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BEHAVIOR OF GLASS FIBER REINFORCED PIPE CONTRACTED IN CLAYEY SOIL (CASE STUDY: AL-HINDI DISTRICT SEWAGE NETWORK)

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ABSTRACT

Behavior of glass fiber reinforced pipes includes several important points which are as worthy to study as the main aim of present study which is to find stability represented by pipes deflection. To find pipes deflection, it was decided to take AL-Hindi district Sewage network as a case study. The diameter of Grp pipe was selected of 1.4m that to be made in KSA. Two methods have been chosen to check stability and behavior of this type of pipes under real field condition. The first method was done by using AWWA formula, while the second method was performed by using finite element analysis which is done by plaxis 3D software. It was found that the maximum predicted value of pipe deflection reached the value of (2.9388%) at maximum depth of (10) m but when applying finite element method the above maximum mentioned deflection was reduced to (0.6744 %) at the same maximum depth of (10) m. The significant difference between the two values which have resulted by using the two different methods can be attributed to the technique used in these two methods and the personification of field condition in each method. Both results consider safe value according to specification limit 5% with difference of safety factor degree. Field test must be done to find measured deflection which is considered Conclusive evidence and degree of pipe line stability.

Keywords: pipe stability, safety analysis, stress simulation, installation condition.

INTRODUCTION

Many researches were done in this field to find stability parameter with time and soil effect on deflection value; some researcher got to find deflection with traditional method by AWWA formula. Another researcher went to use software with the same condition and make field test for case study and to compare these Results together (Lee *et al*., 2015); other work evaluate pipe line using the same material of native soil and back filling, But The change will happen in pipe stiffens. To evaluate Stiffness effect on stability parameter (Ch.E.), 2001), some paper paid attention to measure initial, long term deflection by checking readings which directly read from installed dial gauge immediately after installation, after period of complete filling to read final, long term deflection(Faria et al., 2005), (Lee *et al*., 2015). one of these project was in SAUDI ARABIA, in the middle east many location selected to check pipe stability; YANBU, 600 mm GRP Pipe for gravity sewer application with minimum stiffness of 1250 N/m^2 in sandy soil with proper compaction of (70%) relative density depth above crown which (4-4.5) meter; water table was above pipe crown and initial deflection values between 0.8% to 1.55% comparing with limitation value 3% consider safe reading. Another location was selected in DUBAI, U.A.E deflation reading vary from 0.2% to 1.14 of (1600 mm) pipe diameter which is considered safe result (Buczala, 1990). In this paper selected study area work done by drilling borehole and performing soil investigations for soil layers, making all necessary soil classification and determining soil strength parameter cohesion and friction angel with field density and some chemical test. Borehole location was located in Figure-1 which is symbolic by (B.H.1). borehole layer was also shown in Figure-2 which indicates the type of soil; first layer depth was (1.5-3)m consisting of (OH) organic clay high to medium plasticity, the second layer was from (3-6)m containing (CL)clay low plasticity, third layer was from (6-9)m containing (CH) clay high plasticity.

Figure-1. Borehole location (Ltd. *et al.*, 2011).

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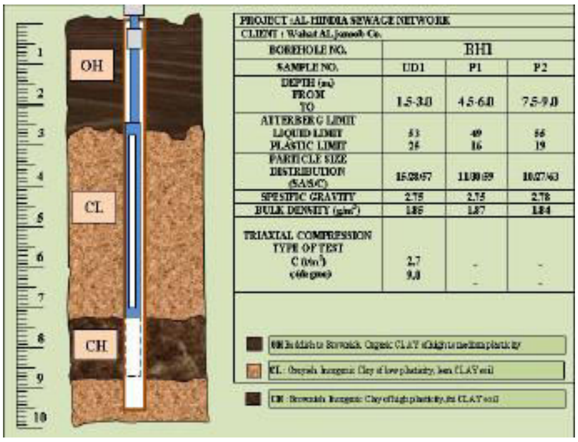

Figure-2. Borehole soil layers (Ltd. *et al*., 2011).

2. METHODOLOGY

Calculation process will contain two phases, Calculating deflection value was from (AWWA M45) predicted method for pipe with different depth, starting from (2 to 10) m.

Using the same condition with constant water table head equal to 2 m below ground level then draw relationship between depth versus deflection extracting equation to compute any interpolated value exactly. Pipe trench end embedment zone illustrated in Figure-3. Parameters used are found in the table below Table-1.

Table-1. Soil and pipe properties.

Soil density (gm./cm^3)	1.85
Kx	0.1
Ps (psi)	72
DL	1
E '(PSI)	1300
WL(Ib)	16000

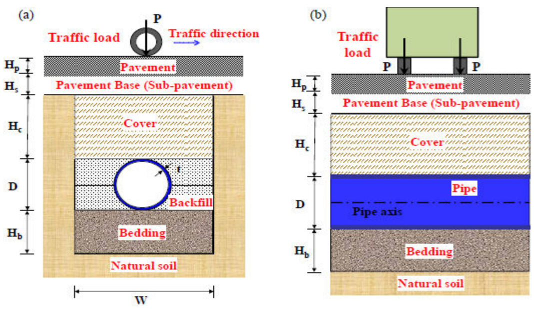

Figure-3. Pipe zones terminology(Barbato *et al*., 2010).

3. RESULT AND DISCUSSIONS

For depth from (2 to10) m with maximum deflection value of (2.93%) at depth of 10 m, the best thing we can say is the standard limit recommended is (5%). From this result, graph relation shown in Figure-4, curve equation was y = 3.6022x - 0.5199 where x value represents depth value, R squared value is $R^2 = 0.9993$.

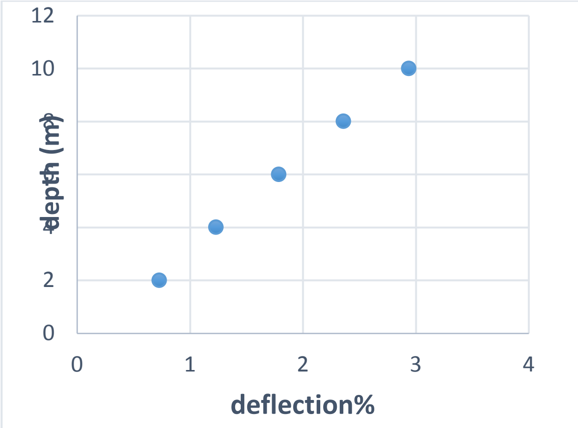

Figure-4. Deflection depth relationship by AWWA equation (vertical).

The Result shown in Table-2 is for depth from (2-10) meter. Phase two, build simulation models for this case using the same condition for depth, water table and pipe size by using PLAXIS 2013 3Dcode. Drawing resulted deflection value versus depth. before performed simulation it must be verified program result with field test, the work done by taken another paper which preformed filed deflection test ,putting soil, pipe properties in plaxis with making proper model and comparing result with visualized data chart, verification done with (Lee *et al*., 2015), Figure-7 shows difference of plaxis simulation with filed data. Difference was found between simulation and filed data, but this difference is acceptable because small values between two methods and give good predict near to real deflection values the plotted results combined together, make comparison to find the difference between two cases. Table-3 shows simulation result, Figures 5, 6 show 3D model output of program solution.

Table-2. Shows calculation result by equation.

Deflection (%)	**Depth** (m)
0.7298	2
1.2311	4
1.789	6
2.3611	8
2.9388	10

Figure-5 indicates maximum deflection occurring dirctly under traffic load (5mm) also to explain stress distribution in all models, Stress around pipe and beeding material, where smallvalue of load effecting the pipe. model in Figure-5 program explain horizontal displacement in all model, which indicate, horizontal displacement occurring at maximum value exactly below traffic, also pipe is effected by this displacement because of soil behavior and movement transition in horizontal direction. Maximum value (0.7) mm, but top soil with smaller value (is) at pipe wall.

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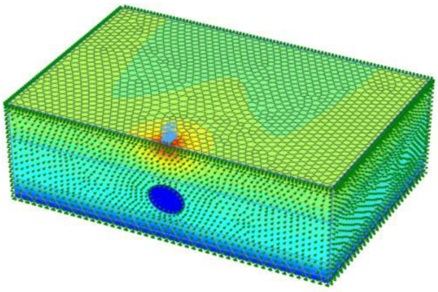

Figure-5. Vertical deflection simulation.

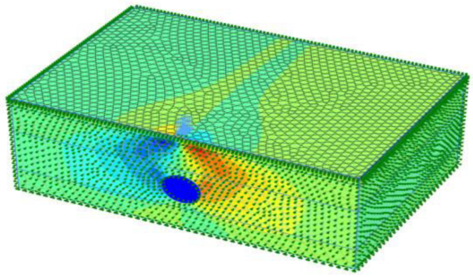

Figure-6. Horizontal deflection simulation.

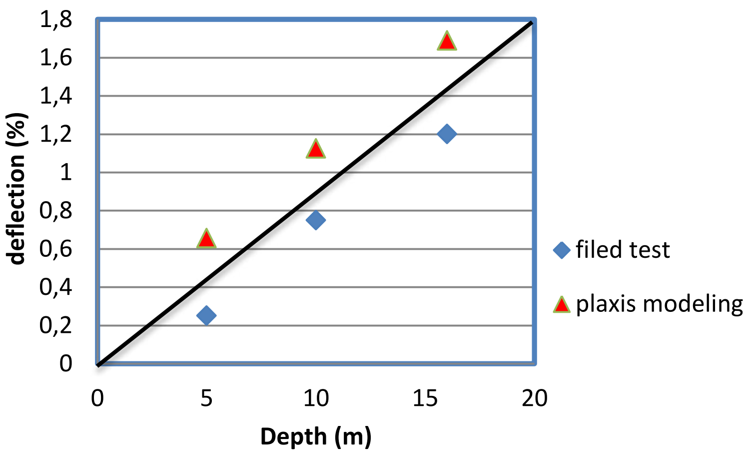

Figure-7. Resualt verification.

Table-3. Shows finite element solution result.

Depth	vertical deflection	horizontal deflection
2	0.2949	0.0325
4	0.3777	0.0361
6	0.4689	0.0442
8	0.57135	0.0536
10	0.6744	0.0626

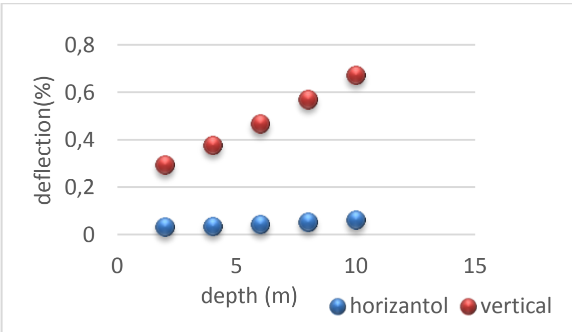

Figure-8. Horizontal and vertical deflections on pipe wall.

Figure-8 explain resualt different of horizontal versus vertical with depth by using plaxis modeling.Vertical deflection versus horizontal deflection by using finite element approach the plotted results combined together, Figure-9, make comparing, when make comparison between horizontal and vertical deflection there is huge difference between AWWA solution and plaxis. Where AWWA assume same condition in horizontal and vertical direction, while this is not true by, comparing with field test and finite element approach take real condition and behavior of soil is unpredictable therefore AWWA solution is not recommended for horizontal deflection calculation, go to finite element or field test to find out considerable value of calculated horizontal deflection.

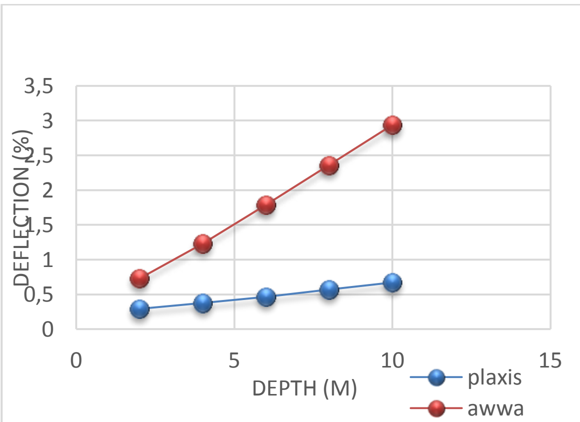

Figure-9. Relation of AWWA solution versus plaxis model result.

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CONCLUSIONS

From above calculations and curves it can be conclude that equation used (AWWA) m- 45 resulted over estimating values for pipe deflection, providing high safety factor for pipe design, were finite element deflection values near to real field deflection values. Thus, we need to make field test for all soil and pipe condition and properties with making proper model to find out proper equation to calculate deflection for specific case, AWWA equation (is) considered old and sometime inefficient for soil with a lot of fine material. According to ASTM classification with overestimated values need special treatment in design and contraction stage, sometime field test hard to apply, time cost consuming for design purpose AWWA equation give good estimation for stability parameter as mentioned before with high safety factor to predict stability parameters, but for analysis purpose, we must check with finite element and field test to ensure stability value with real condition. In this study, deflection value using equation at maximum depth which doesn't reach (3%) which is considered safe value According to specification limits of (5%), with using 3D simulation maximum value not reach (0.1%) for vertical direction and not reach (0.04%) for horizontal direction thus lead to test this software for case contain field test with real reading and check This software with this situation to compare and extract factor can used to found real deflection value when we simulate any model.

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