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Ground Improvement Techniques for Railway Embankments

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Abstract:
In this current scenario the development of railway infrastructures demands a high-speed congestion free network in order to create a railway network with speeds above 160 kmph. For this various ground improvements are to be implemented. These ground improvement techniques will help in improving the bearing capacity and reducing the settlement of soft cohesive soil. In this paper the suggested ground improvement techniques are Vibro Compaction, Vibro Replacement (Stone Columns), Grouted Stone Columns (GSC), Vibro Concrete Columns and Dry Deep Soil Mixing.

Keywords **— *Ground Improvement, Vibro Compaction, Vibro Replacement and Grouted Stone Columns.***

I. INTRODUCTION

In recent times, there has been an increasing demand from modern railway organisations to increase the axle load, decrease the traffic congestions and significantly increasing the train speeds. For the better performance of the rail system attention should be focused on the post development settlement of the subsoil. For this paper currently taking the Case History for USA.

An improvement in the subsoil characteristics will mean a significant development in mitigating vibrations by high speed trains. Considering the rail history in USA engineers have invested most of their time in maintaining rail traffic through the complex geographical settings prevailing in there. They have to suffer from unforeseen landslides and washouts.

Another very important case history can be seen in Scandinavia where more than 80 ground improvement works have been carried out recently mostly including dry deep soil mixing method. Over 12 million linear meters of columns have been installed within the last 20 years by LCM Markteknik.

The West Coast Line is converted is converted into a double track one to facilitate the traffic speed and reduce congestions. The new twofold track is situated 0-3m underneath the encompassing ground level. Following the tests it was reasoned that 3260 lime bond (50/50) segments with width 600mm divided 1.5m out of a rectangular lattice design and an aggregate of 33,950 straight meters would need to be introduced.

A comparable case history from Germany expresses that the present prompting Berlin required upgradation including Deep Vibro Techniques. The subsoil under Hamburg-Berlin course which is approximately a 6km extend was enhanced utilizing Vibro Replacement

GROUND IMPROVEMENT TECHNIQUES

The nearness of delicate soils along the railroad track arrangement represents a greater risk for the post development settlement, security against slip disappointment and obviously ground vibrations. With a specific end goal to beat these issues following strategies are to be executed.

1.1 Vibro Technique

This procedure can be utilized for treating delicate firm soils with profundity vibrators. It includes Vibro Compaction and Vibro Replacement strategies.

1.1.1 Vibro Compaction

In this strategy the particles of non strong soil, for example, sand and rock can be adjusted by vibrations. The essential procedure is to briefly decrease the bury molecule erosions and revamping in denser state. The accompanying chart indicates Vibro Compaction. Fig.1.

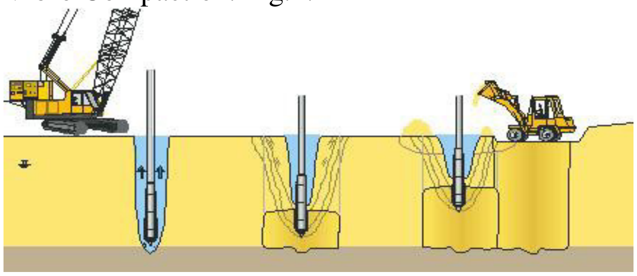

Fig.1 Schematic showing Vibro Compaction

In this technique as obvious from the above graph, a vibrator infiltrates the dirt by water planes and once at full profundities it is step by step pulled back abandoning a section of all around compacted soil.

This method is massively useful in densifying moderately clean soils, for example, sand and rock. No extra materials are required consequently making this procedure moderately particularly efficient.

1.1.2 Vibro Replacement (Stone Columns)

This technique is widely utilized for sandy soils with high fine substance (>15%) and strong soils, for example, residue and earth. Stone sections are introduced in the delicate ground utilizing profundity vibrator. Initial a gap is dove in the ground utilizing the vibrator and afterward stone is filled into it amid vibrator withdrawal. The stone is along the side dislodged into the dirt by repenetrating the vibrator. Along these lines a stone section having width 700-1100mm is introduced in the ground.

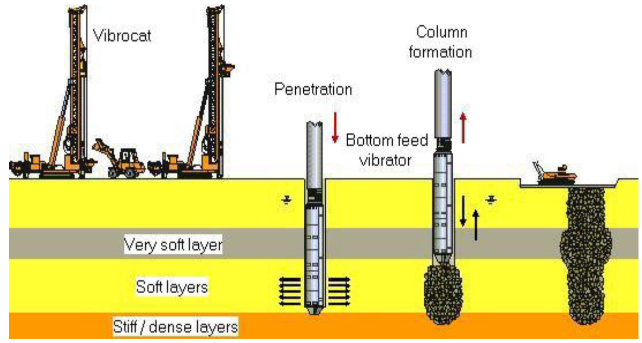

Fig.2 Schematic showing Vibro Replacement

There are two strategies for establishment i.e. wet and dry. Wet strategy encourages the making of openings utilizing water planes which aids infiltration. While in the dry technique gaps are made utilizing vibratory vitality and a draw down power. The Vibro Replacement procedure gives a financial and adaptable arrangement, which effectively adjusts to shifting ground conditions. Utilizing Vibro Replacement, the accompanying geotechnical changes are achievable:

- Compaction of the subsoil and increment in thickness
- Improvement in the firmness of the subsoil to diminish inordinate settlements
- Improvement in the shear quality of the subsoil to diminish the danger of disappointment
- Increase in the mass of the subsoil to moderate ground vibrations
- Ability to convey high loads since segments is very malleable
- Rapid combination of the subsoil.

1.1.2 Grouted Stone Columns (GSC)

A stone section depends on the horizontal help offered by the in-situ soil for its solidness and load conveying limit. If there should be an occurrence of natural soil, for example, peat there is an absence of sidelong help as time cruises by. In that situation rock can be binded with bond grout suspension to make the segments. The establishment procedure is delineated in Fig.3.

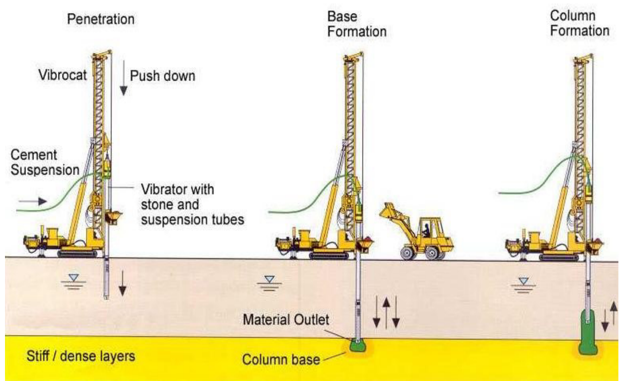

Fig.3 Schematic showing the installation of Grouted Stone Columns.

1.1.4 Vibro Concrete Columns

This strategy includes the establishment of unbending heap like establishment component. In this strategy concrete is filled straightforwardly to the tip of the base bolster vibrator to frame the segment. The procedure is exhibited in Fig.4. Because of the development of base and its entrance into compacted bearing strata making the sections as end bearing segments and can bolster high bearing burdens.

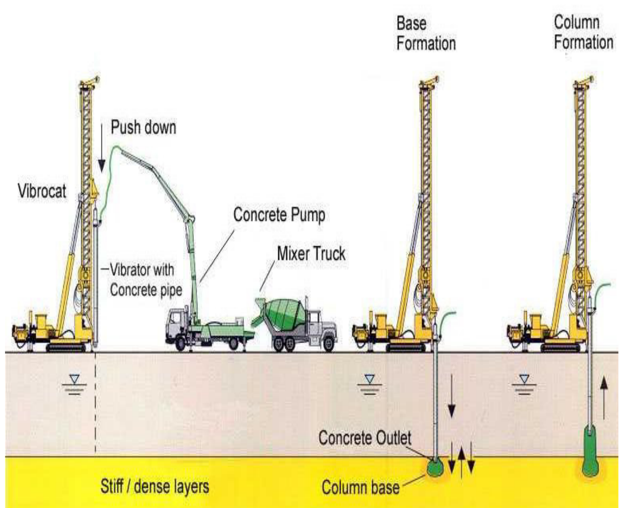

Fig.4 Schematic showing the installation of Vibro Concrete Columns (VCC)

With an amplified base and section heads the segments lengths are diminished and an expansion in segment dispersing which will prompt a general abatement in the cost of the establishment framework. VCCs are perfect for frail alluvial soil, for example, peat and delicate mud. Working burdens up to 750 KN can be accomplished in suitable soils.

Where the VCCs are needed for structures, for example, intensely stacked floor pieces, pontoons, streets and dike, the sections can be built with an extended heads as appeared in Figure 5. The amplified make a beeline for diminish punching shear and can either be utilized to give guide contact support to the section or to give a uniform bearing weight through a geo grid strengthened granular bedding as appeared in the Fig.5

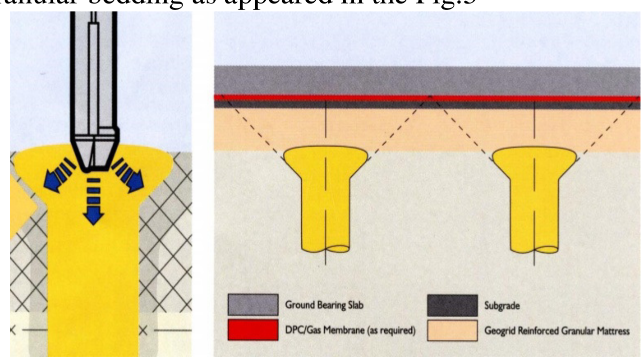

Fig.5 Example of non suspended soil on enlarged VCC heads

Quality control is an essential piece of all the previously mentioned Vibro Techniques consequently all the development work is completely instrumented. An in-taxi screen is utilized to screen the development grouping as indicated by [2].

1.2 Dry Deep Soil Mixing

This method being an enhancement of the lime-cement column method, which was invented by Kjeld Paus roughly 3 decades ago. It includes the mechanical blending of in-situ delicate and feeble soil with a cementitious compound, for example, lime, bond or both taken in extents. This fastener blend is mixed into the dirt in dry state. The dampness in the dirt is used for restricting bringing about dirt with higher shear quality and lower compressibility as in [2]. The process is described in Fig.6 below.

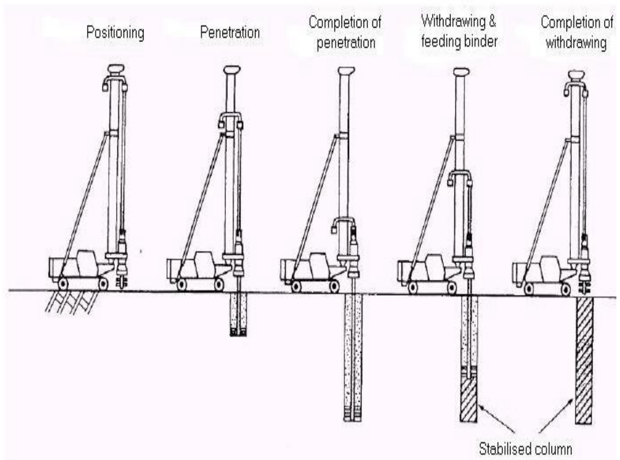

Fig.6 Schematic showing execution of dry deep soil mixing

This method can be used for foundation of embankment fill for highway and railway, slope stabilization, stabilization for deep development and also for housing development. Sort of soils appropriate are delicate strong stores, broad dirt, free granular soils and pummeled fuel cinder. The measure of restricting operator generally utilized is 100-150 kg/m^3 in silty earth materials. The quality grows diversely with the progression of time, measure of folio and extent utilized. In most of the cases the quality begins to increment following a couple of hours and afterward proceeds to increment quickly amid the main week. In the vast majority of the cases 90% of the last quality is come to in around three weeks. The plan and assessment of enhanced miss happening can be seen in [2] and [7]. This strategy helps in diminishing subsidence and expanding sheer quality and furthermore the bearing limit of the dirt. Broad work which is completed can be seen in [4].

CASE HISTORY FROM USA

Railroad framework advancement has a long history in the United States of America. All through this history, engineers have been gone up against with the trouble and cost engaged with the upkeep of existing rail activity through troublesome and complex geographical settings. Railroad updates are frequently required to deal with expanded cargo and worker movement, two fold stack autos or high speed trains. Also, there are issues identifying with avalanches or washouts of slope rail, sinkhole action and adjustment of compressible and liquefaction inclined soils. The following Table-1 record suitability of different ground changes systems executed at different areas in the United States.

Technique	Site Location	Purpose
Vibro Replacement	LACTC Flyover, Los Angeles SFM Rail yard, San Francisco	Densification of loose silty sands Mitigation of liquefaction potential
Deep Soil Mixing	Alameda Corridor, Los Angeles	Stabilisation of in-situ soils
Lime/Flyash Injection	Santa Fe Railroad, St. Joseph, MO	Subgrade stabilisation
Compaction Grouting	Union Pacific (UP) Railroad, Kansas CSX Railroad, Georgia Union Pacific Embankment Tunnel, Longview, Texas	Filling of voids in the shale Avoidance of sinkhole formations Densification of soil mass
Jet Grouting	Tilford Tunnel, Atlanta, Georgia Charles Street Bridge, , Rhode Island Union Pacific Storm Drain Tunnel, Ft. Worth, Texas	To replace the existing support To increase the slope stability To stabilise the soil mass
Chemical Grouting	West River Bridge, New Have, Connecticut Claremont Detention Basin, Albuquerque, New Mexico	Stabilisation of granular soils Solidification of sandy soils
Mini Piles	Canton Viaduct, Canton, Massachusetts Straight Creek Bridge, Tazewell, Tennessee	To form load bearing elements To form a deep foundation system
Anchors	Embankment slide, Green Bottom, West Virginia	To form an earth retention system

Table-1

Petronas Kedah Fertilizer Plant Line at Gurun (1997)

The development of Petronas Kedah Fertilizer Plant in 1997 close Gurun in Northern Malaysia was finished by building a railroad track from the plant to the KTM primary station. The track particularly required dikes with stature extending from 2m to 8m. So a strengthened earth divider was utilized as the earth slants can't be utilized because of the prior KTM track as said in Fig.7.

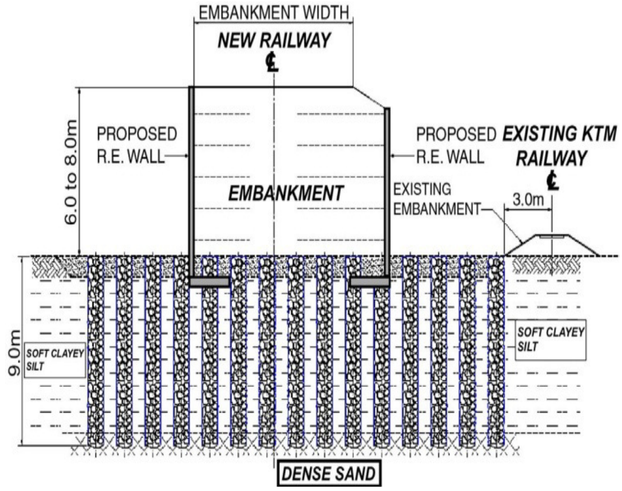

Fig.7 Cross segment demonstrating the strengthened earth divider, the bordering existing KTM line and the ground change plot.

The nearness of delicate clayey residues (SPT N = 0 to 2) to profundities down to 9.0m postured issues of divider solidness and unreasonable settlements. Vibro Replacement utilizing the dry base sustain system was made to treat the delicate soils. Altogether 18,000 km. of 1.0m width stone segments were introduced utilizing two Keller Vibrocats. Figure 8 demonstrates the two Vibrocats at work with the KTM prepare in the fore ground.

Fig.8 Vibro Replacement works along the KTM railroad line at Gurun for the Petronas Kedah Fertilizer Plant

CONCLUSION

Involvement in a few nations has demonstrated that ground change is regularly required for establishing dikes for current rapid railroad foundation. Profound Vibro procedures and profound soil blending strategies have discovered broad application worldwide and have ended up being adaptable in the capacity to treat an extensive variety of soils and site imperatives/conditions and productive as far as time required to finish the treatment works and for solidification. The way that they have been broadly utilized is an affirmation that the procedures are in fact sound and in the meantime temperate.

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