Performance of Steel Pile Wrapped With Bidirectional GFRP

Annie Sweetlin Jebarani.J.P[1], Linga Krishna.C[2], Harish.K[3], Karkuvel Raja.B[4], Santhosh Kumar.S [5]

[1]Associate Professor, Department of Civil Engineering, Velammal College of Engineering and Technology, Madurai, Tamil Nadu, India
[2,3,4,5]UG Student, Department of Civil Engineering, Velammal College of Engineering and Technology, Madurai, Tamil Nadu, India

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Abstract – *GFRP has become one of the most popular materials due to its ease of applications and the special physical characteristics. Glass Fiber reinforced polymers, a relatively new class of non corrosive, high strength, light weight material have over the past approximately 15 years emerged as practical materials for a number of structural engineering applications. Furthermore, some of the more common GFRP applications in Civil Engineering structures and design rules are described in detail, including their bond with steel plates, wraps for steel to have a contact with the soil. In the field of Civil Engineering Glass Fiber reinforced polymers is wrapped with the steel and act as a good roughness material and enhances the steel to produce more interfacial friction. Pile with Bidirectional GFRP Wrapping not only increase the strength but also the ductility considerably. The life span of Bidirectional GFRP wrapped pile will be more and there is no need of maintenance*.

Keywords: ***Bidirectional GFRP, Specific gravity, Relative density, Direct Shear Test, Interface friction, Dynamic Load Test***

1. INTRODUCTION

Piles are generally used to transfer the load from superstructures to the deeper harder soil strata. . Piles of timber, steel, or concrete are driven into the ground to support a structure in the modern civil engineering Piles are driven into the ground by pile drivers, machines consisting usually of a high frame with appliances for raising and dropping a pile hammer or for supporting and guiding a stream or air hammer.

Glass Fiber Reinforced Polymer are first developed in the mid 1930's, GFRP has become the staple in the building industry. GFRP is made of continuous glass fibers embedded in a polymeric resin matrix and additives. Because of the non-corrosive nature of GFRP bars, they have been regarded by the engineering community as a promising alternative to steel reinforcement in concrete infrastructure.

GFRP is more durable, non-corrosive and cost effective. Pile with GFRP Wrapping not only increase the strength but also the ductility considerably. The Ductility increases as the number of layers of wrapping increase.

2. MATERIAL PROPERTIES

The type of soil sample Used for the study is ordinary river sand. Preliminary tests were conducted to find out the Index properties of cohesion less soil and are listed in **Table 1.** The fibre chosed for the study is Glass fibre reinforced polymer (GFRP) and it is Bidirectional. The properties of the fibre are listed in **Table 2.** Mild steel plates of size 6cm x 6cm x 0.6cm were used in the experiments.

Table 1: Index properties of sand

S.No	PROPERTY	VALUE
1	Specific Gravity	2.62
2	Fineness Modulus	4.63
3	Uniformity Coefficient	3.5
4	Coefficient of curvature	1.785
5	Minimum Density (kN/m^3)	15.63
6	Maximum Density (kN/m3)	17.50
7	Relative Density	50%
8	Test Density (kN/m3)	16.37

Table 2: Properties of Bidirectional GFRP(E-Glass)

S.No	Fibre Property	Bidirectional GFRP
1	Density (kN/m3)	24.90
2	Tensile Strength(MPa)	3400
3	Modulus(GPa)	72
4	Percent Elongation	4.7

2.1 BIDIRECTIONAL GFRP

Glass fiber is a material consisting of numerous extremely fine fibers of glass. Glass Fiber Reinforced Polymer (GFRP) rebar is made of continuous glass fibers embedded in a polymeric resin matrix and additives. Because of the non-corrosive nature of GFRP bars, they have been regarded by the engineering community as a promising alternative to steel reinforcement in concrete infrastructure.

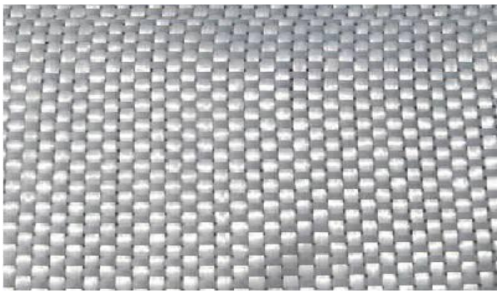

Figure 1: Bidirectional GFRP

2.2 Steel Pile

Steel piles are a big screw, made of galvanized steel with a helical flange that not only helps to insert the pile, but also helps secure it into the ground. By using a mini-excavator with special attachments, a drill can enter the ground while measuring the load bearing capacity of the soil. The two steel piles of dimensions we used are 3.34cm and 4.3cm.

a) Unconfined **b) Bi- GFRP**

Figure 2: Unconfined and Bidirectional GFRP Wrapped Steel piles of Dia 3.34cm and 4.3cm

3. METHODOLOGY

As per Indian Standard Soil Classification System (ISCS) IS: 1498-1970, the soil is classified as **poorly graded sands or gravelly sands with little or nofines.** The direct shear test was adopted to find the shear strength of soil and hence the interface friction angle. The interface frictional strength study was carried out in a conventional direct shear apparatus as per IS 2720 Part XIII -1983, with the shear box of size 6cmx6cmx2cm and the steel plate specimen of size 6cmx6cmx0.6cm. The experimental set up is shown in **Figure 3.** The shear test was conducted for control samples Soil – Soil, Steel – Soil, Mild Steel GFRP Wrap – Soil.

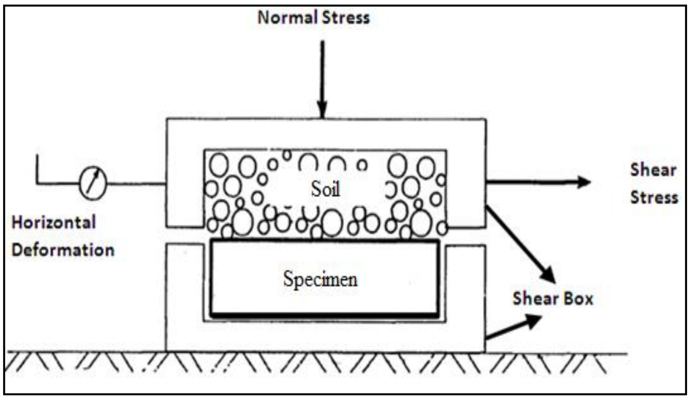

Figure 3: Experimental set up for Direct Shear test

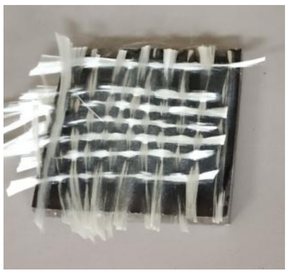

Figure 4: GFRP wrapped With Steel plate

3.1 Dynamic load Test

The ultimate load capacity formulas are based on the principle that the resistance of a pile to further penetration by driving depends upon the energy imparted to the pile by hammer. To apply a load, an impact ram or heavy block (drop hammer) is dropped onto the Bidirectional GFRP Wrapped Pile. The GFRP wrapped piles to be driven is graduated for every 5 cm and the blow count for every 5 cm settlement is noted

Figure 5: Dynamic Load Test

4. RESULTS AND DISCUSSION

4.1: Normal Vs Maximum Shear stress in Poorly Graded sand

The conventional direct shear test was conducted for various normal stress and the maximum shear stress was found. The variation of Normal and Maximum shear stress for Poorly graded sand is shown in **Figure 6.** It was found that as the Normal stress was increased the maximum shear stress also increased. The tensile strength of fibre also has a significant impact on the interface friction.

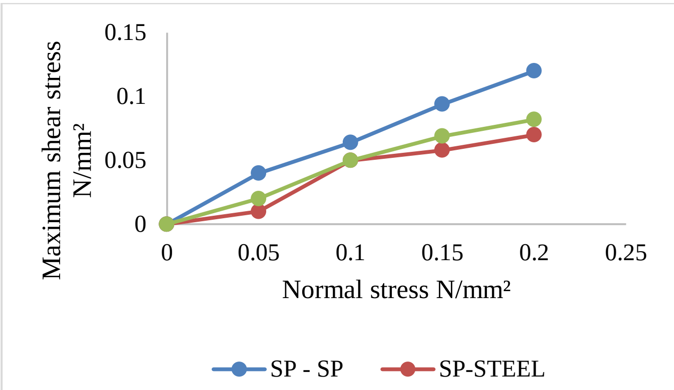

Figure 6: Normal Vs Maximum Shear stress in Poorly Graded sand

4.2 Internal / Interface Friction Angle

It is essential to determine the interface strength between soil and geotechnical structures to make a good estimation of load transfer between structures and soils. GFRP is wrapped with the steel and act as a good roughness material and enhances the steel to produce more interfacial friction. The interface frictional strength study was carried out in a direct shear test apparatus.

Table -3: Internal /Interface Friction Angle

Samples	Internal/Interface Friction Angle
Soil – Soil	$35^0$13’19”
Steel – Soil	$23^0$18’50”
Bidirectional GFRP - Soil	27° 12' 11.39"

4.3 SAFE LOAD BASED ON DYNAMIC LOAD TEST

The allowable load Q_a is the safe load which the pile can safely and is determined on the basis of (i) ultimate bearing resistance divided by suitable factor of safety, (ii) the permissible settlement, and (iii) overall stability of the pile foundation.

Engineering news formulae:

The Engineering News formula was proposed by A.M. Wellington (1818) in the following general form.

$$Q_a = \frac{WH}{F(S + C)}$$

Where,

Q_a = Allowable load in kg
W = Weight of hammer (Short hammer 2.6Kg)
h = Height of fall in cms
S=Final settlement per blow known as set
F=Factor of safety (usually taken as 6)
C=Empirical constant (2.5cm for drop hammer & 0.25cm for single and double acting hammer)

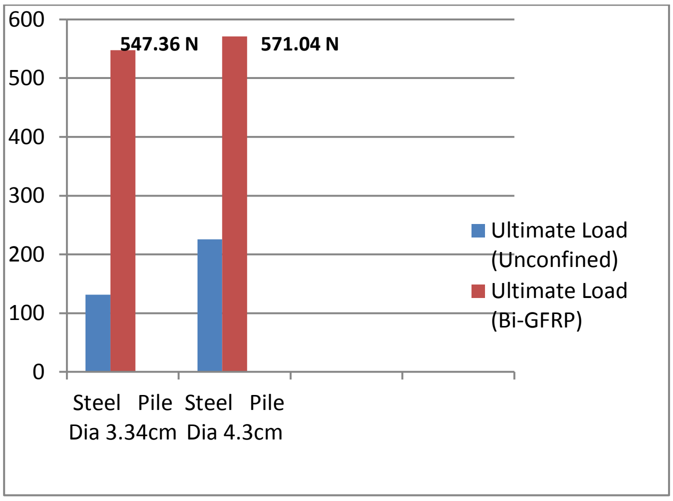

Chart -1: Bar Chart for Dynamic Load Test

5 .CONCLUSIONS

In poorly graded sands, the ultimate load of unconfined pile dia 4.3cm was found to be 225.83N and by comparing this to the ultimate load of pile wrapped with GFRP sheets it is obtained that the ultimate load increases by 152.859%, The ultimate load of unconfined pile dia 3.34cm was found to be 131.74N and by comparing this to the ultimate load of pile wrapped GFRP sheets, it is obtained that the safe load increases by315.5%

1. Finally we conclude that pile with Bidirectional GFRP Wrapping has high Interface Shear Strength and high load bearing capacity compared to the unconfined pile.
2. Pile with Bidirectional GFRP Wrapping is more durable, non-corrosive.
3. Pile with Bidirectional GFRP Wrapping not only increase the strength but also the ductility considerably.
4. The life span of Bidirectional GFRP wrapped pile will be more and there is no need of maintenance.

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