Overview of High Vacuum Densification Method (HVDM) for soft soils Improvement

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Presentation On

OVERVIEW OF HIGH VACUUM DENSIFICATION METHOD (HVDM) FOR SOFT SOILS IMPROVEMENT

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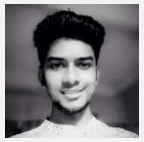

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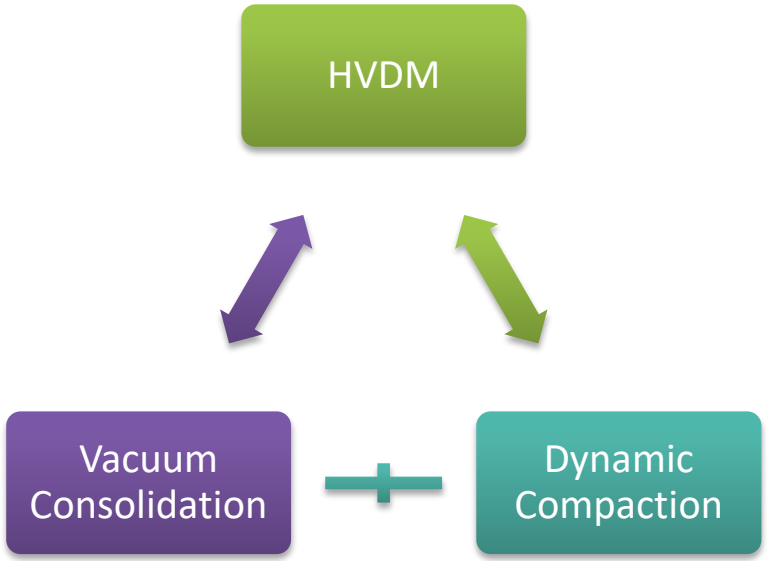
INTRODUCTION OF HVDM

High Vacuum Densification Method (HVDM) is an innovative technique based on the combination of the two processes of Vacuum Consolidation or Vacuum dewatering and Dynamic Compaction to improve saturated soft cohesive soil.

This method utilizes several runs of vacuum dewatering and deep dynamic compaction to generate negative and positive pore pressure, respectively, which help to facilitate pore pressure dissipation and achieve both consolidation and densification effects that lowered water content and increased density. As a result, soil strength and stiffness are improved.



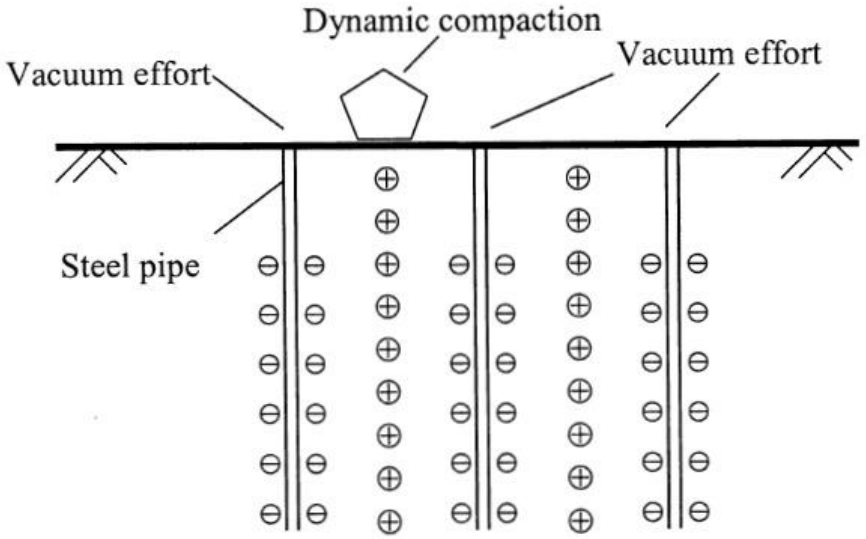
WHY SHOULD WE PREFER HVDM

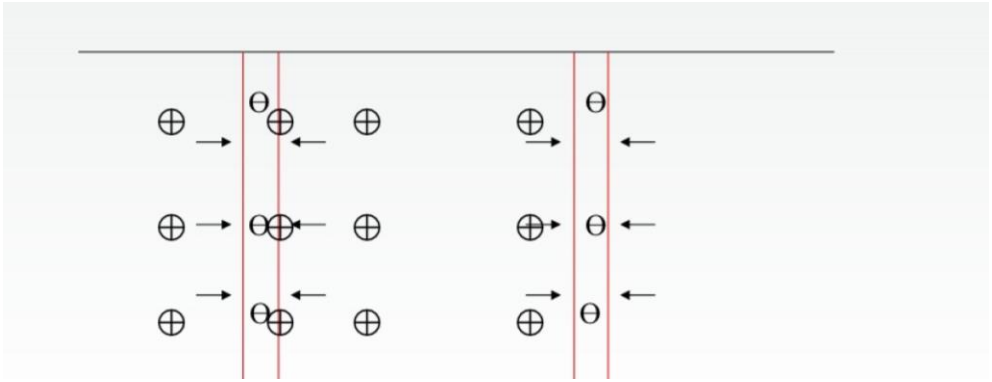
- Save 30% in cost compared to conventional Methods
- 50% Schedule Saving
- Environment Friendly

Items	Patch 1 (500,000 m²)	Patch 2 (460,000 m²)
Treatment methods	PVD+surcharge preloading	HVDM
Consolidation	~44 cm	~60 cm
Schedule	10 months	4 months
Post-treatment settlement of 2 yr	31 cm	14 cm

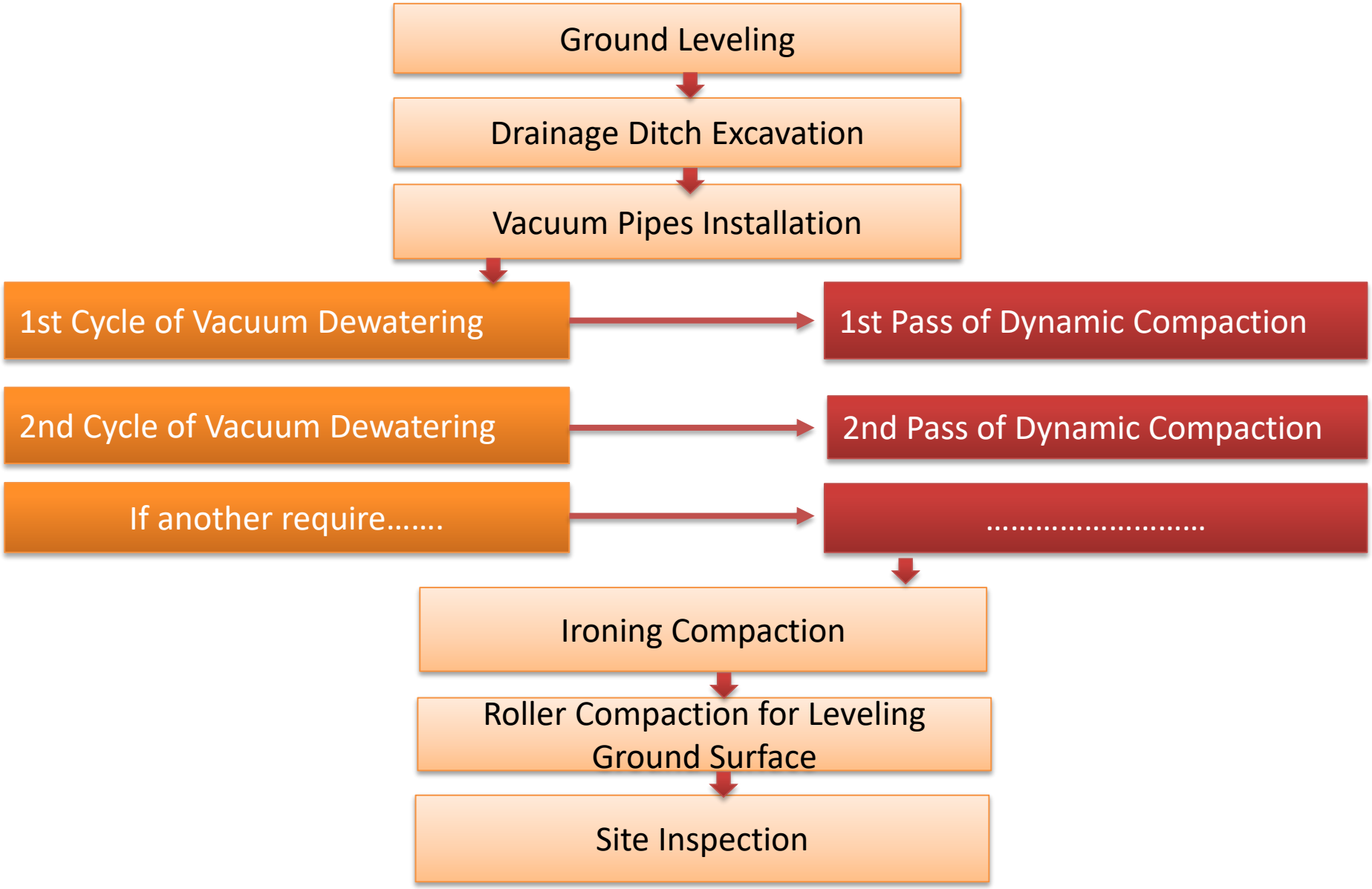
MECHANISM OF HVDM

- HVDM Employs vacuum Effort to suck or drain the soil moisture out and on the other hand, HVDM employs conventional dynamic compaction procedures to densify the soil
- Each HVDM run ,Vacuum effort leads to negative pore pressure in the soil around the vacuum pipes ,whereas the dynamic compaction leads to positive pore pressure .
- The two opposite pore pressures from a lateral pressure gradient in influenced soil if the vacuum and compaction spacing are well designed on the construction site .
- The pressure gradient is generated to expedite the pore pressure dissipation and moisture discharge





TYPICAL CONSTRUCTION PROCEDURES OF HVDM



SITE PREPARATION AND CONSTRUCTION PROCEDURE OF HVDM

Step -1 :

- Conduct details soil investigation and determining soil profile at the site.
- Some important basic soil properties, including gradation curves, Atterberg Limits, water content, hydraulic conductivity, compressibility, and coefficient of consolidation should be estimated and determined .
- Also, need to conduct some in-situ tests, such as CPT or STP to establish baseline values prior to commencing HVDM in the field

SITE PREPARATION AND CONSTRUCTION PROCEDURE OF HVDM

Step -2 :

- Install vertical vacuum pipes and horizontal drainage pipes by vibratory hammer and a mandrel, or a hydraulic system to directly push vacuum pipes into ground method.
- The vacuum pipes contain perforated holes and are wrapped around on the outside by a geotextile fabric for filtration purpose.
- The horizontal drainage pipes are typically PVCs, which are connected to steel vacuum pipes through an elbow connector

SITE PREPARATION AND CONSTRUCTION PROCEDURE OF HVDM

Step -3 :

- Apply first cycle of vacuum to reduce water content and initial degree of saturation, in addition increasing load bearing capacity of soil, therefore soil can tolerate weight of labors and equipment's for the next phase of work (deep dynamic compaction)
- This phase is fulfilled usually within one week before proceeding to the next step

SITE PREPARATION AND CONSTRUCTION PROCEDURE OF HVDM

Step -4 :

- Apply deep dynamic compaction to densify the soils and to generate positive pore water pressure
- Its noted that during the dynamic compaction, the vacuum pipes are not removed, while vacuum pressure and dynamic compaction energy act on the soil at the same time, under the “ pressure gradient ” caused by them.
- The duration of this phase is usually within 1 week for an area of approximately 10,000 square meters

SITE PREPARATION AND CONSTRUCTION PROCEDURE OF HVDM

Step -5 :

- Apply the second cycle of vacuum for dissipating generated non-uniform EPWP during DC efforts, and reducing degree of saturation and void ratio of soil mass.

- The combined efforts of vacuum generated negative pore water pressure and the deep dynamic compaction generated positive pore water pressure create very high pore pressure gradient, which in turn help facilitate accelerated dissipation of pore water pressure, resulting in reduced water content.

- The duration of this phase is generally one week or less

Step -6 :

- Evaluate the soil properties after completing Step 5. In particular, the water content, pore water pressures, ground water elevation, ground subsidence, and in-situ test results such as cone resistance of CPT or N values of STP, need to be determined to assess the results of the first cycle (Steps 4 and 5) of HVDM process

- Assessing the outcome of ground improvement at this step would allow for adjusting the operation parameters (spacing and depth of vacuum pipes, dynamic compaction energy level and grid spacing of tamping points, etc.) in the next cycle of HVDM process

SITE PREPARATION AND CONSTRUCTION PROCEDURE OF HVDM

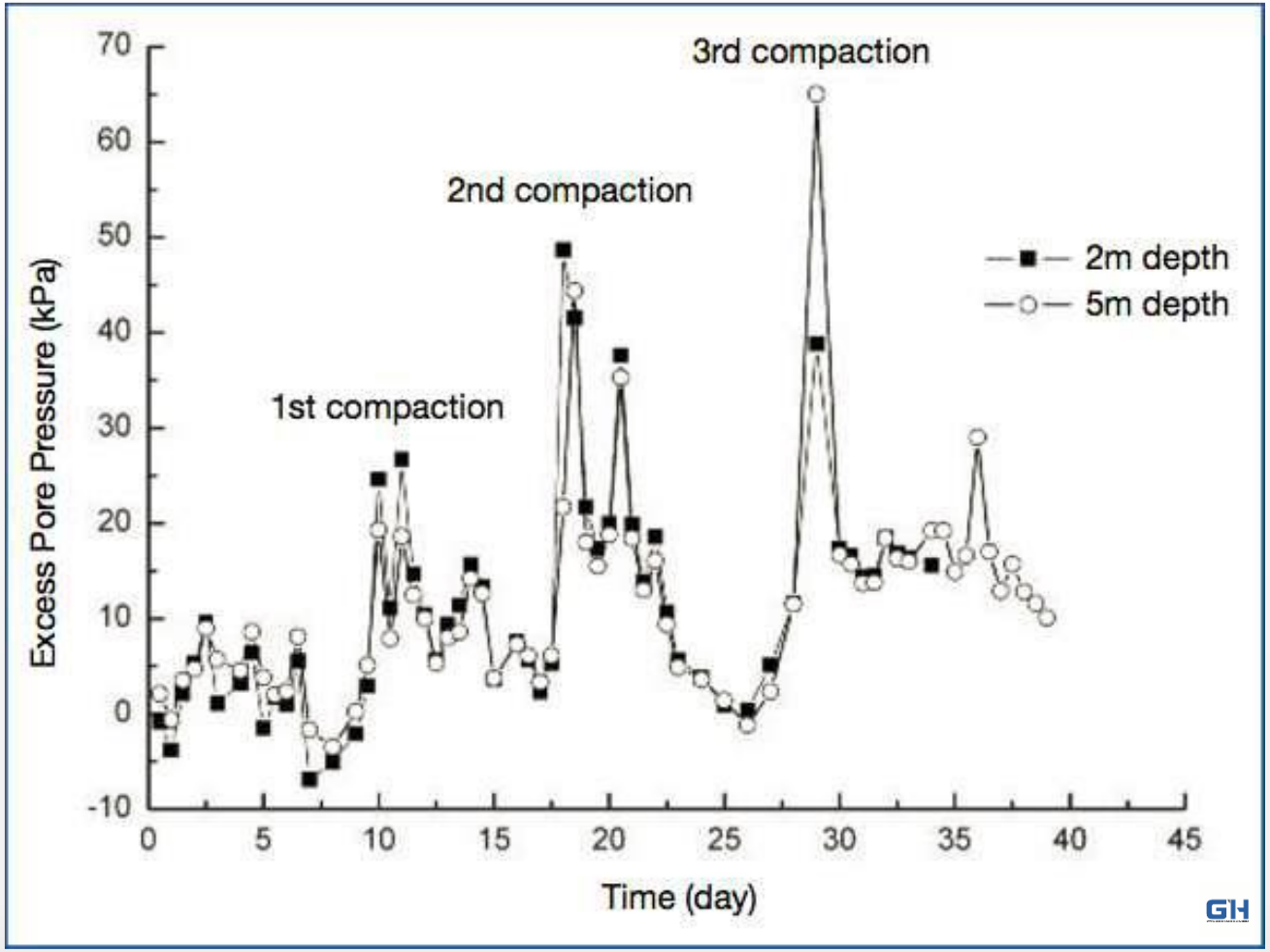
Step -7:

- Repeat Steps 4 to 6 until the performance criteria are satisfied.

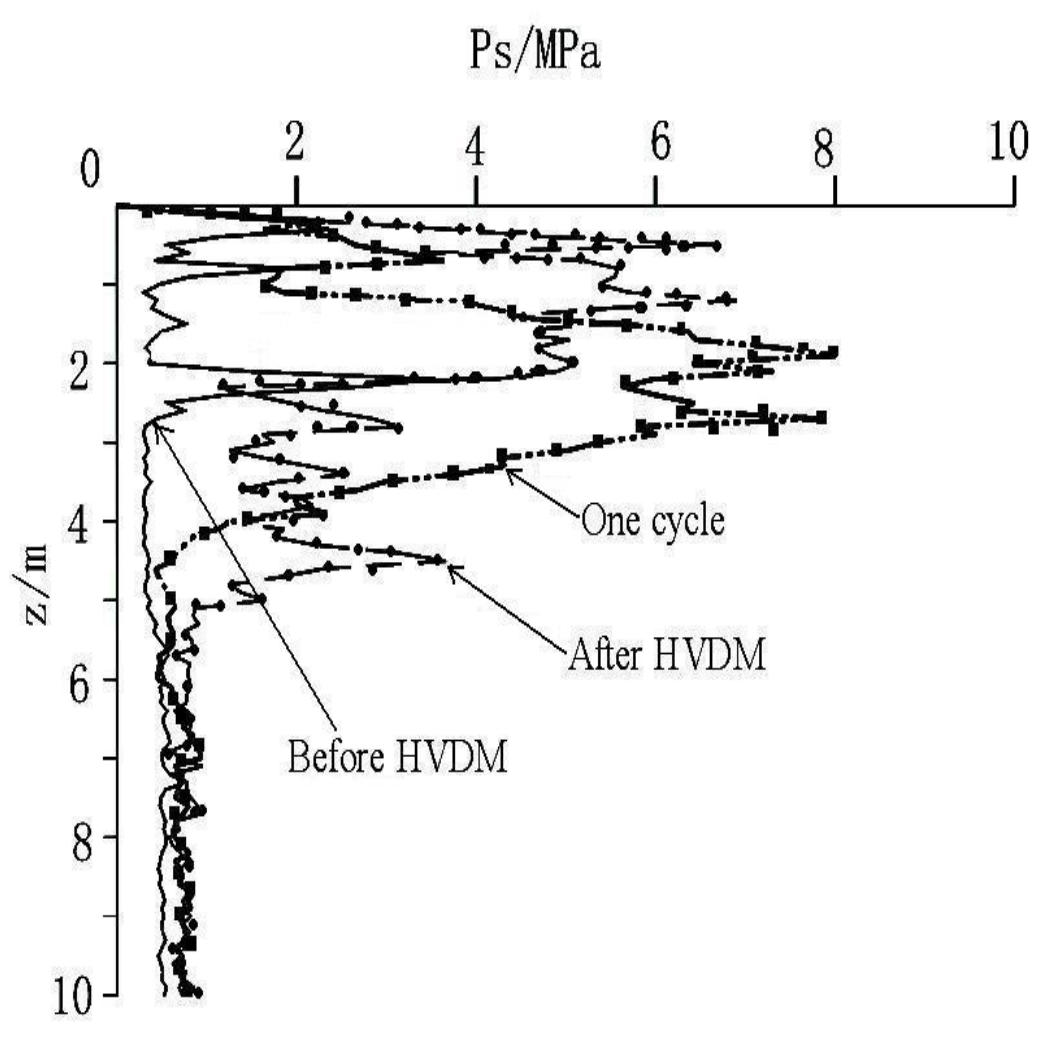
- It should be pointed that in general two cycles of HVDM process are generally sufficient to achieve the required performance criteria, such as strength as determined by CPT or STP and the posttreatment settlement

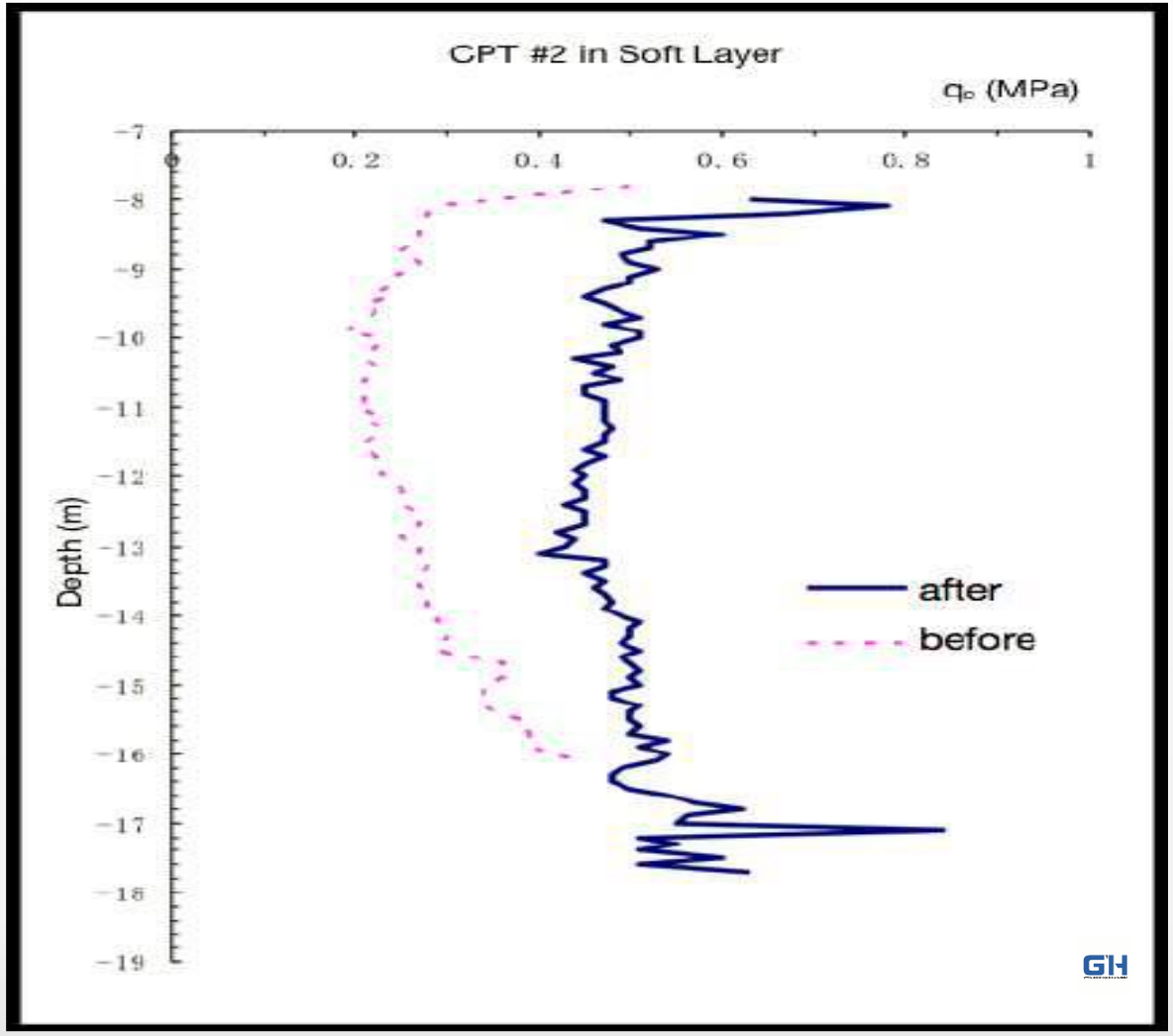
Fig : Site condition after improvement

EXCESS PORE PRESSURE MONITORING DURING CONSTRUCTION



Before And After Result Of HVDM From Previous Practices





CPT cone resistance readings between before and after ground improvement

Before And After Result Of HVDM From Previous Practices

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REFERENCES

[1] Chang, D. T. T., Lou, X. M., Xu, S. L., Wang, J. C., & Guo, L. L. (2010). Innovative soft soil stabilization using simultaneous high-vacuum dewatering and dynamic compaction. Transportation research record, 2186(1), 138-146

[2] Xu R. Liang, S & Edil, Tuncer. (2015). Innovative Soft Soil Improvement Method through Intelligent Use of Vacuum De-Watering and Dynamic Compaction Techniques. Geotechnical Engineering. 46. 57-67

[3] Liang, R. Y., & Xu, S. L. (2012). High vacuum densification method for soft soil improvement. Proceedings of the 2012 GeoCongress, Oakland, California, USA, 25-29 March, 2012: state of the art and practice in geotechnical engineering, 1928-1937

[4] Liang, R. Y., & Xu, S. (2010, December). Innovative Soft Clay Improvements Using Vacuum and Dynamic Compaction. In Proc. Indian Geotechnical Conference-2010 (pp. 133-141).

[5] Tuncer B. EDIL (2017) .Soft Soil Improvement by Vacuum Dewatering and Dynamic Compaction .3rd International Conference on New Advances in Civil Engineering APRIL 28-29, 2017, Helsinki, Finland

[6] Tabatabaei, S. (2014). Design and Analysis of" High Vacuum Densification Method" for Saturated and Partially Saturated Soft Soil Improvement (Doctoral dissertation, University of Akron).

[7] Liang, R. Y., & Xu, S. (2011). Innovative soft clay improvement technique using vacuum and dynamic compaction (HVDM). In 2011 Pan-Am CGS Geotechnical Conference.

[8] Ta-I Chang, Dave & Lou, Xiao-Ming & Xu, Si-Long & Wang, Jen-Chin & Guo, Li-Lun. (2010). Innovative Soft Soil Stabilization Using Simultaneous High-Vacuum Dewatering and Dynamic Compaction. Transportation Research Record: Journal of the Transportation Research Board. 2186. 138-146. 10.3141/2186-15

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