GEONET AS A SOIL REINFORCEMENT SYSTEM FOR THE PROTECTION OF BURIED PIPELINES

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Abstract - *Buried pipelines cover a critical part of our modern infrastructure. To protect the public and for a trouble-free transport of resources society will rely more on buried Infrastructure. These pipelines are subjected to traffic and construction loads in addition to the dead weight of the soil. Geosynthetic materials have been used in a broad range of ways to improve the performance of buried pipes and conduits. This study aims to determine the suitability of using geonet in the protection of such pipelines. Tests were conducted in a scaled down model for both reinforced and unreinforced condition in sandy soil under static loading. Electric strain gauges were installed at the crown of pipe for measuring strain on the pipe. The performance of the pipe was examined both in reinforced and unreinforced case. Experimental results are validated with Plaxis 3D software. The study lead to a conclusion that geonet can use efficiently in protecting pipelines.*

***Key Words*: Buried pipelines, Geonet, Traffic loads, Strain, Plaxis 3D**

1. INTRODUCTION

Buried pipeline systems are commonly used to transport water, sewage, natural oil/gas and other materials. They are classified as lifelines since they carry essential materials for the support of human life .Repeated vertical loads like traffic loads cause a severe hazard. Methods of relieving stress and strain, reducing surface deflection, and reducing deflections in buried pipes and conduits include: induced trenches, casings, and more recently, geosynthetics. Geosynthetics potentially offer a number of innovative and economical methods to enhance the performance of the pipe-soil system. Geosynthetics, which are factory-manufactured polymer materials in sheets (e.g., geotextiles, geogrids, geonet and geomembranes) or cells (e.g., geocell), can be used as a stand-alone protection, or as a supplement to one of the other methods of protecting pipes and improving their performance. Geosynthetics have been used extensively to reinforce soil in retaining walls, embankments, and pavement applications. The geonets are planar products and they are very similar to geogrids. They consist of ribs in 2 directions. Thickness of a geonet is much larger than that of geogrid.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials used

The sand used for the study was dry sand. Properties of the sand are given in table 1. The sand was classified as well graded. Chart -1 represents grain size distribution of sand.

Table -1: Properties of sand

Properties of sand	
Specific Gravity (G)	2.65
Effective Particle Size D_{10}	0.135
Coefficient of uniformity C_u	6.67
Coefficient of curvature C_C	2.96
Angle of Internal friction	36°

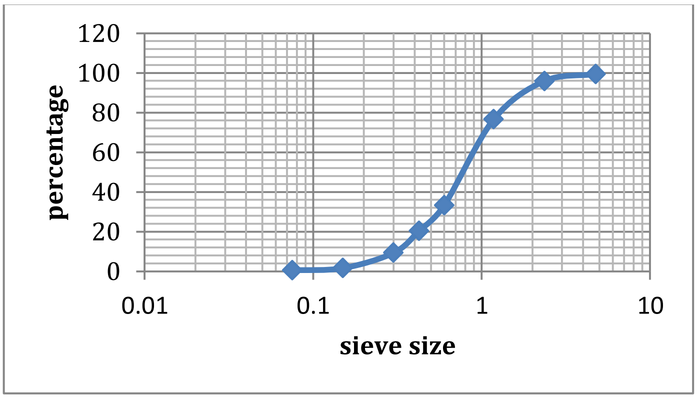

Chart -1: Grain size distribution of sand

Geonet having thickness 2.75mm is used as soil reinforcement. PVC pipe of diameter 75mm and 2mm thickness is used for the study.

2.2 Methodology

The study aims to investigate the effect on pipe under static loading in both unreinforced and reinforced condition. Traffic loads are the most frequent loads that act on buried pipelines. Equivalent single l axle whee load 8170 kg is selected as design load [2]. Here load acting on a single wheel is considered. The load is then scaled down as per scaling laws [5]. To simulate vehicle tire contact area, a steel pate of size 150mm x 150mm x 20mm is used. As per provision of IS 1888-1962, the width of the test tank should not be less than 5 times the width of the test plate. Therefore a tank of size 900mm x900mm x 600mm is used for testing. The tank was made of steel and necessary stiffening is provided on the sides of tank to avoid bulging of the tank. Height of fall method was chosen to fill the sand in the tank. Loading was given by means of a manually operated hydraulic jack. Dial gauge was used to measure the plate settlement.

For measuring strain on pipe electric strain gauges were used. Maximum displacements and stresses are occurred at the middle of pipe.[3].Strain gauges (120 ohm) were mounted on the crown of pipe exactly below loading. These are connected to a strain indicator through Whetstones Bridge. The strain indicator gives strain values in micro strains. It has measuring capacity up to 20,000 micro strains. Fig -1 shows the placing of pipe and strain gauge in tank.

Fig -1: strain gauge mounted on pipe

Pipe was placed at a depth of 1.5B (where B is the width of steel plate) from the top surface of soil.[4] Length of pipe was made 1mm less than the size of tank to avoid boundary effects.[1] Caps are provided at both ends to avoid entering of soil particles inside the pipe.[1] Geonet was placed at a depth of 0.1m from the top. Width of geonet was 3.2B, where B is the width of steel plate[6] Height of fall selected for filling the sand in tank. The scaled down value of design load was 500kg. Loading was continued for a settlement of 25mm.

2.3 Results and Discussions

Experiment was conducted for unreinforced and reinforced case and obtained ultimate bearing capacity as 88Kpa and 267kPa respectively. The strain on pipe for different loads was also measured. Chart 2 represents the bearing pressure settlement response of sand bed. From the figure it is clear that use of geonet increases the load carrying capacity of sand bed. It gives very minute settlement when compared to unreinforced condition. This is because of the resistance provided by the geonet against downward movement of soil due to loading. Char-t 3 represents comparison of strain values at the crown of pipe for different loading conditions.

Reinforcement system provides a smaller value for strain on pipe. Compared to unreinforced case 30% reduction for 45kPa loading and 25% reduction for 88kPa loading were observed for reinforced case.

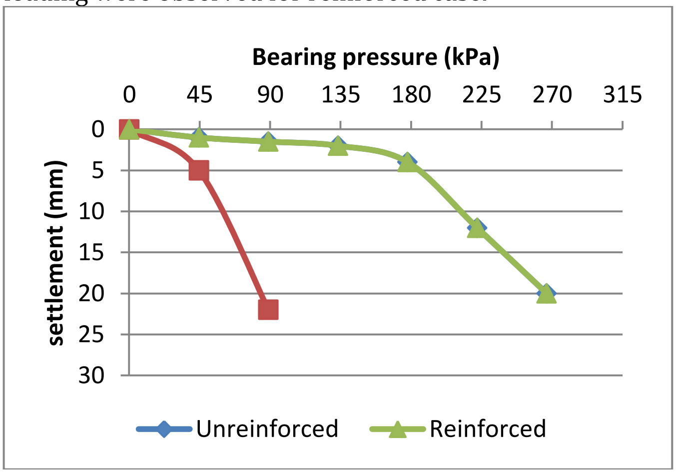

Chart -2: Variation of bearing pressure with plate settlement for different conditions.

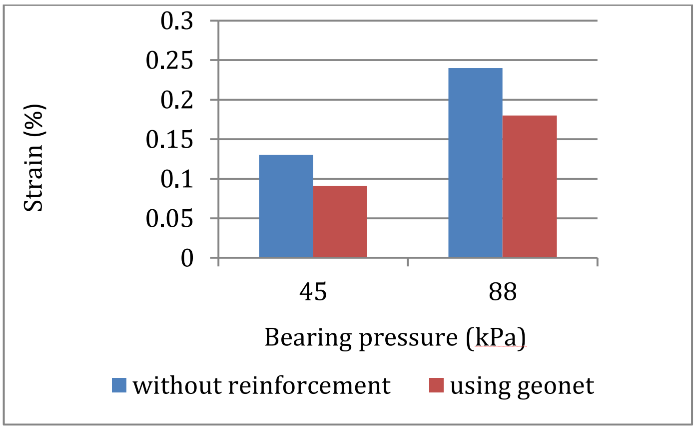

Chart -3: Strain values at the top of pipe for different conditions.

3. NUMERICAL STUDY

Numerical study was carried out using PLAXIS 3-D Software. PLAXIS is a finite element package intended for 3- dimensional analysis of deformation, stability, and groundwater flow in geotechnical engineering. Many geotechnical projects involve the modeling of structures and the interaction between the structures and the soil. Mohr –Coulomb model was used to simulate the soil. The Mohr-Coulomb model is a simple and well-known linear elastic Plaxis model. It is based on Hooke's law of isotropic elasticity. Pipe was modeled using polycurve tool and plate element. Geonet was modeled using geogrid structural element available in Plaxis.

The simulation was carried out for both unreinforced and reinforced case. The plate settlement behaviour, strain on pipe, and vertical stress distribution were observed in both the cases. Chart 4 represents the plate settlement behavior for both the cases. It shows similar behaviour as that obtained from experimental study.

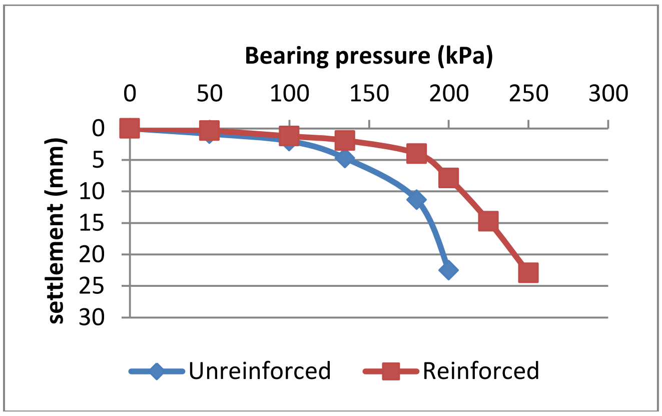

Chart -4: Variation of bearing pressure with plate settlement for different conditions.

Fig-2 and Fig-3 shows the total normal stress acting on pipe. An obvious reduction in stress was obtained in presence of geonet reinforcement.

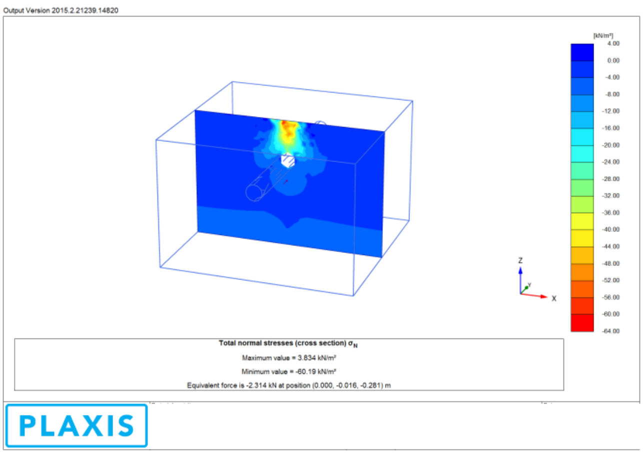

Fig -2: Vertical stress distribution in unreinforced condition.

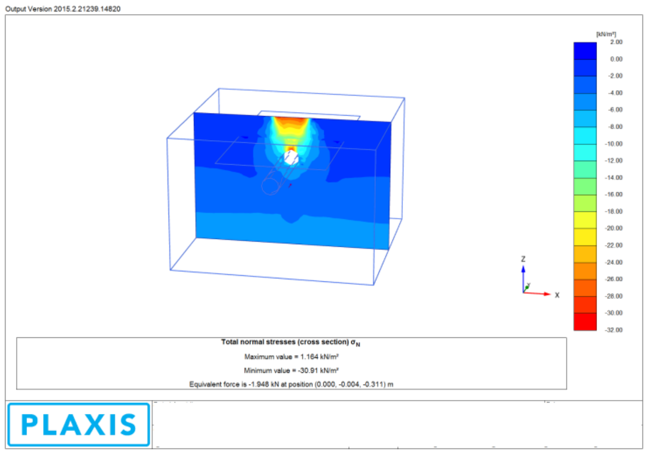

Fig -3: Vertical stress distribution in reinforced condition

Fig-4 and Fig-5 shows the strain values on the top of the pipe for both the cases under 77.5kPa pressure, which is the ultimate bearing capacity of unreinforced soil obtained from numerical analysis. A substantial reduction in strain values were obtained for reinforced case.

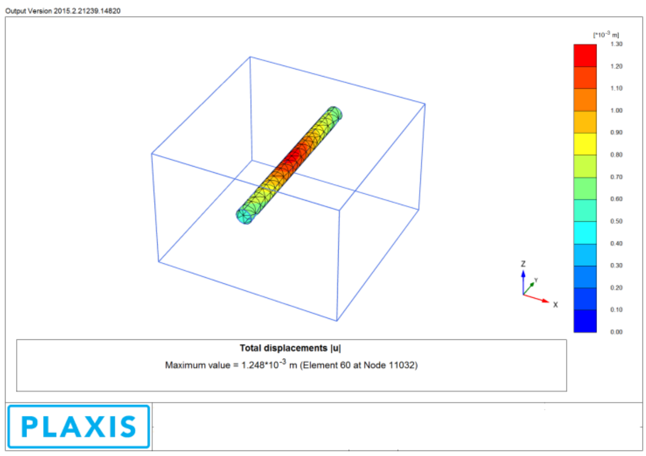

Fig -4: Strain on pipe under unreinforced condition

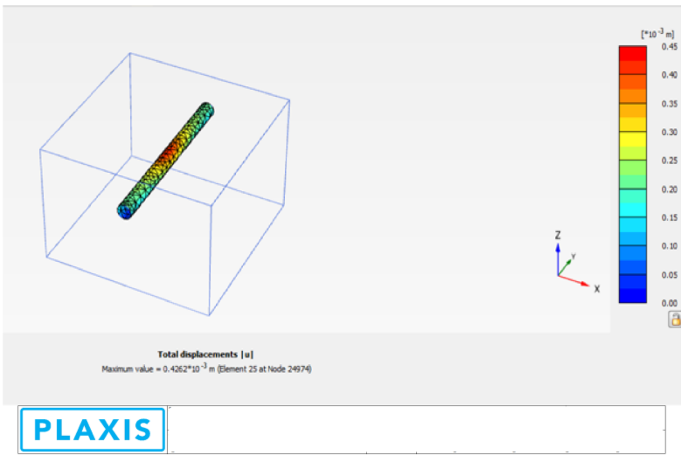

Fig -5: Strain on pipe under reinforced condition

4. CONCLUSIONS

Experimental study was conducted to determine the suitability of using geonet for the protection of buried pipelines. Results indicate that geonet provide a proper reinforcement to the soil system which reduces the stress acting on the pipe. More than 65% increase in pressure value and 25% reduction in strain on pipe were obtained. A good agreement in measured strain values on the pipe was observed between the experimental and numerical studies.

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