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Innovative Techniques of micropiles for embankment foundation

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Abstract:- In this study embankment foundation is treated with micropiles using MIDAS GTS 2D software. The embankment foundation is having clayey silt, soft soil and coarse sand which is treated by micropile. Reduction in settlement is observed in embankment foundation. Micropiles are small diameter reinforced piles having diameter less than 300mm, grouted in place with neat cement. They are constructed in seismic areas due to its flexibility and ductility. Micropiles are used for foundation support of new structures and retrofitting of old structures which were not built as per the requirement of seismic codes. They increase the bearing capacity of the soil and reduce the settlement. Based on this study it is concluded that micropiles are used in any soil type and ground condition.

Index Terms—micropile, flexibility, embankment, FE analysis, reduction, seismic areas, settlement

I. INTRODUCTION

To transfers the loads of the super structure to the hard bearing strata piles are used. They are mainly used for the support of bridges; buildings and other heavy structures. Piles resist the axial, lateral and uplift loads and also cheaper than any other ground improvement techniques. Many structures which were built when there was less knowledge of seismic design. During earthquake they have damaged and the extensive damage of these structures motivated to find some retrofitting techniques [2] which keep the structure safe. The selection of the type of retrofit is often influenced by site constraints. Seismic retrofitting means to strengthen the already built damaged or undamaged, old or new building structures those are found to be weak in earthquake loading that may occur in future. Micropiles are increasingly being used to retrofit deep foundations of heavy structures.

II. HISTORY OF MICROPILES

The first use of micropiles was in the early 1950's in Italy, where new methods of underpinning for existing structures were needed to restore structures and monuments damaged during World War II [3],[7]. Dr. Fernando Lizzi is commonly recognized as the inventor of micropiles in the form of the root pile or palo-radice. This technology was used extensively in Europe for the restoration of various structures and monuments. There was slow growth of the technology in the time period between the mid 1970's and the mid 1980's but due to the research effort of FHWA [4]and trade association there has been a rapid growth in the specification and use of micropiles in the United States. The FHWA undertook a number of research and development projects to encourage innovation in geotechnical applications and produced several design manuals including the first on micropiles. This was the beginning of the use of micropile in the United States.

Currently Micropiles are widely used in all construction sectors worldwide and are gaining greater popularity due to its small size and only small dimension of equipment is needed for construction. They are reinforced piles having small diameter ranging from 90mm to 250mm, grouted in place with neat cement [6]. It can be used to drill through any type of soils, boulders and hard materials. It is installed without risking the stability of structure. They are constructed in seismic areas due to its flexibility and ductility and used as foundation support of new structures as well as for seismic retrofitting structure which have been affected seismic damage. Inclined micropiles can be easily constructed.

III. FE 2D MODELLING USING MIDAS GTS SOFTWARE

By using MIDAS GTS finite element analysis 2D software, the modelling of embankment [1] which is treated by micropile is studied. The soil strata are of clayey silt, soft soil and coarse sand. The upper layer of the soil is clayey silt and the bottom is coarse sand. But the majority of the soil in the middle is of soft soil which is greatly affected by static loading and dynamic loading. In this study the embankment is treated with micropile in static loading. The properties of soil taken for embankment foundation are listed in Table 1[8].

The micropile with diameter 0.2m and length 14m were modeled using as a beam element. Interface element set out between the Interface element set out between the soil and the pile for the interactions between soil and piles. The thickness of the interface element was assumed 0.1 to 0.01 times the length of the interface element. The displacement at bottom boundary in all directions was fixed and on vertical side it was allowed only in vertical direction.

Table1 Soil Properties For The Embankment Foundation

Soil Type	Unsaturated Unit Weight KN/m^3	Saturated Unit Weight KN/m^3	Cohesion KN/m^2	Friction Angle (Degrees)	Young's modulus KN/m^2	Poison's Ratio
Fill	16	20	1	30	8000	0.3
Clay Silt	16	18	5	25	10000	0.35
Soft soil	17	18.5	7	20	5000	0.35
Coarse sand	17	20	1	34	30000	0.3

The embankment foundation was analysed in FE analysis without micropile and with micropiles. The settlement at various level is observed in both the cases which are tabulated in Table 2 and Table 3 witout and with micropile respectively.

IV. RESULT AND DISCUSSION

The embankment is modelled in MIDAS GTS software using 2D FE analysis. Static load is applied and settlement is observed at the top of the embankment, at ground level and an interface of each layer of soil strata. The settlement treated without micropile and treated with micropile as tabulated in Table 2. We observed that the settlement is reduced approximately 67% at the top of the embankment, 72% at the ground level, 77% in the soft soil layer and approximately 35% at the interface layer between soft soil and coarse sand after treated with micropiles. The percentage reduction in settlement is shown below in Table 3.

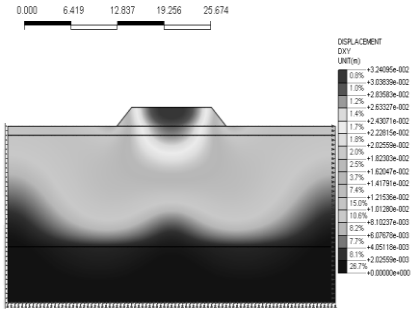

Fig. 1. Total displacement treated without micropile

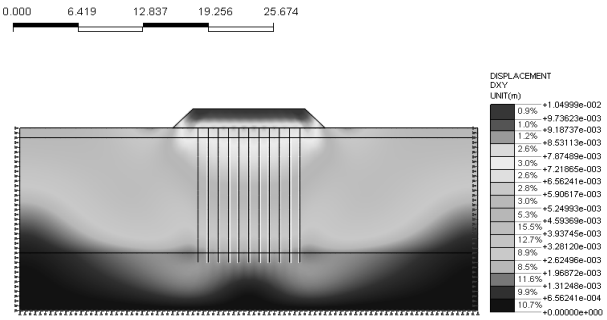

Fig. 2. Total displacement treated with micropile

Table 2 Total Settlement Of Embankment Foundation

Sr. No.	Description	Settlement of Embankment Foundation
Treated without micropile		
1	At +2 m height/Embankment top	32.41 $X10^{-3}$ m
2	At 0 m	28.35 -30.38 $X10^{-3}$ m
3	At -1 m depth	26.33 -28.35 $X10^{-3}$ m
4	At -13 m depth	2.02 $X10^{-3}$ m
5	At -19 m depth	0
Treated with micropile		
1	At +2 m height/Embankment top	10.50 $X10^{-3}$ m
2	At 0 m	7.88 $X10^{-3}$ m
3	At -1 m depth	5.91 -7.22 $X10^{-3}$ m
4	At -13 m depth	1.31 -1.97 $X10^{-3}$ m
5	At -19 m depth	0

Table 3 % Reduction In Settlement Before Treated And After Treated

Sr. No.	Description	Settlement of Foundation Subgrade treated without micropiles	Settlement of Foundation Subgrade treated without micropiles	% reduction in settlement
1	At +2 m height/Embankment top	32.41 $X10^{-3}$ m	10.50 $X10^{-3}$ m	67.6%
2	At 0 m	28.35 -30.38 $X10^{-3}$ m	7.88 $X10^{-3}$ m	72.2%
3	At -1 m depth	26.33 -28.35 $X10^{-3}$ m	5.91 -7.22 $X10^{-3}$ m	77.55%
4	At -13 m depth	2.02 $X10^{-3}$ m	1.31 -1.97 $X10^{-3}$ m	35.14%
5	At -19 m depth	0	0	-

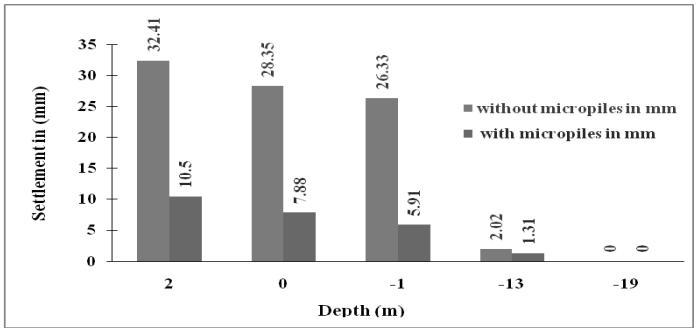

Fig. 3. Settlement Vs Depath before and after treatment of embankment foundation

V. CONCLUSION

The embankment model using 2D FE analysis in MIDAS GTS shows that the foundation treated by micropile has reduced the settlement of subgrade in clayey silt and soft soil up to 72% and 77% respectively. Micropiles are grouted small-diameter piles, which can be installed in almost all soil types and ground conditions. Micro piles are very useful for retrofitting of structures those have not build as per seismic codes. Due to the treatment of foundation by micropiles, increased the stability of embankment and greatly reduced the settlement of the embankment. Micropiles are very much effective for clayey soil and soft soil. They increased the bearing capacity of the soil [5]. If properly designed then they can use for liquefiable soil.

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