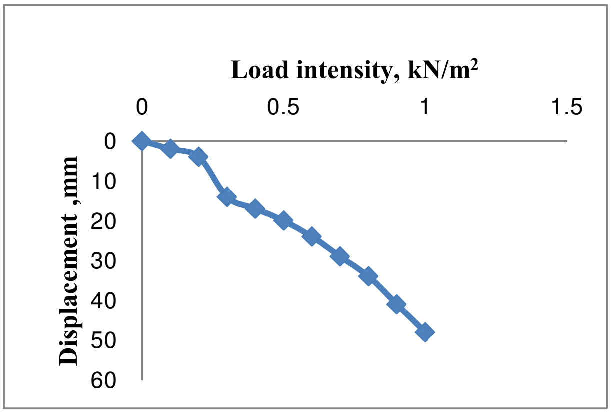

Fig 5: Graphical representation - Pipe @ 10 cm depth

Table 6 : Load Vs Displacement with respect to PVC at 15-cm

Load intensity, kN/m^2 @15cm	Displacement, mm
0	0
0.1	2
0.2	4
0.3	14
0.4	17
0.5	20
0.6	24
0.7	29
0.8	34
0.9	41
1	48

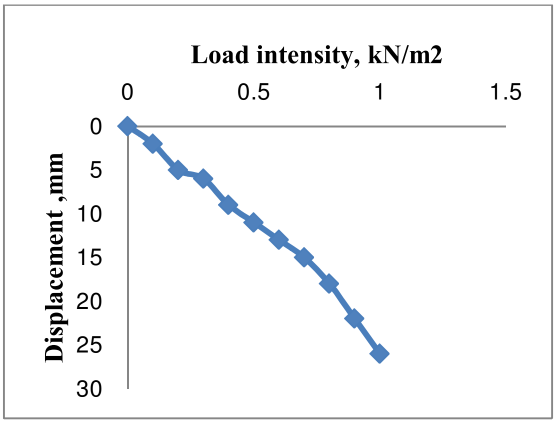

Fig 6: Graphical representation - Pipe @15-cm depth

4.RESULTS AND DISCUSSION

From the pipe line interaction with soil ,it is vividly seen that the enomorous change in the bearing capacity is due to the horizontal factor which is diameters of the pipe. It is observed that the failure occurred due to excessive displacement of the loading plate when the pipe is placed at 5 cm depth .The load effect on pipe decreases gradually in 10 cm and 15 cm depth respectively as in Fig 7.

Load carrying capacity of the pipe increases with the increase in the depth of the pipe. A bar diagram is drawn between the Depth Vs Ultimate load as shown if Fig 8 and the results are tabulated in table 7.

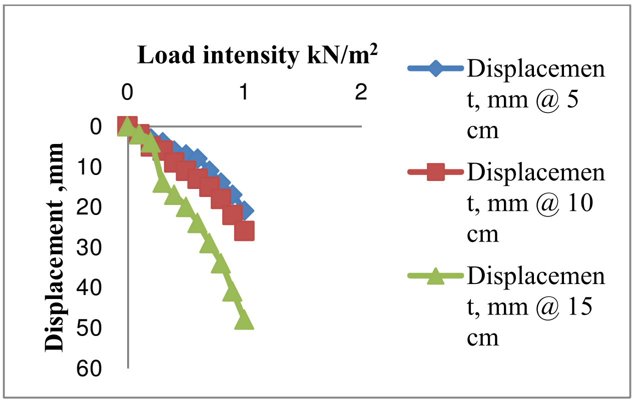

Fig 7: Graphical representation for comparing 5,10,15 cm depth

From the above graph it clearly states that the load intensity is more on pipe at shorter depth and vice versa it increases at larger depths.

Table 7: Depth Vs Ultimate load with respect to pipe

Depth cm	Ultimate load kN/m^2
5	1.4
10	1.2
15	1

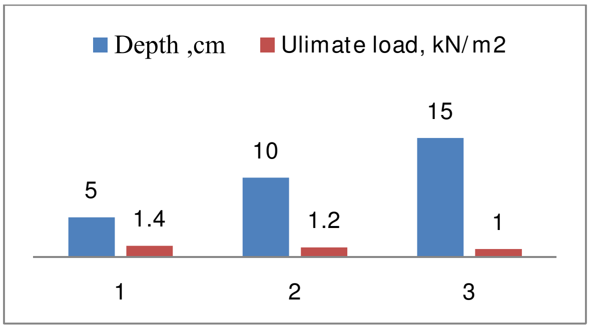

Fig 8: A bar diagram representing Depth Vs Ultimate load

5.CONCLUSIONS

In this work based on the tests carried out to study the behaviour of buried rigid PVC pipes at various positions, the following results are concluded that,

1) The Load bearing capacity of pipe is more effective as depth increases.

2) It is also observed that the pipe has higher resistance to load distribution when the soil is higher above the pipe.

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